Research for Development

Oscar Eugenio Bellini · Andrea Campioli · Claudio Del Pero · Cinzia M. L. Talamo · Davide Chiaroni · Stefano Guidarini · Camillo Magni *Editors*

Innovative Approach for the Development of Sustainable Settlements in East Africa

Affordable Housing for Mogadishu

Fondazione Politecnico di Milano

Springer

Research for Development

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Foreword

BECOMe: A Bet and an Act of Reciprocal Trust

Over the past decades, the role of Academia in the complex field of Cooperation and Development has seen a major evolution and recognition. Universities are indeed capable of producing innovation and high-level knowledge, suitable to find solutions during emergencies as well as support strategies with a long-term vision, making them the main driver of science diplomacy, a qualifying element of the European Union foreign policy designed to meet the shared needs of development and equity.

This is the context in which Politecnico di Milano Cooperation strategy and initiatives are activated, with an approach that enhances scientific knowledge and skills and puts people back at the center of innovation processes, as globally required by the 2030 Agenda of the United Nations and Agenda 2063 of the African Union. At a national level, Law 125/2014 recognizes the academic world as an actor in the system of development cooperation. The efforts of Academia to enrich its traditional missions of teaching and research are therefore encouraged. In the last 15 years, our university has refined its own vision, giving origin to a more specific elaboration of its efforts linked to the valorization of the different polytechnic competences and the institutionalization of Cooperation towards a progressive alignment with the international reflections.

Sustainable and affordable urbanization is one of the most pressing issues for the global community and it also stands at the core of BECOMe (Business ECOsystem Design for Sustainable Settlements in Mogadishu), an investigation into innovative approaches to build sustainable settlements in Mogadishu. The research discussed in this publication was conceived in 2018 and initiated in 2019 with the aim to deliver an integrated development plan for a business ecosystem based on the co-existence of affordable housing, local entrepreneurship, social facilities, and renewable energies as an enabling factor of the sustainability of modern settlements. In line with the approach to Cooperation at Polimi, BECOMe starting point is the belief that complex issues should be approached from a multidisciplinary perspective.

BECOMe contributes to the mission to build an academic institution committed to dialogue with society and capable of serving communities by addressing major social issues. Since 2005, the vision on the role of Politecnico di Milano in the ever-evolving field of Cooperation and Development has been refining, giving way to an alignment with the national and international frameworks. Politecnico di Milano has institutionalized its vocation for Academic Cooperation, which originated from the commitment of individual professors who, over time, laid the foundations to build an institutional interest.

Among the over 100 Cooperation initiatives mapped within our university from 2010 to 2021, projects involving one or more African countries are around three times more than those involving Asia and six times those involving Latin America, showing a well-defined interest in working with African partners. A recent in-depth mapping revealed that the projects activated in the past 10 years involve 25 African countries, with 70% of the total represented by 10 nations: Mozambique, Tunisia, Egypt, Kenya, Ethiopia, Morocco, Senegal, Somalia, Tanzania, and Algeria. The number of initiatives in collaboration with African partners tends to increase every year.

In accordance with Politecnico di Milano tradition, collaborations developed with African universities and research centers prevail, but a share of partners from the private sector and national institutions is in constant growth. Partnerships and networks lead to the development of a constructive and continuous dialogue between universities and the outside world: these partnerships guarantee an effective and efficient impact on Cooperation and Development strategies at both national and international levels. Additionally, acting in synergy with a variety of stakeholders facilitates enhancing the technical, scientific, and innovation contributions intrinsic to our university, and such approach will help Politecnico di Milano to further consolidate its institutional commitment. The latter can be synthesized in three strands of work, sometimes interlinked:

- Higher Education and Capacity Building
- Research for local Development
- Science Diplomacy

Within this framework, more than 50% of Higher Education and Capacity Building projects focus on Africa, as well as over 60% of Research for local Development initiatives, while 100% of Science Diplomacy actions involve the Continent.

It is worth mentioning that BECOMe is part of a growing portion of Cooperation and Development initiatives activated by Politecnico di Milano that are self-funded by our university through the competition Polisocial Award in support of scientific research with a high social impact. The Award is made possible by the 5 per Mille IRPEF funds and promotes projects in a variety of scientific areas at Politecnico di Milano, involving all 12 departments. Since its creation in 2013, a total of 46 projects have been funded, 18 of which are in cooperation with developing countries. The initiative, which is unique at the national level, has strengthened several constructive interactions between Politecnico di Milano and the outside world, focusing on a combination of traditional forms of knowledge transfer and a "horizontal" exchange with stakeholders.

One of the common traits of the Polisocial Award projects is the attempt to tackle needs identified outside of the academic realm: university research is enriched by such an approach and becomes a practice of Cooperation, based on scientific evidence, characterized by inter-actor dialogue and mutual learning.

The Award has strengthened a culture of university-society collaboration with numerous partners, including public service bodies (local authorities, hospitals, etc.), universities and research centers, associations, NGOs, international organizations, foundations, companies, universities, and schools

BECOMe responds to the urgency of the housing emergency affecting the Somali population after decades of unrest, that the research team proposed to approach through the construction of neighborhoods that can guarantee stability and durability. The project has promoted several declinations of how the commitment and social responsibility manifest within Politecnico di Milano:

Multidisciplinary research creates synergies to address complex issues of relevance to communities for human and socio-economic development in international socio-economic development.

Innovation, through the placement of research activities in problematic contexts, with the aim of developing methods and knowledge of more general applicability.

Dialogue with the outside world and the co-production of knowledge, through the creation of stable partnerships with institutions, companies, civil society, and international organizations, in which the role of the university is enhanced as an expert interlocutor and organizer of research activities on issues of direct interest to multiple communities.

BECOMe is therefore a bet and an act of faith by all the stakeholders—Somali and Italians—local institutions, construction workers, representatives of business activities, and academicians. The Somali National University, UN-Habitat, AICS Somalia, ANCE Lombardia, Holac Construction Company, and Architetti Senza Frontiere Italia made their expertise available in the spirit of co-production of knowledge for a local development plan to be shared with local stakeholder. The project has also contributed to strengthen the research team experience, which can be transferred to students—a future generation of professionals.

Despite the challenges that it encountered in the 2 years of work, the project was made possible thanks to both institutional and personal dedication.

Our gratitude goes to the principal investigator Prof. Oscar Eugenio Bellini, the project managers Prof. Claudio Del Pero, and Prof. Camillo Magni and all researchers, research fellows, Ph.D. candidates, and partners that embarked on challenging research that—we hope—will encourage further joint projects with Somalia.

Emanuela Colombo
Rector's Delegate for Cooperation and Development, Politecnico di Milano

Manuela Nebuloni
Polisocial

Introduction

The book deals with sustainable affordable housing in developing countries, providing the main results of the research BECOMe "Business ECOsystem design for sustainable settlements in Mogadishu: affordable housing, local entrepreneurship and social facilities", winner of the Polisocial Award 2018 competition, promoted by Politecnico di Milano.[1]

The topic of sustainable affordable housing in developing countries is becoming increasingly important for African and international stakeholders. At present, massive urbanization processes involve many countries, that are consuming large parts of territories and natural resources. These processes are developed far from any strategy of sustainability and social equality, without considering the long-term effects on the environment and on the next generations. Attention to the natural and human resources, the specific climate conditions, the preservation of the traditional culture, the improvement of social welfare, the development of enterprises, and expertise at the local scale are some of the hardest challenges that most of the

[1] This research "Business ECOsystem design for sustainable settlements in Mogadishu: affordable housing, local entrepreneurship and social facilities—BECOMe," was funded by "Polisocial Award 2018—City and Smart Community in Africa—Politecnico di Milano, fifth edition." It involved the following Departments: Architecture, Built Environment and Construction Engineering (DABC); Architecture and Urban Studies (DAStU); Management, Economics and Industrial Engineering (DIG). Scientific Coordinator: Oscar Eugenio Bellini. Project managers: Claudio Del Pero, Camillo Magni with Andrea Campioli, Davide Chiaroni, Stefano Guidarini, Cinzia Maria Luisa Talamo. Project team: Nazly Atta, Abdihakim Awaale, Anna Dalla Valle, Davide di Summa, Giuliana Maria Miglierina, Maricla Martire, Armin Mostafavi, Lucrezia Sgambaro. The research received the endorsement of the following subjects: ASF Italy (Architetti Senza Frontiere), no-profit design organization with an international network knowledge; Agenzia Italiana per la Cooperazione allo Sviluppo (Italian Agency for Development Cooperation) (AICS) Mogadishu (Somalia); ANCE Lombardia (Associazione Regionale dei Costruttori Edili Lombardi) Milan, (Italy), Regional association knowledge of the Italian Architecture, Engineering & Construction (AEC) sector/business; HOLAC Construction Company, Mogadishu, (Somalia)—Somalian construction company; UN-Habitat—United Nations Agency for Human Settlements and Sustainable Urban Development, Nairobi (Kenya).

African countries will face in the next years. In this perspective, the issue of affordable housing opens to many aspects that need specific approaches adapted to the many different African contexts.

Focusing on East Africa,[2] it is possible to assume the case of Somalia as representative of a fragile context characterized both by the uncertainty of the social, political, and economic situation and the lack of common shared legislative references and strategies. In this kind of contexts, the risk of developing inadequate construction practices is very high and the negative effects of unregulated urbanization are widespread and persistent. At the same time, the economic recovery and the high demand for affordable housing disclose the opportunity to create sustainable and durable settlements, going beyond basic shelters.

Starting from these premises, the book reports the main contents of the research whose aim is to provide knowledge, propose a methodological framework for the development of affordable and sustainable settlements and provide housing models and tools for the simulation of various scenarios. The long-term perspective is the development of sustainable settlements involving local entrepreneurship, boosting social facilities, and using renewable energies in order to stimulate the growth of a new housing market and attract national and international investors. The investigations and the proposals presented in the book are focused on the case of Mogadishu, but they are replicable in other high-risk environments, especially in East African countries.

On the basis of this main objective, the book deals with:

1. Knowledge, criteria, approaches, leverages, and barriers related to the development of strategies for the creation of new sustainable housing ecosystems, able to activate and boost local enterprises and to stimulate foreign investors for the revamping of the national AEC sector and the related manufacturing industries.
2. Models for modular settlements (considering typological, technical, economic, social, and environmental aspects), able to answer to the housing demand of low-medium-income population. The modular settlements integrate various types of flexible low-cost single/multi-family houses with adaptive spaces for craft, productive, and commercial activities for artisans/small local enterprises and social services.
3. Business models and assessment methodologies are useful to evaluate a set of appropriate technological solutions. These solutions are related to various types of construction process organization and some possible economic strategies, in the perspective to ensure a balance among the sustainability pillars (economic, environmental, social, and cultural).

The book is structured in three parts and nine chapters.

[2] East Africa (Eastern Africa or East of Africa) is a subregion of the African continent. According to the United Nations Statistic Division it consists in 18 countries and 2 dependencies. The subregion extends from Eritrea to Mozambique and borders the Indian Ocean. The Countries are Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, South Sudan, Tanzania, Uganda, Zambia, Zimbabwe (Worldatlas, accessed in 2021).

Part I—East Africa Context

- Chapter "Ecosystem Perspective for Sustainable Settlements in East Africa", starting from some recent trends characterizing the social and economic context of the East Africa region, opens up some research questions related to the development of housing settlements assuming the ecosystem perspective and affordability and sustainability as strategic goals.
- Chapter "Housing in East Africa" analyses the housing issue in East Africa in its various forms. The chapter focuses on climate context and related climate responsive design and the new housing needs of the growing population.

Part II—Mogadishu as a Representative Case

- Chapter "The Dynamic and Fragile Context of Mogadishu as a Representative Case" provides an overview of the geographic, historical, political, and socio-economic dynamic and fragile application context of Mogadishu (considered as a representative case), highlighting its construction traditions and the main strengths, weaknesses, and open issues connected to a sustainable development. It investigates housing demand and defines levels of affordability.
- Chapter "Climate-Responsive Design and Energy Performance Goals" analyses the climate features of Mogadishu and provides the main rules for climate-responsive design and renewable energy integration.
- Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu" sets up an investigation methodology appropriated for the specific context to describe the fragmented and heterogeneous nature of manufacturing and construction sectors in Mogadishu, underling main information gaps, current local practices, technical solutions, and organizational models.

Part III—Proposals for Sustainable and Affordable Housing in Mogadishu

- Chapter "Settlement Strategy Towards New Business Ecosystems" presents the concept of modular settlements for new business ecosystems, based on a set of incremental housing typologies to meet the high rate of low-medium-income population housing demand.
- Chapter "Construction Technologies and Materials for Sustainable Affordable Housing" proposes a methodology for assessing and selecting appropriate

building technologies for affordable housing, including a method for the systematic classification of building components, and investigates construction technologies and materials for sustainable affordable housing. It outlines possible perspectives of improvement towards industrialization of construction, use of local raw materials, and enhancement of construction quality through training.

- Chapter "Estimation of Construction Costs: From Technological Solutions to the Settlement Scale" introduces an estimation of construction costs to overcome inaccurate information, ranging from building to settlement scale.
- Chapter "Appropriate Tools for Decision-Makers: Proposal of a Decisional Support System (DSS)" develops a Decisional Support System (DSS) whose aim is to support decision-making processes towards affordable settlements in Mogadishu and the achievement of their long-term sustainability.

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About the Editors

Oscar Eugenio Bellini Architect, Associate Professor of Architectural Technology at the Department of Architecture, the Built Environment and Construction Engineering of Politecnico di Milano, where he works on research issues concerning building and construction design with a special interest in social and student housing, environmental design, and sustainability in architecture for new construction as well as renovation. He also conducts research in the area of housing and appropriate building technologies in developing countries. He is in research programs funded by Ministries and Public Bodies at different levels and in UE international projects. He is the author of books, essays, articles in reviews, and academic papers included in international conference proceedings, on topics related to sustainability in architecture and environmental comfort at building scale. He has overseen various projects for public and private buildings' new construction and refurbishment. He was the scientific coordinator of the research project Become.

Andrea Campioli Architect, Ph.D. in Architectural Technology, since 2005 full professor of Architectural Technology at the Politecnico di Milano, Department of Architecture, Built Environment and Construction Engineering (DABC). The research activity is focused on the effects of technic and technological innovations on design culture in architecture with particular attention to the innovation processes oriented towards environmental sustainability of buildings and components in the whole life cycle. He coordinates and participates in national and international research programs. He writes books and papers on reviews and attends international and national seminars and conferences about the topics of his research work. He's editor of the section Details of the review Costruire in Laterizio since 1991 and of the section Architecture of the review Costruzioni Metalliche since 1998.

Claudio Del Pero Engineer, Associate professor at the Politecnico di Milano University (Department of Architecture, Built Environment and Construction Engineering). He is actively involved in research and advisory activities related to energy efficiency in the building sector and to the exploitation of renewable energy sources, with particular reference to the topics of solar technologies and distributed energy generation.

Over the years he has been involved in various National and International research projects related to the exploitation of renewable energy sources, energy efficiency, and energy management at building and district levels. Since 2014, he has also participated in different research and cooperation activities on the above-mentioned topics in African Countries.

Cinzia M. L. Talamo Architect, Full professor of Architectural Technology at the ABC Department of Politecnico di Milano, she earned there a Ph.D. in Technical innovation ad design in architecture and a Master Degree (five years program) in Architecture, awarded with honours. She is President of the Sub Committee U/CTO25/SC03 Maintenance of Real Estate and Facility of UNI (Ente Italiano di Unificazione, the Italian institution dedicated to standardization). She is the Coordinator of the Scientific Committee of the ABC Department. Her main and long-term interest focus on planned maintenance, as well as building and urban facility management. A recent area of interest concerns cross-sector waste recycling in the perspective of industrial symbiosis and circular economy.

Davide Chiaroni Engineer, Full Professor of Strategy & Marketing at Politecnico di Milano, where he obtained cum laude his Master of Science in Management Engineering in 2002 and later in 2007 his Ph.D. in Management, Economics and Industrial Engineering. His research interest is in the management of innovation, with a particular focus on energy, sustainability, and smart ecosystems (grid, buildings, communities, cities). He is also among the most cited author in the field of Circular Economy, where he studies the implications of the adoption of circular business models. He is the co-founder of Energy & Strategy, a research group of the School of Management that publishes every year several research reports in the abovementioned fields that actively promote the debate in the industry and among policymakers.

Stefano Guidarini Architect. He worked in the Studios of the architects Giancarlo De Carlo (1982–86), Gino Pollini (1986), and BBPR-Belgiojoso (1987–90). Since 1990 he is practicing design research on public and private architecture, mostly related to the city and social housing. In 2011, he founded the post-graduate Master's Degree in Social Housing at the Politecnico di Milano. He is the Associate Professor at the Department of Architecture and Urban Studies of the Politecnico di Milano, where he teaches Architectural Design. He published the books Ignazio Gardella nell'architettura italiana (2002), Precisazioni sull'Housing Sociale in Italia (2017), New Urban Housing (2018). He won the 1996 In/Arch-Domus Architecture Prize and the Gold Medal for Italian Architecture of the Milan Triennale (2006). In 2010, he was invited to exhibit at the 12th International Architecture Exhibition of the Venice Biennale.

Camillo Magni teaches Architectural Design as Adjunct Professor at Politecnico of Milan and is Director of the Master "Design for development in the Global South." In 2004, he has been participating in the international research program "Casapartes" to build low-cost houses in Latin America. He is the author of more than 90 scientific

papers, 2 books, and co-the editor for Casabella. In 2007, he founded "Operastudio" a design office in Milan. In its first years, Operastudio has been focussing on both private and public sectors, soon achieving notoriety and awards in international competitions. Operastudio's work has been exhibited in the Lisbon Architectural Triennale, in the Milan Triennale, and in the Venice Biennale (2014). He leads the NGO Architetti senza frontiere Italia, working in several countries around the word and winning in 2015 the honourable medal of "Medaglia d'oro all'architettura italiana" and Silver medal "Fassa Bortolo" for the school project in Cambodia.

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East Africa Context

Ecosystem Perspective for Sustainable Settlements in East Africa

C. M. L. Talamo, N. Atta, A. Dalla Valle, and A. Campioli

Abstract The chapter provides an overview of the complexity of the East African housing issue, characterized by disparities and diversities. The challenge is to reduce the inequality and poverty levels towards adequate and sustainable settlements, combining building development, economic growth, and social and environmental improvement. In this changing and dynamic scenario, the still-open issues are introduced and argued, paying particular attention to the match of affordable housing with sustainable strategic goals; the activation of social cohesion through inclusive ecosystem settlements, enhancing local entrepreneurship within affordable housing; the promotion of local circular economy and sustainable resource management.

Keywords East Africa · Inclusive ecosystem settlements · Sustainable development · Housing demand · Social cohesion

1 East Africa: A Fast Growing, Changing and Complex Region

The issue of sustainable settlements in East Africa should be considered in relation to its many contradictions. Between the development and the backwardness that characterize this vast and varied region, the awareness of the urgent demand for new settlements emerges together with the long-standing housing problems also in the perspective of the effects of the current pandemic, that are redefining the growth expectations and the solvency of the housing demand.

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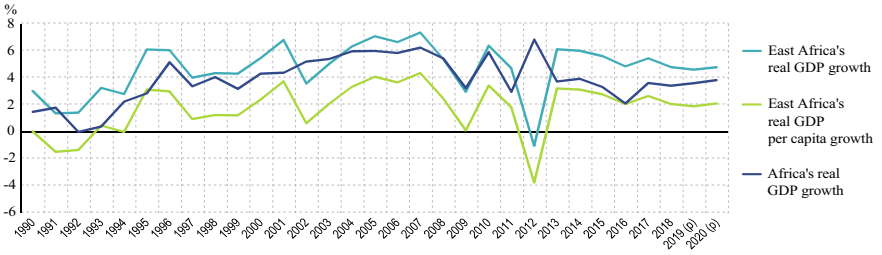

Fig. 1 Growth dynamics in East Africa and Africa, 1990–2020. *Source* AUC/OECD (2019)

Certainly, some trends are shared by the many states of the East Africa (the 14 economies of East Africa represent approximately 15.2% of African GDP and 29% of the population[1]), at the same time, however, the geopolitical and economic differences do not facilitate a unitary interpretation of this articulated and complex regions. The interpretative task is currently made even more difficult by the effects of the pandemic. Consequently, the reading of phenomena must take into account both those trends consolidated in the years preceding the pandemic and the current contingent situations, with all its repercussions in the medium- to long-term that are now difficult to predict, especially in contexts characterized by data shortage, as the African one (AfDB 2021a, b, Furi 2021).

Even if the growth has been uneven across the region owing to various situations,[2] East Africa has been the second fastest-growing African region for the past two decades (Fig. 1), averaging 5.2% gross domestic product (GDP) growth between 2000 and 2018 with a per capita averaged income per year growth of the 3% since 2000 (with a population growth of 2.9% over the same period).

Before the pandemic (ADB 2019), East Africa was projected (Fig. 2) to achieve a growth of 6.1% in 2020 (Table 1). Growth in this region (Fig. 3) has been mainly driven by services[3] and construction, including public investment programs, but also

[1] World Bank, World Development Indicators (database), http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

[2] For instance, according to reports of the United Nations Economic Commission for Africa (ECA), in Burundi and Comoros growth remained weak due to political uncertainty, in South Sudan GDP continued to fall due to political and military conflicts and because the 2015 peace agreement had not been implemented, a drought-induced decline in agricultural output in 2016 for Kenya, Rwanda, and Uganda and political instability in Somalia.

[3] According to reports of the United Nations Economic Commission for Africa (ECA) and the International Labour Organization (ILO), the services sector has seen its share of the regional economy increase by ten percentage points since 2000, representing 43% of value added in 2017; moreover, the sector share of formal employment in the region in 2019 stands at 26% with the permanence of low value-added trade services and a high degree of informality.

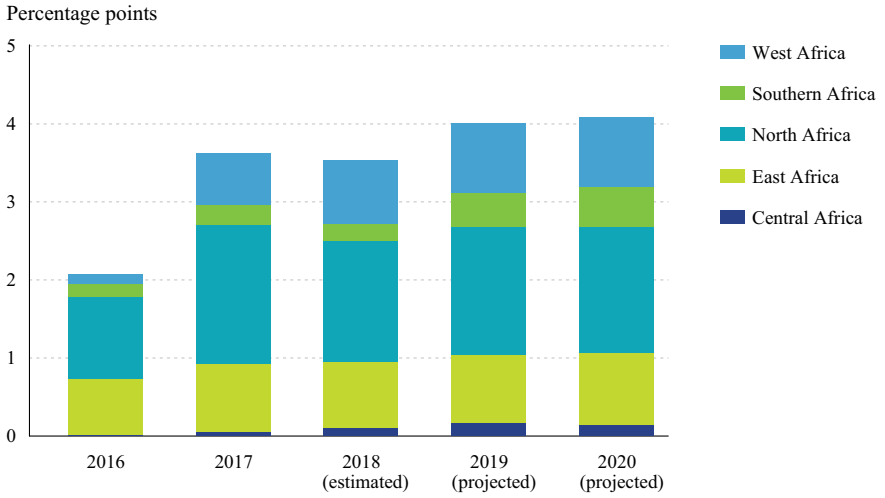

Fig. 2 Contribution of the regions to GDP growth in Africa in the period 2016–2020. *Source* AfDB (2019)

Table 1 Real GDP growth in Africa, 2010–2020

Indicator and country group	2010–2014	2015	2016	2017	2018 estimated	2019 projected	2020 projected
Central Africa	5.0	3.3	0.2	1.1	2.2	3.6	3.5
East Africa	5.9	6.5	5.1	5.9	5.7	5.9	6.1
North Africa	3.7	3.7	3.2	4.9	4.3	4.4	4.3
Including Sudan	3.6	3.7	3.2	4.8	4.3	4.4	4.3
Southern Africa	3.8	1.6	0.7	1.6	1.2	2.2	2.8
West Africa	6.2	3.2	0.5	2.7	3.3	3.6	3.6
Africa	*4.7*	*3.5*	*2.1*	*3.6*	*3.5*	*4.0*	*4.1*
Excluding Libya	4.4	3.6	2.2	3.0	3.5	3.9	4.1
Sub-Saharan Africa	5.2	3.4	1.5	2.9	3.1	3.7	3.9
Excluding South Africa	5.9	3.9	1.8	3.3	3.6	4.2	4.3
Oil-exporting countries	4.7	3.3	1.5	3.2	3.4	3.8	3.7
Oil-importing countries	4.6	3.7	3.1	4.2	3.8	4.3	4.5

Source AfDB (2019)

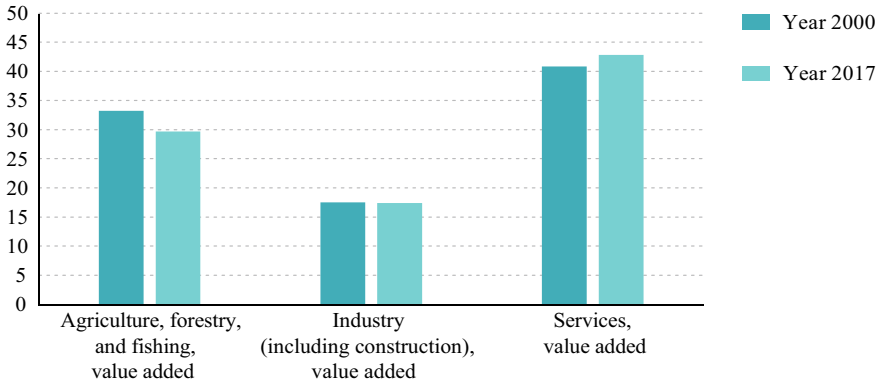

Fig. 3 Sectoral share of gross domestic product in East Africa, 2000 and 2017. *Source* AUC/OECD (2019a, b)

partly by industry,[4] tourism[5] and—where weather conditions remained favorable (Sudan and Tanzania)—by agriculture[6] (AfDB, OECD, UNDP 2016). Even if the services sector represents the largest contributor to the value added of the region, the need for an increase in labor productivity was widely perceived across all sectors of the economy (AUC/OECD 2019a, b).

Despite the good growth performances (Fig. 2), the tax ratios in African countries remain comparatively low (Fig. 4). The large share of the informal sector and the number of small-scale firms limit the ability to raise a large amount of taxes. In addition, a taxation system that favors multinational enterprises (MNEs), which exploit natural resources and pay taxes in the countries in which their headquarters are located, narrows the tax base particularly in resource-dependent countries (UNCTAD 2019).

Nonetheless, several countries in East Africa were noted in 2015 for increasing revenues from indirect (mostly consumption-based) taxes and direct taxes on incomes and corporate profits. Ethiopia doubled indirect and direct tax revenues between 2012 and 2015; Kenya and Rwanda displayed a dynamic upward trend in tax revenues as well into 2015 (AfDB, OECD, UNDP 2016).

[4] Before the pandemic, the manufacturing sector has grown in absolute terms but has seen its share of total value-added decline by four percentage points since 2000. The industry share of total value added had dropped to 15%—three percentage points lower than at the turn of the century. The sector was increasingly driven by growth in extractives and construction, with averaging growth of 9% and 7%, respectively, between 2008 and 2017 (AUC/OECD 2019a, b).

[5] In the past years, tourism, also thanks to considerable national investments, was a major sector in East Africa, with receipts accounted for over 16% of total exports (goods and services) for Kenya, Rwanda, Tanzania, and Uganda, far above both the global (5.7%) and continental (8%) average (Gereffi 2015).

[6] Agriculture remains a large sector in East Africa, but its share of GDP is declining in most countries (AUC/OECD 2019a, b).

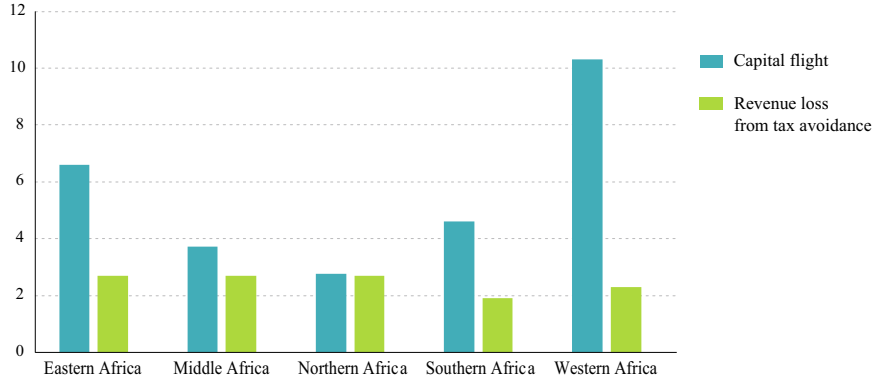

Fig. 4 Capital flight and revenue loss from tax avoidance, median by region, 2013–2015 (Percentage of gross domestic product). *Source* UN (2020)

The dynamics of the complex scenario in East Africa were partly influenced by a plurality of development factors and funding sources (Table 2) that: generated in the past decade important financial flows, led to changes and challenges involving urbanism policies and new housing needs, and stimulated questions about the most appropriate strategies for sustainability.

In the last past years, East Africa benefited from one of the most significant Foreign Direct Investment (FDI)[7] growth in percentage terms (Fig. 5) among African regions (ADB 2019). The region had seen a very high FDI since 2010, in 2015 the figure rose 16% to USD 8.9 billion from USD 7.7 billion in the previous year (AfDB, OECD, UNDP 2016), in part also due to some local events, such as the disclosure of energy resources like the oil fields in Uganda or the mineral assets of gas in the United Republic of Tanzania (Hemed and Suleiman 2017).

The growing trend, that characterized the last decade (Fig. 6), had originated in the years before. Of the total estimated value of USD 61 billion of FDI inflow in 2010 received by all the five sub-regions in Africa, East Africa attracted USD 5.5 billion and USD 5.8 billion in 2011, reflecting an increase in value compared to the total value received in 2010. On the other, the total amount of the outflows by East Africa in 2010 and 2011 was USD 188.7 million and USD 174 million, respectively (Evans et al. 2018).

[7] "In the aspect of sectors, FDI inflow has improved on the efficiency of various sectors in both Central and East Africa. As far as industry dissemination, the primary sector (mostly coal, oil and gas) represented 43%, manufacturing for 29% (of which half was in the industry) and service (mainly real estate and communication) accounted for 28% (UNCTAD 2011). For instance, investment from foreign farmers and incentives for foreign farmers to invest in agriculture in Kenya and the United Republic of Tanzania has increased efficiency in production. Overall, FDI inflow and outflow in Central and East Africa has aided in transfer of expertise, technology and employment of both skilled and unskilled labor in both sub-regions" (Evans et al. 2018).

Table 2 Financial flows and tax revenues to East Africa and private savings (current USD, billion), 2000–2017

			2000–2004	2005–2009	2010	2011	2012	2013	2014	2015	2016	2017
External financial inflows	Private	Foreign direct investments	2.1	5.6	7.8	7.7	9.3	8.4	8.3	8.9	9.3	9.1
		Portfolio investments	0.0	0.0	7.6	5.7	2.5	1.2	2.8	1.5	-6.5	-5.4
		Remittances	1.8	3.0	4.5	4.4	4.9	5.0	5.9	5.0	5.1	5.5
	Public	Official development assistance	6.1	12.6	14.3	15.5	15.8	18.4	16.5	15.9	16.0	18.3
Total foreign inflows			9.9	21.2	34.2	33.3	32.5	32.9	33.5	31.3	23.9	27.6
Tax revenues			8.1	17.1	23.3	24.6	27.7	32.0	35.6	37.0	38.7	40.4
Private savings			11.0	21.0	31.2	41.8	36.1	38.8	49.6	51.4	54.1	55.5

Source AUC/OECD (2019a, b)

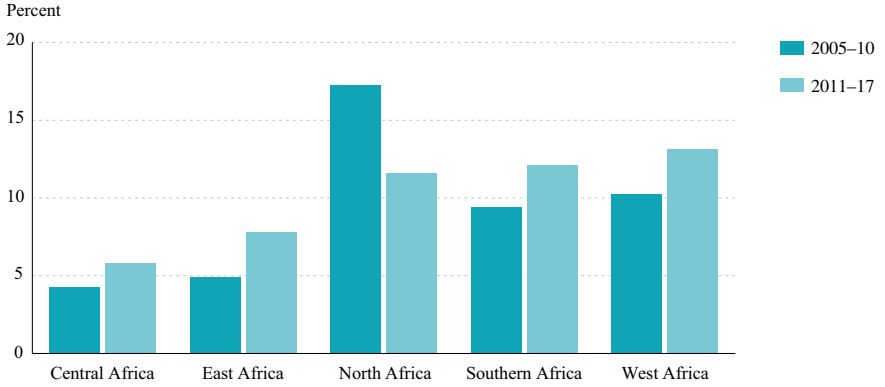

Fig. 5 Average annual Foreign Direct Investment inflows to Africa, by region, 2005–2010 and 2011–2017. *Source* AfDB (2019)

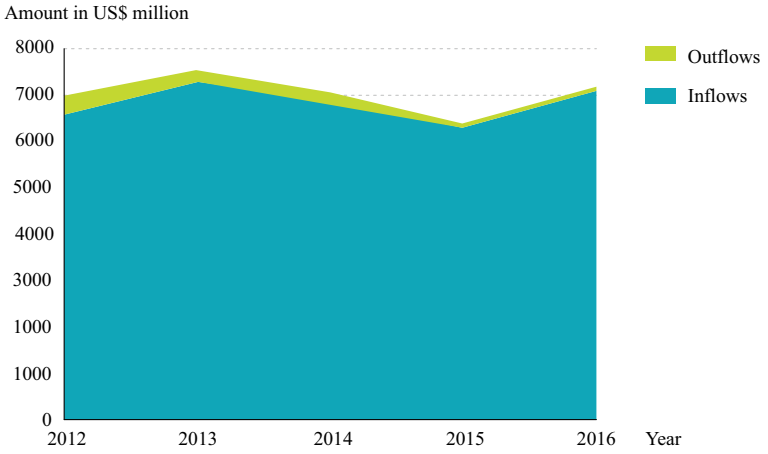

Fig. 6 The growing trend of the total value of the FDI inflows and outflows in East Africa from 2012 to 2016. *Source* Evans et al. (2018)

A constant growth trend for the region regarded also the remittances (AfDB, OECD, UNDP 2016) coming both from African countries and other continents (Fig. 7). The remittances represent an important source of capital for African countries,[8] even if several obstacles still tend to prevent many countries from getting the full benefit of remittances. The World Bank estimates that in 2018 the diaspora sent USD 86 billion to Africa through official channels such as money transfer operators, banks, non-bank financial institutions, and mobile money. In addition to financial institutions, migrants and the diaspora still use unregistered and informal channels

[8] Several African countries are tapping into the pool of remittances funds by issuing bonds for investments in their homelands (AfDB, OECD, UNDP 2016).

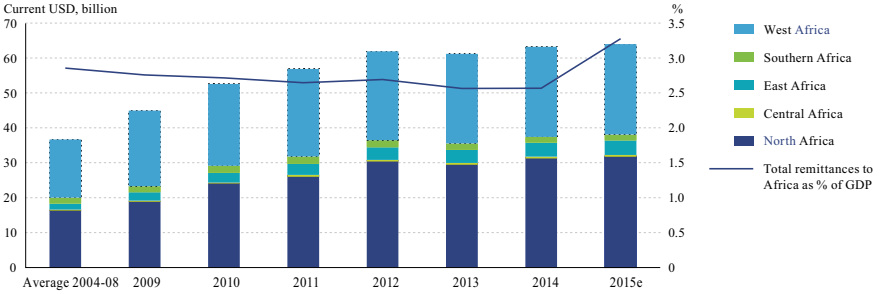

Fig. 7 Remittances per African sub-region, 2004–2015 current USD billion. *Source* AfDB, OECD, UNDP (2016)

to send money to Africa (Faal 2019), hence for many African countries, the data on informal flows, in-kind remittances, and usage of remittances for informal business or formal investments are scarce. Some experts stated that unrecorded remittance flows through informal channels may be at least 50% larger than the recorded flows, estimating that the total annual remittances can be about USD 200 billion (Faal 2019) creating an economic multiplier effect beneficial for the social economy based on local goods and services.

Remittance inflow to Africa is the most important evidence of diaspora investment in Africa. Focusing on Diaspora Direct Investment (DDI),[9] it is interesting to highlight that, according to some scholars (Faal 2019), acquisition and development of real estate in the countries of origin or heritage is often the favorite investment for individuals in diaspora, pursuing different purposes: providing housing for their, often extended, family (no rental income); acquiring housing for self and nuclear family resident abroad (no rental income); developing future residence for self and nuclear family (rental income from paying tenants); developing residential and commercial units for rental, leasing or sale (income). Within this scenario some tendencies towards mixed functions are developing: residential housing is often completed in the same location with rental units and commercial units such as shops, offices, and storage facilities. People in the diaspora use also to reap the asset as leverage and guarantee for local bank loans in order to invest in other real estate or in other business sectors. Furthermore, money raised through diaspora[10] issues can be used to

[9] DDI relates to direct investments whereby the investor has origins or heritage in the foreign country of investment, irrespective of their nationality. The notion of heritage-based African DDI is useful because millions of Africans diasporans are unable to identify their origin in a specific country in Africa, so their investments in any African country qualify as DDI (Faal 2019).

[10] Government agencies attempt to improve their contacts with diasporas to generate investment opportunities for origin-country firms. Ethiopia, Ghana, Kenya, Nigeria, Rwanda, and other African countries tried to involve their diasporas for investments in their homeland countries. For example, the East African Community recognizes the need to create a suitable mechanism to encourage diaspora members to channel remittances towards investment projects in partnering states (Plaza et al. 2011).

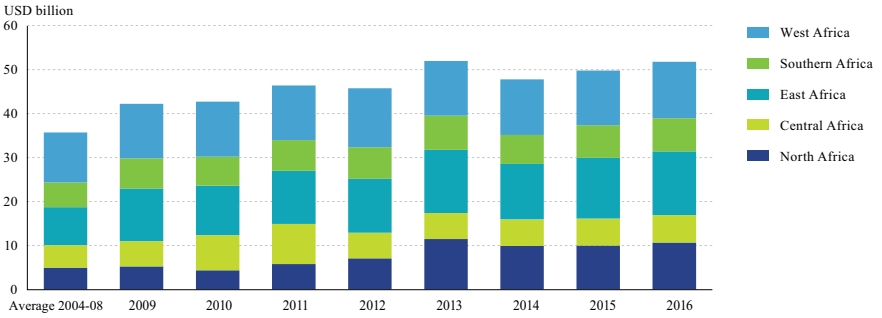

Fig. 8 Net official development assistance disbursements to African countries by region, 2004–2016. *Source* AfDB, OECD, UNDP (2016)

finance projects of interest to overseas migrants, such as public housing, schools, hospitals, and infrastructure.

Considering other sources of financial resources, as shown in Fig. 8, East and West Africa are the continents leading recipients of official development assistance from all recorded donors.[11]

EU is playing an important role in cooperation activities for East Africa through programs[12] such as the EU strategic framework for the Horn of Africa (2011) and regional action plan (2015), complemented by the Valletta Summit on migration's political declaration and action plan (2015).

EU cooperates at different levels with East African partners supported mainly by the EU budget and the 11th European Development Fund, through different methods like budget support or investment mechanisms. Additionally, the EU Emergency Trust Fund for Africa finances actions to promote stability and address the root causes of irregular migration and forced displacement.

In East Africa, EU addresses cross-regional issues in three priority topics: regional management of natural resources; regional economic integration; peace and security. European cooperation deals also with the development of regional infrastructure, such as roads, sustainable energy and water infrastructure, and information and communications networks relaying on different types of programmes, variously combined in order to optimize the effectiveness and impacts of the actions.

[11] In particular, in the reference year 2014, Ethiopia (USD 3.6 billion), Kenya (USD 2.7 billion), and Tanzania (USD 2.6 billion) topped the list of the recipients countries in the region (AfDB, OECD, UNDP 2016).

[12] See the official EU website.

At regional level, European cooperation provides mainly:

– the Eastern Africa, Southern Africa, Indian Ocean (EA–SA–IO) regional indicative programme;
– the Pan-African programme[13];

the thematic programs, including the "Global public goods and challenges" programme,[14] the European Instrument for Democracy and Human Rights (EIDHR), and the Instrument contributing to Stability and Peace (IcSP).

[13] PanAf is an ambitious €845 million commitment to continental and inter-regional projects that mutually benefit Africa and Europe. The PanAf is based on Regulation (EU) No 233/2014 establishing a financing instrument for development cooperation (DCI) for the period 2014–2020. It is based on the Treaty on the Functioning of the European Union (TFEU), which establishes the fight against poverty as the primary objective of EU development policy and refers to the European Consensus on Development (2006/C 46/01), the 'Agenda for Change' COM (2011) and subsequent relevant Commission communications. In 2014, the PanAf was launched to lend support to a strategy first adopted at the Lisbon Africa–EU Summit a decade ago. PanAf is just one of the many EU instruments that are supporting the Africa–EU Partnership but it is the only EU program designed to 'treat Africa as One'. (European Union 2018).

Aligned with the Roadmap 2014–2017, the PanAf focuses on five key areas of cooperation between Africa and the EU, namely:

Peace and Security.

Democracy, good governance and human rights.

Human development.

Sustainable and inclusive development and growth and continental integration.

Global and cross-cutting issues.

The added value of the PanAf builds on three main criteria:

The cross-regional, continental or global dimension of projects and programs in areas ranging from sustainable agriculture and environment to higher education, ICT and research.

The joint interest of Africa and the EU and therefore the clear link with the Strategic Partnership.

The financial complementarity with other instruments such as the European Development Fund (EDF), the European Neighbourhood Instrument (ENI), and the Development Cooperation Instrument (DCI) thematic programs.

In July 2014, the EU launched the first phase of the PanAf with a total allocation of €415 million for the period 2014–2017. As of August 2016, the total allocated funding of this instrument amounts to over 300 M€ implemented through 25 projects. (https://africa-eu-partnership.org/en/pan-african-programme).

[14] The Commission Implementing Decision C (2014) 5072, adopting a Multiannual Indicative Programme for the Thematic Programme "Global Public Goods and Challenges" for the period 2014–2020 aimed to guide the implementation of the GPGC with an important role of the EU as a global actor also in the delivery of the 2030 Agenda and the Paris Agreement by encouraging the strengthening of inter-linkages and cross-sectoral action at the nexus between different action areas that can contribute to multiple Sustainable Development Goals.

The European Union (EU) Global Public Goods and Challenges Programme 2014–2020 ('the GPGC') aims to contribute to poverty eradication, social cohesion, inclusive and sustainable development through the promotion of sustainable investments, job creation, broad multi-stakeholder partnerships, domestic resource mobilization, various sources of funding, notably from the private sector. In particular, with the COMMISSION IMPLEMENTING DECISION of 22.5.2018 "adopting a Multiannual Indicative Programme for the Pan-African Programme for the period 2018–2020 to be financed from the general budget of the Union" it is confirmed the role of the Multiannual Indicative Programme (MIP) in promoting sustainable investments and job creation, strengthening societal resilience, addressing irregular migration and forced displacement,

At a wider level of the EA–SA–IO region, East African countries are members of one or more key regional organizations, that benefit from EU support:

- the Common Market for Eastern and Southern Africa (COMESA) including six East African countries (Djibouti, Eritrea, Ethiopia, Kenya, Sudan, and Uganda);
- the East African Community (EAC) including three East African countries (Kenya, Tanzania, and Uganda);
- the Intergovernmental Authority on Development (IGAD) covering all East African countries except Tanzania (Eritrea suspended its membership in 2007).

Furthermore, EU development cooperation also involves bilateral cooperation with partner countries dealing with programs related to specific national challenges and priorities.

Overall, the EU cooperation initiatives at different scales converge to encourage the strengthening of inter-linkages and cross-sectorial action at the link between different action areas that can contribute to multiple UN Agenda 2030 Sustainable Development Goals trying to support some key enablers for sustainable development, notably youth involvement, gender equality and women empowerment, human rights, and digital technologies and services.

2 Changing Scenarios and Housing Demand

Undoubtedly the Nations of East Africa are characterized by different rates[15] and roles in the growth of the region[16] and for the foreign companies'[17] presence in the construction activities; anyway, in general before the pandemic East Africa was

boosting sustainability and security through several leverages such as multi-stakeholder partnerships, domestic resource mobilization, various funding sources from the private sector Source (Multiannual Indicative Programme for the Thematic Programme on Global Public Goods and Challenges for the period 2018–2020, ANNEX, Ref. Ares(2018)3,552,908—04/07/2018).

[15] Before pandemic, Rwanda, South Sudan, Ethiopia, Tanzania, Uganda, Kenya, and Djibouti were the fastest growing nations of the fastest growing region in Africa.

[16] The values of the East Africa's top ten projects (51.7% of the total value of projects in the region) give a view of the most dynamic countries (Deloitte 2019):

Tanzania: Likong'o-Mchinga LNG Plant, Oil & Gas, 30.0 USDbn; Bagamoyo Mega Port, Transport, 10.0 USDbn; Mtwara Fertilizer Plant Real Estate, Industrial Construction, 3.0 USDbn.

Kenya; Kenya-Uganda-Rwanda-South Sudan Rail Project, Transport, 9.8 USDbn; Nairobi - Mombasa Highway Expansion Project, Transport, 3.0 USDbn.

Ethiopia: Grand Ethiopian Renaissance Dam Project, Energy & Power, 4.8 USDbn; Tams Hydropower Project, Energy & Power, 4.2 USDbn; New Addis Ababa International Airport, Transport, 4.0 USDbn; Fairfax Oil Refinery Project, Oil & Gas, 4.0 USDbn; Koysha Hydroelectric Dam Energy & Power 2.7 USDbn.

[17] According to Deloitte analysis (2019) the composition of the companies responsible for building in 2019 was: 40.1% China, 14.8% Private Domestic, 14.8% EU Countries, 13.7% Single Countries, 4.9% African Countries 4.9% Consortiums, 4.4% Middle East Countries, 2.2% Government.

dynamically changing the economic and social scenarios, with consequent influences also on housing demand.

The growth of the region had been driven also by a strong public spending[18] on infrastructure, a rising domestic demand, the benefits of improved stability, new investment opportunities, and incentives for industrial development across countries.[19] Deloitte, in its annual report (Deloitte 2019), had highlighted how, in 2019, the number of infrastructure projects had risen steadily for the past few years in East Africa, with an increase of the 30.9% of the total number of projects between 2018 and 2019, with 182 projects under construction. Deloitte (2019) estimated that between 2018 and 2019 the East Africa region accounted for 40.3% of projects across the continent and 29.5% of the value.[20] Similar to other regions in Africa, construction projects in East Africa are mainly owned by governments. Governments own 83.1% of projects underway, followed by Consortiums with a share of 13.6% and private domestic companies with a share of only 1.7% (Deloitte 2020).

The region is also among the world leaders in certain segments of the digital economy. East Africa has the highest penetration rate of mobile money in the world.[21] In particular, Kenya, Rwanda, Tanzania, and Uganda lead the world in mobile money transactions and other countries in the region, including Comoros, Ethiopia, Mauritius, Seychelles, Somalia, and South Sudan, have also launched or are in the process of launching mobile money services.

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[18] "All countries in East Africa had relatively high fiscal deficits, which were projected to decline in 2017 and remain at the 2017 level in 2018 and 2019. The deficits partly resulted from weak domestic resource mobilization in addition to high public investment spending. To address resource gaps, countries generally resorted to external borrowing" (Temesgen Furi, Impact of Financial Crisis on Economic Growth in East African Countries 2021).

[19] Governments in the region are adopting a series of pro-trade reforms to reduce barriers to trade and improve the overall trade environment (AUC/OECD 2019a, b). In this regard, it is interesting to mention the East African Community (EAC) Common Market Protocol. It is a customs union that covers: goods, in addition to zero tariffs on intraregional trade, there is a common external tariff toward non-partners and the removal of nontariff barriers; capital, free movement covers 20 operations related to securities, direct investments, a credit operations, and personal capital operations; services, partner states are obliged to guarantee the free movement of services and service suppliers. In addition to progressively removing restrictions, EAC customs laws prevent member states from introducing any new restrictions on the provision of goods, capital, and services. This initiative is part of a wider regional integration strategy based on the idea of an "integrated continent with free movement of people, goods, capital, and services and infrastructure connections" in support of broad-based economic and human development, that has been part of the African Development Bank's mandate since its creation in 1963 and is also now a key priority for the African Union under the New Partnership for Africa's Development, Agenda 2063, and the RECs (Regional Economic Communities) (ADB 2019).

[20] In particular, the total value of construction projects increased by 67.6% between 2018 and 2019, from USD 87 bn to USD 146 bn, with investments in large infrastructure projects within the Transport and Oil & Gas sectors stemming the increase.

[21] According to data from the IMF Financial Access Survey, the region has 1106 registered mobile money accounts for every 1000 adults, compared to 600 for the whole of Africa, 533 for Asia and 245 for Latin America and the Caribbean (AUC/OECD 2021).

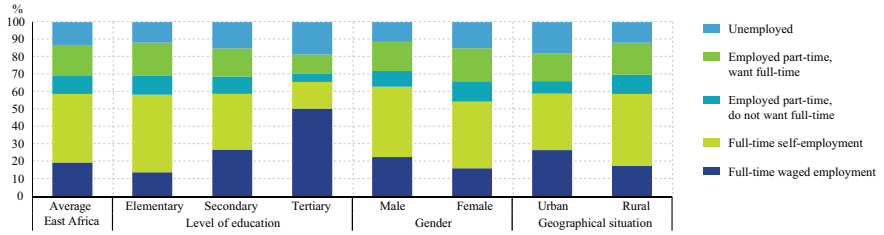

Fig. 9 Employment status among young people in East Africa labor force according to level of education, gender, and geographical situation, 2010–2018 averages. *Source* AUC/OECD (2021)

As AUC/OECD (2021) highlights, digitalization and empowerment by governments are improving productivity and creating jobs in East Africa,[22] high local demand for ICT services is prompting the private sector to sustain investment in ICT infrastructure, the average international Internet bandwidth per user in the region is 48 kilobits per second (kbit/s), compared to 31 kbit/s for Africa as a whole. The digitalization agenda of the region has also attracted broad support and commitment from both public and private actors. East African governments have identified ICT as a key strategic sector for development and sought out various strategies.

Notwithstanding this boost to modernization, in East Africa, there is still inequality between employees in the formal sector and those who work in the informal economy. According to AUC/OECD (2021), in East Africa, about 7.2 million youth are expected to reach working age each year between now and 2030, and there is a limited number of formal sector jobs—those with normal hours and regular wages that are recognized as income sources on which income taxes are paid (Fig. 9). According to the Gallup World Poll (2019), only 20% of young people have full-time waged employment.

Self-employment and household enterprises, often associated with the informal sector, continue to account for most of the employment in the region due to a lack of better livelihood options. Own-account and contributing family workers currently represent 75% of full-time employment in East Africa, down from 80% in 2000 (AUC/OECD 2021).

Furthermore, AUC/OECD (2021) highlights that the labor force seems to be moving slowly from the agricultural to the services sector: the agricultural sector still employs the largest proportion of the labor force through its share has been slowly decreasing, while the services sector is absorbing most of the workers who leave agriculture, however, allocating them mainly in low-productivity activities such as retail trade and hospitality, limiting the gains of labor reallocation.

Economic activities in Africa have been strongly constrained in 2020 by the global pandemic. Although all economies in Africa have been affected by the pandemic,

[22] For example, in Madagascar, 233 BPO (Business Process Outsourcing) companies are employing between 10,000 and 15,000 people, in Mauritius, about 800 ICT/BPO enterprises employed about 24,000 workers and contributed about 5.7% to the country's gross domestic product (GDP) in 2018 (AUC/OECD 2021).

tourism-dependent economies, oil-exporting economies, and other-resource intensive economies were the most significantly hit by the pandemic. According to the African Development Bank (2021), Tourism-dependent economies are projected to recover from an 11.5% GDP decline in 2020 to grow by 6.2% in 2021; oil-exporting countries, from a 1.5% decline to grow by 3.1%; and other resource-intensive economies, from a 4.7% decline to grow by 3.1%. Non-resource-intensive countries, where output shrank by 0.9% in 2020, are projected to grow by 4.1% in 2021 (AfDB 2021a, b).

Although counterbalancing forces kept average headline inflation stable at 10.4% in 2020, core inflation (excluding food and energy prices) has risen in many countries. Significant currency depreciations have occurred in Africa, particularly in frontier market economies, partly as a result of the disruptions in external financial flows—including remittances, foreign direct investment, portfolio investment, and official development assistance. Fiscal deficits are estimated to have doubled in 2020 to a historical high of 8.4% of GDP, leading to increased debt burdens, but a gradual consolidation process is expected in 2021 and beyond. Countercyclical easy monetary policy and fiscal stimulus packages are expected to support the continent economic recovery. Investor sentiment is still weak compared to pre-pandemic levels, and the capital flight from developing countries experienced at the peak of the pandemic in March–June 2020 has been only partially reversed (AfDB 2021a, b).

In general, in Africa, the impact of COVID-19 on incomes and jobs, particularly for low-income and informal workers is proving to be very severe. About 30 million Africans were pushed into extreme poverty in 2020 as a result of the pandemic, and it is estimated that about 39 million Africans could fall into extreme poverty in 2021 (AfDB 2021a, b). The World Bank estimates that 87% of the world's extreme poor will be in Africa by 2030 if current trends continue (Oxfam 2019).

Those with lower levels of education, few assets, and working in informal jobs are most affected. Inequality is also set to increase, because of the disproportionate impact of the pandemic on such vulnerable groups as women, youth (AU 2018), and low-skilled informal sector workers (AfDB 2021a, b). Informality, underemployment, and the precarious nature of employment affect almost all Africans of working age and most work is self-employment (80% in Africa overall). Africa is rapidly becoming the epicenter of global extreme poverty: while massive reductions in the numbers of people living on less than USD1.90 a day have been achieved in Asia, these numbers are rising in Africa.

Focusing on East Africa, Un-Habitat (2020) has drawn a scenario characterized by the effects of the COVID-19 pandemic transmitted to the region through at least five major channels, namely reduced commodity prices and trade, FDI, tourism and travel, volatility in financial markets, and disruptions in the education[23] and health sectors. The impact on commodity prices, tourism, and financial markets is largely

[23] In some regions, such as East Africa and North Africa, schools were closed for much longer—an average of 137 days in East Africa and 106 days in North Africa (African Development Bank 2021a, b).

expected to be short term while lasting effects are envisaged for FDI, education, and health.

The observers agree that owing to the outbreak of COVID-19, the projected growth rates in 2020 and 2021 are significantly dampened (east Africa economic outlook 2020): East Africa (Deloitte 2020) has recorded the largest decline in the number of projects and the value of projects compared to 2019.[24] The number of projects in East Africa dropped by 35%, while the total project value dropped by 47%, between 2019 and 2020, from USD 146 bn to USD 77.7 bn., inter alia due to the completion of several large projects.

Considering housing, these estimations and predictions redefine the thresholds of affordability for both property and rent.

Inequality and unemployment impact on urbanization and housing problems. Countries in East Africa are not spared from the many criticalities, related to the quality and characteristics of urbanization[25] that affect in general Africa. These problems are nowadays further aggravated by pandemic and related economic crisis: increasing levels of urbanization on one hand and the scale and extent of poverty and marginalization on the other hand (Ekeocha, 2021) with the consequence that informality in human settlements is prevalent in the continent (Fig. 10). In the East and West Africa regions, at least half of the urban population lives in slums or informal settlements (UN-Habitat 2020).

Agriculture, industry, and services, as said before, are all growing, with services taking up an increasing share of the regional economy and high-productivity sectors struggling to grow. As much of the continent, the region is facing the effects of rapid urbanization. Workers are moving from low-productive agriculture jobs to only moderately more productive retail trade and distribution activities (De Vries et al. 2015). Higher productivity sectors are not generating enough jobs to absorb a growing labor force. The future of productivity growth in East Africa depends on countries' abilities to maximize productivity gains in existing sectors and develop new high-productivity sectors.

Some critical issues can be recognized as representative of the that are facing spatial planning practice in Africa (UN-Habitat 2020):

– accelerated demands for housing and other municipal services and an increase in political and social instability (UN-habitat 2014). Civil conflicts across many

[24] According to Deloitte (2020) East African countries have experienced increasing foreign debt burdens in light of the COVID-19 pandemic. Consequently, China has reconsidered African countries' debt repayments in 2020, with some financing commitments reduced as a result,

leading to projects being stalled. There has also been increased scrutiny of China-funded infrastructure projects in the region, given a greater focus by African governments on financial.

sustainability. This too has contributed to a decline in China's funding involvement in East African infrastructure projects.

[25] According to the UNHabitat_APA (2014) all Africa regions (except those in Eastern Africa) have urban populations greater than 40%. Africa has the highest urban growth rate in the world. Most of this growth takes place in cities with populations of fewer than 750,000 people. An estimated 21.6 million Africans lived in cities in 2000; in 2010 there were 30.7 million. It is estimated that the population of Africans in intermediate cities will increase to 47.2 million by 2025.

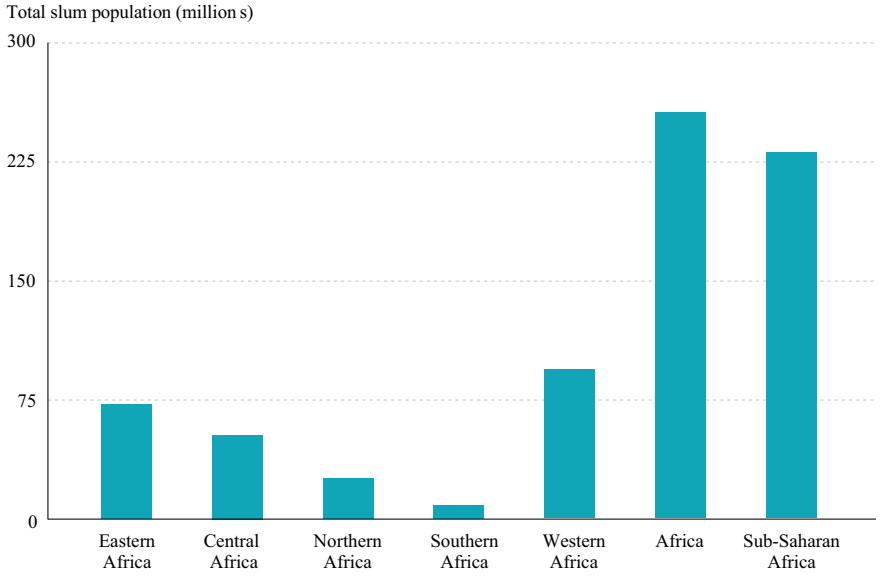

Fig. 10 Distribution of slum population in Africa. *Source* UN-Habitat (2020)

regions have resulted in uneven urban development with disproportionate urban hierarchies as a consequence of political disorder;

- millions of urban residents are living in overcrowded settlements and slums (Fig. 10), without adequate shelter and lacking access to basic services such as water supply,[26] health care, and sanitation where the authorities have irrelevant control over the informal areas (UN-Habitat 2020). The rapid expansion of informal settlements and slums in most African urban settlements has influences not only on the form of the cities, uncontrolled population densities (Fig. 11), and the social well-being but also from an economic development perspective[27];
- fragmentation of urban mobility systems, road design not oriented to boost non-motorized and pedestrians mobility, inadequate road safety systems, mobility depending on informal services, without a plan for the entire city;
- the disordered growth of the cities and the lack of widespread strategies of urban maintenance make the settlements and the infrastructures unable to face the climate change and its associated recurrent shocks;
- open-air public places for sociability, meetings, services provision, sale of goods, and production are typically poorly designed and often informal;
- lack of adequate planning with efficient city management. The low number of urban planning experts, available in Africa, has implications for the extent to

[26] In absolute numbers, about 69 million African urban residents have no access to safe water services, in East Africa it is estimated 19 million (UN-Habitat 2020).

[27] Urbanization yields significantly less value to the GDP in Africa than it does in Asia and the existing GDP growth does not translate into matching improvements in the quality of life.

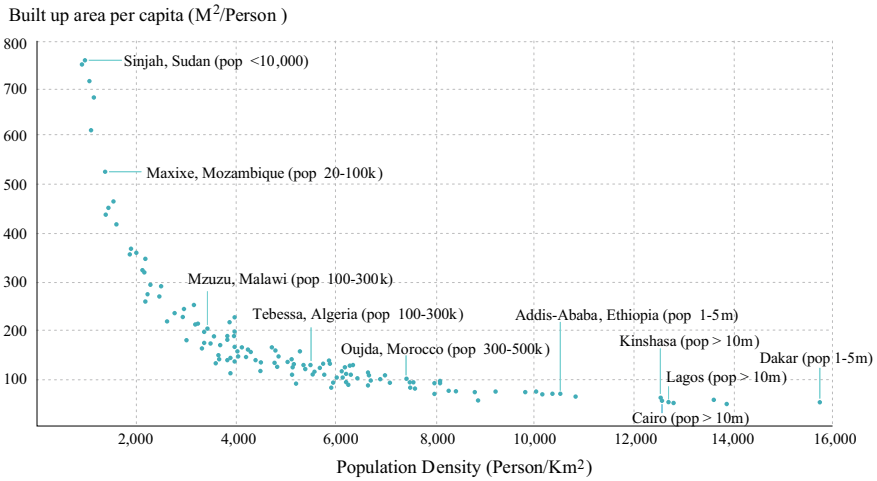

Fig. 11 Distribution of population density and built-up area per capita in select cities. *Source* UN-Habitat (2020)

which urban growth is planned in advance and fosters chaotic and unplanned development;

– lack of adequate financial, technological, and human resources, institutional and regulatory frameworks, tools, and capacities of African local authorities and city managers to handle equitable delivery of quality services or the means to effectively act in various critical situations. Africa's rapidly growing cities need investments. As much as USD 93 billion (about one-third of which is for maintenance) is required annually to finance the urban transition in Africa, but this amount has an estimated 40% financing gap (Foster and Briceño-Garmendia 2010);
– lack of autonomy to mobilize and use revenues or incur long-term debt to support the urban development. Cities and local governments are not financially equipped to respond to people's needs and to boost long-term strategies pursuing better living conditions for the population.

Although at present it is difficult to quantify[28] the effects of the spread of COVID-19, it is sure that pandemic is hindering the pursuit of the objectives of the Sustainable Development Goals (UN 2021) and having impacts on people living in informal settlements and homeless. It exposes families to food and health insecurity and exacerbates the vulnerability of cities and the seriousness of the housing problems,

[28] "Since the adoption of the SDGs, funding for data and statistics has increased four years in a row. (…) Despite a surge in data demand to inform pandemic-related policymaking, development support to data and statistics has not risen commensurately. A recent survey found that 63 per cent of low-income and lower-middle-income countries are in need of additional financing for data and statistics to face the challenges posed by COVID-19. In 2020, 132 countries and territories reported that they were implementing a national statistical plan, with 84 having plans that were fully funded. Only 4 out of the 46 LDCs (Least developed countries) reported having fully funded national statistical plans that year" (United Nations 2021).

already affecting millions of people, with significant threats of housing eviction due to lack of income and consequential rent arrears with the risk of an increase of informal settlements, considering that in Africa the share of people renting their accommodation can be as high as 70% in urban areas (Oxfam 2019).

Adequate housing is essential for social distancing and adequate hygiene conditions, but the present crisis heightens the risk of an increase in the number of homeless people, particularly vulnerable to health pandemics. For example, in Kenya, 30.5% of households were unable to pay their rent on the agreed date with the landlord due to temporary loss of job, unemployment, and reduced income (KNBS 2020). Governments across Africa seek to protect those most vulnerable to the pandemic, even if the lack of data and transparency on tenants is making it very difficult to estimate at this moment the total amount required for the rental subsidies planned by some African countries in response to COVID-19.

3 Many Questions for Many Challenges

In this changing and complex scenario, characterized by the synergic influences of consolidated trends and disruptive effects of pandemic, dealing with housing issue means at present to face the contingent emergency and at the same time cope with the many pre-existing structural problems through a unified, integrated, and systemic approach, developed on various fields and time scales. The challenge is to search for opportunities and reach new milestones in reducing inequality and poverty levels and at the same time to move towards adequate and sustainable settlements and urban spaces, seeking to identify the links between building development, economic growth, and social and environmental improvement.

In this perspective, surely the suggestions, reported by UN-Habitat (2020), are valid for all African regions, including East Africa: "*To promptly and adequately address the challenges of COVID-19 pandemic in Africa at the urban scale and through local governments, six key responses are recommended for short, medium and long term interventions led by national and local governments with the support of the African Union, United Nations System and Regional Economic Communities (RECs)1. Apply local communication and community engagement strategies 2. Support SMEs and the informal economy 3. Deepen decentralized responses to COVID-19 through strengthening local government capacities 4. Target informal settlements through data driven contextualized measures 5. Establish mechanisms to promote rapid access to housing and prevent forced evictions 6. Integrate urban planning and management as key priorities for recovery and rebuilding strategies towards long-term resilience*" (UN-Habitat 2020).

The observation, albeit partial, of the complex and varied scenario of East Africa, still reveals big potential for rapid economic growth together with problems of political instability, accentuation of inequalities, and uncontrolled use of resources. These problems are difficult to control because of the lack of data and are further aggravated by the growth of the informal economy.

The issue of building and urban development in this dynamic, uncertain, and contradictory reality becomes central: the transformation of the built environment on the one hand is witness to the many inconsistencies and disparities of the socio-economic context, on the other new building development models provide ideas for a more general reflection on sustainability strategies appropriate for the African context.

Some key objectives, emerging from the interpretation of the regional context, can be taken as reference topics both for the definition of building development strategies and for the research in the field of sustainability:

(a) Combining affordable housing with sustainable strategic goals. The many goals assumed by agenda 2030,[29] in particular the Development Goal 11, give new reading keys for the subject, extensively discussed in literature (Moghayedi et al. 2021; Nubi and Anderson 2021; Galster and Lee 2021; Haffner and Hulse 2021; Wakely and Martaraarachchi 2021; UN-Habitat 2011; Bredenoord et al. 2014; Pullen et al. 2010) of affordable housing. This implies searching for new models of governance for the development and management of the settlements, based on collaborative and innovative social housing schemes, rooted in the indigenous socialpolitical context (Vaziri et al. 2021), aiming to promote people's access to welfare services, fight exclusion and desegregated residential patterns, limit real estate speculation, increase affordability. All these aims should be strictly connected to some main general goals, such as environmentally sustainable energy services, efficient infrastructure development, improvement in air pollution, quality of water, waste generation, and adaptation to impacts of climate change (mainly drought, desertification, and flood). Enhancement in data collection and observation capabilities are some of the key conditions for the pursuit of these many, and interconnected objectives. Some questions should be answered: what traditional and new stakeholders should be involved? What knowledge is needed? How ready are the local levels (universities, industries, practitioners) to face the complex challenges connected to sustainability? How much the widespread people's awareness can boost alternative forms of urban and building development, able to connect affordability to sustainability, and which are the most appropriate local strategies and instruments to disseminate knowledge?

(b) Activating social cohesion through inclusive ecosystem settlements and enhancing local entrepreneurship within affordable housing. Oumar Sylla[30]

[29] When dealing with settlements surely the 2030 Agenda Sustainable Development Goal 11, "make cities and human settlements inclusive, safe, resilient and sustainable" is the main reference goal. Anyway, the cross-cutting nature of urban issues imposes to consider the links and the impacts on a number of other Sustainable Development Goals, including SDGs 1, 6, 7, 8, 9, 12, 15, and 17, among others. UN-Habitat's complementary New Urban Agenda, adopted as the outcome document from the Habitat III Conference in 2016, seeks to offer national and local guidelines on the growth and development of cities through 2036.

[30] Oumar Sylla, Africa Regional Director for UN-Habitat. Interview by Onyekachi Wambu, In: Housing is at heart of social change in Africa, New African Magazine, April–May 2021.

highlights as new forms of partnership (public, private, and people partnership) should be pursued, in order to enable communities to invest in their housing system, experimenting with models of "owner-driven housing" where communities can be supported to get access to small funds to build their house, sustained by governments establishing policies on affordability, for access to low-cost housing and for incentivizing the diaspora people to formalize their investments, searching for win-win strategies connecting the human rights dimension with the private sector engagement (UN-Habitat 2021). The housing sector can play a critical role to increase wealth through job creation, the promotion of local construction materials, and affordable housing markets, all of which reduce inequalities. One of the conditions for this role to be effectively played is to reach a level of aggregate demand capable of creating critical mass. In this direction, an affordable housing market can activate various virtuous processes: on one hand, the development/reinforcement of construction supply chains based mainly on local resources (materials, workforce, knowledge, soft and hard technologies, infrastructures), dealing with both the manufacture of constructions products and the construction of settlements; on the other hand, hosting craft activities and micro-enterprises within the settlements activating forms of self-sustaining, that can act as attractors and enhancers of the investment capacity of the households and at the same time as enablers to give legality and visibility to the so widespread informal economy. Many questions arise: how the many economic resources (private and public, endogenous, and exogenous) can be mixed and moved towards the affordable housing market avoiding fragmentation, discontinuity, and phenomena of building speculation? Which is the critical mass necessary for boosting virtuous processes? Which are the most appropriate production and business models for manufacturing and construction searching for an original approach to local affordability and sustainability? Which can be the most appropriate combinations between the local, regional, African and international levels in relation to the various models? Which are the most appropriate patterns of urban development, space organization, building typologies, and technical solutions for affordable settlements integrating housing, local entrepreneurship, and public services?

(c) Promoting local circular economy and sustainable resource management. The subject of circular economy, referred to as the development of sustainable settlements in the African perspective, opens various research questions involving several issues, such as: which are the criteria for identifying the meaning of local scale and the boundaries of the systems where the climate, economic, political, natural conditions are so strongly different, the distances are so huge and the presence of foreign companies so important? How to design and construct buildings appropriate for both the local economies and the productive and natural resources and at the same time supported by sustainable business models? How to create a local market for construction materials and products—competitive compared to low-cost foreign products—to be reused, repaired, or remanufactured? How to create, manage and monitor closed-loop processes according to the capacities of the local enterprises?

So many questions, many uncertainties in their answers, but at least certainty in the common goal—maybe ambitious but surely not deferrable—for the region: to set and reach new milestones in reducing inequality and in poverty levels and to move towards access to adequate housing for all as well as progressively delivering universal human rights everywhere (UN-Habitat 2020).

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Housing in East Africa

O. E. Bellini and C. Del Pero

Abstract This chapter analyses the complex issue of housing and the related needs of East African countries marked by the need to move from shelter to home. The chapter introduces and investigates the concept of accessible and sustainable housing in the specific context of East Africa, presenting the characterizations of the climatic context, the related climate-sensitive design solutions, as well as the housing needs of the rapidly growing local population.

Keywords East Africa · Housing demand · Affordable and sustainable housing · Climate context · Climate zone

1 Housing Needs in East Africa: From Sheltering to Affordable Housing

Even today East African countries are facing endemic criticalities, such as internal conflicts, poverty, migrations, unemployment and unstable economy. Within this context, the challenge is to develop strategies able to improve living conditions and local communities' welfare, thus ensuring social equity while avoiding negative impacts on the environment. The effects of these criticalities are very evident in low-income social groups living in inadequate, overcrowded and informal settlements located in segregated areas of large cities. These settlements present multiple issues such as poor air quality, poor public lighting, polluted water, open sewers, unpaved narrow paths, etc. The accommodations are often inadequate and the limited access to public spaces, transportation, education, and healthcare facilities reduces the quality of life. Many people live in homes which are usually just shelters built with waste materials, without adequate safety, hygiene, and comfort requirements (World Vision 2021).

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Furthermore, these locations are often the most exposed to the impacts of climate change. In fact, over 95% of the 234 cities most affected by climate change are located in Africa and Asia.[1] This situation inhibits the achievement of the Sustainable Development Goals (SDGs)[2] and the Leave No One Behind (LNOB)[3] criteria. This is the reason why access to affordable housing has become one of the priorities, not only for East African BOP[4] households but also for governments and local politicians, due to the rise in housing prices not comparable to the increases in income.

BOP urban households are often trapped in a distorted and dysfunctional housing market wherein "affordable housing is inadequate and adequate housing is unaffordable" (UN-Habitat 2005).[5]

In this situation, housing affordability becomes multi-dimensional and doesn't just involve the simplified conception of the ratio of the house purchase price to household income. The people who need adequate housing are individuals who cannot own it due to a lack of adequate income.[6]

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[1] The cities most affected by climate change and considered at extreme risk are Africa and Asia, compounding fears that the world's poorest countries with the greatest rates of urbanization are set to pay the highest price of climate change. The scale of the risk could threaten the capital flows that have streamed into these markets to take advantage of burgeoning economies, emerging consumers and cheap labour (Maplecroft, accessed in 2021).

[2] The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, includes the 17 Sustainable Development Goals (SDGs): no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace—justice and strong institutions, partnerships for the goals (UN DESA, Sustainable Development, accessed in 2021a, b).

[3] Leave No One Behind (LNOB) is the central, transformative promise of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals. It represents the commitment of all UN to eliminate poverty in all its forms, end discrimination and exclusion, and reduce the inequalities and vulnerabilities that leave people behind and undermine the potential of individuals and humanity (UN Sustainable Development Group, accessed in 2021).

[4] The Bottom of the Pyramid (BOP) is the largest and poorest group of the world's population, which lives with less than $2.50 a day and is excluded from the modernity of our globalized civilized societies, including consumption and choice as well as access to organized financial services (Saefullah 2019).

[5] The World Bank clarifies that to have all citizens access to quality housing the following policy items need to be reviewed: cost of infrastructural services, cost of land, building cost, development and planning control regulations, design standards, subsidy levels, profit margins to developers, socio-economic status, government policies/incentives, cost of financing and rent/mortgage rates (World Bank/IFC 2012).

[6] The right to adequate housing is a fundamental human right, enshrined in various international human rights treaties and instruments, and applies equally to all people, all around the world. Therefore, as stated in the Global Strategy for Shelter to the Year 2000, Point 13: "All nations without exception, have some form of obligation in the shelter sector, as exemplified by their (…) policies, programs and projects" (UNCHS 1990). Indeed, in the Istanbul Declaration on Human Settlements, Paragraph 8, governments reaffirm their commitment to 'the full and progressive realization of the right to adequate housing (…) and equal access to affordable, adequate housing for all persons and their families' (UNCHS 1997).

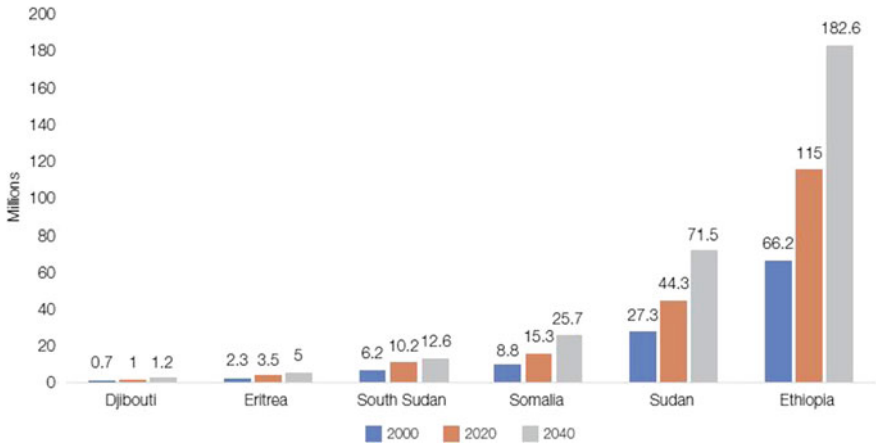

Fig. 1 Eastern Africa population in 2000, 2020 and 2040. World Population Prospects website. *Source* Kouassi and Jakkie (2021)

For the United Nations, the issue of people without a shelter presents very different characterization: "it varies from a situation where someone lives in open space, public space, on the street and other places that are not meant for human abode" (UN DESA 2004; Obioha 2019).

Africa counts more than a billion inhabitants, with about 455 million only in East Africa,[7] the most populous region of the continent. Nowadays, more than 50% of the African population lives in rural areas, while the rest in cities. The urbanized areas often coincide with the capitals, in fact about 2.1 million people live in Mogadishu, the capital of Somalia, 3.5 million people live in Nairobi, the capital of Kenya, and 3.4 million people live in Addis Ababa, the capital of Ethiopia. The most populous city in East Africa is Dar El Salaam, which was ones the capital of Tanzania, and now has been transferred to Dodoma. Nearly a quarter of the East African population lives in Ethiopia (Fig. 1), the largest country in the region in terms of land area and the second most populous country on the continent (with 117.5 million inhabitants) after Nigeria. Tanzania, with a population of 59.7 million, is on the other hand the second most populous country in East Africa, but it has half the number of inhabitants compared to Ethiopia. Comoros and Seychelles are the only two countries in the region with a population of fewer than 1 million people (Worldatlas, accessed 2021).

In these great countries, as the World Bank report on the state of the global urban population clearly highlights, the housing crisis is very evident. In 2018, roughly 35 million people in East Africa were living in informal settlements. Ethiopia,

[7] The population growth matches with an increase in the housing market's demand: in the next decade, a need for 5 million new homes is expected, without considering the current deficit. The increase in the population of the entire continent will contribute to more than half of total growth worldwide by 2050, and to more than three quarters by 2100 (Oxfordbusinessgroup, accessed in 2021).

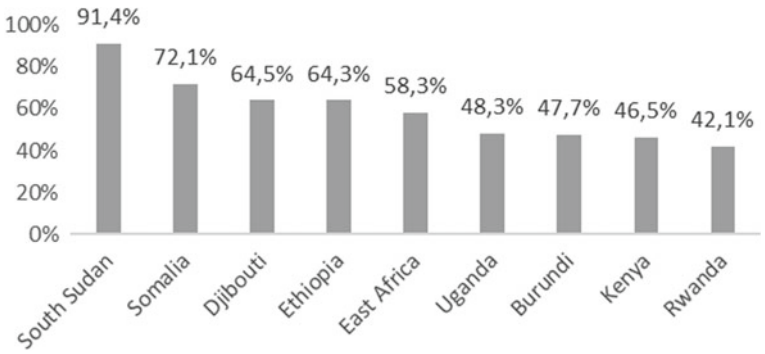

Fig. 2 Urban population living in slums in East Africa in 2018. Statista website. *Source* UN-Habitat and World Food Programme (2020)

for instance, had the highest number of slum residents, approximately 14 million, followed by Kenya with 6.4 million. In contrast, Djibouti and Burundi had the smallest number of inhabitants living in slums in terms of absolute numbers, 490,000 and 700,000, respectively (UN-Habitat and World Food Programme 2020; Statista website).

Currently, the lack of about 51 million units is evidence of the housing crisis in the African continent (Bah et al. 2018), while in 2019, sub-Saharan Africa's deficit was approximately estimated at 60 million dwellings, for a potential market of approx. 3,500 billion dollars (World Population Prospect, accessed in December 2020, World Bank 2016).

The possibility of East African cities to cope with population growth is moreover directly affected by problems of underdevelopment and poverty, which cause an overall increase of slums (Fig. 2). This situation is confirmed by data provided by UN-Habitat, which estimated that 62% of Africa's urban population lived in slums in 2014 (UN-Habitat 2014).

To all this, it should be added that East African communities continuously face wars, conflicts and migrations from rural to urban areas. Although Africa represented in 2018 the most rural country in the world, with only 42% of the population concentrated in urban areas (Table 1). Nowadays it is estimated that the high rates of urbanization could drive more than half of the African population (59%) to live in cities by 2050 (UN-Habitat and World Food Programme 2020).

These processes cause different problems such as unsustainable land use, pollution and environmental degradation, lack of urban infrastructure and services, and indirectly, climate change. It is also important to underline that, although urban sprawl has become the most common way of urban development, some African countries have adopted policies that aim to promote urban densification (Seto et al. 2020). This approach, only if well managed, can lead to economic efficiency and resource conservation since services and infrastructures are more easily integrated with the city (Chapman et al. 2017).

Table 1 Urban population in East Africa, 2018

Country	Urban population (million)	Urban population (% of total)	Annual growth rate (2000–2018) (%)	Slum population (million)	Slum population (% of urban population)
Burundi	1.46	13.00	5.70	0.70	47.70
Dyibouti	0.76	77.80	1.80	0.49	64.50
Eritrea	2.08	40.10	4.60		
Ethiopia	22.33	20.08	4.60	14.36	64.30
Kenya	13.77	27,00	4.40	6.40	46.50
Rwanda	2.15	1720.00	3.30	0.91	42.10
Somalia	6.83	45.00	4.60	4.92	72.10
South Sudan	2.53	19.60	4.60	2.32	91.40
Uganda	10.53	23.80	6.00	5.08	48.30
East Africa	**62.44**	**23.10**	**4.50**	**35.17**	**58.30**

Source UN-Habitat and World Food Programme (2020), United Nations DESA (2018)

Public attempts to provide decent housing for East African urban BOP households often failed or have achieved only a minimal yield notwithstanding several experiences (CAHF 2021). For instance, interesting studies approaches on slum regeneration, from the perspective of integrated land economics and spatial planning, demonstrate that informal settlement generation can successfully be managed by applying land value capture and inclusive housing strategies. This approach was adopted in Nairobi by proposing a master plan, and related housing policies and strategies, that aimed at meeting housing needs in Kibera, the largest slum in the city. This simulated masterplan was integrated with an economic and residual land value analysis, which demonstrated that by involving private developers in inclusive housing development it is possible to meet the housing needs of slum residents and to include at least 27.9% of affordable housing in new settlements, entirely paid by the private sector (Seeta 2019).

Several studies also agreed that only under a robust public-led governance umbrella, market forces could contribute to bride the financial gap to achieve the end of slums by 2050 in coherence with the United Nations Agenda 2030 goals and to increase both affordable and market housing in upgraded neighbourhoods (Nzau and Trillo 2020).

In this region, the scarcity of affordable housing supply is also due to the lack of more permanent access to long-term financing solutions, which are made available only on an ad hoc basis by international development banks. Another cause is the developers' search for higher yields on high-end developments aimed at wealthier buyers who have more disposable income. The situation is further aggravated by other factors which regard the high costs of housing development, the problem of land protection, poverty, the difficulties associated with obtaining property titles,

overcrowding, the resultant pressure on available accommodations and corruption in government land allocation systems (CAHF 2021).

The rapid population growth continues to be not adequately matched by a corresponding increase in housing quality.

Affordable housing can be described in many ways, using a lot of definitions, depending on the quantitative or qualitative perspective we decide to analyze. Generally speaking—using the World Bank definition—housing can be considered affordable if its cost (mortgage or rent) is below 30% of the household income and if a family pays more than about 30% of their income for housing, it is considered a cost burden (World Bank/IFC 2012). In addition to the economic perspective, which remains fundamental, building affordable housing also means having houses physically adequate and suitable for human habitation. Houses cannot be considered affordable if it is overcrowded, unhealthy and inadequate from a social and constructive point of view. To evaluate the level of affordability, the real cost of housing should be estimated considering also housing-related expenditures related to its functional organization, as plumbing, electricity, gas, etc. Therefore, affordable housing involves two main aspects: one that focuses on people and what they can afford to pay for their house, and the other that focuses on the specific characteristics of the house.

Regarding housing policies in East African countries, the different possible approaches for the creation of new dwellings can be grouped into three categories: the elimination of slums and the resettlement of their residents to new homes, the construction of low-cost public housing for low-income groups and government subsidy or rent control strategies (UN-Habitat 2010a, b). In Africa, most policies focus on the first category as informal settlements are becoming a growing problem (Metcalf 2018).

Some factors such as population and economic growth, coupled with the infrastructure gap, conducive business environment, favourable economic development policies, cheap labour and a fast-growing consumer market are the possible driving forces for the growth of the construction market in this region. In East Africa, investing in new development strategies, innovative housing solutions and updated policies to promote access to housing for BOP families, can become an interesting and appropriate approach for moving from sheltering to affordable housing.

2 Housing in East Africa: The Challenges of Affordability, Accessibility and Sustainability

Housing is one of the basic human needs and it is a major concern for people living in every corner of the world given that every citizen of any nation has the right to basic shelter.[8] The World Health Organization (WHO) has defined residential

[8] The right to housing is recognized by international treaties and conventions that include the 1948 General Assembly of United Nations proclaiming the Universal Declaration of Human Rights and

housing infrastructure as a "residential environment which includes, in addition to the physical structure that man uses for shelter, all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and social well-being of the family" (WHO 1989).

This implies that the housing infrastructure is a type of infrastructure consisting of both soft and hard infrastructures (Spacey 2017), which include the building itself and other internal and external facilities that makes the house functional (sewage and sanitation facilities, roads, electricity, water, drainage, waste disposal and other systems, etc.). From this point of view, housing is more than shelter itself but a multi-dimensional package of goods and services that are essential for good quality community life. It is possible to assert that housing is the key urban infrastructure the wheel that processes other economic aspects, thus providing the favorable environment for sustained economic growth and wealth creation. Housing links all other land uses such as residential, commercial, industrial, recreational, institutional, and even transportation use.

The affordable housing deficiency becomes in this sense a major problem that potentially affects economic development, education, land use, health, business, neighbourhood vitality, transportation and other aspects of the community (Enwin et al. 2021).

In the recent past, UN-Habitat tried to exemplify the idea of affordable housing by identifying its basic components. In this regard, two distinct aspects, that characterize the housing affordability for households, can be outlined: capital variables and occupational variables (UN-Habitat 2011). While the first one referes to the house purchase cost and the ability to finance purchases, the second one referes to the house maintenance costs and the ability to finance services (Fig. 3).

Nowadays, providing housing to people is still one of the main challenges for East African countries because of the high demand and the high cost of both construction and financial credit[9] (CAHF 2021). Affordable housing have to imply solutions that are adequate in terms of quality, location, and economic accessibility while respecting

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the 1966 committee on the economic, social and cultural rights convention and a subsequent one in 1991 for which the general comment n. 4 outlined that adequate housing is not just having a roof over one's head but should explicitly be defined to incorporate security of tenure, availability of services, affordability, location and cultural adequacy.

[9] In Kampala, the capital of Uganda, only about 20% of families can afford to own a house. On average, the selling price for a newly built two-bedroom house is around $13,500. Most lenders offer financing up to 80% for residential mortgages and loan interest rates of 17%. In Kigali, Rwanda's capital, it is estimated that the price of a cheaper two-bedroom house is $19,760, but middle-income households can afford a mortgage of up to $4390 million at an interest rate of 17.3% and a 15-year mortgage. In South Sudan, most urban households earn an annual income between $5,000 and $8,000, and so they cannot buy the cheapest formal housing unit in urban areas because the average price is $80,000 for 90 m^2. In Burundi the poverty rate is $1.9, and decrease from 74.7% in 2017 to 71.8% in 2018. Whereas the interest rates are high, on average 15.98%. All this makes it difficult for most citizens with modest incomes to afford credit. Considering the average construction cost of $37,500 for a 50 m^2 affordable home, Eastern Africa will need $187.5 billion for affordable housing (Abiq website, accessed in 2021).

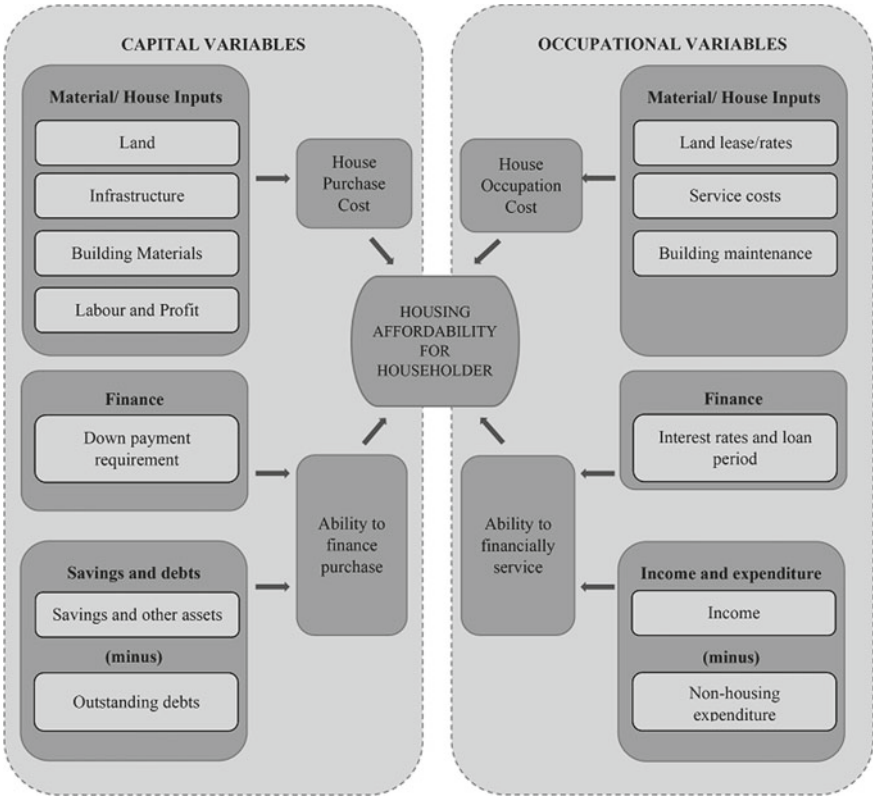

Fig. 3 Breakdown of the housing affordability concept into its components. *Source* UN-Habitat (2011)

fundamental human rights (UN-Habitat 2011). These houses must be not too expensive both in terms of construction and maintenance costs, besides they must be close to basic urban services and facilities, as recommended by the World Economic Forum: "if a house is cheap enough to buy and run but located far from livelihood opportunities or amenities such as schools, it cannot be said to be affordable" (World Economic Forum 2019).

In this regard, the essential components of affordable housing settlement are as shown in Fig. 4.

It is very important to consider that the affordable housing concept differs across the world: an affordable house in Europe is not comparable to an affordable house in East African countries due to the deep differences in economy, quality of life and living standards.[10] In East Africa, the affordable housing concept is made even

[10] Expression "low-income housing" is usually associated with terms such as social, affordable and mass housing (Huang 2012). "Social Housing" answers to housing needs mainly considering social aspects, as the name suggests. The target group is households with low financial resources,

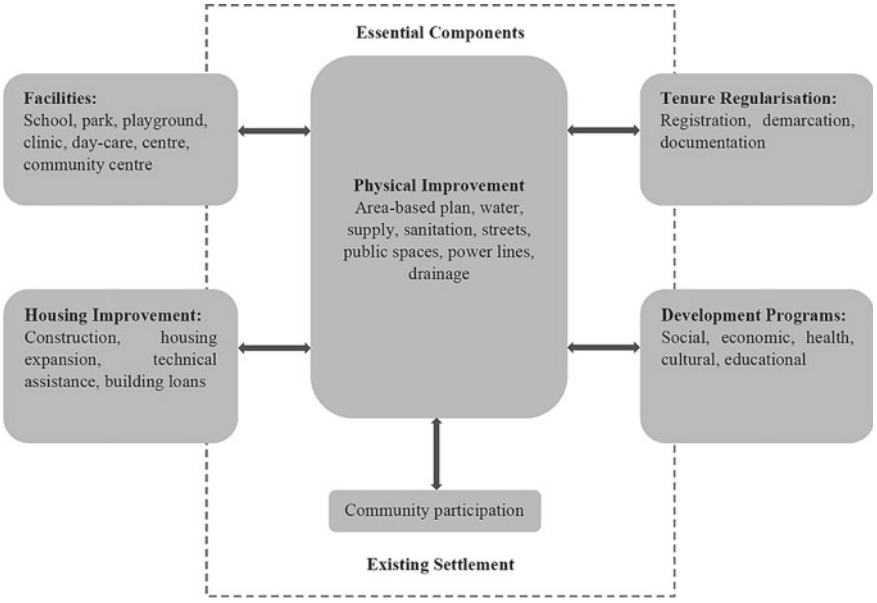

Fig. 4 Essential component of affordable housing settlement. *Source* UN-Habitat (2012)

more complex because there is not a unique standard index price to measure the housing affordability, as can be seen in Table 2 and Fig. 5.

To solve the problem of people who cannot afford the expense of a adequate housing (Majale et al. 2011; World Vision 2021), East African countries[11] apply

which have for this reason inadequate housing standards (Czischke 2007; Granath and Lundgren 2019). The social housing systems offer rents or selling prices lower than the general market, and they usually require forms of public or private subsidies (Granath and Lundgren 2019; Curoso 2013). In general, various investors work with incentives provided by public entities and non-profit organizations (Curoso 2013). "Affordable housing", instead, considers the economic criteria and this expression is generally used to refer to the relation between the housing cost and the habitants' income. An interesting definition is given by Euro cities (Eurocities 2009), where "affordable housing" is defined as housing available to all individuals and families who require it, including low-income groups (Eurocities 2009), without that causes a disproportionate burden on their income (Stone 2006). "Mass-housing" mainly considers the design aspects and refers to a standardized approach to housing production, useful for responding rapidly growing housing demand in developing countries (Ahadzie et al. 2008, Karji et al. 2019). The term is inspired by the concept of mass production (Karji et al. 2019) and refers to standardized house units, within the same project scheme, without reference to any specific customer, and usually located in the same area (Ahadzie et al. 2008). The downside of mass housing is the lack of attention to the quality of the design due to the time-saving and cost-effectiveness of the projects (Kazaz and Birgonul 2005).

[11] The formation of the Kenya Mortgage Refinancing Company promotes affordable housing by enabling long-term loans at attractive market rates. The Government of Rwanda has pioneered the development of various affordable housing development projects and recently planned to implement a Green City Concept in Kigali. In Uganda, banks such as the Housing Finance Bank and Bank of Africa have introduced 100% financing for residential mortgages, while the Government of Uganda

Table 2 In 2020, the cheapest newly built house by a private developer, in the most important East African countries (CAHF 2021)

Djibouti	US$30,365 cost	30 m^2 in size
Eritrea	US$19,753 cost	30 m^2 in size
Ethiopia	US$17,226 cost	20 m^2 in size
Kenya	US$25,356 cost	88 m^2 in size
Mozambique	US$37,946 cost	60 m^2 in size
Somalia	US$35,000 cost	150 m^2 in size
Sudan	US$65,111 cost	120 m^2 in size
Tanzania	US$77,649 cost	288 m^2 in size

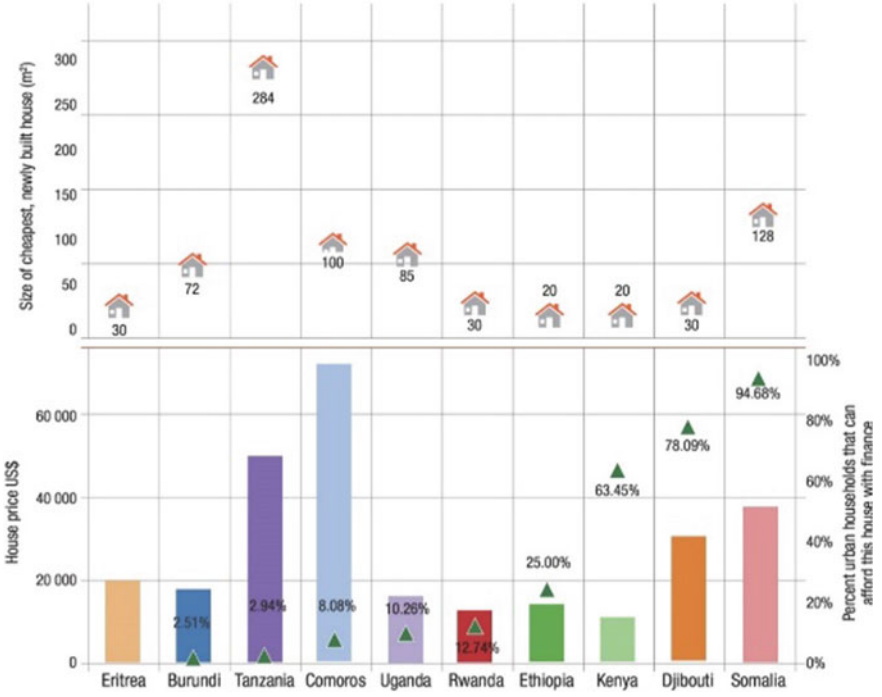

Fig. 5 Cheapest newly built house: cost, size, and percent urban population that can afford. *Source* CAHF (2021)

different strategies[12]. Table 3 summarizes some affordable and social housing policies in East Africa.

wants to deliver housing units to families evacuated from the landslide-prone Mount Elgon Region (CAHF 2021).

[12] In many cases, attention has focused on mechanisms to stimulate the provision of affordable housing for very low incomes. The strategies are many and different: supply-side subsidies, provision of mortgage liquidity through a joint ownership structure (Tanzania, Egypt, Kenya etc.) and direct provision of housing through real estate companies nationally. Complementary demand-side strategies were also tested to match the target population with the housing produced (Seeta 2019).

Table 3 New policies and legislation on housing and housing finance adopted in the last two years in the same countries in East Africa

Country	Policies and legislation	Description
Kenya	Kenya Sectional Properties Act (2020)	It is expected to boost the development of multi-dwellings, such as apartment blocks, where buyers will have titles to their respective units
Malawi	Malawi 2063 (MW2063) Agenda (2021)	The MW2063 recognizes that land-related laws are key factors in realizing the vision. Ten land laws are currently under review
Mauritius	Real Estate Agent Authority Act (2020)	The Act provides for the establishment of a Real Estate Agent Authority which would assist in offering enhanced protection to all parties involved in real estate transactions
Somalia	The Interim Protocol on Land Distribution for Housing to Eligible Refugee-Returnees and Internally Displaced Persons (2019)	The Interim Protocol on Land Distribution for Housing to Eligible Refugee-Returnees and Internally Displaced Persons was implemented to address the crisis around forced migration
Tanzania	The Financial Inclusion Framework (2018–2022)	The framework is aimed at driving the availability of financial products and services in a way that ensures the resilience of low-income households
Zambia	National Housing Policy (2020–2024)	The policy vision is "affordable and decent housing for all"
	National Lands Policy (2021)	The policy seeks to achieve a transparent land administration and management system for inclusive sustainable development by the year 2035

Source CAHF (2021)

A conceptual framework may be useful to understand the meaning and value of affordable housing from the perspective of the beneficiaries, including basic needs. A possible framework is synthetically reported in Table 4.

The first determining factor for the promotion of affordable housing regards social and cultural aspects. The concept of home differs from person to person, so the design and its "concept" should correspond to the local housing traditions as well as to the user's way of living (Ebsen and Ramboll 2000). Believing that in East Africa the most suitable types of houses are those of Western countries is one of the most serious mistakes, especially in relation to this geographical context. As matter of fact, in most of these communities, houses are treated as part of the local identity able to label the social status of individuals. People do not want to live in a house that stigmatizes them as belonging to a low-income class. Location, quality and housing typology often reflect social inequalities, influence social relationships, psychological wellbeing and

Table 4 Evolving concept of sustainable and affordable housing in less developed economies

Socio-cultural factors	Economic factors	Technological factors	Environmental factors
1_Integration of amenities and services	l_Affordabilily benchmark	1_Feasibility	l_Renewable resources
2_Self-help housing or beneficiary participation	• Housing loan repayment and income	• Simple	2_Material efficiently
3_Community participation	• Income thresholdatio rental cost income cost	• Easy maintenance	3_Healtly environment
4_Housing standards and quality	• Mortgage to income	• Unskilled labor	4_Energy efficiently and water conservation
• Household composition and size	• Debt to income	• Labor availability	5_Non-housing consumption
• Good quality and appropriate quality	2_Mortgage finance and initial deposit	• Less energy intensive materials	• Ability to sustain other day-day cost of living
• Income threshold	• Access to mortgage and subsequent deposit requirement	• Reusable material	• Socially acceptable standard of living
• Energy efficient	• Market-value home ownership products	• Materials availability	• Social Cohesion
• Efficient waste management	• Availability of rented accommodation	• Local materials	6_Public facilities and amenities
• Deprivation in area	• Availability of low-cost ownership product Interest rates and mortgage Availability	2_Functionality	• Access to transportation services
5_Housing supply	3_IIousing cost and household income	3_Strength	• Opportunities for employment and job
• Deprivation in area	• Affordability definitions and aims set by local, regional or nation authorities in official policy documents	4_Durability and reliability	• Access to quality education
• Adequate housing supply			• Early childhood care services
• Sufficient private housing			• Access to shopping facilities
• Availability of owner occupier housing			• Health sendees

(continued)

Table 4 (continued)

Socio-cultural factors	Economic factors	Technological factors	Environmental factors
• Availability of low-cost housing			• Open green public spaces
• Adequate housing supply			7_Neighborhood quality
6_Adaptability			• Safety and comfort
• Culture			• Clean and attractive
• Tradition			• Reduced environmental problems
• Profession			• Social equity
• Way of living			
• Status			
• Household size			
• Equity			

Source elaboration of the authors

reinforce family and community ties, especially if the social structure is based on local clans or specific ethnic groups. To achieve these results, a very effective strategy is "participatory design methods", during which the inhabitants are involved in the early stages of the design of the new intervention. Participatory housing helps to avoid problems in defining the architectural quality of the intervention and facilitates its level of acceptance. To achieve this result, adequate management of the activities is required, to favour the construction of relations of transparency and legality. Proper management allows for a better definition of the future needs of the inhabitants in terms of public services and facilities and, above all, improves the social relations among people.

Many strategies often seek to "relocate" community members to new habitable housing solutions. In this case, slum dwellers are considered as equal citizens with the power of ensuring transformative settlements by rehabilitating the housing units in the same place.

These communities pool their resources to purchase pieces of land to build better housing units (greenfield development). This concept aims to address the complex issue of space inadequacy. In the most overcrowed urban poor settlements, houses occupy almost the entire plot, leaving little room for upgrading. Most slums in East Africa are an outcome of a slow, incremental, internally driven bottom-up process that mixes residential, commercial and industrial units.

A people-centred action approach ensures the protection of their current identity and retains the existing community networks as well as economic activities intact. A bottom-up process is demand-driven and therefore incremental. The involvement of slum dwellers in the development process ensures that they are able to identify

the outcome, and this emotional attachment can lead to better maintenance of the new housing. Consequently, upgrading becomes cheaper and easier to implement. Independent development upgrading can be an uphill task, so groups of dwellers often get together to collectively upgrade their own houses.

The second critical determinant that defines the conceptualization of affordable housing in East African countries is the economic factor, even if it alone cannot eliminate the risk of housing abandonment. To achieve affordabiliy results, opportunity actions and strategies in the economic and financial field must be promoted (Veron 2001), even if the mere financial assistance usually does not help the poor to meet their housing needs. In developing economies, like East African countries, housing is an expensive project venture. Communities, that never imagine getting affordable credit services, have often only one option: the slum. Major cities (Nairobi, Mombasa, Dar-es-salaam Mogadishu, etc.) are bombarded with high costs of living and they always need a special attention from central governments to address the levels of abject poverty.

Affordable housing for households in developing countries depends on the possibility to manage the various required resources. According to the most recent scientific references (Ezenniam and Hoskara 2019), the most important economic factors that influence, in broad terms, this measure are housing prices in relation to income, availability of mortgages and interest rates, rental cost in relation to income, energy bill in relation to income, transportation cost in relation to income, employment opportunities, taxation and subsidy influences, household income level, tenure security, accessibility, building typology, maintenance and management of properties, and household size.[13] Other factors include clear access to easy credit loans and effective family empowerment for income generation.

It is also important to remember that, traditionally, people in East Africa build incrementally as their resources allow, so housing becomes a process, not a product. These families cannot afford a long-term, traditional mortgage. Instead, they build in stages, first creating a makeshift shelter and then eventually replacing it with permanent materials and expanding it. Small, short-term loans can fund the steps of this process with payments that are affordable for families with little money who want to improve their living situation.

At the level of economic investment, affordable housing is also directly influenced by land costs and the political management of land ownership. These factors become very critical in those contexts where access to land is particularly expensive and difficult. In all these cases, the most important financial resources are the actual and potential savings of the inhabitants, therefore the housing programmes should always be linked to policies aimed at generating employment or income, thus enabling the

[13] To be economically viable, affordable housing should be also connected to the major employment centres, stores, primary services and infrastructures. In these cases, the economic benefits of increasing housing provision could be various. The housing sector can play an important role in national and regional economic development: "After several decades of debate on what housing might contribute to economic growth, it is now a widely held view that housing is not just a peripheral activity but a central force in sound economic development, much in the same way as investment in transportation, power and communication" (Tibaijuka 2009).

poorest to afford and maintain their dwellings. The housing sector is employment-intensive and generates employment opportunities both during the construction period and the entire life cycle of the building. In this perspective, affordable housing doesn't just provide a place where to live, in fact "housing investment contributes, directly and indirectly, through backward and forward linkages in the economy, to national economic growth and, to a large extend, to national capital stock" (UN-Habitat—Nairobi et al. 1995). The housing-related supply chain can also support the creation of new employment opportunities thus improving the human capital and the business capacities of the communities (Green 1997). Expanding the availability of affordable housing solutions does not have only social or equity implications, but it has also economic benefits because it contributes to the overall economic development. Affordable and sustainable housing can become, in the future, a real strategy to overcome poverty and give a new future to these communities. A third factor that could define the conceptualization of affordable housing concerns building technology, through appropriate policies of investment in the construction industry, like the case of Kenya.[14] Nowadays, it is generally agreed that development in East Africa must proceed in parallel with the improvement of building technologies. The goal is to use fewer intensive solutions in terms of the use of primary resources that produce less environmental damage. Adequate building technology can be achieved through the use of local manpower, and consumption of renewable resources, minimizing the impact of waste materials and pollution. This means investing in research and development, promoting innovative technologies increasing awareness and responsibility, and also to conserve and protect the environment and its natural resources. Alternative building materials, such as those obtained from recycling, can lower the carbon footprint of affordable housing, while improving thermal comfort and energy efficiency. For this to happen, two other conditions should be developed: on one hand training and informing and, on the other, the definition of accurate building standards and regulations that define the quality of new affordable settlements. The fourth and last determinant that defines the conceptualization of affordable housing concerns the environmental aspects. In general terms, in developing countries, it is possible to say that building solutions and technologies can be described as sustainable only if they exploit local resources, use local workforce and materials already available in the area without requiring heavy capital investment. In these contexts, solutions that involve as many inhabitants as possible throughout the entire development process can be defined as sustainable. These solutions should also be flexible and functional, i.e., adaptable to the changing needs of the users (Atta et al. 2021). Lastly, accessing affordable housing in East Africa also means promoting health, well-being, escaping the cycle of urban poverty, violence and degradation, and supporting the development of communities. Research highlights the low level of awareness of the link between

[14] The Kenyan Government aims to build 500,000 affordable homes in all major cities by the year 2022. This, no doubt, will also create about 350,000 employment opportunities. It has been observed that the national Kenya Vision 2030 is also aimed towards propelling "Kenya becoming Africa's industrial hub". As per "Kenya Construction Industry Databook Series—Market Size & Forecast (2015–2024) report, the construction industry in Kenya is projected to reach a CAGR of 10.4% to record KES 1,023.4 billion by 2024.

sustainability and affordable housing (Olanrewaju et al. 2018). In affordable housing programmes, sustainable development implies the need to achieve a better quality of life through efficient use of resources which ensures continuous social progress and stable growth and environmental care (Vehbi et al. 2010), satisfying the needs of the present generation without compromising future generations' ability to meet their own needs (Adabre and Chan 2019; Ezenniam and Hoskara 2019). From this point of view, the most correct definition of affordable housing should be "sustainable and affordable housing". However, the four measures of the affordable housing conceptualization are not sufficient if not supported by adequate policies that implement coherent legislative measures, i.e. measures for environmental, economic, and technological sustainability and political measures for ecological sustainability. The contribution of local governments is very important. In East Africa, affordable and sustainable housing first requires a solid institutional framework to accelerate and integrate the local development process (UNCHS-GSS 2000). Because housing is a place-specific activity, governments, especially local ones, are considered the most important partners in the process of providing housing or rather facilitating people to have one (Ebsen and Ramboll 2000). An integrated policy framework is essential to coordinate the activities of all actors and to create a "push" by beneficiaries rather than a "pull" by authorities.

However, there is still a wide range of actions to bridge the gap between the supply and demand for affordable housing through multiple approaches. In general terms, it is possible to summarize (Table 5) some other factors that could allow forms of collaboration between stakeholders.

In conclusion, considering what has been reported, it can be said that many East African cities present paradoxical situations. They appear to be built in reverse, with housing development occurring prior to planning and not as it normally should be. This phenomenon is due to a multiplicity of causes and factors: a combination of rapid urbanization and uncontrolled population growth, inadequate policies and systems of economic incentives, poor governance of land ownership, inappropriate regulatory frameworks, dysfunctional real estate markets and a lack of effective political actions. As a result, informal and inadequate settlements continue to develop and proliferate to house BOP families. In the contemporary world, this situation represents a significant challenge for governments and policymakers. This situation is creating a vicious and dangerous cycle that keeps many families in a condition of poverty. A situation that will become increasingly worrying for the future. This process must be stopped and reversed by building the basic infrastructures needed (roads, water and sanitation), improving the security of tenure, and ensuring the quality of affordable housing.

A participatory and local community-based approach, which includes all key stakeholders, and the right institutional framework are indispensable factors. Certainly, the cost of informal settlement upgrading can turn out to be very onerous. Microcredit and governments' traditional limited budgets and transfers may not suffice to mobilize the necessary funding. This implies the need to encourage more sustainable and affordable financing schemes and market-based innovative solutions such as, municipality bonds. An interesting example is a solution that has recently been successfully used in Kiambu County in Kenya (Urbanet, accessed in 2021).

To support this situation, it also necessary to increase private-sector engagement by using public–private partnerships models. African countries should adopt national urban planning and construction programmes, also to make an important and significant contribution to the economic growth and, at the same time, to provide significant opportunities for improving the livelihood of local communities. It is therefore appropriate that a combination of innovative sites-and-services housing solutions and incremental auto-construction solutions should be considered as an adequate and viable way to provide affordable and sustainable housing for low-income households.

Table 5 Overview of factors that can influence affordable housing in East Africa

Design, construction and innovation
In affordable housing, more than 70% of the entire cost is for construction. This is one of the biggest challenges affecting housing affordability. Innovative construction methods such as the use of local or reclaimed materials, adoption of new planning and cost management systems, use of design innovations, and application of appropriate solutions, including environmental ones, could all contribute to the efficiency and low cost of housing construction. Affordable and sustainable housing can be applied if policy measures also for technological sustainability are implemented. Technology research and promotion, improvement of skills and training programmes should be promoted through initiatives supported by local governments through targeted policies. Building codes and standards should also be implemented and applicated to promote: (a) very simple technologies adequate to unskilled local labour, the use of locally available or locally developed materials, which are cost-effective, abundant, durable, resilient and environmentally friendly, should be preferred to the imported ones, (b) the use of renewable, reusable and recyclable materials, which should be socially acceptable and affordable, (c) the use of low energy-intensive materials and methods, and (d) construction quality requirements. Local policies should be also formulated considering the specific needs: integrate alternate solutions for renewable energy, reuse of water and proper measures for conservation of resources; promote of a healthy indoor and outdoor environments; basic infrastructure facilities, such as the provision of drinking water, drainage, sanitation and solid waste management should be ensured as an integral part of housing development. Community participation should be ensured to speed up the growth of sustainable residential neighbourhoods. This is also a priority to promote technological advancements and innovative solutions reducing poverty, improving equal opportunities and guarantee sustainable growth. For this reason, affordable and sustainable housing became the objective of UN Sustainable Development Goals (SDG) number 11 (UN DESA, Sustainable Development, accessed in 2021a, b). The rapidly changing landscape of technology and constant innovation offers numerous and ever-changing ways to not only accelerate the start-up and delivery of homes but also to simplify the entire process, increasing transparency, reducing costs and improving the eco-friendly nature of homes. This also ensures that residential units are fast, affordable and reach the widest number of buyers. Therefore, in such contexts, the issue of appropriate and sustainable technologies remains critically important. This requires a strong focus on morphological, technological and typological research housing. Finally, it is important to emphasize that there is a "small scale of research in housing matters largely due to shortage of investment in research and development in many African countries" (Gbadegesin and Lochner 2020), especially on accomplishments in affordable and sustainable housing schemes.

(continued)

Table 5 (continued)

Tenure security of land and homes and legality This factor plays a critical role in facilitating urban residents' own economic investment and development in the housing sector. Security of tenure can be achieved in different ways, for instance, through clear, long-term rental contracts, or formal recognition of customary land rights, with indispensable accessible and effective dispute resolution mechanisms. The question of housing and land ownership is no small matter. Enhanced tenure security generates many household and community benefits and encourages investments in housing, infrastructures, services etc. Aside from being a basis for shelter and access to services and facilities and giving economic and social tranquility to the family, secure land rights can act as a safety net in times of hardship and provide financial security. They are an important transferable asset that, in case of necessity, may be sold, rented, inherited or loaned. Secure land rights also encourage people to invest in improved housing and in the purchase of land. For this condition, it is necessary to define the political and administrative level a framework of legality. A certain legal and policy framework does not always exist in these contexts. This prevents certainty and protects the interests of both users and stakeholders. Many times, legal and policy frameworks can be a barrier for investors to promote projects, with implications that could negatively impact the entire industry value chain (land ownership). The question is therefore to address priorities and various conflicts of interest to facilitate the financing and delivery of affordable housing, within the framework of certainty and legality. Uncertainty in land ownership creates a poor functioning of the housing market. Slums and informal settlements often are a result of poorly functioning housing markets that do not provide an adequate range of affordable housing alternatives, especially for low- and middle-income households. Such settlements are rarely healthy, comfortable, dignified places to live and inhabit, and they have extremely low housing quality, caused to an inability to consolidate houses ownership, due to a lack of de facto and real land tenure.
Investment and financing The key to a good return on affordable housing development is based on a bankable investment structure, optimal project management, and certain and predictable returns. Multiple channels, public and private, to secure and increase returns and alternative financing options could help restore investor/financier confidence in affordable housing projects. It is also important to underline how conventional housing finance in this region is undeveloped and rarely serves low-income households. Microfinance and community-based savings groups are providing alternative housing finance, but they remain constrained by unsupportive institutional and regulatory frameworks. Pioneering "bottom-up" micro-finance solutions and community savings schemes are enabling low-income households, to develop and prove their savings capacity, and negotiate for further development funds, whilst strengthening the resilience and strength of these communities. Unfortunately, these potentially widely transformative schemes remain constrained by unsupportive institutional and regulatory frameworks. Moreover, recent evidence suggests that only 15% of urban dwellers in Africa can secure housing finance, excluding the remaining 85% (Shah 2019). In addition to what is above, it must be added that the low capacity of the building design, the low quality, the high mortgage interest rates, the high rental fees and credit policies are some of the challenges faced by homeowners. Generally, real estate markets in East African cities "suffer from inadequate and uncoordinated housing policies. Land ownership is often unclear, and the legalization of settlements is contested" (African Development Bank 2016).

(continued)

Table 5 (continued)

Public–private partnerships Public–private partnership models are now taking centre stage as governments turn to them for long-term commitments and actions; risk sharing and large-scale investments. This model is not only cost-efficient but also time and target efficient. However, the model raises multiple concerns regarding accountability, oversight and contract rigidity. In many developed economies, the role of government in the public housing sector provision has evolved and it turned the 1950s post-war government into providing housing and meeting the enormous demand for housing. In the 1980s and 1990s, governments became facilitators and regulators of housing by withdrawing from their direct provision. From this stage, governments began to focus on facilitating the private sector to provide housing effectively and assist the poorest segment of the population. The point of departure is the belief that housing is essentially a private good that could be best provided by the market. Today, the government's role ~~is~~ in this sector should be therefore focused on establishing the enabling environment for the private sector (including private individuals) to deliver housing; addressing the market failures and avoiding and/or correcting government policy failures. As the private sector and public sector fail to provide adequate and affordable housing for the lower-end of the market segment , governments could reposition themselves as partners and entrepreneurs to avoid the private sectors's entry in the affordable housing market (World Bank 2020).
Promote proactive approaches and policies The supply and affordability of key inputs for housing land, finance and building construction costs need to be systematically and simultaneously improved. The urgent task facing local governments is to increase affordable housing supply through appropriate policies and legislation that stimulate housing production, recognize its potential economic benefits and focus on large-scale programmes, not small one-off projects. It is indispensable to require governments to shift away from laissez-faire projects to systematic and integrated policies and strategies that can increase housing supply and reduce housing costs, with a special focus on those groups who often need government support the most: low-income households, women, and vulnerable and marginalized groups. Local governments must be more than enablers and proactive leaders. For these reasons, a crucial proactive role for governments is related to the implementation of infrastructure and community facilities and services. Homes that are near jobs, educational institutions and other recreational areas are always a hit with the local community. This attracts both investors and buyers by providing them with low-cost homes and facilities that are, today, critical to life (technology networks, schools, stores etc.). The issue of basic services for healthy living becomes, then, crucial to achieving the success of these interventions. Within this framework, the proactive role of politics and governments is indispensable (In the last few years, several African countries have demonstrated that important progress is being made towards the provision of affordable housing. North African countries, for instance, are currently experiencing negative slum growth, and both the absolute number and percentage of slum dwellers in the region have decreased over the past 20 years. Egypt, Morocco, and especially Tunisia are the most successful countries in this regard. They have reduced their collective slum populations from 20.8 million in 1990 to about 11.8 million in 2010. The decrease is largely attributable to the success of housing policies and programmes that have increased the supply of low-income housing and systematically improved slums and informal settlements.) (Brown 2015).

(continued)

Table 5 (continued)

Giving priority to the most fragile social subjects: women
In many East African countries, there are often people who are socially fragile and lacking in help and support. Among these individuals, women are particularly vulnerable. Women remain often marginalized and disempowered without their human rights. Today, the women's right to land and housing needs to be placed at the centre of policy debate. In many situations, this can become a human and social problem. When relationships break down or women are widowed, they are often disadvantaged through traditional prejudices and practices, even though most African constitutions enshrine women's equal rights. Losing land and housing further increases their vulnerability and hardship. In African developing countries it is estimated that only 2% of women own land (UN-Habitat 2010a, b). Such lack of access to land and housing can reflect the existing poverty, but it can also make women poorer. Female-headed households typically represent high proportions of the poorest group living in informal settlements.

Source elaboration of the authors

To build sustainable and affordable housing and settlements, there is clearly the necessity for government subsidy or international financing, because the limited resources available often undermine the final sustainability and purpose of interventions, without proposing viable and effective solutions. This suggests the need to go beyond financing and implement adequate institutional and policy frameworks that are needed to rationalize governments' spending. In addition, there is also a need for local governments to engage in the private sector while putting in place the necessary incentives mechanisms. For instance, rental housing which is an important affordable housing solution, especially for the urban poor and low-income households who cannot be homeowners. A final, but no less important, aspect of the sustainability and accessibility of housing in East African countries is the urgent need to invest in research, innovation and to experiment with new designs, starting from the specificities of the local context.

3 A Difficult Climate Contest and Related Climate Responsive Design

Sustainable and energy-efficient buildings must be designed with attention to the climate, which means that their features must be climate responsive. The careful assessment of climatic data is therefore pivotal in relation to the impact on building design strategies.

More in detail, for the East African context, some generally applicable rules can be identified, such as the use of ceiling fans to increase comfort while avoiding air-conditioning, or the exploitation of solar energy by means of photovoltaic systems to have low cost and clean energy. However, more specific guidelines depend on peculiar climate conditions; in this sense, it is possible to identify six homogeneous climatic zones (Butera et al. 2014), each characterized by a set of design strategies to be adopted to minimize energy consumption and maximize thermal comfort. The

characteristics of the six bioclimatic zones and the main climate responsive design strategies are described below.

Hot-Humid Zone

The hot-humid zone includes coastal areas and islands, which are located less than 300 m above sea level. The zone is characterized by high humidity, high temperatures and a small daily temperature swing. Furthermore, the prevailing north-east and south-east monsoon winds are modified by sea–land breezes. The average annual precipitation is typically around 900–1250 mm.

High temperatures and high humidity cause discomfort, so ventilation that facilitates convective and evaporative cooling of the body is essential for comfort during day and night. Nights, often muggy, give little or no relief to the heat of the day. Therefore, minimizing discomfort during the night is of high importance, preventing the structures from releasing heat and causing an internal temperature higher than the external one.

In a hot-humid climate, natural ventilation and solar shading are the most effective passive design strategies for improving thermal comfort. Houses should be located on sites exposed to sea breezes and trees should be used for shading. Layouts should be open, and houses should be widely spaced to allow maximum ventilation. Buildings should be orientated along the east–west axis, to provide effective shading, unless the direction of the prevailing breezes suggests an offset from this orientation. The roof and walls should be lightweight and light-coloured or reflective, as well as with an air cavity which is permanently ventilated. The distance between the opposite walls should be limited to allow maximum cross ventilation. Openings should be large and shaded, preferably on the north and south walls, while the glazed area should not exceed 20% of the area of the wall.

Hot-Arid Zone

The hot-arid zone includes areas that are far from the sea, with altitudes ranging from 0 to 500 m. Maximum temperatures are higher than those of the hot-humid climate, but the daily temperature variation is also huge. The humidity is low, particularly in the hottest hours. Breezes are usually light with no predominant direction. The average annual rainfall is usually in the 0–500 mm range.

High temperatures during the day are accompanied by low humidity, which mitigates the level of discomfort. Moreover, the greater daily temperature range implies that the nights are comfortable. The heat during the hottest days does not allow people's outdoor activities, thus houses should aim to keep indoor temperatures low during such periods.

In such a context, night ventilation, high thermal mass, solar shading and evaporative cooling are the most effective passive design strategies for improving thermal comfort. Housing layouts should be compact, besides plants and water features could be used to protect houses from hot and dry winds. Buildings should be oriented with the axis along the east–west direction to provide effective shading; it is not necessary to change this orientation for wind direction. A heavyweight building envelope is important due to the high daily temperature fluctuation, but indoor environments

should be ventilated at night. The external surfaces of the structures should be reflective. Large openings along the walls can reduce comfort unless they are well shaded. Heat gain should be reduced as much as possible by avoiding windows on the east or west walls and with well-shaded windows on the north or south facades. Ventilation must be controlled to ensure that the building is not heated during the day when the internal temperature is below the outdoor temperature and that it is cooled during the night. Evaporative cooling should be used to improve comfort every time outdoor relative humidity is low.

Hot Semi-Arid/Savannah Zone

The hot semi-arid/savannah zone covers the broader area of East Africa and includes parts with altitudes between 500 and 1500 m. Compared to the hot-arid zone, it has relatively higher humidity values, lower peak temperatures and smaller daily temperature swings. Average annual rainfall varies by topography and ranges from 500 to 750 mm in semi-arid areas to 1000–1500 mm in savannah regions. The high temperatures during the day cause discomfort most of the year, however, constant breezes often alleviate the heat. Comfort conditions at night vary considerably over the year. From June to August and during the rainy season the temperature can be cool at night.

In such a climate, night ventilation, high thermal mass and solar shading are the most effective passive design strategies for improving thermal comfort. The building design strategies are the same as those for the hot-arid zone, except for evaporative cooling which is not as effective due to the higher relative humidity.

Great Lakes Zone

The Great Lakes Zone includes the areas along the shores of the Great Lakes, which are located from lake level to about 150 m above lake level. The temperature is a little lower than that of the savannah zones, but the daily variations are similar. Due to the presence of the lakes, the humidity is higher than in the savannah zones, even though it is in the same altitude range. The average annual precipitation is over 1200 mm.

In some parts of the zone, due to the relevant altitude, nights and early mornings may be uncomfortably cold during the cold and rainy season, therefore complete sun exclusion is not desirable. In other areas with lower altitudes, sun exclusion is required and shaded outdoor spaces are highly appreciated, provided they face the lake in order to catch the cooling breeze.

In a Great Lakes climate, natural ventilation and solar shading are the most effective strategies for improving thermal comfort. Houses should be located on exposed sites, to ensure free air movement and minimum solar exposure. Sites in depressions or on the leeward side of hills should be avoided. The building design strategies are similar to those for the hot-humid coastal zone.

Upland Climate Zone

The upland climate zone refers to mountainous areas and plateaus at altitudes between about 1500 and 2000 m. They are cool areas where heating is needed on the coolest days of the year. The relative humidity is not high during the day, but it is high at

night. The breezes are moderate with no predominant direction. The average annual precipitation is over 1200 mm.

Temperatures are moderate during the day and rarely exceed the upper limits of the comfort zones. During the night, however, the temperature is probable to drop below the lower limit of the comfort zone. Low night temperatures are a major source of discomfort.

In upland climate, passive heating and medium thermal mass are the most effective strategies for improving thermal comfort. Houses should be in sheltered sites and should have compact layouts that protect them from the wind. The outdoor spaces adjacent to the house should be exposed to the sun but protected from the wind. The floor plan should be organized so that the sun penetrates into daytime environments on cool days. Medium weight walls and roofs are recommended, to store passive heat during the cold season and the night coolness during the warm season. The windows should be located mainly on the north and south facades; moreover, they should be glazed and with airtight frames. Lastly, the design of passive solar buildings should be highlighted, and the use of high-efficiency biomass stoves/boilers can be considered.

High Upland Zone

The high upland zone refers to areas with altitudes above 2000 m. These are generally cold areas and heating is necessary for most of the year. The humidity is fairly high, and the average annual precipitation is more than 1200 mm.

Due to the altitude, the temperatures during the day are not high, but during the night they are very low, below the comfort zone. In this area, there are many locations exposed to strong winds, which with the cold air temperature can be uncomfortable.

In a high upland climate, passive heating is the most effective design strategy for improving thermal comfort, but the use of high-efficiency biomass stoves/boilers is required. The building design strategies are the same as those for the upland zone.

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Mogadishu as a Representative Case

The Dynamic and Fragile Context of Mogadishu as a Representative Case

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Abstract This chapter provides a general overview of the urban context of Mogadishu, characterized by a dynamic and fragile nature. In particular, the chapter focuses the attention on the housing traditions of Mogadishu, highlighting key strengths, weaknesses and open issues related to the sustainable development of the city. Moreover, an investigation of the main urban challenges and housing demand trends is carried out, defining proper levels of accessibility.

Keywords Mogadishu · Housing demand · Urban challenges · Access to land · Housing types · Urban planning

1 Mogadishu: A Urban Representative Case

Mogadishu is one of the most representative cases of East African developing countries, struggling for decades with social and economic instabilities and environmental issues. Conflicts, poverty, violence, insecurity, migration and famine are just some of the many issues that afflict the city.

The Somali capital also faced a civil war which led to an unstable political context, characterized by terrorism and incomplete constitutional transition. Moreover, according to the World Bank, the Covid-19 pandemic contracted the economy by 1.5% in 2020 and, in particular, the livestock sector, which makes up at least 40% of the country's GDP, was strongly affected (Hujale and Davies 2021).

In this fragile context, access to housing—although it represents a primary service—is currently not guaranteed to the entire population. Most of the no- or low-income population (including displaced persons) does not have access to this fundamental right. The housing emergency, perpetrated for years and continuously

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DESCRIPTION	DATA 2016–2018
Somalia population	14.74 million (2018 estimates)
Mogadishu population	1.97 million (2018 estimates)
Urban share of population	40.5% (2015 data)*
Fertility rate	6.26 (4th highest in the world)
Access to clean drinking water	31%**
Access to improved sanitation facilities	23%**
Access to electricity	32.2% (2017 data)**
Employment rate	39.91% (2018 data)**

Fig. 1 Demographic statistics and access to services (*Source* Bonnet et al. 2020a, b, p. 11)

worsening, is affecting the entire Somali territory with disastrous and unprecedented consequences.

In recent years, the dynamic context of widespread instability has left room for a chaotic and uncontrolled growth in the construction sector. This construction boom, mainly funded by diaspora investments and refugee returns, accentuates urban inequalities. Indeed, the beneficiaries of this growth often belong to the upper-middle class. At the same time, large-scale evictions of informal settlements, inhabited by internally displaced persons (IDPs) and low-income people are expanding the city to unplanned suburbs without the necessary urban services. It is precisely the informal nature of the housing sector that poses cross-cutting challenges to Somalia. In the absence of clear laws to regulate transactions, the number of illegal evictions, mostly affecting IDPs, is likely to rise and worsen the already chaotic situation. In this context, the topic of affordable housing represents a challenging goal to address the housing emergency that is affecting Mogadishu and the entire country (Fig. 1).

- *Geographical and historical context: a fragile city*

Mogadishu is situated on the Indian Ocean coast of the Horn of Africa in North-east Africa, in the Banaadir[1] administrative region, located in south-eastern Somalia (Fig. 2). It is administratively divided into 17 districts.[2] Beyond the districts, the city is further subdivided into departments (*waah*), sections (*laan*) and neighbourhoods,

[1] Historically, "Benadir" was a term used to refer to indigenous minority clans from Mogadishu. The name was applied to the recently created region to allow these minority clans to have representation in the Transitional Federal Parliament. They constitute the 0.5% in the current transitional representation system, a type of clan-based representation known as the "4.5", alongside the four other major clans (SSF 2017). Today, the Benadir Regional Authority has reassumed a dominant position in land administration and governance and with the support of UN-Habitat has become more active in strategic and spatial planning.

[2] The districts of Mogadishu are as follows: *Abdiaziz, Bondhere, Daynile, Dharkenley, Hamar-Jajab, Hamar Weyne, Heliwa, Hodan, Howl-Wadag, Karan, Shangani, Shibis, Waberi, Wadajir, Wardhigley* and *Yaqshid, Hamarwein* and *Gezira Beach* (Districts of Somalia website, accessed in 2021).

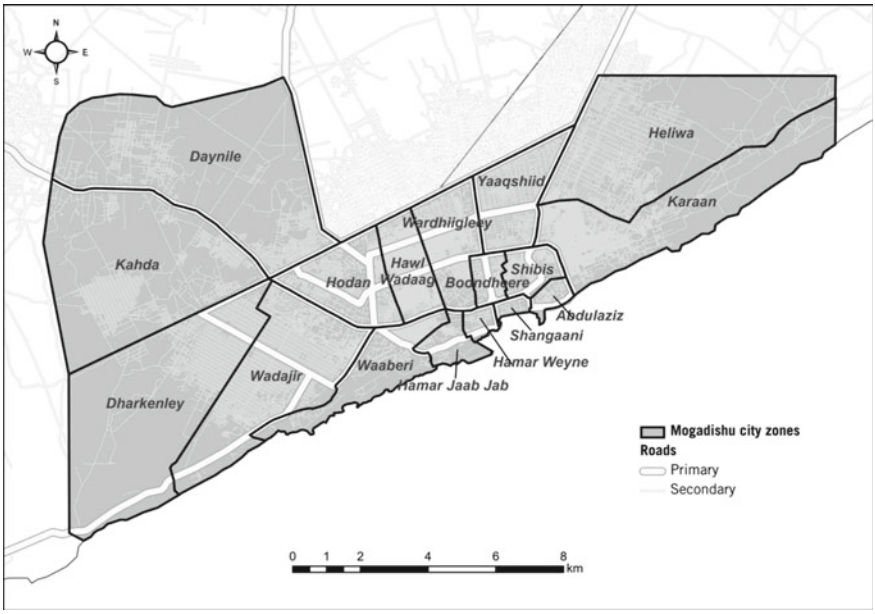

Fig. 2 Mogadishu city zones (EASO 2021)

and most of the districts are controlled by one or more clans (El Bushra and Gardner 2004; Marchal 2006).

From a historical point of view, the city is the heir of the ancient city-state of Sarapion, a settlement of traders and navigators founded by the ancestors of modern Somalis.[3] Mogadishu represents the largest port in Somalia and for hundreds of years, due to its geographic location, it has served as a hub on the Indian Ocean trade routes.

At the beginning of the twentieth century the city expanded in a grid around the port, thanks to the urban planning promoted during the period of Italian colonization (Alpozzi 2017).

After the independence, in 1960, the city experienced rapid urbanization (RIV 2020), growing by about 10% per year in the 1960s, due to the construction of informal settlements, banking activities, land grabbing, speculation and high levels of corruption in public and private land markets (RVI and HIPS 2017).

In 1969, a *coup d'état* planned by General Mohamed Siad Barre ended the democratic government established after the end of the Trust Territory of Somaliland under Italian Administration. The new dictatorial regime, characterized by a particular

[3] The ancient city of *Sarapion* is mentioned in the Periplus of the Erythraean Sea, a Greek travel document dating back to the first century AD, as one of a series of commercial ports on the Somali littoral (Mohamed 1962). According to the Periplus, maritime trade already connected peoples of the Mogadishu area with other communities along the Indian Ocean (Huntingford 1980).

ferocity towards the opponents, fell in 1991 giving rise to a new phase of political-administrative fragmentation from which, up until now, Somalia has not yet recovered. This instability led to conflicts over property and land. When specific clans were targeted, they fled their lands and their homes were confiscated. This history of social distrust and repeated displacements posed a significant obstacle to the normalization of political and social relations in Mogadishu. The following period coincided with the almost complete disintegration of urban services as well as the fracturing of the city into a complex network of fiefdoms controlled by warlords (World Bank 2020a, b).

Mogadishu has always been the scene of conflict, even after the Union of Islamic Courts took control of the city in 2006, only to be expelled by Ethiopian forces in the same year (RVI and HIPS 2017). Further damage was inflicted in 2007/2008 following clashes between the transitional government and al-Shabaab militias,[4] until the latter's withdrawal in some areas of the city in 2008, thanks to the action of the African Union Mission in Somalia. However, al-Shabaab terrorists continue to be present in Mogadishu, as evidenced by the periodic attacks carried out in the city with truck bombs.[5]

In June 2021, the UN stated that Somalia was facing the worst funding shortage in the last six years (OCHA 2021). In an emergency appeal launched in July, the IFRC stated that it was seeking to raise £7 m (8.7 m Swiss francs) to support the Somali Red Crescent Society. After several postponements, elections were scheduled for December 2021. In order to better frame the complex and articulated history of the city, a brief chronology of the most important "events" is reported (Table 1).

- *Urban Challenges*

Mogadishu is an extremely vulnerable city with diverse needs and problems. The city is currently experiencing an important set of macro and micro urban issues that cannot be underestimated. These are critical issues that unite many East African cities and the entire continent. Mogadishu's population is growing at a very rapid rate (Karruna et al. n.d.) and today it is the most densely populated city in Africa (IDMC 2018) and the most populous city in Somalia,[6] with just under 2.4 million inhabitants (estimates 2021).[7]

[4] A terrorist organization linked to al-Qaeda, initially operating in Somalia, but more recently in the East African region.

[5] In 2017, a truck bomb killed 350 people (Hills 2017).

[6] Somalia's current population is 16,511,898 as of Friday, November 26, 2021, according to World Meter elaboration of the latest United Nations data. Somalia's 2020 population was estimated at 15,893,222 at midyear according to UN data. Somalia's population is equivalent to 0.2% of the total world population and the country ranks number 73rd in the list of countries (and dependencies) by population. The population density in Somalia is 25 per km^2 (66 people per m^2). The total land area is 627,340 km^2 (242,217 sq. miles) and 46.8% of the population lives in urban areas (7,431,038 people in 2020). The median age in Somalia is 16.7 years (https://www.worldometers.info/world-population/somalia-population/).

[7] Somalia (https://www.cia.gov/the-world-factbook/countries/somalia/#people-and-society).

Table 1 History of Mogadishu: chronology of key events

Early settlements (150 BCE–1499)
150 BCE_Himyarite (South Yemen) presence in the coastal enclaves of East Africa including Somalia. As'ad al-Himyary rule Mogadishu and environs *100/700* CE_An anonymous Greek merchant and author of the Periplus of the Erythraean Sea (who resides in Egypt) gives a description of the coastal trading towns of East Africa, including Zeila and Mogadishu in Somalia *1286* Ibn Sa'id al-Maghribi, a Muslim geographer, notes that Mogadishu is Madinat al-Islam, an Islamic centre *1331_* Ibn Battuta, globe-trotter, visits East Africa port cities of Zelia and Mogadishu *1434* _The Ming ruler's expedition arrives in Mogadishu *1450_* The Persian Zuzni Dynasty comes to power in Mogadishu *1499_* Vasco de Gama launches attack on Mogadishu
The Horn of Africa has been home to Somalis since ancient times (from the 13th century to 1941)
Ajuran Sultanate dominates much of the Horn of Africa before collapsing into rival regional sultanates *1875* Egypt occupies towns on the Somali coast and parts of the interior *1860s* France acquires a foothold on the Somali coast, which later it becomes Djibouti *1887* Britain proclaims protectorate over Somaliland *1888* Anglo-French agreement defines the Somali possessions of the two countries *1905* Italy made Mogadishu the capital of the newly established Italian Somaliland *1936* Italian Somaliland joined the Somali-speaking parts of Ethiopia to form a province of Italian East Africa *1940* Italians occupy British Somaliland *1941* British occupy Italian Somalia
Independence (1950–1967)
1950–1960 Mogadishu was made the capital of the Trust Territory of Somaliland, an Italian administered fiduciary political entity under the ONU mandate *1956* Italian Somaliland was renamed Somalia and granted internal autonomy *1960* British and Italian parts of Somalia become independent, merge and form the United Republic of Somalia; Aden Abdullah Osman Daar was elected president *1961* Through a popular referendum, the people of Somalia ratified a new constitution, which was first drafted in 1960 *1967* Abdi Rashid Ali Shermarke beats Aden Abdullah Osman Daar in presidential elections
Drought and war (1969–1991)

(continued)

Mogadishu in 2015 was ranked as the world's second-fastest-growing city, with a population of 2.1 million growing at a rate of 6.9% (The Guardian website, accessed in 2021).

The population of the city has a youth structure, considering that a significant number of middle-aged people work abroad and also considering those who die from famine and infection (UNFPA 2016). The borders of Mogadishu have never been formalized and the estimates of its area range from 80.4 km^2 to 148.9 km^2. According to the World Bank, in Mogadishu there would be a population between 1.7 and 2.9 million (World Bank 2020a, b). Despite this, the population of Mogadishu has undergone considerable fluctuations over the years (Fig. 3).

Table 1 (continued)

Early settlements (150 BCE–1499)
1969 Muhammad Siad Barre assumes power in coup after Shermarke is assassinated by one of his own bodyguards *1970* Barre declares Somalia a socialist state and nationalizes most of the economy *1974* Somalia joins the Arab League *1977* Somalia invades the Somali-inhabited Ogaden region of Ethiopia *1978* Somali forces expelled from Ogaden with the help of Soviet advisers and Cuban troops. Barre expels Soviet advisers and gains support of United States *1981* Opposition to Barre's regime begins to emerge after he excludes members of the Mijertyn and Isaq clans from government positions, which are filled with people from his own Marehan clan *1988* Peace accord with Ethiopia *1991* Mohamed Siad Barre is ousted. Power struggle between clan warlords kills or wounds thousands of civilians *1905* Italy made Mogadishu the capital of the newly established Italian Somaliland *1925* Territory east of the Jubba River becomes part of the Italian protectorate
Somaliland breaks away (1991–1996)
1991 Former British protectorate of Somaliland declares unilateral independence *1992* US Marines land near Mogadishu ahead of a UN peacekeeping force sent to restore order and safeguard relief supplies. General Aideed opposes the peacekeepers *1993* Eighteen US troops and over 300 Somalis die in clashes in Mogadishu. US mission formally ends in 1994 (Battle of Mogadishu) *1996* Mohamed Farah Aideed dies of wounds and is succeeded by his son, Hussein
Puntland autonomy (1997–2005)
2000 Abdulkassim Salat Hassan becomes president of Somalia *2000* Hassan and his newly appointed prime minister, Ali Khalif Gelayadh, arrive in Mogadishu to heroes' welcomes. Gelayadh announces his government, the first in the country since 1991 *2004* In 14th attempt since 1991 to restore central government, a new transitional parliament inaugurated during a ceremony in Kenya. Abdullahi Yusuf becomes the president *2005* Ali Mohammed Ghedi, Prime Minister, survives an assassination attempt in Mogadishu
Islamist advance (2006)
2006 People are killed, and hundreds are injured during fierce fighting between rival militias in Mogadishu *2006* Militias loyal to the Union of Islamic Courts conquer Mogadishu and other parts of the south after defeating the clan warlords. Ethiopian troops enter in Somalia *2006* Mogadishu's airport and seaports are re-opened for the first time since 1995
Islamist's retreat (2006–2009)
2006 Ethiopian and transitional government capture Mogadishu, Islamist's flee *2007* President Abdullahi Yusuf enters Mogadishu for the first time since taking office in 2004. Air strikes in the south against al-Qaeda members are first direct US military intervention in Somalia since 1993 *2007* African Union troops land in Mogadishu, after UN Security Council authorized a six-month peacekeeping mission *2009* Ethiopia completes troop withdrawal. Sharif Sheikh Ahmed becomes the president and extends transitional government's mandate for another two years

(continued)

Table 1 (continued)

Early settlements (150 BCE–1499)
Al-Shabab highpoint (2009–2011)
2009 Islamist insurgents launch an onslaught on Mogadishu and advance in the south *2010* Al-Shabab formally declares alliance with al-Qaeda, which wants to capture the capital *2010* Pirate attacks peaked *2011* UN formally declares famine in three regions of Somalia. Al-Shabab partially lifts ban on foreign aid agencies in the south, and UN airlifts its first aid consignment in five years to Mogadishu. Al-Shabab withdraws from Mogadishu with what it calls "tactical move"
New parliament, president (2012–2013)
2012 Somalia's first formal parliament in more than 20 years was sworn in at Mogadishu airport, ending the eight-year transitional period. Pro-government forces capture the port of Merca, south of Mogadishu *2012* MPs in Mogadishu elect academic and civic activist Hassan Sheikh Mohamud president over the incumbent Sharif Sheikh Ahmed. First presidential election in Somalia since 1967 *2013* USA recognizes Somalia's government for the first time since 1991 *2013* International donors promise 2.4 billion dollars in reconstruction aid in the three-year "New Deal"
Al-Shabab attacks Kenya (2014–2021)
2014 The government launches the country's first postal service in more than two decades. Mogadishu's first ever cash withdrawal machine was installed in a hotel *2015* US Secretary of State John Kerry visits Mogadishu, Al-Shabab raids the city's government quarter and kills 17 people *2017* Mohamed Abdullahi Mohamed, known as Farmajo, becomes the president. Al-Shabab threatens to target anyone collaborating with him *2021* The African Union (AU) proposed to "prolong and expand its military operations against the Islamist militia of Al-Shabaab" *2021* After several postponements, elections were scheduled for December

In the past described as "cosmopolitan", during the early years of the civil war Mogadishu saw minority clans driven out of the city (SSF 2017) in a process controversially labelled as "clan leansing" (Kapteijns 2013; Menkhaus 2016). This resulted in land and property being forcibly appropriated, leaving a legacy of disputes that remains to this day (World Bank 2020a, b).

The city has also a population composed of a high percentage of vulnerable individuals: female-headed households and single women, people with disabilities, as well as young single men. The real estate market is unable to provide an adequate housing response even to these individuals, who are often socially isolated, but paradoxically depend much more on community support or charitable neighbours to find housing (Earle 2021).

Another important challenge is related to the lack of targeted policies and specific urban planning strategies. The complexity of the situation requires specific actions that, starting from the local specificity, can contribute improving the situation of the city. The end of the transition period in 2012, and the partial liberation of the city from al-Shabaab, have recently triggered reconstruction and development initiatives—supported not only by the international community but also by the Somali diaspora.

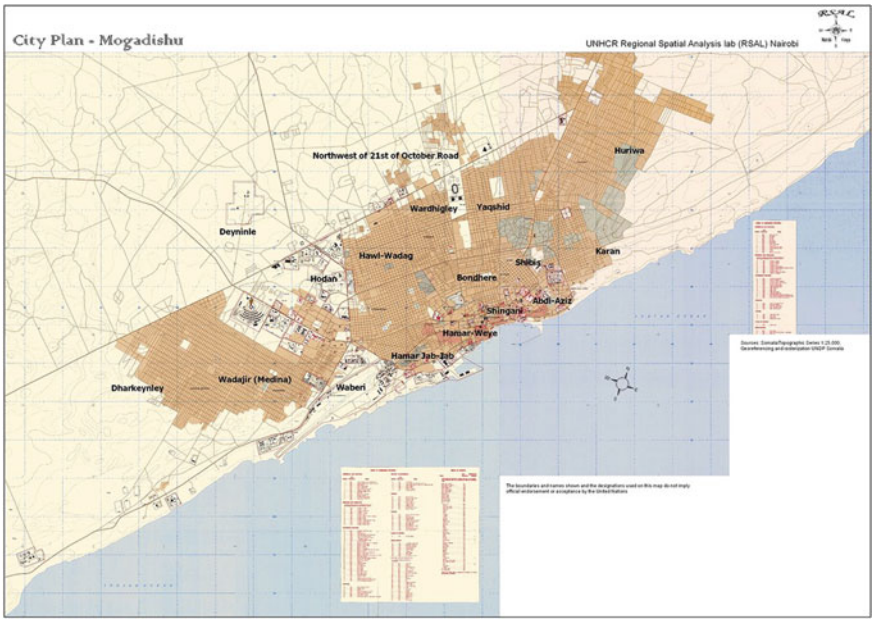

Fig. 3 City plan of Mogadishu (*Source* United Nations High Commissioner for Refugees – UNHCR; Understandingthehorn website, accessed in 2021)

Above all, the construction sector is rapidly growing thanks to money transfer from other countries and also from the Somali diaspora.[8]

Another important challenge regards land prices. It is estimated that they have increased 10 times since 2012, all due to the absence of an urban policy (Willenberg 2017). Several factors are producing this rapid and uncontrolled rise in land price, which consequently can undermine any urban policy: (a) lack of clarity, after the war, on ownership, entitlements and official rules governing land and property, that created a situation where speculation and the ability to pay go a long way in determining property ownership; (b) irregular acquisition of public land by private actors and clans; (c) irregular influx of IDPs[9] and increase of informal settlements

[8] A total of 91,828 persons have returned to Somalia between 2014 and 2020. This number includes Voluntary Repatriation from Kenya (84,981) and Assisted Spontaneous Returnees (ASR) from Yemen (5,416) as well as 1,431 returnees from other countries such as Djibouti (773), Libya (469), Sudan (143), Eritrea (34), Angola, Tunisia, Gambia, China, Ukraine and others. Somali refugees from these or other countries who return spontaneously without assistance from UNHCR are not included (The Federal Government of Somalia 2020).

[9] Internally displaced persons, who migrated to Mogadishu from another part of Somalia due to, e.g., conflict or famine/drought. It has not yet been clarified how much time a person must live in Mogadishu to no longer be considered an IDP.

and inhabitants in the city[10]; (d) increasing number of returnees, including Diasporic Somalis, seeking to reclaim their property; (e) presence of foreigners, including international development agencies, that can pay higher prices for properties.

The continuous influx of people into the city puts enormous pressure on the already fragile urban systems and infrastructure, causing people to settle in informal settlements inside and around the city.[11] There is a clear connection between urban poverty and internal displacement persons[12] (IDPs). Many informal settlements are inhabited by a mix of people displaced from other regions and low-income residents. This produces not only large flows of refugees into the city but also significant flows of internally displaced persons. This is further aggravated by the high housing insecurity of the urban poor that can be evicted with little or no notice by their landlord (Landinfo 2016). Mogadishu has suffered in recent years from strong pressure due to the presence of IDPs, which are mainly located in the north-west part of the city and in the Banadir region. They are often referred to as refugees, although they do not fall within the legal definitions of a refugee,[13] with big problems in terms of security, availability of public services, public health services, economic resources, etc.[14] In Banadir, a total of 137 IDP sites were identified in October 2020, corresponding to 25,814 households and for a total of 158,923 individuals.[15]

In 2019, a first attempt to respond to this housing emergency was carried out by the Benadir Regional Authority, which launched a series of actions to give permanent residence status to all internally displaced persons by 2022 (Bryld et al. 2019a, b, c). The Benadir Regional Authority has also established a "Durable Solutions Unit", which represents a significant shift in policy action (ReDSS 2019; DRC et al. 2017). Now, Mogadishu is more aware of the need to promote and encourage the construction of durable solutions (Yarnell 2019). This awareness is supported by official planning documents (The Federal Government of Somalia 2020).

Since Mogadishu's IDPs live in slums, it is possible to find many informal and formal settlements in the city. Informal housing or informal settlements include any

[10] The Benadir Regional Administration, local government of Benadir Region, which covers the same area as the city of Mogadishu, had 77.6% of urban residents, the highest proportions of the regions and 22.4% internally displaced people in the country. 13 (UNFPA 2014).

[11] Mogadishu has 45% of the urban population in all of Somalia and presents a rapid urban growth over a short period (FAOSTAT 2019).

[12] An Internally Displaced Person (IDP) is someone who is forced to leave their home but who remains within their country's borders (UNCHR website, accessed in 2021).

[13] «The African Union is unique in having a convention that specifically addresses the protection needs of IDPs. African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa. Finally, the United Nations High Commissioner for Refugees (UNHCR) provides protection to IDPs and stateless individuals in addition to 1951 Convention refugees» (International Justice Resourch Center website, accessed in 2021).

[14] «Between 2017 and mid-2018, 32% of new displacements recorded in Somalia were to, or within, the capital city of Mogadishu. Urban displacement is contributing to the fact that Mogadishu now has the second highest urban population density in the world» (IDMC 2018).

[15] For more information download dataset: https://bit.ly/3llsoLz.

form of housing, shelter or settlement (or lack) which is illegal and falls outside of local government control or regulation.[16]

In informal housing, "a state of deregulation, one where the ownership, use, and purpose of land cannot be fixed and mapped according to any prescribed set of regulations or the law" (Roy 2009). There is no global unified law on property ownership, so the informal occupant or community will lack security of tenure[17] and, consequently, ready or reliable access to civic amenities (potable water, electricity and gas supply, road creation and maintenance, emergency services, sanitation and waste collection) (Edesio and Varley 1998).

UN-Habitat defines an informal housing solution, or better slum household, as a group of individuals living under the same roof in an urban area who lack one or more of the following: "1. Durable housing of a permanent nature that protects against extreme climate conditions; 2. Sufficient living space, which means not more than three people sharing the same room; 3. Easy access to safe water in sufficient amounts and at an affordable price; 4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people; 5. Security of tenure that prevents forced evictions" (UN-Habitat 2010).

The critical role played by informal housing and service providers is perhaps most evident in Mogadishu. The inability of the national or local government to meet the shelter and security needs of the city's most vulnerable residents has generated an entire industry, that both maintains and exploits these inhabitants. Known as "gatekeepers" (Bryld et al. 2017) or informal settlement managers, these individuals negotiate access to plots from local landlords or chieftaincies and then facilitate access to shelter, not only for internally displaced persons but also for long-term urban poor residents, refugees and returnees. Informal settlement managers provide land, security, and basic services for a fee. They have established themselves as unavoidable actors for the delivery of aid to internally displaced persons, acting as intermediaries between the displaced communities and external actors, including the local government and the humanitarian community. There were approximately 140 gatekeepers in Mogadishu in 2017 operating outside formal accountability systems, in some cases, leading to the abuse and exploitation of internally displaced persons.[3] The Mogadishu case makes it clear that informal spaces are rarely "ungoverned" (Bonnet et al. 2020a, b).

[16] Swedish International Development Cooperation Agency (2004), The Informal Economy, Edita Sverige AB, Stockholm.

[17] Persistent conflict and insecurity can also often weaken the institutions that would record and formalize housing transactions. For instance, until 1991 municipal officials possessed a registry of land in Mogadishu, but these records are now held by a diasporic Somali living in Sweden, who charges a fee to verify land deeds (Bonnet et al. 2020a, b).

2 Mogadishu: The Four Different Existing Cities

From an urban and architectural perspective, Mogadishu could be perceived as composed of four different cities, which coexist without intermingling, with clearly recognizable margins. These four groups were identified by observing the city's urban fabric and are distinguished as follows: the *Historical city*, the city of urban sprawl that has grown over the years in an unregulated but well-defined pattern, within two distinct urban grids (the *24 × 24 city* and the *100 × 40 city*) and the *IDPs city*. The methodology used was helpful in better understand the urban morphology inside the different districts of Mogadishu and to further recognize the peculiar patterns and physical characteristics that delineate the its distinct parts.

The historical city

Mogadishu has grown with an approximately semi-concentric form, expanding from the Old Town, the original nucleus from which the capital was founded, to the outskirts. Shingaani and Hamar Weyne (Fig. 4) are the historic districts that made up the Old Town, and are characterized by a unique mixture of architectures: from the city's oldest fabrics, to the colonial constructions to the most iconic religious buildings. Before suffering the consequences of decades of war these buildings expressed the exceptional mixture of Islamic, norman gothic, indigenous vernacular, colonial, and modernist aesthetic (Ali and Cross 2014). The oldest stone houses were built as a dense urban fabric, with small and tangled alleys and to this day, many elements of the facades show the different layers of the city's evolution through the years, as revealed by the clear influence of the Arab and Persian culture, which originated when the traders settled in the area in the sixteenth century. The survival of these buildings is essential for the preservation of the cultural heritage and identity of Mogadishu (Ali

Fig. 4 Satellite image of Mogadishu—the historical city

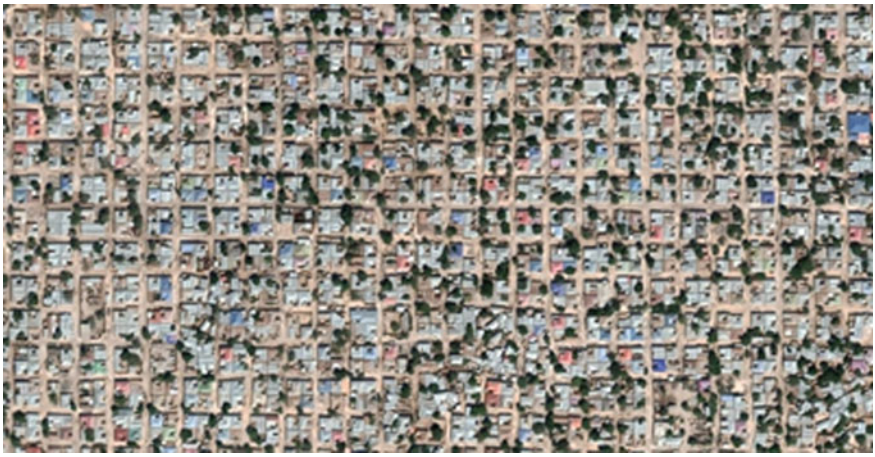

Fig. 5 Satellite image of Mogadishu—the 24 × 24 city

and Cross 2014).However today, the legacy of this area is under threat. From one side most buildings are severely damaged and still at risk of collapse, on the other, threatened by the construction boom, which has increased the value of land and the consequently the desire for fast profit, with no care for preserving these buildings.

The 24 × 24 city

The second group considers the constructions built in the first stripe around the historical centre. It is defined by a regular urban tissue composed of blocks of approximately 24 × 24 m (Fig. 5), split into four squared plots of 12 × 12 m; in some cases, these are grouped in clusters of four, defined by a wider road. The plots are almost entirely built, with only a small patio located on a side. The buildings are usually enclosed by stone walls, and the streets around them have a width of about 6 m. If the plot is located in a commercial area, small shops are built facing the road while the house is located in the back. Nowadays, by observing the ongoing trasformation of the city, especially closer to the centre, it is evident that single-unit dwellings are being replaced by taller multistorey buildings with a footprint that uses all the space available on the plot. This reflects the city's accelerated urbanization and the increase in the single plots' value caused by the growing demand.

The 100 × 40 city

The third group is defined by regular blocks that measure approximately 100 × 40 m (Fig. 6). The length of these blocks varies from 90 to 120 m while their depth is always 40 m long, made up of two lines of regular plots of 10, 15 and 20 m wide and 20 m deep. The only exception to the emplacement of the plots occasionally occurs when they are located at the edge of the block. In this case, the plots are rotated, and the entrance is positioned on the short side. The 100 × 40 m pattern covers the most significant portion of the city and maintains the same basic characteristics overall,

Fig. 6 Satellite image of Mogadishu—the 100 × 40 city

from the more central and compact areas to the more peri-urban parts, shaping the uncontrolled urban sprawl. It mainly develops around the principal roads that link to the city centre by creating new trajectories of expansion of this fabric and slowly dissolves when it reaches the limits of Mogadishu. Even recent extensive housing projects use this pattern—and the same plot dimensions—but instead of completing the existing urban fabric, they form new detached developments on the city's fringes.

If we move our focus to the very peri-urban areas of the city, by observing the satellite map of Mogadishu it is possibile to observe a recurring phenomenon all around the limit of the built city: significant portions of land have already been divided into plots and urban blocks by marking a recognizable grid (Fig. 7). These circumstantes however takes no account of soil consumption, potential natural hazards, such as flooding risk (MPIC 2016) or proper urban management. The proportion of the blocks has retained the essence of the city as it has grown in the last decades, maintaining the same plot dimension, street width and block size. The most likely hypothesis is that private companies and/or estate corporations are buying big portions of land and subdividing it following the logic of the market for later reselling them and making profit. But it's still uncertain if this is done through legal transactions or by land grabbing (UN-Habitat 2019). This ambiguity is also due to the fact that exists lot of vagueness about former land titling, because customary and traditional norms are still widely used (NRC 2009). The first signs of this peculiarity are visible on satellite images since 2005, especially on the northern side of the city, between the Afgoye corridor and the Daynile airstrip, while starting from mid-2009, it is increasingly visible on the western side. According to UN-Habitat, the total area marked by this grid reaches almost 6000HA, which is more than half of the current size of Mogadishu (UN-Habitat 2019).

Fig. 7 Satellite image of Mogadishu—empty urban block

The IDPs city

The last group is the least-homogeneous one and forms detectable irregular pockets inside the consistent tissue of the city (Fig. 8). It is made up of formal and informal refugees camps, which differ depending on the longevity of the settlements, the material used to build them and the regularity, or non-regularity, of their arrangement. They are inhabited not only by IDPs, but also by returnees, refugees and urban poor, affected by urban impoverishment due the unstable political situation. These settlements are concentrated mainly in the peri-urban areas of the city and their number has increase due to repeating displacements, as a result of more frequent

Fig. 8 Satellite image of Mogadishu—IDPs city

drought, flooding (or other extreme climatic events), political instability and forced eviction from more central and valuable parts of the city. These settlements are characterized by inadequate housing conditions, overcrowding, poor social services, lack of livelihood opportunities and unsafe living conditions (MPIC 2016). IDP camps are spread all around the city, but the higher percentage is located along the Afgoye corridor and more recently towards the Daynile airstrip. Daynile and Kaxda neighbourhoods, both situated on the northern outskirts, host the most significant number of internally displaced persons in the region. Out of the overall 486 identified IDP settlements, Kaxda and Daynille districts have the highest number of settlements, which amount to over half of all settlements in Mogadishu (Joint IDP 2016).

Informal settlements, in most cases, are constructed on private land, and the residents pay a monthly rental fee without any form of documented tenure security agreement, only relying on informal oral agreements. Rent is paid either in cash or in kind, including with the humanitarian aids they receive. The lack of a formal tenure arrangement means that IDPs in Daynile and Kaxda districts, as in most parts of Somalia, live under perpetual intimidation and constant threat of being forcibly evicted (Joint IDP 2016). This is certainly one of a series of factors that precludes IDPs from the right to an adequate housing, with consequences also on social and health issues.

Observing the existing housing plots, typologies and urban fabrics

As for the analysis of the urban block, a similar procedure was adopted to observe the individual properties at a morphological level, comparing the different types of construction and land occupation manner (Fig. 9). This observation led to categorizing the elements according to the plot's size and to order them with respect to the percentage of land occupied at a given time. It is therefore plausible to say that the first portion of the plot that is occupied, in most cases, is at the rear end, and is then gradually filled almost entirely. Usually, a small central portion is left free, and the house is built around it. The prominent presence of double-pitched roofs and compact volumes juxtaposed with one another, that increase as the house grows with its inhabitants, are identifiable features.

3 Concerns About the Future Urban Growth

In the last 30 years, Mogadishu has been mainly shaped by spontaneous and uncoordinated actions, without any real development plan. This is mainly due to an unstable political situation, uncoordinated governmental vision, and lack of a reorganized and restructured urban legislation framework. The consequences on an urban scale are uncontrolled growth, fragmentation, lack of basic infrastructure, problems with mobility, illegal occupation practices, and continuous conflicts over land ownership (UN-Habitat 2019). Nevertheless, these circumstances diverge in particular when compared to the neat grid, which has guided the expansion of the capital (as shown previously), without any unequivocal guidance. This peculiar setting could offer an

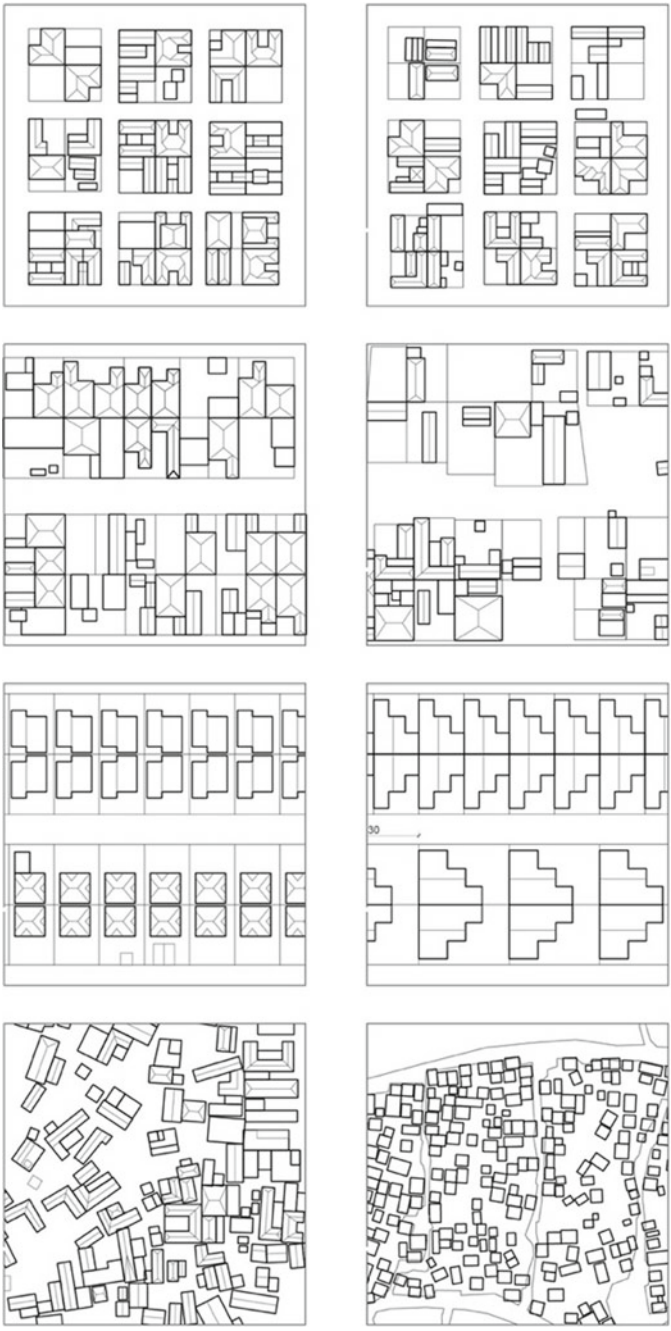

Fig. 9 Comparison of different urban blocks in Mogadishu

uncommon opportunity because it has kept space and fair regularity to implement unserved areas, for example, with primary infrastructure works. It is, however, imperative to equip the city with a proper regulatory framework, solid urban legislation and urban planning and regulation mechanisms to direct and address its future growth. It becomes even more pressing considering the increasing impact of global warming which manifests with more frequent and severe droughts, floodings and inundations, producing a massive increase of IDPs towards urban areas to seek better living conditions. Although some progress has been made in the last years, the consequences to face are still significant, and the challenges to confront are vast.

Somalia is projected to become predominantly urban by 2050 (UN/DESA 2019), and its capital, Mogadishu, today has one of the highest growth rates globally. The urbanization rate in 2019 was 4.13% (CAHF 2019), and it does not appear to downtrend in the future. Mogadishu is predicted to increase by approximately 126,000 inhabitants per year (UN/DESA 2019). This implies that a more or less large portion of land will be needed depending on the density rate at which this new population will find accommodation, and it could result in very different outcomes. This, once again, brings a particular focus on observing the patterns in which the city is already growing and consuming new unbuilt land.

UN-Habitat, in collaboration with BRA (Benadir Region Administration), has hypothesized three different scenarios that could structure Mogadishu in the next decades (Fig. 10). These were created in an attempt to anticipate the consequences of the fast transformation that the capital is witnessing, and to possibly take early actions, on decision such as infrastructure and service provision for example.

The first scenario is referred to as Compact City and foresees the occupation of the suburb areas of the city growing contiguous to the existing parts, filling the gaps left unbuilt. In this case, some areas could be designated to be residential while others would become mainly economic investment zones. This model would take advantage of the existing public facilities and services, with the guarantee of strengthening the already precarious infrastructures. The existing street network should be upgraded and extended to improve connectivity, and essential public facilities will need renovation and expansion. Simultaneously, the former industrial cluster should be restored to create new jobs at a close distance. This scenario would have lower investment costs, with short-run benefits.

The second scenario is the Satellite Town and differs from the first in that it conceives the development of satellite towns outside of the city. These new towns would require a lot of effort to be self-sufficient, considering both urban services and job opportunities, and it would be achievable only with a well-planned economic strategy due to the significant investments required. If not supported by well-managed development plan which foresees the creation of new jobs, the risk is that commuters will put even more pressure on the already very limited infrastructures.

The third scenario, the Regional Development Scenario, extends its objectives to a bigger scale, assuming that neither of the previous ones would be capable of responding to the need of a very fast-growing population. In this case, the systematization of a regional general strategy should be adopted in order to strengthen the

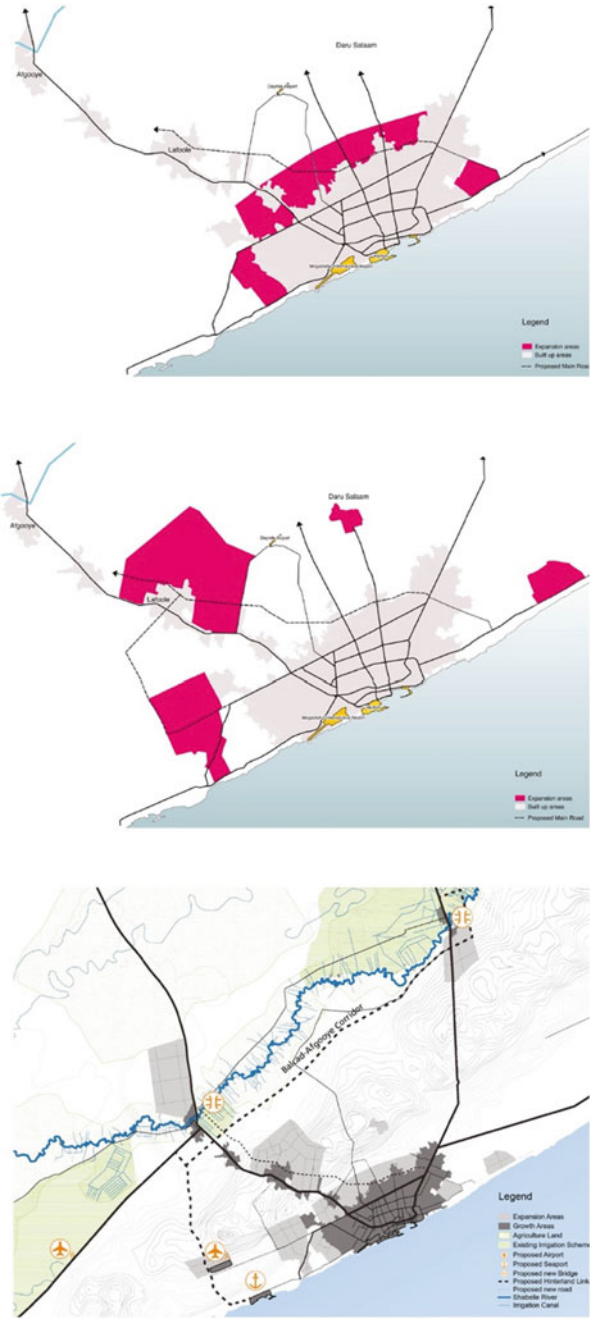

Fig. 10 Representation of possible future scenarios for Mogadishu (UN-Habitat 2019). In order: the Compact City, the Satellite Town, and Regional Development Scenario

urban–rural connection and promote economic expansion, integrating the development of the cities of Afgooye and Balcad with the fertile agricultural land of the surroundings. The assumption is that rural and urban economies are interdependent, and strengthening their linkages will benefit both the promotion of economic growth and the reduction of rapid urbanization. (UN-Habitat 2019).

These three scenarios are already proceeding on parallel tracks with different ends and targets. The first scenario would prevent land consumption and focus more investment towards reinforcing the existing infrastructure, but would require considerable efforts because of disputes and contentions between the people involved. The second scenario is well interpreted by the construction of the Daru Salaam City project, which embodies the interests of the real estate market and of private investors. The project, an ongoing construction site on the northern part of the city, is planning to build 6000 new units, with modern facilities and internal services—such as schools, universities, hospitals and a green area—in an empty area, away from the congestion of the city, but along a well-connected road. On the other side, moving more funds toward the third scenario would support also the more disadvantaged part of the rural population on a more integrated and widen view, but would require a longer period to be implemented, important humans and economic resources, and an enormous planning effort.

4 Concerns About the Issue of Housing: Housing Demand and Levels of Affordability in Mogadishu

The last decade, the housing market of Mogadishu has been on the move. Investors have renewed interest in Somalia, and the real estate and construction market are now seen as a potential to boost the country's economy. This is driven by the high housing demand due to rapid urbanization and the growing interest and investments in this sector by the diaspora, especially in Mogadishu (CAHF 2020). As a result, the Somalia Real Estate Association (SREA) was established for the first time in 2014 to provide professional assistance to the real estate sector and assist the government in establishing a proper regulatory framework (The Somalia investors, article 2015).

The consequences of this shift had different outcomes. The volume of the demand has notably increased the land value and, as a consequence, many investors have moved to the city's outskirts to develop extensive housing programs, where land prices are lower. As previously mentioned, this is the case of Daru Salaam City, a housing project with the ambition to build 6000 new units in three phases, over a supposed period of 5 years. A second similar example is the Jazeera Estate housing project, located in the southwest area, near the airport. It should host 1200 units, along with commercial and public social facilities. Needless to say, these projects target a very specific and small percentage of the population without really helping bridging the housing supply gap.

On the other hand, property prices in the city have doubled and tripled. In 2019, the price of the cheapest newly built house constructed by a developer in Somalia was US$70,000, with double-storey houses costing approximately 130,000$ (CAHF 2019). Assuming a mean housing price of 100,000$, this would be affordable to almost 0% of the Somali population. This house would cost 769$ per month, and 276,809$ over the term, at an interest rate of 8.5% and repaid over 30 years (CAHF 2017). Given that the average monthly salary after tax is 225$ (CAHF 2019), this clearly shows how unaffordable formal home ownership is for the average Somali. As an effect of the high demand and the rising land values, Mogadishu is witnessing more and more forced eviction events (Joint IDP 2016), pushing those living in already fragile conditions outside of the city.

Within this context, challenges are also associated with the access to financial instruments, repayment period and total amount. Some of the problems are short repayment periods (only three years in some cases) due to the risk of liquidity, downpayment value requirements, the high Murabaha rate[18] and the limited number of real estate developers, which adds to the affordability challenge in Somalia (CAHF 2020).

The general conclusion is that affordable housing is completely out of reach for most of the population, especially for IDPs and urban poor, but also for a developing low-middle class. Consequently, a vast housing gap demands urgent action and is especially pressing the need for affordable housing.

Case studies

Three case studies have been investigated to verify different criteria regarding typology, type of investment, construction technology and morphology. The limited data available has narrowed the investigation to these case studies, even if they reach a different user than the one who is the target of the final proposal. However, the data collected was helpful to have a general understanding of the current housing and construction sector.

The first two cases are projects built within the formal market and target a small percentage of the population with good to high incomes. These are residential neighbourhoods that offer internal services for their residents, such as spaces for leisure, private educational centres and medical services. The third case is a newly designed housing project that attempts to find a solution to the demands of the low-income population. The Heliwaa Social housing project was designed by the Benadir Regional Administration through the Durable Solutions Unit to build 300 new units for IDPs (UN-Habitat 2020).

Daru Salaam city project

The Daru Salaam city (Fig. 11) project is the first project of this entity in Mogadishu. As already anticipated, its intention is to build 6000 new units, with modern facilities

[18] In Islamic finance, Murabaha financing is used in place of loans. Murabaha is also referred to as cost-plus financing because it includes a profit markup in the transaction rather than interests. A seller and buyer agree to the cost and markup, which are then paid in installments.

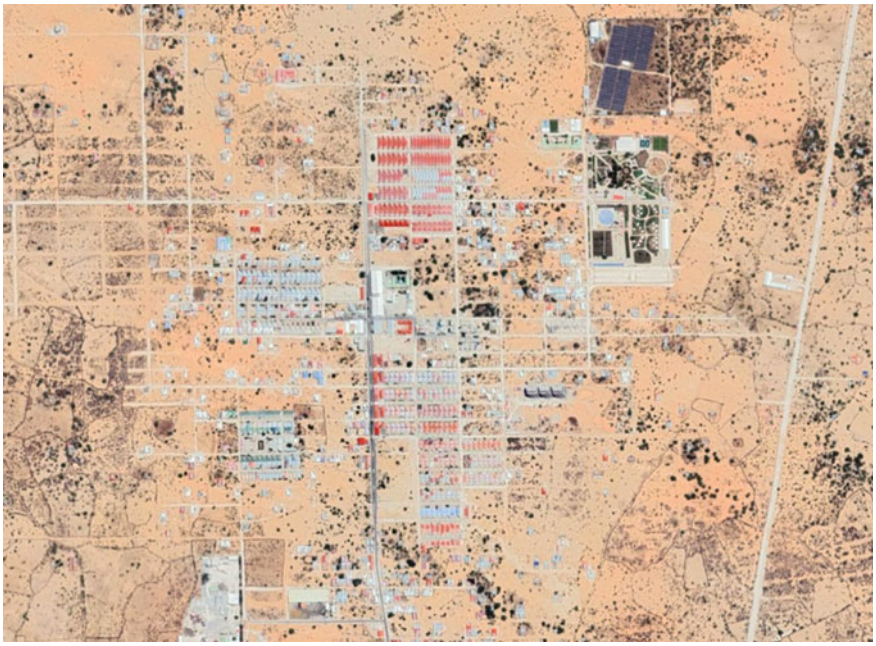

Fig. 11 Satellite image of Daru Salaam city

and internal services—such as schools, universities, hospitals and a green area—in an empty plot, away from the congestion of the city, but along a well-connected road. The first phase of 500 houses is now completed, and the first residents have already moved in. The project is based on the idea of gated communities to offer security and quietness to its inhabitants away from the city. It proposes different housing solutions, from apartments in small condominiums to a two-floor villa with six bedrooms, for a total of seven different typologies. The most common one is the single-storey detached house built on a plot of 15 × 20 m, with four bedrooms, and sold at approximately 70,000$ (CAHF 2018). Tall fences enclose the property, and the building occupies the back portion of the lot, freeing the front (space mainly used for parking). The entrance is characterized by a paved floor and a front porch with some decorations. The living and dining spaces occupy a generous portion of the total surface and are separated by the kitchen. A second corridor leads to the bedrooms, which have generous proportions.

Jazeera estate

The Jazeera Estate Project is similar to Daru Salaam, but there is no evidence of its implementation even though it was fairly publicized. The project proposed to build over 1200 new houses, villas and townhouses, along with commercial and public facilities, in the southwest part of the city, close to the seaside and 3 km away from the airport. As in the previous case, they offered different building typologies: three types

of Maisonettes (villas with 6–7 bedrooms), two types of Bungalows (one detached and one with a shared wall between two properties, both with four bedrooms), and two different apartment buildings (four floors with two apartments each). This settlement offered commercial areas, a park and a mosque. The different typologies proposed by Jazeera Estate are all equipped with air conditioning, central heating and laundry areas. The renders of the design proposal show the use of finishes that respond to the international standards, moving away from local patterns and traditions.

These two projects show how the current trend is to move away from traditional aesthetic in favour of a more "international" taste that responds to economic rather than aesthetic principles. In this context, there is no great typological attention or particular care to the internal subdivision of the living spaces. What seems to characterize most of these typologies is the presence of several rooms, and a living space separated from the more domestic functions. There is no particular attention to area, which size is often small and mainly reserved to accommodate the family's car.

The Heliwaa social housing project

Very distant from these first two projects is the Heliwaa social housing project, developed in January 2019, through the partnership between the EU-RE-INTEG and the Benadir Regional Administration. With this project, the Durable Solutions Unit (DSU) and the municipality of Mogadishu aim to find lasting solutions to protracted displacement (Municipality of Mogadishu 2020).

The pilot project of 300 housing units should host approximately 1550 people and will be integrated with new public spaces, commercial units and medical facilities. The project offers two different typologies designed for families of different size. One is a four-unit block arranged over two floors, with a total of 73 sqm per unit, divided into three bedrooms, one bathroom, one kitchen and a living area for five people. The second is a single housing unit, intended to host elderly or people with special needs in 48 sqm, divided in two bedrooms, one living, a kitchen and one bathroom. The intervention site was chosen because of its location and affordability and it is already equipped with numerous social and community assets, which would be strengthened and upgraded by the project, instead of building new ones. The new integrations will include a community centre, a prayer space, improved accessibility for people with disabilities. The community already living in the area was consulted through workshops and engagement programmes so that they would gain more confident in the project. They have been offered upgrading opportunities for the same reasons, and some of the units will be allocated to the host community.

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Climate-Responsive Design and Energy Performance Goals

C. Del Pero and M. Martire

Abstract The design of sustainable buildings is a process that involves the three dimensions of sustainability: economic, environmental and social. However, due to the massive urban development underway in Africa, one of the main objectives for designers is to reduce the energy consumption of the constructions to consequently avoid a dramatic increase in GHG emissions. For this reason, in this chapter, the attention will be focused more on the energy issue, but also considering the economic and social aspects. In fact, a transformation is needed in the building design procedure, which must include a careful analysis of the climatic context and of the economic and social constraints.

Keywords Climate context · Site planning · Building shape · Technical system · Current energy · Water supply

1 Climate Analysis of Mogadishu Context

This section presents the assessment of the climatic context of Mogadishu (Del Pero et al. 2021). The city, located very close to the equator, has a climate classified as hot semi-arid (Köppen *BSh* climate classification) like much of southeastern Somalia, as shown in Fig. 1. However, due to the coastal location of the city, the relative humidity is quite high, so some features of the tropical savanna climate (Köppen *Aw*) are present.

The typical meteorological year (TMY) weather file used to perform the climate analysis was constructed from weather data acquired between 1958 and 2017 and by selecting the most typical data for each month available from the Climate.OneBuilding.org database (Climate.onebuilding.org).

The results of the analyses performed are reported below; the graphs were obtained through the Climate Consultant software (Climate Consultant Software).

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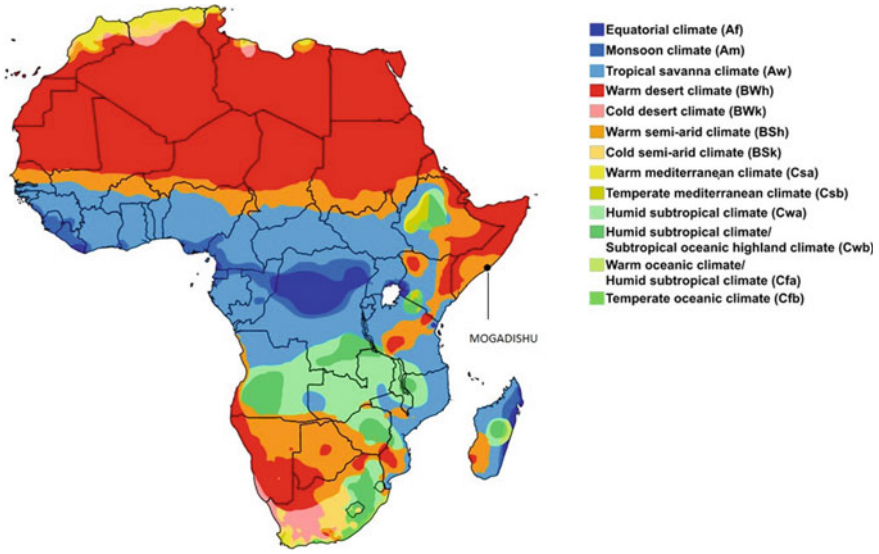


Fig. 1 General climatic classification of Africa and position of the city of Mogadishu. *Source* Beck et al. (2018)

Air temperature and relative humidity

The average monthly temperatures are almost constant throughout the year, between 26 °C and 30 °C, as shown in Fig. 2. About the average monthly maximum and minimum temperatures, there is a minimal annual variability; in particular, the

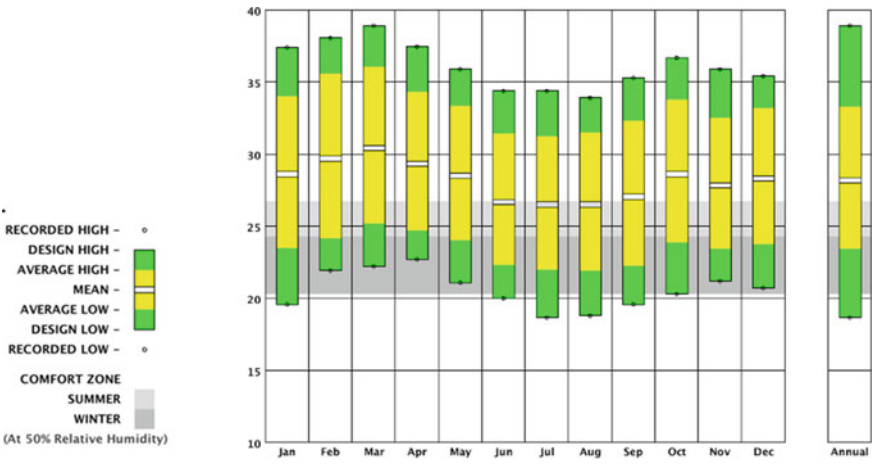


Fig. 2 Monthly average dry bulb temperature. *Source* Climate.onebuilding.org Database; Climate Consultant Software

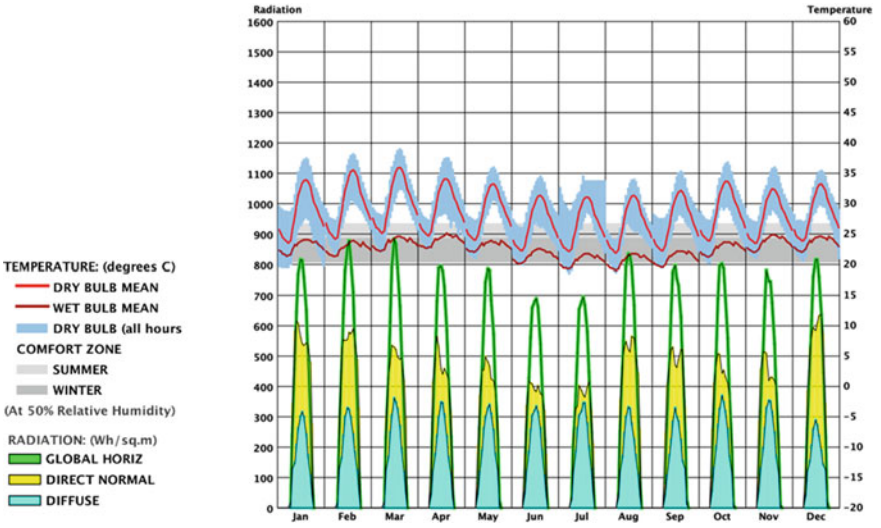


Fig. 3 Monthly diurnal averages. *Source* Climate.onebuilding.org Database; Climate Consultant Software

minimum average temperature touches 22 °C in July compared to a peak of 25 °C in March, while the maximum average monthly temperature touches a minimum of 31 °C in July compared to a peak of 36 °C in March. At an average temperature of 30 °C, March is the hottest month of the year. A more comfortable season is experienced between June and September due to a small temperature drop.

As shown in Fig. 3, the daily trend of temperatures is similar in the various months of the year, except for the period between June and September, which presents a decrease in the average daytime temperatures compared to the other months. The excursion between maximum and minimum average daily temperature varies between a minimum of 8 °C in July and a maximum of 11 °C in March.

The average relative humidity is very high throughout the year, as shown in Fig. 4. In fact, the parameter shows minimal variations on a monthly basis and also during the night, when it is always around 80%. In the daytime, the relative humidity reaches daily values that are generally 80% in the morning, then fall to 50% in the afternoon hours and finally reaches 60% after sunset.

Solar radiation

Global solar radiation over a horizontal surface is high in all the months. May, June and July are the only months with average irradiance less than 500 W/m^2 (Fig. 5). The annual average of direct normal radiation, calculated on an hourly basis, is higher than 400 W/m^2, while the global horizontal is almost 500 W/m^2.

It is important to note that the difference in global solar radiation, particularly in the period of July, is mainly due to the high precipitation and cloudiness, as can also be seen from the average sky cover values shown in Fig. 6. The average annual

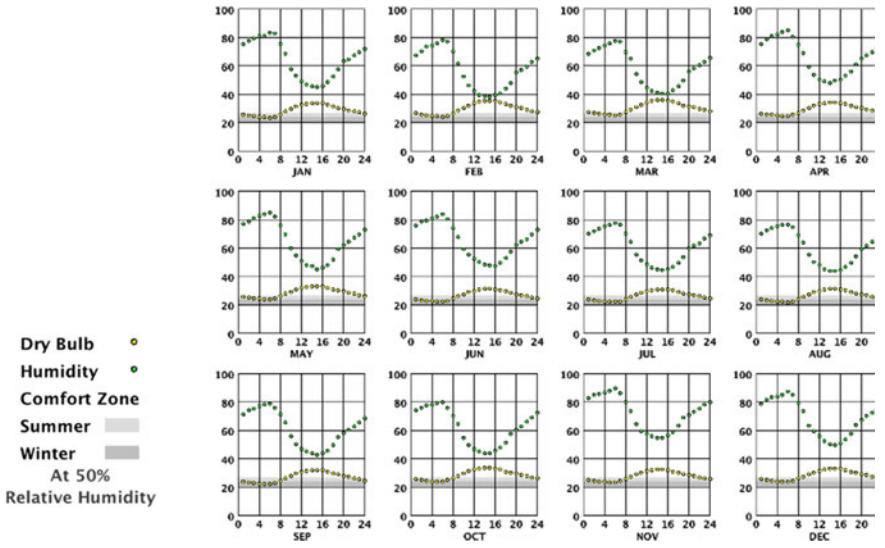


Fig. 4 Hourly average dry bulb temperatures and relative humidity. *Source* Climate.onebuilding.org Database; Climate Consultant Software

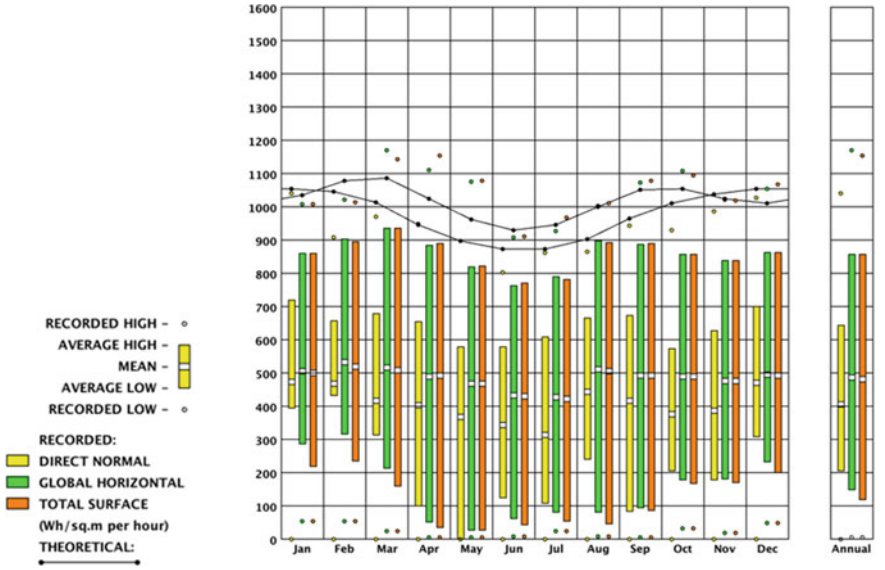


Fig. 5 Average hourly solar radiation during daylight hours. *Source* Climate.onebuilding.org Database; Climate Consultant Software

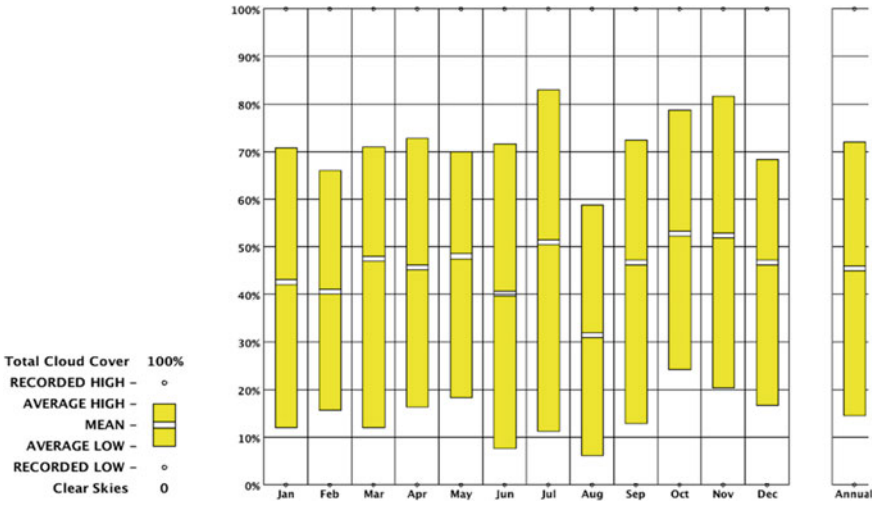


Fig. 6 Maximum, minimum and average values of sky cover. *Source* Climate.onebuilding.org Database; Climate Consultant Software

coverage of the sky is 45%, with mean maximum values in October/November of 52%, while in August the percentage drops to 30%.

The average annual daylight illumination is very high, around 54,000 lx (Fig. 7), of which less than half is due to direct solar radiation. This value falls below 50,000 lx in the period between June and July. The high contribution of natural illumination

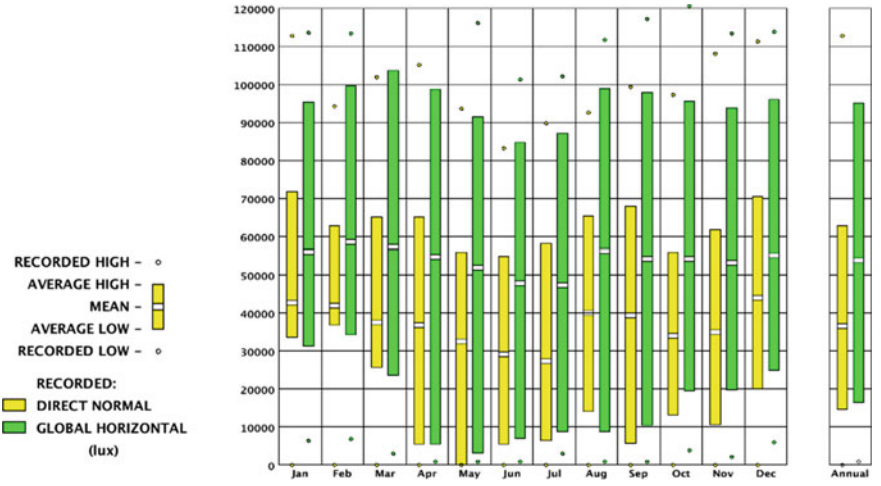


Fig. 7 Hourly averages of daylight illumination. *Source* Climate.onebuilding.org Database; Climate Consultant Software

must certainly be taken into consideration for the design of the windows, the artificial lighting systems and the shading systems.

Wind velocity and direction

Wind speed has a low annual variability: the minimum average is 1 m/s in December compared to the maximum average of 5 m/s in August, as shown in Fig. 8.

The prevailing wind direction is from the north-east from November to March (Fig. 9) and from the south-east from April to October (Fig. 10). To select the orientation of the buildings in order to maximize the natural ventilation, the north-east direction of the wind must be considered because of the higher temperatures during the period from November to March compared to other months.

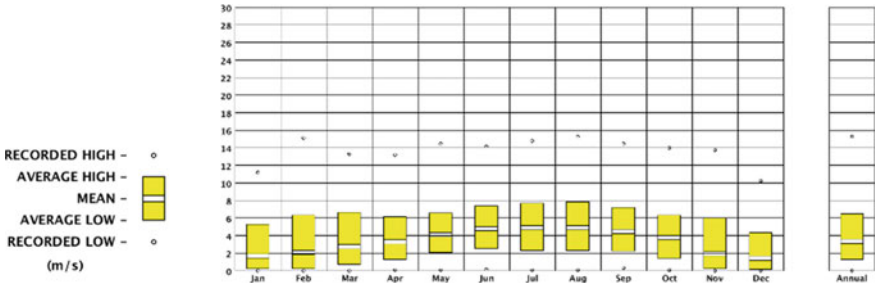


Fig. 8 Maximum, minimum and average values of wind velocity. *Source* Climate.onebuilding.org Database; Climate Consultant Software

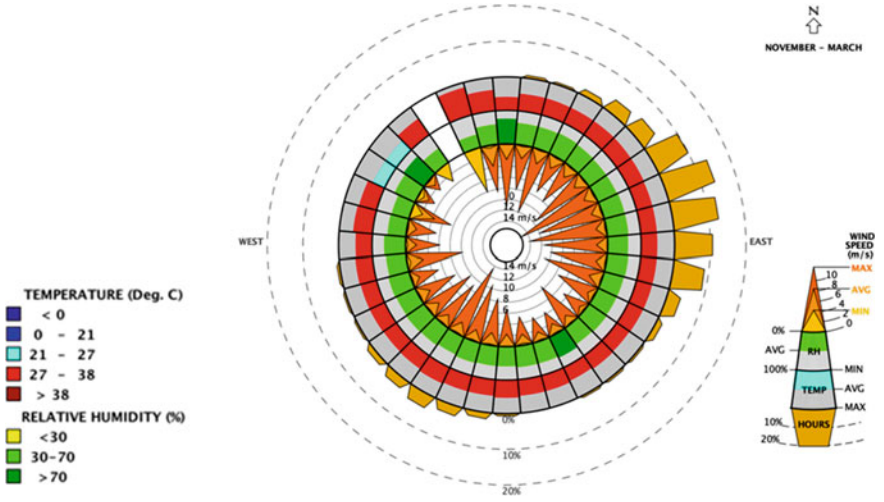


Fig. 9 Wind wheel from April to October: direction, speed, temperature and windy hours per day. *Source* Climate.onebuilding.org Database; Climate Consultant Software

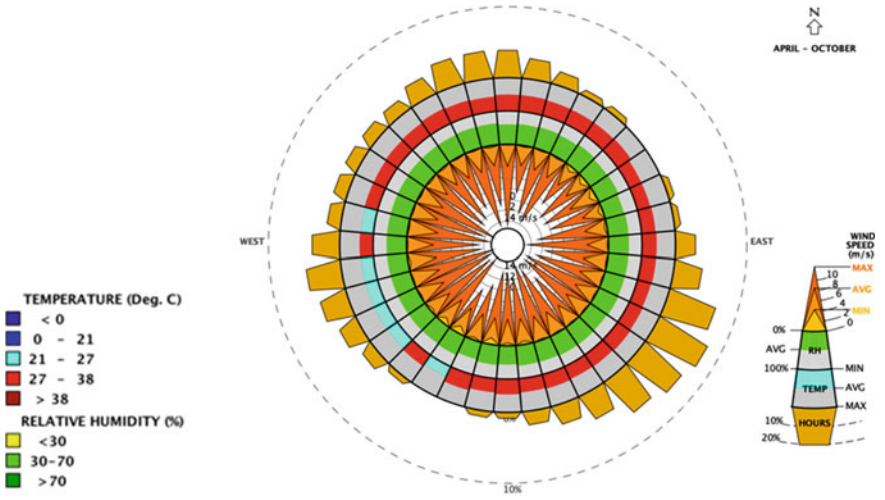


Fig. 10 Wind wheel from November to March: direction, speed, temperature and windy hours per day. *Source* Climate.onebuilding.org Database; Climate Consultant Software

Bioclimatic chart

According to the Givoni bioclimatic chart, in a climate such as that of Mogadishu, characterized by permanent high humidity, high temperatures, small daily temperature swing, moderate wind and high values of solar radiation, sun shading of windows and dehumidification are the most effective design strategies for improving thermal comfort, as shown in Fig. 11. From the same diagram, it is also possible to note the need for ventilation (natural and fan-forced) and thermal mass.

2 Main Rules for Climate-Responsive Design

On the basis of the climatic analysis, it is possible to identify important indications that allow a more adequate architectural and energy design. This section describes some building design rules to be adopted in Mogadishu and in similar climates, in order to improve the comfort conditions inside buildings and to reduce energy consumption due to the use of mechanical cooling.

The considerations reported below are mainly based on studies carried out by Politecnico di Milano in collaboration with UN-Habitat, to identify the most adequate and effective strategies for sustainable buildings in tropical climates (Butera et al. 2014). In particular, the following considerations are related to site planning, building's shape and envelope and windows design.

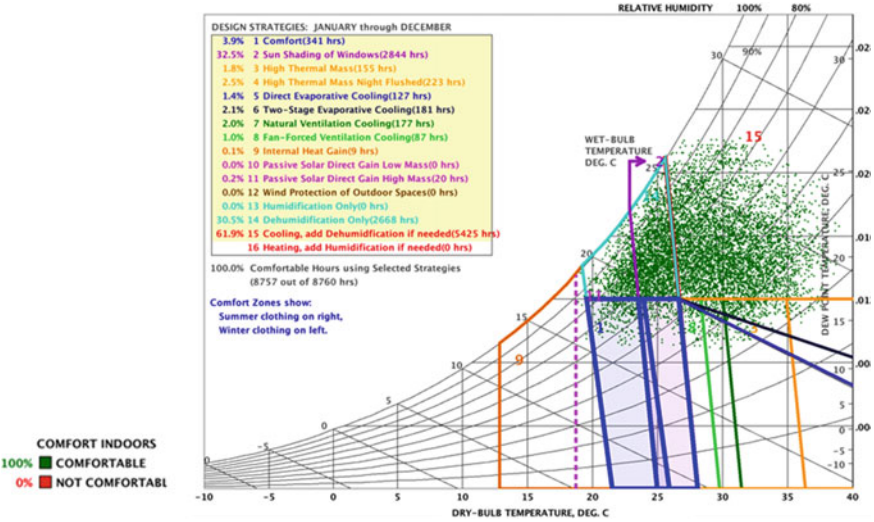
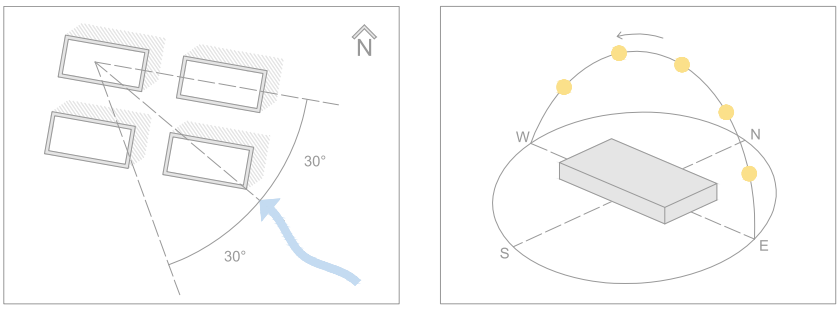


Fig. 11 Givoni's bioclimatic chart. *Source* Climate.onebuilding.org Database; Climate Consultant Software

Site Planning

In hot-humid climates, the basic measures in terms of site planning concern the provision of shading and air movement.

In order to favour ventilation, it is important to dispose the buildings according to a pattern in which each building should be oriented at an angle of about 20–30◦ to the prevailing direction of the wind (Fig. 12a). In addition, the distance between the opposite facades should be limited and large openings should be provided on the opposite exterior walls. Vegetation should be arranged to provide shade, but without interfering with natural ventilation.



(a) (b)

Fig. 12 **a** Orientation of building according to the wind; **b** orientation of building according to the sun. *Source* Butera et al. (2014)

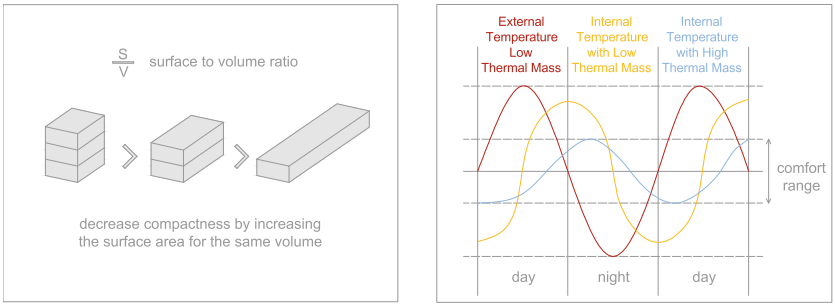


Fig. 13 **a** Variation of surface to volume ratio; **b** effect of thermal mass on the behaviour of a building. *Source* Butera et al. (2014)

To protect buildings from the sun, the axis of the building should be oriented along the east–west direction (Fig. 12b) in order to maximize the north and south facades, which are easy to protect with small overhangs, and to minimize the east and west facades, which are difficult to protect, minimizing heat gains.

To maximize the indoor comfort of occupants, the habitable spaces should be arranged in the south and north portions of the building, while buffer spaces, such as staircases, should be located in the east and west portions.

Building Shape and Envelope

Conduction heat flow through the building is influenced by the shape of the building, that is the surface–volume ratio, and by the thermal insulation qualities of the envelope (Szokolay 2008).

Heat losses and gains, at a constant volume, increase if we move away from a compact form of the construction (Fig. 13a). In climates such as that of Mogadishu, where daily temperature variations are minimal and relative humidity is high, the shape should be open to improve natural ventilation and use air flow to remove indoor heat and enhance thermal comfort for the occupants.

The design of the building envelope should be made with the objective to reduce heat gains by minimizing solar exposure of envelope components such as external walls, roof and windows.

Thermal insulation must be considered to reduce the heat flow through a wall or roof due to incident solar radiation. However, insulation could be not economically advantageous in residential settlements where affordability is a priority; for this reason, cost-effective construction techniques with an insulating layer should be studied.

Thermal mass has the role to absorb heat during the day and return it at night, helping to maintain the environmental conditions in the comfort range (Fig. 13b). If the daily temperature swing is low, the use of materials with medium–low thermal

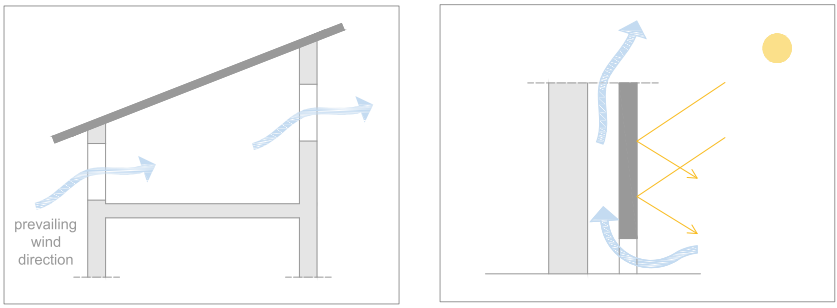


Fig. 14 **a** Section of double leaf roof; **b** section of double skin wall. *Source* Butera et al. (2014)

mass is preferable because the heat stored during the day from incident solar radiation would be released at night, worsening the comfort.

The design of the roof requires particular attention. To reduce heat gains due to solar radiation, the roof should be reflective, insulated and ventilated. In particular, to keep the roof cool, it should be sloped towards the prevailing breeze, and obstructions along the roof surfaces should be avoided. A double leaf roof is the most effective roof type in hot-humid climates (Fig. 14a). It is a roof with ventilated double skin, where the outer layer shades the inner one and absorbs solar heat according to its reflectivity, which should be as high as possible. Ventilation of the space between the roof and the ceiling is essential to remove heat and ensure comfort.

The design of the walls is important because they constitute the majority of the building envelope. If walls are not protected from the sun, they transmit heat inside the building. North and south-facing walls receive moderate radiation because of the steep angle of incidence. East and west-facing walls receive greater heat load and it's difficult to protect them from the sun by using roof overhangs. If, however, the walls are exposed to the sun, it is possible to limit the flow of heat through the adoption of measures, such as cavity structures (Fig. 14b), insulating materials, radiant barriers and light colours on the external surfaces to favour the reflection of solar radiation, always taking into account the installation cost to ensure affordability.

Windows Design

Windows design requires attention in order to improve the comfort conditions inside buildings. To allow the ventilation, the windows should be large, it is better to expand them horizontally (Fig. 15a), and they should be located on opposite walls; if openings are only on one wall, ventilation will be less effective. Moreover, to control solar gains, they should be placed on the north and south walls, and glazing should not exceed 20% of the wall area.

It is important to consider the prevailing wind direction concerning the openings. If the openings are aligned in the direction of the wind, the air flow passes right through the space, influencing a reduced part of it, with modest induced air movements. If the

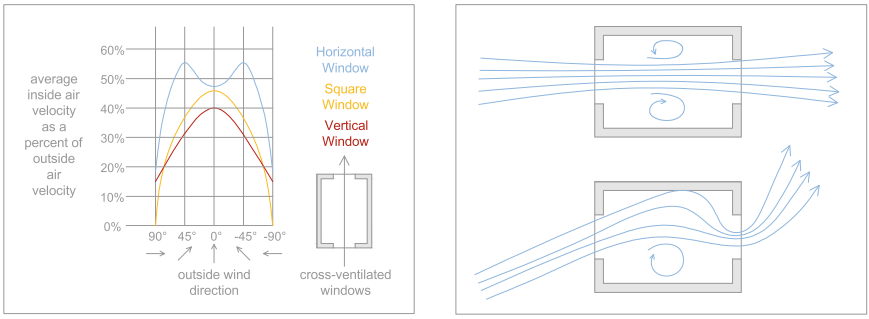


Fig. 15 **a** Impact of window shape on air velocity; **b** effect of the alignment of openings on cross ventilation. *Source* Butera et al. (2014)

wind blows obliquely, however, the ventilation involves a wider zone and a higher air movement is induced. If the wind blows parallel to the openings, there is no significant air movement in the space (Fig. 15b). Lastly, in order to have a stack effect ventilation, one-fifth of the total openings should be at ceiling level and some openings should also be placed at floor level.

All openings should be protected from solar radiation with shading devices. Shading systems can be internal and external, but the external ones are much more effective in controlling solar gains. The shading elements to be used are different, depending on the orientation of the openings: horizontal elements should be used to shade openings facing south and north, while a combination of vertical and horizontal elements should be used on the windows facing east and west.

Technical Systems

The use of active HVAC systems should be minimized to ensure affordability and reduce energy consumption, which are key priorities in the context of analysis. Therefore, only cost-effective solutions should be considered, like small-size air–water heat pumps with an integrated tank for domestic hot water preparation and ceiling fans to improve the thermal comfort, avoiding air conditioning.

Taking advantage of daylight is essential in order to reduce energy consumption and, in the meantime, to reduce internal thermal gains caused by artificial lighting. When necessary, artificial lighting systems should always adopt high-efficiency LED lamps. Rainwater, as a free source of almost pure water, should be collected from roofs during the wet season and stored inside underground concrete/PVC tanks to be reused for non-drinking purposes. A septic tank should always be provided if no district/urban wastewater treatment systems are present.

The electricity consumed by all appliances in the building should be supplied from renewable sources. The most cost-effective solution for building-level renewable energy generation is photovoltaic technology. The photovoltaic modules can be easily integrated into the roof of the building, with a sub-horizontal angle of inclination, also working as a shading layer for the roof.

3 Current Energy and Water Supply and Distribution

Somalia is engaged in the reconstruction of the state in the absence of public funds and with little institutional capacity. The federal government's ability to provide public services is limited; however, improving infrastructure is particularly important as it is the base of all social and productive activities. Among the infrastructures, it is fundamental to develop the energy sector as it contributes to improving the standard of living and the growth of productivity.

The energy sector in Somalia presents the problems of the lack of qualified personnel and the uncertainty about the future, given the several years of interruption of the educational processes; the limited access to electricity, especially in rural areas, has consequences on the quality of life as well as on productivity; in addition, the excessive use of biomass causes damage to the country's environmental resources (African Development Bank Group 2015).

Biomass

Somalia's energy needs are met between 80 and 90% with coal and firewood, as large-scale energy imports have never been possible. Coal consumption is estimated to be around 4 million tons per year, a rate that is depleting the few remaining Somali forests, further exploited due to illegal coal exports. The use of charcoal and wood for cooking also causes damage to the health, due to indoor air pollution (African Development Bank Group 2015; Coolidge and Poplack 2016). A study conducted by UN-Habitat for the European Union (UN-Habitat 2013), about the energy situation of Mogadishu, noted that biomass supply is running out near the city; therefore, the poorest use waste paper, plastic and other garbage as fuel for cooking.

Electric power

The supply of electricity for about two decades has been characterized by looting and lack of investment, which destroyed the few infrastructures that existed before the 1991 state collapse (African Development Bank Group 2015). In the late 80 s, shortly before the collapse, Somalia had installed a power generation capacity of about 175–180 MW, of which about 100 MW in Mogadishu (World Bank 1985). Major cities, such as Mogadishu, Hargeisa and Kismayo, had conventional electricity grids, while other smaller cities relied on small diesel electricity generators and mini-grids, very similar to those present today. The tariffs were low and the same nationwide (African Development Bank Group 2015).

The public supply of electricity ceased after the collapse of the state, and it was replaced by small companies providing low tension power. This is the only type of supply available, with the exception of some cities where the grids have been rebuilt or have not been destroyed. The service often does not cover 24 h/day, but it is limited to five or six hours a day. Furthermore, since the distribution is in low voltage (480/220 V) and covers long distances, the drop in tension and the losses are high (African Development Bank Group 2015).

Currently, the primary sources for providing electricity are diesel generators, with limited use of grid-connected solar photovoltaics and very limited use of grid-connected asynchronous wind turbines (The Ministry of Planning Investment and Economic Development 2020).

Electricity tariffs are the most expensive in the world, with rates ranging from 0.80 to 1.50 $/kWh. The tariffs of neighbouring Kenya and Ethiopia are much less expensive, respectively, 0.15 and 0.06 $/kWh (IRENA 2013).

Electricity tariffs vary widely across the country: consumers far from cities pay more, while tariffs within the city vary between different providers and customer types; larger customers pay less, as do public and some private institutions such as government offices, charities and hospitals (Coolidge and Poplack 2016).

Not only do Somalis pay higher tariffs for electricity, but they also have a low income. In fact, the GDP per capita in Somalia is 105 $, compared with the GDP per capita of 828 $ in Ethiopia and 1817 $ in Kenya, according to UN 2019 estimations (UNdata 2021).

Only a small percentage of the Somali population can afford the energy services provided by the grid. The World Bank (World Bank 2019) estimates that only 36% of Somalis had access to electricity in 2019. These estimates neglect a large rural–urban gap; in fact, electrification in rural areas is almost non-existent, while in urban areas, electrification varies significantly by region.

Most recent estimates for the city of Mogadishu indicate that 60% of the urban population has access to electricity. However, these estimates probably refer to areas of the city with fewer IDPs, which are more difficult to track (Coolidge and Poplack 2016).

The expansion of access to electricity is conditioned by increased efficiency and lower tariffs. This can happen by using cheaper fuels and adding larger shares of renewable energy (African Development Bank Group 2015).

The limited access to electricity can be considered the biggest constraint on the country's economic growth. Due to continuous power outages and unreliable service, many Somali businesses have been forced to reduce local production or relocate to neighbouring countries, such as Ethiopia, where there are large-scale hydropower and lower energy generation costs (Coolidge and Poplack, 2016).

Petroleum products

Petroleum products account for about 10% of Somalia's total energy consumption. The production of electricity, almost entirely fueled by diesel, represents about 20% of the consumption of petroleum products. The remaining share is represented by transport.

Petroleum products are imported and available throughout Somalia. LPG is used for cooking by the more affluent urban population, while kerosene is used for lighting by low-income urban and rural populations. Gasoline and diesel, used for transport, are of poor quality and lead to premature wear and breakdown of engines.

The prices of petroleum derivatives follow those of the world, with limited taxation by federal and regional administrations (approximately 0.04 $ per liter) (African Development Bank Group 2015).

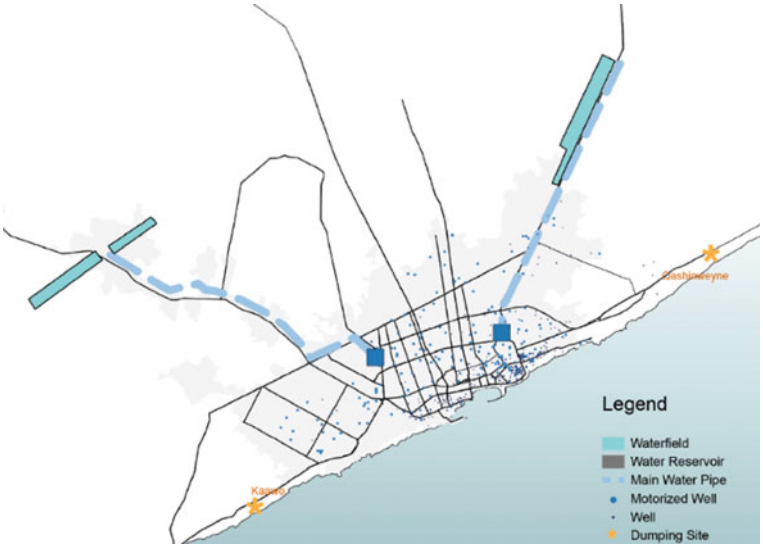


Fig. 16 Mogadishu water supply system. *Source* UN-Habitat (2016)

Water supply and distribution

Somalia is a country with water scarcity: the access to clean water is very low so it is seen as an economic and social good and it is often the cause of conflicts. In urban cities such as Mogadishu, only 35% of the population has access to safe drinking water, while in rural areas the percentage is up to 10% (African Development Bank Group 2016).

The public water supply system was built in the 1960s and it was extended in the 1980s by the state-owned Mogadishu Water Agency. Water withdrawn from two large wellfields along Afgooye and Balcad corridor (Fig. 16) was distributed to the city through a network of over 120 km (UN-Habitat 2016).

In the mid-1990s, the public water supply system collapsed and, despite the efforts by local authorities and international agencies, the system has not yet been resumed (UN-Habitat 2016). Nowadays, the city's water supply (Fig. 17) is based on shallow wells and few boreholes (UNICEF 2019).

All wells draw water from a continuous water table along the coast. Some wells reach depths of 70 m or more, but most are in open dug wells and their depth generally is not greater than 20–30 m. The water table is a few metres above sea level and the freshwater lens floats on the salty water which is denser.

The water quality is very poor; Mogadishu does not have a central wastewater evacuation network, so buildings dispose their waste through septic tanks that expose the aquifer to contamination. Due to the contamination of the groundwater, diseases are often transmitted by the water (UN-Habitat 2016).

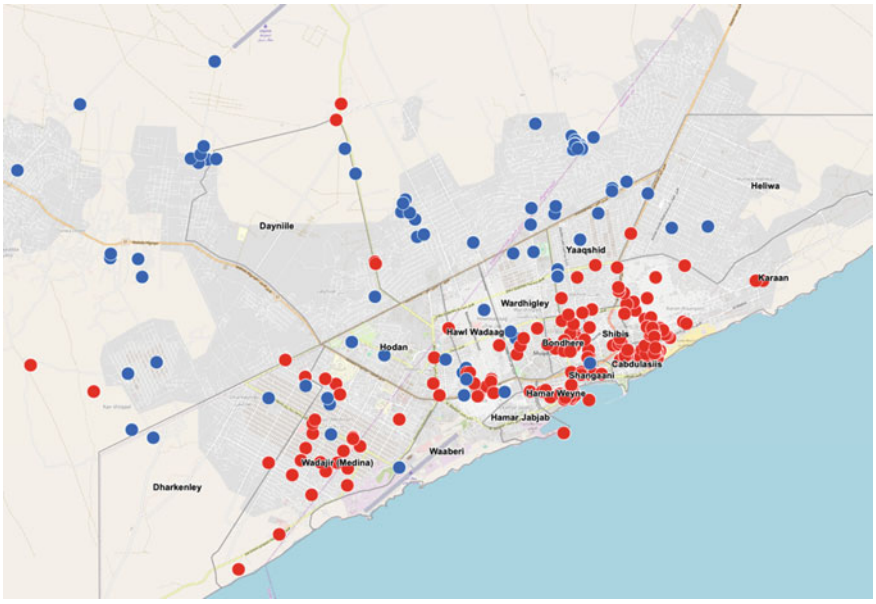


Fig. 17 Mogadishu water points map: in red shallow wells, in blue boreholes. *Source* UNICEF (2019)

4 Renewable Energy Potential Assessment

Somalia has a high potential in terms of renewable energy, in particular, there is the greatest potential among African countries for onshore wind power and one of the highest daily total solar radiation rates in the world (African Development Bank Group 2015). A World Bank document states that the potential of onshore and offshore wind power in Somalia coupled with tidal and wave power on its coasts could generate energy potential in the long term that exceeds Ethiopia's hydroelectric potential (Nuñez 2015).

In recent years, the costs of renewable energy systems have decreased; therefore, they are becoming competitive against fossil fuel solutions. According to recent estimates, autonomous renewable systems, such as PV plants, can generate power at a cost lower than 0.15 $/kWh (Walwyn and Brent 2015). This price is much lower than the cost of electricity in Somalia's cities; moreover, in remote areas where low-efficiency conventional generators have no economic advantage, renewable systems are the only viable solution.

Geothermal energy

Given Somalia's proximity to the Rift Valley, geothermal might be another renewable energy option; however, very few studies exist on geothermal potential. Available data indicate that the geothermal energy potential is too low to be exploited commercially

for energy production (REEEP 2012). One study states that Somalia has the potential of 52 MW of power from geothermal sources, but no further research has been done in the area (Nuñez 2015).

Hydropower

The hydroelectric potential of Somalia is limited: it is estimated at around 100–120 MW along the Shabelle and Juba rivers, but it is not exploited due to the lack of proper conditions (African Development Bank Group 2015). In 1985, a hydroelectric power plant of 4.8 MW was built in the country, along the Juba River, but it is not currently working (REEEP 2012). It was reported that the power generation of the plant was unreliable due to the low seasonal flows of the river; however, this information is difficult to validate. In 1989, there was an attempt to build a hydroelectric dam in Bardhere, but these efforts stopped with the outbreak of the conflict and were complicated by relations with Ethiopia, the neighbouring country (Nuñez 2015).

Solar energy

In Somalia, the solar energy potential ranges from 5–7 kWh/m^2/day with more than 310 sunny days in a year and an average of about 3,000 h of sunlight annually. These values are very high; to make a comparison, in Sicily (south of Italy), where there is one of the best solar energy areas in Europe, there are about 150 days of sunshine a year (African Development Bank Group 2015).

In the country, solar energy is used for the off-grid generation, as well as for water heating in municipal buildings. Solar cooking has also seen some diffusion. Solar power is particularly used for the rehabilitation of municipal buildings, such as health centres (REEEP 2012).

In synthesis, intense exploitation of solar potential, in particular using photovoltaic technology, could solve most of Somalia's energy problems.

Wind energy

As introduced, Somalia has the highest onshore wind power potential among African countries (African Development Bank Group 2013). The wind speed, which varies from 1.5 to 11.4 m/s, is sufficient throughout the year to support continuous wind power generators (African Development Bank Group 2015). Higher wind speeds occur in the months between June and August, while lower wind speeds generally occur from April to May (Muchiri 2007).

Some studies estimate that around 50% of the country's land area has wind speeds adequate for power generation. Moreover, near the cities of Mogadishu and Berbera, there are large areas of shallow sea along the coast making it suitable for offshore wind power, with the added advantage that this resource is close to the major load centres (REEEP 2020). Thus, wind power could efficiently flank solar energy to cover the country's energy demand.

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The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu

N. Atta, A. Dalla Valle, C. M. L. Talamo, A. Campioli, and A. Mostafavi

Abstract In order to face the widespread uncertainty characterizing the productive, financial, legislative, political and social contexts of Mogadishu, it is necessary to follow an alternative research approach for collecting reliable information concerning the manufacturing and construction fields. Despite of the lack of entrusted official information sources, the presence of informal information emerges from the dialogue with local operators of the sector. Information is oral-transmitted and mainly unstructured, thus processes of organization and validation of the data and of the related sources in necessary in order to obtain reliable knowledge. In light of this premise, the chapter provides an overview of the construction industry in Mogadishu, based on a continuous and active relationship with key categories of stakeholders of the manufacturing and construction sectors.

Keywords Manufacturing sector · Construction sector · Technological solutions · Information sources · Affordable housing · Mogadishu · Somalia

1 Information Gaps as Barriers to Reliable Analysis of the Construction Industry

The Somali socio-political context is characterized by a very fragile, uncertain and dynamic nature. Particularly, the specificity of Mogadishu involves issues of different nature, related to the difficult retrieval and collection of data, the lack of reliable and

This chapter refers to the manufacturing sector focusing of the field of building materials and elements.

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updated references and sources, as well as the uncertainty in reading the productive, financial, legislative, political and social fields (Webersik 2006; Grünewald 2012; Altai Consulting 2016; Chirisa and Matamanda 2016; IOM 2018; IIED 2019). At present, this information gap represents a significant barrier, which obliges to develop specific methodological approaches for dealing with housing in Somalia and describing the construction industry of Mogadishu by overcoming the absence of reliable information sources and consolidated interpretative tools.

In this context, the lack of up-to-date urban legislation, proper land policies and legal and regulatory frameworks well illustrates the complexity of developing the building environment, today undermined especially by housing demand from rapid urbanization and diaspora movement. The majority of the legislative framework regarding the construction sector is dated back to the pre-war period or even back to the Italian Rule, leaving many grey zones and real legislative voids (MPIC 2016). Only in the last few years, steps forward have been made, for instance by launching the first Somalia National Development Plan (Mogadishu Municipality 2020), to start filling the urgent need to coordinate, control and guide the urban sprawl in the interest of the whole urban society. However, although this plan is intended to establish a solid basis for future plans, define opportunities and vision and address the priorities in terms of economic recovery, security, humanitarian assistance and durable solutions, major efforts still need to be made.

To date, the absence of a well-established urban regulatory framework has led Mogadishu to follow chaotic and unplanned development for addressing the return of internally displaced persons and a significant diaspora population. The situation is even more aggravated by the lack of a clear legal framework on land access and ownership, resulting as a major driver of conflict. Indeed, disputes over land rights and tenure are widely increasing due to formal and informal governance (CAHF 2018), since in Somalia land is regulated by a mixed system of traditional communally owned (administered by clan structure) and privately owned. For these reasons, local people usually buy and sell lands going behind the formal system, bringing up unregistered lands in which ownership cannot be proven (CAHF 2018).

Regarding the technological and productive aspects, the difficulties in the collection of updated, reliable, consistent data, information and documents and the lack of consolidated sources and references imply great efforts for providing an overview of the construction industry in Mogadishu, calling for the necessity to engage key stakeholders of the building process.

It is worth mentioning the adjustments demanded from the methodological point of view for facing the specificity of the application context and the lack of consolidated sources. A hybrid method between formal and informal sources is used to gain information on the manufacturing and construction sectors in Mogadishu. Formal sources are constituted in some regularized, legal, representative manner, including official documents, reports and papers; whereas informal sources have no such basis, depending on personal contact and communications. In addition, it is important to highlight that formal sources are often also impersonal as a sample of groups or wide

audiences; while informal sources are likewise personal as an expression of individual or specific parties. In this way, the adopted methodological approach is based on the mutual comparison and finding of formal-impersonal and informal-personal sources. The major methodological steps are the following:

- retrieval of formal information on construction industry, focusing on Somalia and Mogadishu but in the absence of information enlarging the surveyed area to East Africa;
- in-depth analysis of the retrieved formal information through the comparison of data between different sources;
- identification of inconsistencies;
- engagement of the panel of key stakeholders (including local institutions and industry operators) for filling information gaps and data inconsistency;
- collection of informal information through questionnaire surveys, brainstorming sessions, interviews and e-mail correspondence;
- joint integration and comparison of formal and informal information;
- selection of privileged observer (local construction company) for deepening the way of practice and the construction supply chain.

The process is not intended in a linear manner but as iterative, aiming at collecting and providing information to the greatest extent possible concerning current features and trends of manufacturing and construction sectors in Somalia and, more in detail, in Mogadishu. Informal information becomes structured information when collected, validated and organized according to a well-defined investigation approach based on a continuous clash between formal and informal information. The discrepancies between formal information (documents) and informal information (oral-transmitted) point to the difficulties and challenges of providing reliable insight of the manufacturing and construction sectors. These inconsistencies give rise to the need for constant periodic reviews and validations of the trustability of information and data through an ongoing dialogue with the local key stakeholders.

The following four macro-categories of operators working in the Mogadishu context were involved as sources of informal information:

- institutional stakeholders and NGOs: policymakers, national and local authorities (Government, Municipality of Mogadishu, etc.), NGOs;
- private/public investors and donors;
- private stakeholders of the AEC sector: local and international construction and manufacturing firms, SMEs, medium/small social cooperatives, developers; local and international architects, engineers, builders, etc.;
- citizens: displaced people from Mogadishu, middle and lower classes, workers looking for new opportunities.

2 Manufacturing Sector: The Predominance of Imported Building Materials and Products

From the analysis of available data on the manufacturing sector of Mogadishu (CAHF 2018; UN-Habitat 2016; IIED 2019), it is possible to focus the attention on two main issues: on the one hand, the geographical origin of materials, components and products and, on the other hand, their quality and variety.

For what concerns the geographical origin of materials, in Mogadishu there is an increasing supply of imported building materials from foreign countries, mainly China, Turkey, the UAE and India. This phenomenon is limiting till now the possible growth of local manufacturing production and related economies (Trade Map a-b, accessed in 2021a, b). Indeed, most construction materials—including cement, concrete, steel, wood and ceramic—are currently imported from foreign countries through consolidated international trade routes (Trade Map a-b, accessed in 2021a, b). This claim is confirmed by both the Observatory of Economic Complexity data and International Trade Centre data, estimating in Somalia a significant import share of construction materials, such as metal (about 110 M$) and cement (about 30 M$) (OEC, accessed in 2021; ITC 2014). In particular, metal is primarily imported from China, India and the UAE, while concrete and cement are imported mainly from Oman, Iran and the UAE (OEC, accessed in 2021; ITC 2014). Moreover, ceramics and wood are imported mainly from China and the Middle East (OEC, accessed in 2021; ITC 2014).

Nevertheless, the crucial matter is that in Mogadishu, as in many other African contexts, the import is not limited to the principal building materials but also to the market of finishing, including products such as tiles, windows, doors, plumbing and sanitary. From the dialogue with key stakeholders—involving public authorities and AEC (Architectural, Engineering and Construction) practitioners—even the finishing market appears to be covered by international trades without any significant evidence of local production. Accordingly, the traditional manufacturing plants of building products and components shift into warehouses, since they do not serve as production facilities but rather as storage facilities. Notably, in Mogadishu specialized warehouses are available for timber, cement, iron, piping, hydraulic and electrical systems. All these materials and products are shipped in containers from foreign countries, especially China and Turkey. Thereafter, such cargo arriving by sea is transferred onto trucks for the delivery to the different warehouses. In this way, logistic chains turn out to be the cornerstone for the supply of construction materials and components, giving particular relevance to finishing since they usually highly affect the final price of buildings in Mogadishu and, more in general, in Somalia.

Moreover, regardless of their geographical origin, it is evidenced how most of the imported building materials, products and components offer a very limited variety of choice and poor quality in favour of an easy supply chain and, above all, very low and competitive costs which encourage their widespread use (Atta et al. 2021). According to the surveyed local practitioners, a representative example is the typical envelope solution consisting of Concrete Masonry Unit (CMU) and conventionally used in Mogadishu for different building types (residential but also for service and

commercial purposes). CMU stands for the most common type of wall, carried out through the use of massive technological solutions and labour-intensive activities. On the material level, as it happens for framed structures, concrete for CMU is produced by mixing the cement imported from foreign countries with the aggregates comprised of gravel and sand. The latter are locally sourced, especially from the North and South seaside of Mogadishu, but often prove difficulties in the quality control (e.g. salt content, colour and performance). As regards the production of concrete hollow blocks, the construction sector of Mogadishu still shows a considerable presence of crafting techniques, whilst the industrial manufacturing of concrete blocks is recognized in the surrounding regions of East Africa. However, especially for small-scale projects, it is more convenient to produce blocks on-site rather than supply them from other African countries, due to the low coverage of infrastructure. The same applies to the cement supply chain, where often the procurement from foreign countries turns out to be more suitable than, for instance, from West Africa manufacturing plants.

A sample of the local production process of concrete blocks is reported in Fig. 1 that shows the main procedural steps usually performed by Holac Construction Company, a partnered stakeholder representative of a local construction company and thus taken as a privileged observer for providing insight of the way of practice. From the images, it is possible to see how CMU is mainly produced manually using compressing machine. Typically, cement is mixed with coarse sand and gravel with a ratio of 1:2:3, respectively, for the casting part (Rometa, accessed in 2021). Brick casts are fully filled by the on-site created concrete mix and compressed using the machine, producing CMU with standard dimensions of 40 cm length, 30 cm height and 20 cm thickness. After the compression, pieces of flat wood are placed under the concrete blocks as a support, allowing the operators to transport and set them down under the sun, in order to dry out the blocks for at least 2 days. It is implied that the resistance of blocks depends on the mix composition and curing time. Note that the above-reported data and information on manual production of CMU have been firstly provided by Holac Construction Company and thereafter confirmed by other local companies active in Mogadishu.

In this context, it is possible to outline two main emerging needs, further discussed in the following paragraphs. First of all, the promotion of local production of building products and components together with the identification of key drivers for investments in local manufacturing. Indeed, by the exploration of the construction market, it emerges an on-going rising trend in the import of building materials, components and products that disadvantages local realities, their economies and the related possibilities for development, recovery and growth. In this regard, besides the case of concrete, that is crucial since widespread adopted in building construction, the case of wood is emblematic. Despite being locally available, in fact wood is not used as a construction material but for the production of coal, not exploiting the great potential for construction applications. The second emerging need is the increase of awareness on building quality and sustainability among local stakeholders (see Chap. 7), going beyond the mere economic issue to include also environmental and social issues and thus demanding a triple-bottom-line approach in both manufacturing and construction fields.

Concrete mix is poured into the brick cast.

Concrete is manually compressed using compressing machine.

Concrete blocks are transported over the pieces of flat wood.

Concrete blocks are exposed to sun.

Fig. 1 Concrete Masonry Unit (CMU)—Steps of concrete hollow brick production process. *Source* Holac Construction Company

3 Construction Sector: A Mixed Reality Among Different Size Construction Companies

As regards the construction sector, the investigation of the current supply market, supported by the dialogue with local stakeholders, highlights the presence of more than 20 construction firms now active on Somali territory. In particular, by surveying the construction firms operating in Mogadishu, it is possible to recognize three main typologies that considerably differ in terms of the number of employees, average annual turnover, geographic market area, level of automation of construction

procedures and the partnership relations with foreign companies. The construction companies are appointed as follows:

- local small-size firms;
- local medium-size firms;
- international medium-size firms, meaning construction companies based on partnership between Somalia and a reference foreign country.

In order to better detail the different typologies of construction companies, a description of local small-size firms, local medium-size firms and international medium-size firms is below provided, highlighting related features, including internal organizations, primary markets, adopted construction machinery, tools, etc.

Small-size companies usually have a fixed rate of employees that ranges from 3 to 15 people and a variable number of additional workers, depending on the project scale, the complexity of construction and thus the skills and expertise demanded to the workforce. They deal with the local construction market projects, involving new buildings, additions and renovations and including various functions, such as residential, commercial and industrial projects. They generally operate at a small-scale, ranging from the building unit (e.g. apartment in the case of housing or shop in the case of commercial spaces) to the entire building. Small-size companies include internal accountants, engineers and designers and a variable number of external collaborators with different competencies according to the typology and specificity of the work activities. This kind of company usually employs self-performing on-site foundations, masonry, carpentry, metal studs, drywalls and suspended ceilings. For what concerns the construction materials, small-size companies commonly utilize imported construction materials (e.g. cement, wood, iron and paint) and products (e.g. pipes, electric cables, windows and sanitary), primarily supplied from India and China. During construction, they are accustomed to adopting manual techniques for building material production.

For what concerns local medium-size firms, they usually count about 20–25 employees, including engineers, architects and specialized workers, allowing them to combine in-house different skills, methods and techniques. Moreover, it is possible to observe that they offer not only construction works but also real estate consultancies and project management activities. Hence, they are able to cover the whole building process, including detailed planning, programming and monitoring of construction projects on a long-term basis. The primary market of local medium-size companies ranges from residential, commercial, education, hospitals and warehouses, up to landscape constructions, business malls and complex buildings, dealing as appropriate with single buildings but also district areas. Regarding construction procedures and methods, this type of company utilizes both ready-to-use materials and products imported to Somalia from abroad and on-site production materials for basic building components (e.g. concrete blocks and load-bearing structures). However, contrary to small-size firms, here the on-site production is performed using semi-automated construction machinery (even equipment is imported), including bulldozers, excavators and telehandlers.

Lastly, international medium-size firms are relevant not so much because of the high number of employees but for the fact that workers pertain to different nations, since consisting of partnerships between Somalia and reference foreign countries. The key factor is that these partnerships are based on long-term relationships, contrary to joint ventures that are temporary relationships between two or more parties in the pursuit of completing single projects. Here, the collaboration and cooperation are ongoing, based, one the one hand, on foreign assets, management and headquarters and, on the other, on the local workforce. In addition, it is important to highlight that while the operative office is located in Mogadishu, both construction materials and machinery are entirely imported from the reference foreign country, being available in the most varied types and with a higher level of automation. This results in increased customization options and especially improved efficiency, ensuring at the same time high-quality standards. It follows that international medium-size firms are capable of constructing and handling all types of projects, from small private buildings to large government-based urban settlements. From the organizational point of view, the strategic issue is the joining of different companies intended for the most varied purposes, ranging from manufacturing and construction to design and consultancy but also real estate investments. In particular, the main covered functions are described in Table 1.

4 Current Technological Solutions and Processes Adopted in Mogadishu

Based on the analysis of manufacturing and construction sectors (Sects. 2 and 3) and the examination of a sample of case studies on recent residential settlements in Mogadishu, the widespread use of very simple construction technologies is emphasized. The basic solutions, described in Table 2, consist mainly of concrete structures for columns/beams, traditional concrete hollow blocks for walls and wood frames with metal sheets for roofs. As anticipated, in particular, the most adopted construction technology is Concrete Masonry Unit (CMU), namely a standard-size rectangular concrete hollow block, widely adopted since made of basic materials, easy to make, not demanding in terms of skills level and very versatile for defining different shapes and volumes (NCMA, accessed in 2021). Blocks are made of cast concrete, consisting of a mix of Portland cement and aggregates, like fine gravel and sand. In line with the complexity of building projects and the machinery of construction companies, they are generally produced on-site by adopting manual or semi-automatic techniques and only occasionally off-site, by using industrially manufactured blocks. During construction, the envelope is erected with layers of staggered concrete blocks, commonly manufactured with hollow cores for reducing weight and improving insulation. In addition, for maximizing the structural performance, hollow cores are grouted with rebars, placing steel reinforcement bars both vertically and horizontally inside CMU walls (Maurenbrecher 1986). Finally, concrete

Table 1 Main functions covered by international medium-size companies operating in Mogadishu

Main functions	Description
Architectural and Engineering	Offering of design services to companies, individual clients and collaborators within Somali territory and all over East Africa. The support services include the design of structures, architectural works, mechanical and electrical systems, outdoor spaces, etc. defined according to the specific needs of the client
Consultancy	Offering of consultancy services mainly dealing with project management, including feasibility studies, support for preliminary and final design, choice of suppliers, coordination of workers and subcontractors, etc. The building is, therefore, analysed according to a long-term perspective, from the conception of the idea to the delivery of the finished work and along the building service life
Import	Offering of a wide range of activities related to the import of resources from the reference foreign country. Firstly, the management of relationships, orders and agreements with the reference foreign country. Secondly, the delivery of imported materials, semi-finished components, products and construction machinery. Lastly, the task of coordinating communication and collaboration among the various specialized companies (e.g. for production, assembly and logistics) according to the specific needs of the pursued technological and constructive solutions
Production	Offering of a wide variety of products, fabricated in different manufacturing plants. In particular, the Somali sites usually refer to automized plants for concrete production and mass machinery for the manufacturing of concrete bricks
Assembly	Offering of assembly operations to process the available sources (imported or local), including materials and semi-finished elements. The latter encompasses chipboard, glass, aluminium profiles, wood frames, etc. for assembling furniture, doors, windows and other building products. Finished goods are supplied according to the planned construction activities
Logistics and storage	Offering of stocks and transports from the reference foreign country to Mogadishu site and, as appropriate, within the internal companies. The aim is to provide storage, acting as a wholesaler and retailer with the purpose of providing basic construction products, in order to solve the wide range of materials and logistics problems generally experienced

Source Elaboration of the authors

masonry walls are built as appropriate un-grouted, partially grouted or fully grouted for enhancing their structural strength.

Current construction technologies adopted in Mogadishu are deepened in Table 2, as depicted by the privileged observer of Holac Construction Company and confirmed by a pool of stakeholders and other local construction firms. In particular, they represent the standard solutions implemented for the construction of a residential two-storey building. Nevertheless, except roof construction, they can be extended also to multi-storey buildings intended for different end-use (e.g. residential, commercial and educational), by varying in the size of construction elements but not in terms of constructive solutions.

Focusing on the building construction process, some peculiarities emerge according to the practices of the different construction companies. In fact, the building

Table 2 Current construction technologies articulated according to building sub-systems

System	Sub-system	Description
Sub-structure	Foundations	Grade beams with concrete (M25 grade) and steel bars (9 mm diameter). Wooden formwork (25 mm thick). Plinth with concrete (M25 grade) and steel bars (9 mm diam.). Wooden formwork (25 mm thick)
Shell	Slabs-on-Grade	Concrete slab with concrete (M25 grade) and steel bars (9 mm diam.). Wooden formwork (25 mm thick). Finishing in ceramic tile flooring
	Non-structural exterior walls	Pillars in structural concrete (with steel bars of 9 mm diam.) and non-structural walls in concrete hollow blocks (400L × 300H × 200T). Finishing in painting over a plaster of sand and cement
	Structural exterior walls	Structural concrete hollow blocks (400L × 300H × 200T) reinforced with steel bars (9 mm diam.). Finishing in painting over a plaster of sand and cement
	Exterior windows	PVC profiles with single glass
		Aluminium profiles with single glass
	Exterior doors	Aluminium-framed entrances
	Roof construction	Wood structure and aluminium corrugated sheet
Interiors	Floor construction	Concrete slab with concrete (M25 grade) and steel bars (9 mm diam.). Wooden formwork (25 mm thick). Finishing in ceramic tile flooring
	Interior partitions	Walls in concrete hollow blocks (400L × 300H × 200T). Finishing in painting over a plaster of sand and cement
	Interior doors	Hardwood timber (220L × 100H)
	Stairs	Stair structure with concrete (M25 grade) and steel bars (9 mm diam.). Wooden formwork (25 mm thick). Finishing in painting over a plaster of sand and cement

Source Atta et al. (2021)

process tends to vary with respect to the specificities of the construction companies, for instance in relation to the adopted tools, the employed workforce and the sequential order of the construction procedural steps. To delve more deeply into the construction way of practice established in Mogadishu, Table 3 describes the typical work steps performed by a local small-size construction firm. Indeed, the depicted process refers to the activity of Holac Construction Company taken as a privileged observer of the application context. Note that the work steps refer to a low-rise building and they are evidenced by a set of supporting materials, such as drawings, images, technical data and bills of quantities.

Along with qualitative and quantitative data and information obtained through informal methods, the iconographic apparatus provided by Holac Construction Company (Fig. 2) is particularly helpful for a twofold purpose. On one side, it allows to clearly report the various operations put in practice for the construction process

Table 3 Steps of construction process for low-rise buildings

Macro-phases	Detailed procedural steps of Holac Construction Company
Excavations and soil reinforcement as a basis for foundations	(1) Excavations are carried out for foundations, digging (about 60 cm wide and 30 cm deep) and collecting scraps (2) Soil is placed as fill material in order to obtain adequate compaction (no less than 95% of density) (3) Concrete (M25 grade) is put and cured for providing the base of foundation beams and pillars (4) Concrete is levelled using rake to fill area
Foundation beams construction	(5) Wooden formwork (25 mm thick) is installed for foundation beam (6) Vertical high strength steel bars are installed with steel closed stirrups (7) Concrete (M25 grade) is placed and cured for foundation beam (8) Concrete hollow blocks are installed (1:3 mix cement-sand and 200 mm (9) thick) (10) Multiple layers of concrete hollow blocks are placed for foundation beam (11) Wooden formwork (25 mm thick) is installed for bond beam works (12) Bond beams are constructed at floor level (13) Concrete (M25 grade) is placed for bond beam at floor level (14) Concrete (M25 grade) is cured for bond beam at floor level (15) Wooden formworks are removed and soil is flattened
Floor slab construction and testing	(16) Soil is levelled with mechanical soil compactors (17) Waterproof membranes are laid down for covering the soil (18) Infill materials are placed in order to obtain adequate compaction and levelling (19) Horizontal high strength steel bars are installed with spacer blocks (20) Horizontal high strength steel bars are cross installed (21) Concrete control tests are performed (22) Concrete mixer with reduced capacity is used (allowing the use of a single 50 kg cement bag at once) (23) Cement is mixed with aggregates and water for providing concrete (24) Concrete is gradually placed on floor slab (25) Concrete is finished for floor slab (26) Hollow concrete blocks are prepared for the construction of walls (27) Wall lines are traced on the floor
Vertical walls construction and finishing	(28) Hollow concrete blocks are placed in alignment with wall line traces (29) Walls are built with hollow concrete blocks and cement mortar (30) Workers spread cement mortar with steel trowels (31) Hollow concrete blocks are layered with steel reinforcement bars (32) Cement mortar is applied as interior wall plastering (1:3 mix cement-sand and 10 mm thick) (33) Interior wall plastering is levelled with a linear metal profile (34) Plastering is completed for all building walls
Roof structure and finishing	(35) Wooden truss is installed for roof construction (36) Wooden trusses are gradually installed (37) Wooden trusses are completed for the whole roof area (38) Galvanized corrugated iron sheets are placed as roof finishing (39) Ridge is placed over galvanized corrugated iron sheets at roof level

(continued)

Table 3 (continued)

Macro-phases	Detailed procedural steps of Holac Construction Company
External finishing and furniture	(40) White plaster is applied both on the exterior and interior walls (41) Sliding metal windows are prepared for installation (42) Single glass metal windows are installed (43) Hardwood doors are installed (44) Ceramic tiles are installed as floor finishing

Source Holac Construction Company

of a simple residential building in Mogadishu. On the other, it enables to grasp the working environment and to outline not only the used building materials but also the adopted construction techniques, machinery, tools and safety conditions. In particular, the images give evidence of how construction is still marked by the traditional nature of the sector: performed on-site and manually by local workers with basic skills.

Certainly, this reality is strictly connected to the low complexity of construction works but representative of the most common small-scale interventions pursued within the application context. Indeed, to date the traditional construction techniques turn out to be more industrialized only in large-scale projects by taking advantage of the economy of scale. The issue is that in Mogadishu new urban settlements are limited and generally intended to meet high-level targets (e.g. Daarul Salaam City, Safaari Village, Jazeera Estate), not aiming at affordable housing.

It is important to stress how in this context distinguished by a general lack of information, the identification and support of local partner—in this case represented by a construction company—have played a crucial role for understanding and depicting the construction practice of Mogadishu. Indeed, although offering fragments of reality, the specific point of view conceived as a privileged observer allows increasing shared knowledge and know-how. For this reason, wherever possible, technical details have been specified to give an insight into the size of the technological solutions. Moreover, jointly with the iconographic apparatus, the effort is to enrich the information on the construction industry in Mogadishu, actually not documented and tracked even by official institutions and generally resulting in being very poor, often outdated and not validated. Only thanks to the direct dialogue with the key stakeholders active in the sector as well as with the local privileged observer, it was possible to give an outline of current practices.

In particular, the matching between formal-impersonal and informal-personal sources has confirmed that the economic aspect turns out to be the key driver for the selection of a low-cost constructive solution, often resulting in poor quality and not appropriate to the local climate.

In this context, it is possible to highlight two main issues characterizing the present construction sector. Firstly, the lack of awareness and sensitiveness about high-performance technologies. Although common practices are devoted to the easiest and cheapest solutions without considering performance and sustainability issues, the surveyed panel of stakeholders expresses an increasing need for a wider range

Concrete is placed and cured for foundation beam.

Layers of concrete blocks are placed for foundation beam construction.

Wooden formwork are installed for bond beam works.

Waterproof membranes are lay down for covering the soil.

Concrete is gradually placed for floor slab.

Walls are built with hollow concrete blocks and cement mortar.

Fig. 2 Images of the main work actions of the construction process of a one-storey residential building in Mogadishu. *Source* Holac Construction Company

of construction technologies in order to provide better comfort to users as well as to improve construction sustainability and increase local production capacity. Secondly, there is a proven complexity in mapping the production and supply chains both at local and international levels (e.g. considering existing business relationships for import construction goods), due to the difficulty in finding updated, reliable and

Cement mortar is applied as interior wall plastering.

Wooden truss is installed for roof construction.

Galvanized corrugated iron sheets are placed as roof finishing.

White plaster is applied both on exterior and interior walls.

Single glass metal windows are installed.

Ceramic tiles are installed as floor finishing.

Fig. 2 (continued)

shared data on the application context. This leads to the need for supporting information tools aiming at enhancing the knowledge and know-how of construction practitioners for finding more appropriate and sustainable organizational models and construction processes. In this perspective, the connection with a multitude of privileged observers widespread on the territory turns out pivotal for moving the manufacturing and construction sector of Mogadishu and more generally Somalia and East Africa towards innovative and sustainable practices.

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Proposals for Sustainable and Affordable Housing in Mogadishu

Settlement Strategy Towards New Business Ecosystems

S. Guidarini, C. Magni, and G. Miglierina

Abstract This chapter introduces the concept of modular settlements for new business ecosystems, based on a set of incremental housing typologies to meet the high rate of low-medium income population housing demand. The limitation caused by circumstances around the project didn't allow the implementation of the proposal in a specific area. Therefore, the housing model planned is based on a theoretical scenario. The study of the city, of its tissue and elements provided the instruments to propose a solution that began by the dimension of its urban block. All the proposed typologies result from an optimization process to ensure good internal comfort.

Keywords Settlement · Sustainability · Project strategies · Urban block · Typologies · Mogadishu · Somalia · African countries

1 Definition of the Key Features of the Settlement

The objective of the project is to shape a healthy and dynamic environment so that the new planned neighbourhood can become a valuable space where development and progress can be achieved. Starting from this paradigm, the research aims to create an inclusive urban development, to achieve sustainable and durable solutions in the long term. To do so, the study outlines the current dynamics shaping the outskirts of Mogadishu, contextualizing the project as much as possible and finding achievable and appropriate solutions.

Designing a well-planned sustainable settlement means allowing the urban and architectural proposal to create the most congruous framework, so that it can produce a space that encourages social connectivity and cohesion, and a place that feels appropriate for the needs of its inhabitants. When working on "affordable housing",

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it is imperative to consider the quantity, as much as the quality of space that is being produced. This means providing a safe and proper space to live, as well as a place to improve economic conditions and social development. This needs to be integrated into a complex system that guarantees access to jobs, education and health services.

The adopted solution, consequently, elaborates on these concepts by designing appropriate and affordable housing, balancing ecological, economic, social and morphological aspects, as to create a sustainable environment. The sustainability components (UN 2012) (Oikonomou 2015) guided the process of formulating specific principles used as a reference during the planning and design stages. Some of the assumptions derived from good practice experiences, while others were a direct answer to the assessment of the local context.

1. Increase density, while maintaining a low building height, to keep structure costs down and not jeopardize the appropriation of the ground floor.
2. Optimize the use of the ground floor to activate family-run businesses, shops, and microenterprises to stimulate a new micro-local economy.
3. Create a network of public spaces and facilities to answer basic need (such as education or health), but also to allow cultural and leisure activities.
4. Create different types of open areas to build a hierarchical network of private and semi-public/semi-private spaces (such as patios, terraces and rooftops).
5. Differentiate the housing offered to include a variety of income families.
6. Offer incremental housing solutions that can accommodate different needs and resources over the years.
7. Hierarchize the use of the streets by differentiating main roads and secondary streets.
8. Promote a pedestrian culture by offering basic services at a walkable distance.
9. Create and differentiate the use of spaces, both private and public, considering cultural and traditional factors.
10. Provide sufficient green areas, both public and private. Plant vegetation along the streets and open areas to protect from heat islands and naturally improve the microclimate.

Premise to the settlement overview

The limitation caused by circumstances around the project didn't allow the implementation of the proposal in a specific area. Therefore, the housing model planned is based on a theoretical scenario, where the main design concept aims to be replicated and implemented in different locations. Following this logic, although the proposal that is synthesized in this chapter foresees the construction of a new settlement, the typologies designed may be realized as part of a different program. As an example, they could be built in the voids left by the ongoing urbanization of the city, to complete a fringe of the suburbs. In this case, this approach could be used as an instrument to create a more compact scenario, suggested as a more virtuous growth of the city.

This means that the project can also be implemented by different stakeholders, at different moments and periods of time, depending on the total volume to be constructed. If a new settlement could be implemented by a developer in partnership with the Government (as in the case here), one single typology could be completed by a small building company, a cooperative or even a single-family (Fig. 1).

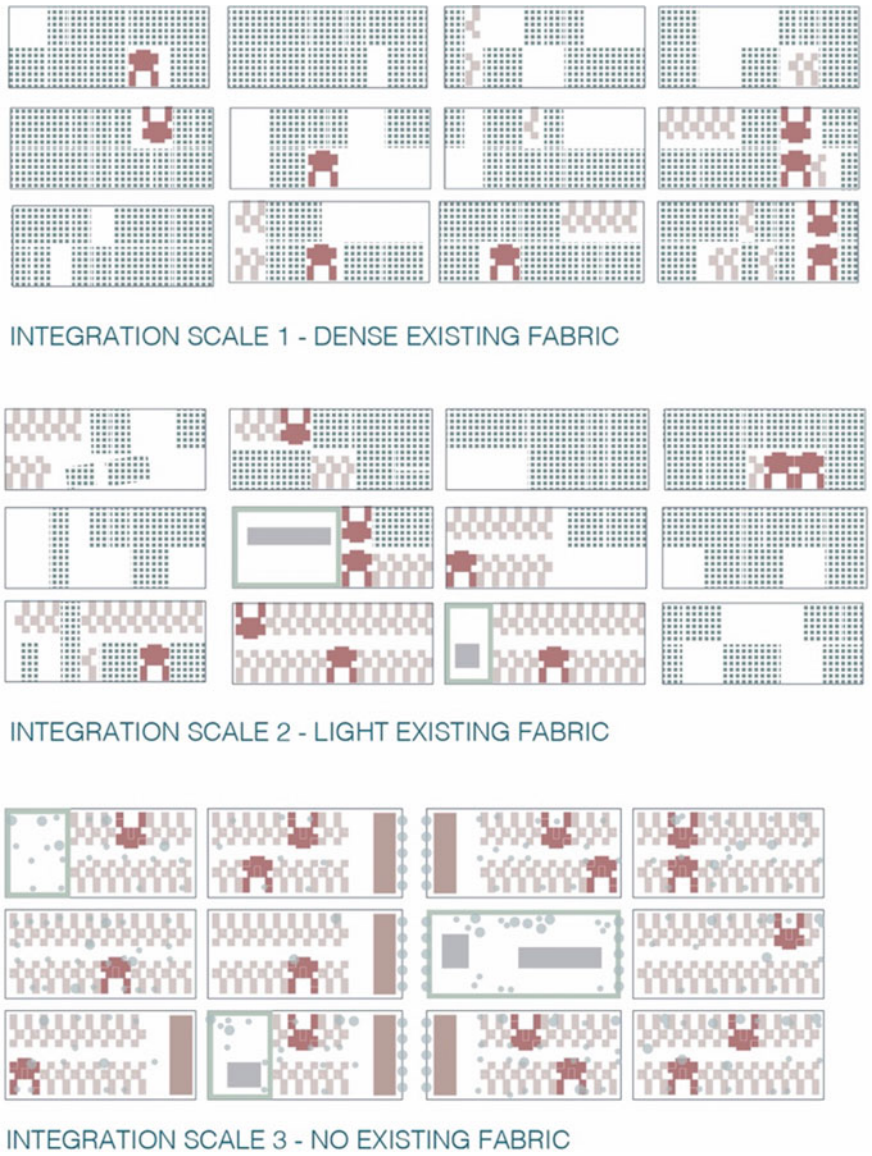

Fig. 1 Project integration strategy. *Source* elaboration of the authors

2 Settlement Strategies

The starting point for the design process was understanding the appropriate density of the settlement. Finding the right balance between built and unbuilt spaces, between the overall dimension of the settlement and the number of inhabitants, was essential to ensure the best possible liveability, for physical and mental wellbeing. Secondly, the observation of Mogadishu's strong grid, as remarked in the urban analysis, suggested to approach the problem by working within the ongoing dynamics of the urbanization of the capital, rather than opposing them. The study of the city, of its tissue and elements provided the instruments to propose a solution that began by the dimension of its urban block.

The grid's dimension around the city, as stated previously, is 90/100 m by 40 m, divided by streets of approximately 10 m in width (Fig. 2). We fixed the urban block dimension at 90 m in length, which coincidentally could be subdivided into an equal number of plots. The second step was finding a plot dimension that would provide a good balance between the number of properties that made up the block and the desirable density.

Figure 3 shows the follow-up of the urban block assessment. The most common dimension for a single plot (A, B, C) was considered to compare the population density they generate. However, neither of the three cases considered had a relative density that could be appropriated for the results that the project aims to achieve. A smaller plot was therefore defined by reducing the width whilst keeping the depth of 20 m. The result is an urban block (90 × 40 m) with 24 plots of 7.5 × 20 m, a compromise able to increase the relative density by approximately 50% of a common block.

Another critical point of the design was avoiding the creation of an all-residential neighbourhood. This is done by diversifying the functional and typological proposals, to create an environment that could be lived and used throughout the day. To achieve this and to favour processes of circular economy in the area, each unit has the possibility of dedicating a portion of the ground floor for generating an income, be it a shop or a small production place. The use of the ground floor linked to the public

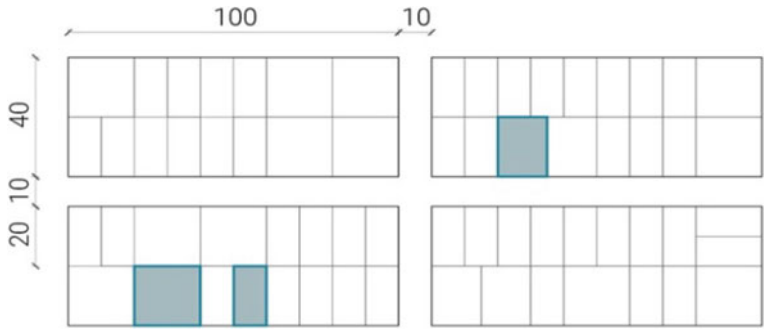

Fig. 2 Scheme of a common urban block in Mogadishu. *Source* elaboration of the authors

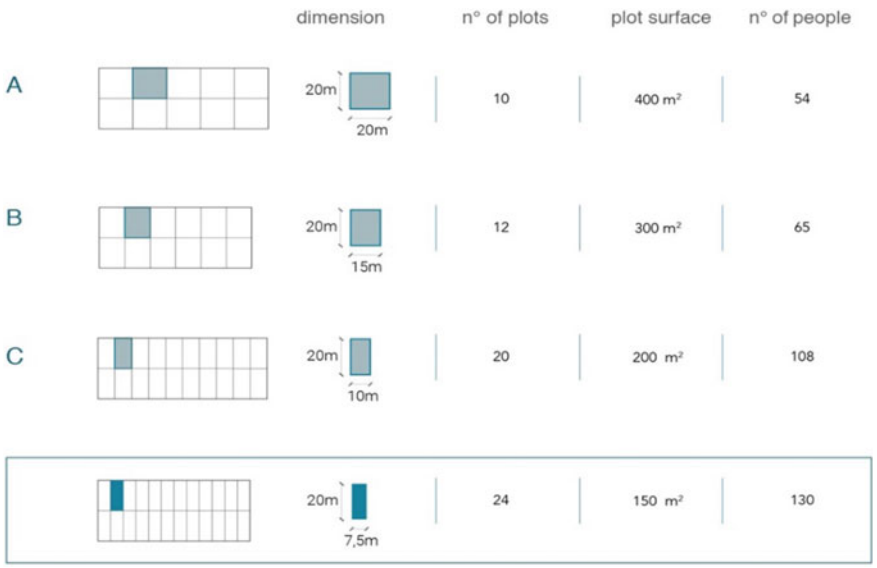

Fig. 3 Configuration variations of an urban block division comparing densities. *Source* elaboration of the authors

will also have consequences on the use of the street and the public space, producing liveable and multifunctional streetscapes and increasing the area's general security. The settlement also dedicates specific areas for public use and new public buildings to offer primary services for the new residents and for the nearby population. This action intends to integrate the newborn neighbourhood with the local community who already lives in the area, responding to the lack of access to essential services, which characterizes many new suburban areas. The total number of community assets is calculated using the presumed number of new residents.

The proposed masterplan, which shows only one of the possible scenarios, hosts 336 new units for an estimated population of around 2218 inhabitants, over a span of approximately 6.3 hectares. It proposes twelve new urban blocks developed around the main road, along which the more prominent buildings are located. In addition to the main public buildings, these architectures form the heart of the neighbourhood, located in a central position easily accessible for the entire community. In this point the main common assets of the new settlement are found, such as a primary school and a multi-purpose centre with a market and first aid point. This new community space aims to create an active area, for social gatherings, leisure activities and new economic opportunities. A third public building and green area are located out from the main road to create a stronger linkage with the local community who can also benefit from these spaces.

The position of the main road defines a more demanding and hectic area, whilst bringing structure and hierarchy to the proposal. Along the main street (which has a width of 12 m and broad sidewalks) are positioned multi-storey residential buildings

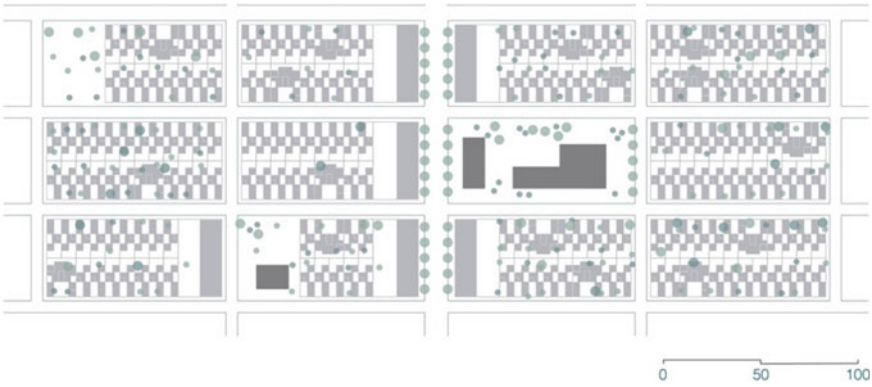

Fig. 4 Project masterplan. *Source* elaboration of the authors

with a commercial ground floor. These four-storey buildings, on both sides of the streets, form the "head" of the new urban blocks. Along the perpendicular secondary streets of 8 m, are, instead, two different building typologies of single houses and small condominiums (Fig. 4). Out of the total amount of 336 units, 96 are apartments inside multi-storey buildings or small condominiums, while the remaining 240 are houses built on a single plot. 18′000 sqm of green open areas at different scales dominate the masterplan. Out of the total, 14′900 sqm are private green areas distributed proportionally among the different typologies (Fig. 5).

The settlement develops around three typologies to fit the different needs and possibilities of the final users. These typologies grow from a common ground of general principles and evolve depending on the specific target. Typology 1 works around the single house concept, responding to the needs of a growing and evolving household. Typology 2 is a multi-storey apartment building, in which units have limited growing potential compared to the first, but adaptability and flexibility are nonetheless key elements. The third one arises as a middle ground solution between the first two typologies.

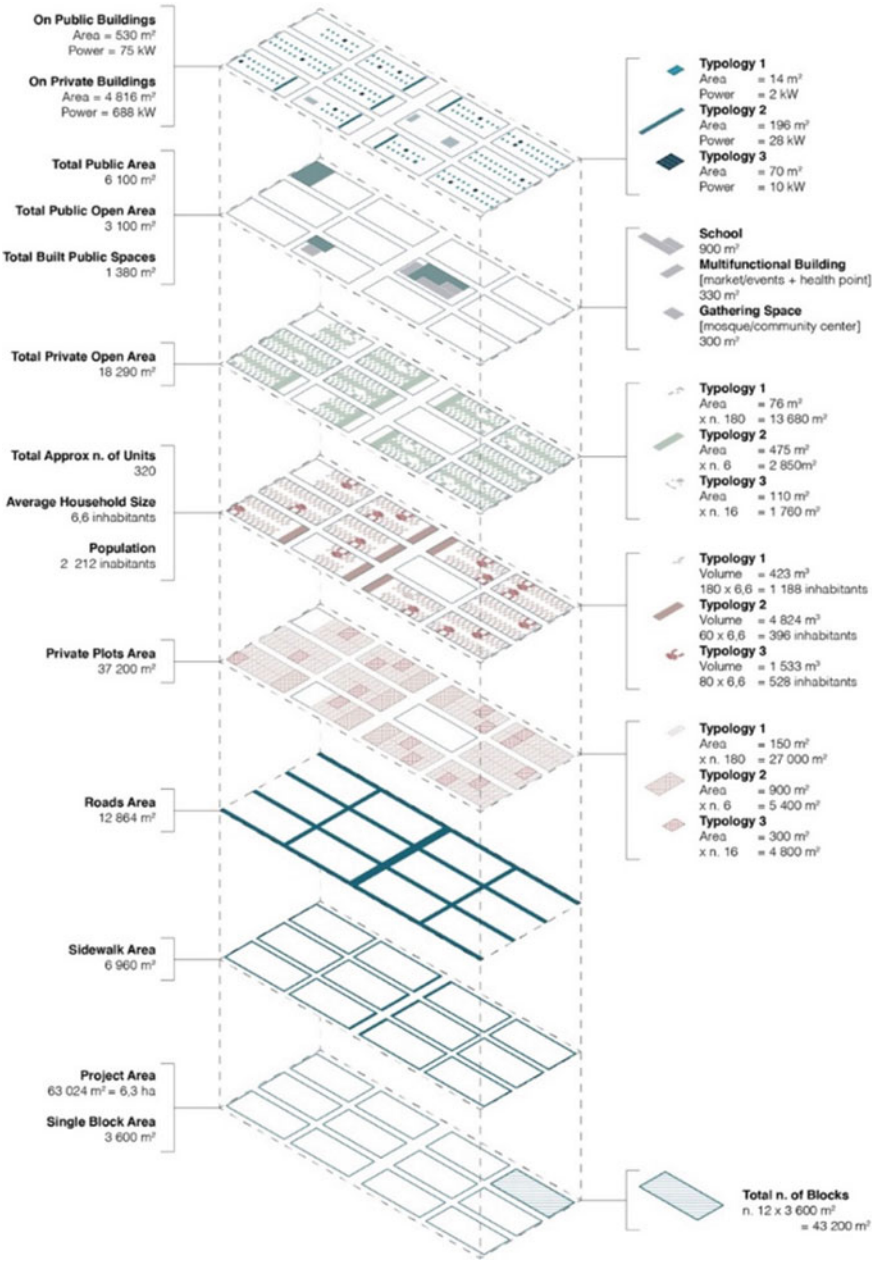

Fig. 5 Settlement overall data. *Source* elaboration of the authors

3 Typological Proposal

The architectural design generates a lively settlement by proposing numerous alternatives and offering a great range of solutions to provide affordable and well-planned homes to a broader range of families. Diversification and variations of form are expected in the final architectural product, as it will reflect every household's specific needs and ambitions, avoiding repetition of the same pattern. Equally important is the design of flexible floor plans that can adjust and adapt to distinct demands to create more habitable environments. Flexibility and adaptability in this context are significant, especially when considering the numerous dramatic events or sudden changes that a territory such as the Somali one is experiencing in these years.

All the proposed typologies result from an optimization process to meet the principles just mentioned, to ensure good internal comfort with simple but effective climate-sensitive solutions, to minimize construction costs; all this, without forgetting the needs of the contemporary Somali population in terms of living spaces.

The typologies have been designed to maximize natural ventilation, reduce indoor heat, and minimize the solar exposure of the building to improve the air quality and temperature of the inner spaces. The project also took a firm position on materials and construction techniques, creating a design that allows the implementation of different technologies and materials. Hence, it was important to consider other possible structure systems and sizing methods and finding an appropriate balance between spans and room dimensions. The structure was therefore always positioned on the exterior walls to free the interior space and allow easier modification of the internal layout without compromising the system.

Another important factor considered while planning the different typologies was the cultural aspect that traditionally shapes the built environment. This is reflected in various features such as the importance of privacy, the distinction and separation of the use of space, the different use of indoor and outdoor areas, and many diverse cultural customs. The various floor layouts attempt to reinterpret traditional models, borrowing some of their characteristics, for example, creating spaces that can be reached and used separately, protecting the inhabitants' privacy from the public. In typology 1, for example, the idea of the traditional courtyard house was re-proposed, creating diversified small patios. Openings and entries were carefully placed, transitional spaces were created, and simple details provide good overall results.

Below is a brief collection of the principles that guided the design:

1. Bioclimatic solutions to naturally protect from weather conditions (allowing for natural ventilation, appropriate shading, natural cooling system);
2. Housing units with sufficient living space, according to the size of the household;
3. Adequate access to water and sanitation;
4. Flexibility and adaptability of use;
5. Possibility of guided expansion;
6. Design distribution appropriate with cultural principles;
7. Visual privacy from the outside.

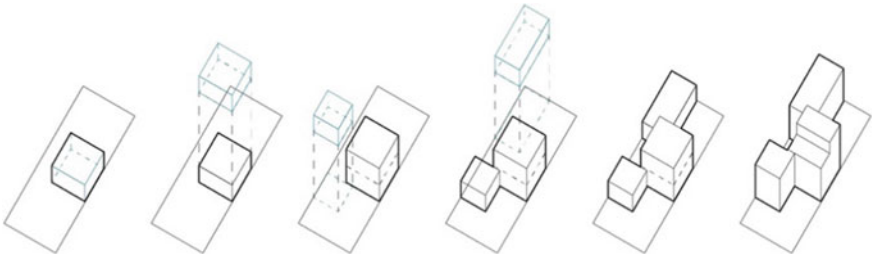

Fig. 6 Typology 1 concept scheme. *Source* elaboration of the authors

Typology 1

The concept design for this typology is to provide an incremental solution that can grow and be modified over time by its inhabitants. This is made possible with a floor layout that combines flexibility and adaptability of space and function (Fig. 6).

All the services and primary systems are gathered in a nucleus that becomes the focal point of the project, around which every functional activity is organized. It contains the kitchen, two bathrooms, the stairs, and a transitional area for horizontal distribution. Two other volumes, which host the main rooms of the house, are connected to this space. They can be used and divided in different ways, depending on the family's specific needs. The leading concept of the design was to give the opportunity of assembling various parts of volumes to build different houses depending on economic possibilities and individual necessities. Thus, the core is the starting point, to which you can add different volumes, whether immediately or later. To guide this possible growth, the foundations of the entire house are built along with the core. This idea took inspiration from construction models seen in much of the global south, implemented by proposing a guided and secure way to build, providing technical support (Fig. 7).

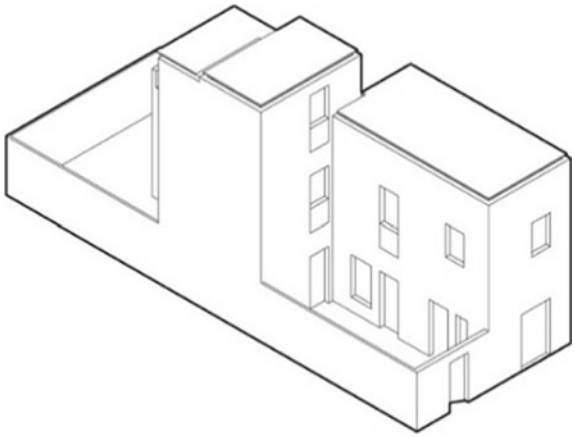

Fig. 7 Typology 1 axonometry. *Source* elaboration of the authors

For reference, a basic model was defined, that could be used as a prototype and later be modified depending on different requirements (Fig. 8). The basic unit, of approximately 100sqm, can host an average Somali household, dedicating a room of 13sqm on the street front for a small family business. The room next to this space can be used as a living area for the family and is directly connected to the house's core by a separate entrance. From the core of the house, there is direct access to the back patio or to a second room that could be a bedroom or adapt to different purposes. On the second floor, there is a second common area, two bedrooms and a terrace. The terrace is a shaded area, to keep the inside temperature of the downstairs bedroom low and has higher wall with perforations providing a comfortable space while protecting the family's privacy. The stairs go up to a third floor, where a small room allows access to the roof on which water tanks and a utility sink are located. Above this small volume are some solar panels used to service the basic needs of the household. A shading system protects the roof to prevent overheating and could eventually be replaced by a pergola, providing an additional space to the house (Fig. 9).

The building is equipped with a basic electricity system to provide lighting and power to every room, a sanitary water plant in the central core, a rainwater collection system with a 3000 L underground tank, a domestic hot water producer with an air–source heat pump, and a sewage plant with a septic tank. Lastly, the roofs host a PV system with a minimum size of 2 kWp/unit, which can be expanded up to 5 kWp.

This supposed scenario may differ, as previously stated, depending on the number of people that make up the household, the composition of the family, their age and occupation (Fig. 10). For example, with simple additions to the house's volume, it could host a larger family or two related households. To pose another example, not

Fig. 8 Typology 1 floor plans. *Source* elaboration of the authors

Fig. 9 Typology 1 sections. *Source* elaboration of the authors

every family demands a space for a business, or in the contrary, some households would prefer to have more rooms or a bigger space than the one proposed. The interior partitions can be easily modified, either before the construction or at a later point, to better accommodate these specific needs. An example of this incremental solution is that another room can be easily built, closing off the terrace space. In this case, a large family could even decide to divide the house into two smaller apartments.

In an effort, to try and balance built and unbuilt areas in each plot, three quiet narrow patios were proposed, instead of a single bigger space. The reasons for this are multiple. First, they considerably improve natural cross-ventilation, which in a context like that of Mogadishu, brings the light inside through their tight dimensions without exposing the facades directly to the sun. Secondly, they recall the concept of the courtyard house and the fact that they can be used for different practices and by various family members, allowing different levels of privacy. The first patio is more public and creates a buffer zone for the more private parts of the house. It can be an

Fig. 10 Typology 1, possible floor layout combinations. *Source* elaboration of the authors

extension of the public areas, directly connected to the ground floor's business area, or could be closed and more private, with the possibility of eventually fitting a parking space. The second one is smaller and has a more protective character. The third one, instead, is "L" shaped to maintain distance at the back between opposite houses and allow sufficient space to create a green corridor and allow adequate ventilation between different properties. To maintain a good level of privacy, each unit only has openings to one side, as to only overlook their own property. The position of the volumes on the edge of the plot separates the properties from one another.

This typology, besides being realized in a planned settlement, as the one proposed here, could be implemented individually inside the city's existing urban tissue. The standard plot dimension in Mogadishu fits two or more of these typologies, allowing a wide range of possibilities. When two or more units are built next to one another they can share the partition walls, the exterior wall along the border of the plot between the properties, as well as the foundations.

Typology 2

The second typology is a multi-storey building made up of four floors, located along the main road of the settlement and positioned on the short edge of the block. It's built on a plot of 20 m by 40 m (Fig. 11).

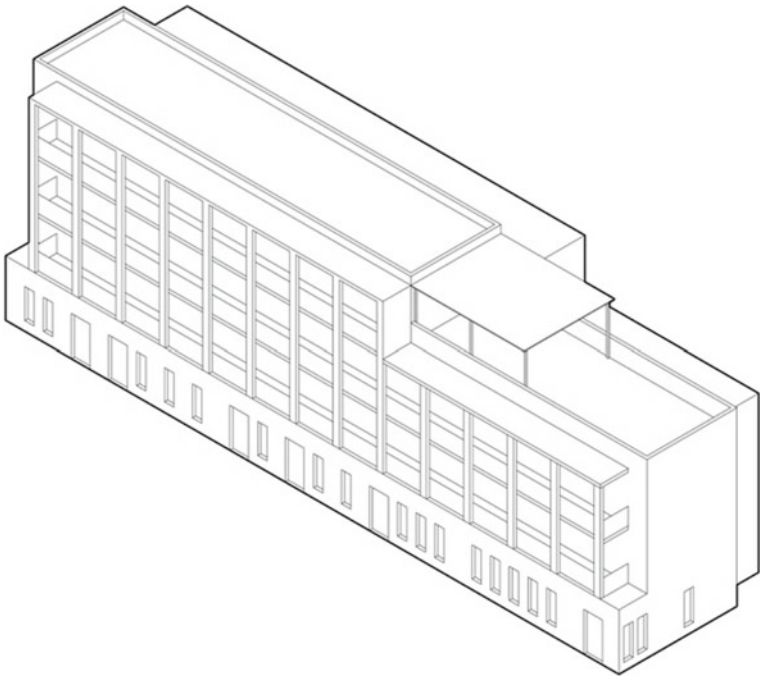

Fig. 11 Typology 2 axonometry. *Source* elaboration of the authors

Fig. 12 Typology 2 front elevation. *Source* elaboration of the authors

The proximity to the main road and the settlements' public services encourages the use of the ground floor, which is allocated to commercial activities. For this reason, the height of this floor is 4.5 m, as opposed to the upper floors of 3 m. This allows for the creation of a mezzanine, if desired, increasing the available floor area

The building is formed by a combined series of volumes that make up the different functions of the building, such as the open-air circulation gallery (2.6 m wide) along the building's rear side, whilst the street side hosts a facade-long covered balcony (1.8 m wide) (Fig. 12). The project has a structural module of 5.6 × 5.6 m creating a regular grid that shapes the entire building. The primary structure, be that a traditional beams-columns or a load-bearing wall structure, is set along the longitudinal lines of the grid, freeing the internal area of all units (Fig. 13). The secondary structural axis runs along the external two sides.

Each floor is made up of 7 modules and can accommodate 3 or 4 units depending on the size (Fig. 14). The design of the different units is based on the module (5.6 × 5.6 m) with the following configurations:

- **Unit A**: 1 and ½ module makes up a two-room apartment of 52 sqm, with one bedroom, a living area separate from the kitchen and one bathroom.
- **Unit B1 and B2**: 2 modules make up a three-room apartment of 70 sqm, with two bedrooms, a common living area, a kitchen and one bathroom. There are two options because of the different positions of the bedrooms: one separates the living from "sleeping" area; while the other positions the living area between the two bedrooms (Fig. 15).
- **Unit C1**: 2 and ½ modules make up a small four-room apartment of 85sqm, with two twin size bedrooms, one single bedroom, a common living area, a kitchen and one bathroom. The space that separates the living room and the bedrooms can be used as a second common area (Fig. 16).
- **Unit C2**: 3 modules make up a bigger four-room unit of 100 sqm. It is composed of three twin size bedrooms, two bathrooms, and a large living area that can be separated by the kitchen if desired.

Each unit is divided longitudinally into two areas, the first is a "service space" 1.8 m deep, that works as a filter between the outside circulation (public space) and

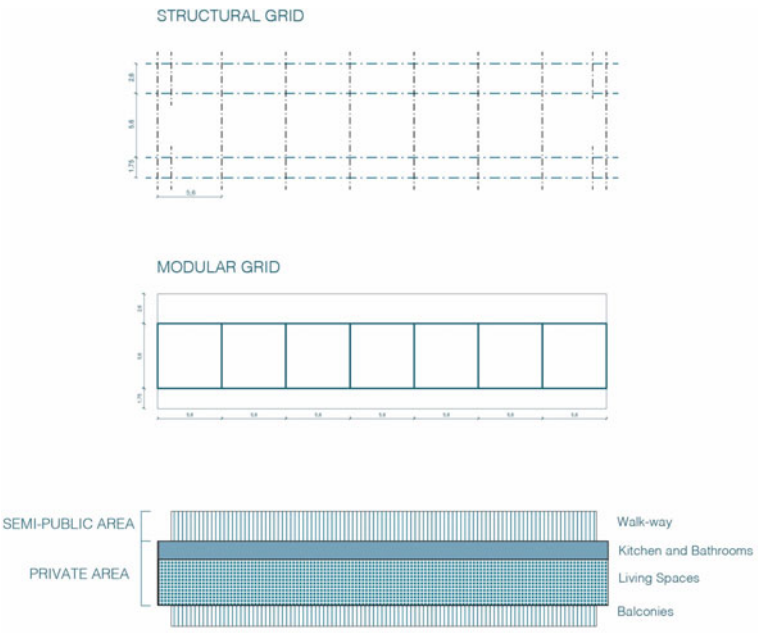

Fig. 13 Typology 2 configuration diagram. *Source* elaboration of the authors

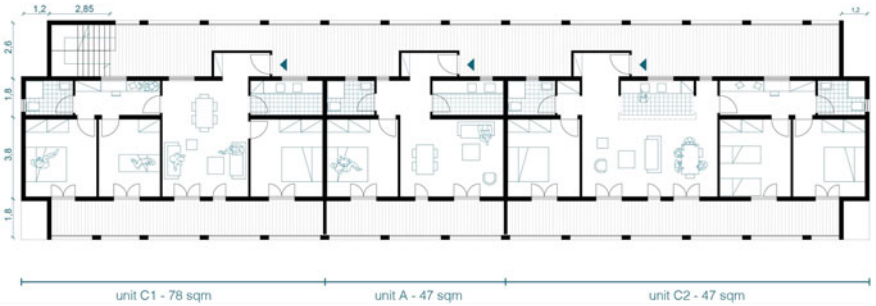

Fig. 14 Typology 2 floor plan, possible unit combination. *Source* elaboration of the authors

the internal rooms (private space). In all the units, this space hosts the kitchen, the bathrooms, and a versatile small space, that could be used for distribution, sitting, studying, etc. It has high windows, positioned at 1, 8 cm to provide privacy, and essential for improving the natural cross ventilation system. The second space is 3.6 m deep and accommodates the apartment's different rooms (bedrooms and living area).

To increase the level of privacy, in addition to the use of high windows on the public circulation side and the provision of a space that separates it from the main room, each unit has a separate entryway which consists of a small space of 1.15 ×

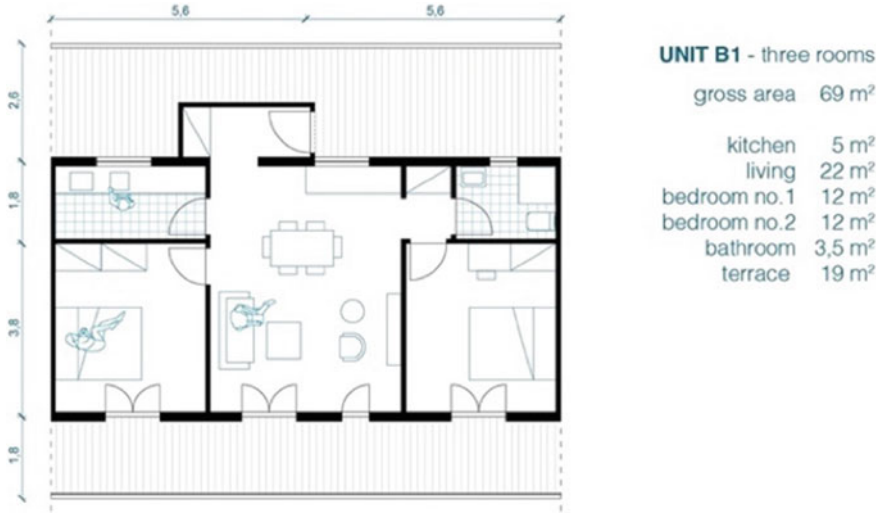

Fig. 15 Typology 2, Unit B1 plan. *Source* elaboration of the authors

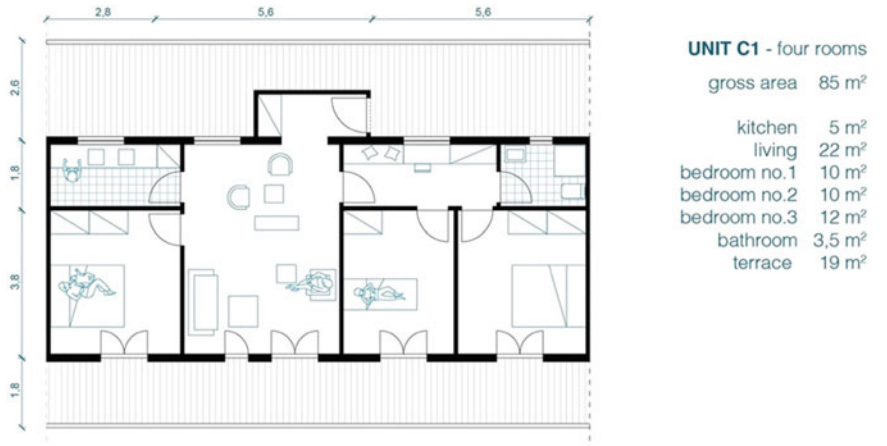

Fig. 16 Typology 2 unit C1 plan. *Source* elaboration of the authors

30 m. This occupies a portion of the circulation corridor, with the door positioned on the short side and in the opposite direction of the main flow. This addition provides an additional filter that separates the outer space from the private internal one. Working on these details and finding simple yet effective solutions help to improve the quality aspect of life, by also taking into consideration cultural and religious factors.

Each unit is designed to allow its inhabitants to live in a comfortable habitat, despite the challenging weather conditions. Natural cross ventilation is allowed in each room, thanks to the double exposure of each unit. Protection from direct sunlight

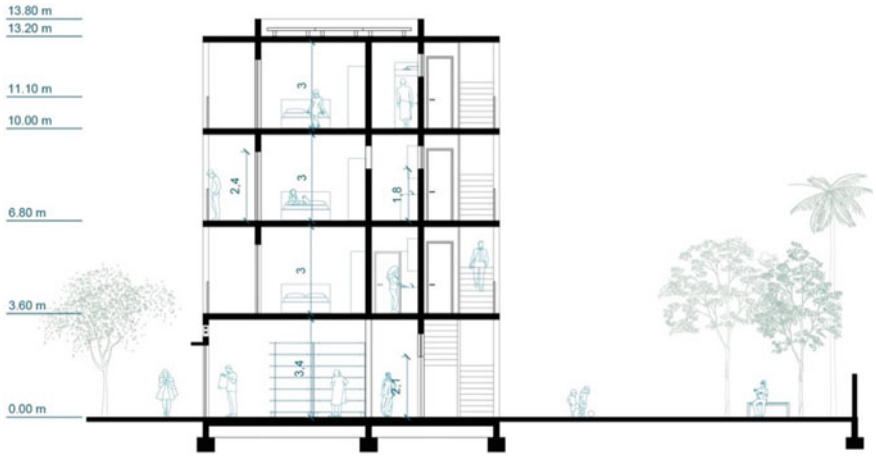

Fig. 17 Typology 2 section. *Source* elaboration of the authors

is implemented on both long sides of the building due to the balcony that runs across the entire front façade and the distribution corridor on the opposite side. The structure that runs along the external longitudinal axis also improves the building's shading and allows for variations in the façade of the different buildings by playing with dimensions and proportions of the structural partition walls (Fig. 17).

Typology 3

This typology merges the first two by working on a single plot of 15 × 20 m (a prevailing plot dimension in the suburbs of Mogadishu), hosting five apartments. It's a three-storey building and, like typology 1, revolves around a central core in which the main services are located: stairs, kitchens and bathrooms (Fig. 18). The other main rooms of the unit are connected to this core. The patio allocation help obtain double-cross ventilation in the different spaces.

The ground floor has a large open area in the front (partially covered) shared by all the units. The unit on this ground floor has a different configuration to the ones above. It is bigger in size and offers various layout possibilities, depending on the family's needs. It has access to a large open area, divided into separate patios, granting privacy and possible diversification of use, with the possibility of creating separate entrances. It measures 90 sqm and has a total 70 sqm of open spaces (Fig. 19).

The upper floors have two units each. These units adopt the same basic layout, with an area of 65sqm, which could eventually become 78 sqm by enclosing the terrace. A small entrance area creates a threshold between the semi-public area and the house's private sectors in each unit. The units have two bedrooms (one single and one double), a living room (18 sqm) and a separate kitchen. A second variation of the basic layout combines two units to make a bigger one, with double the numbers of bedrooms. In this case, the possibilities of variation based on the composition of the household are vast. The layout of the units plays an important part also for

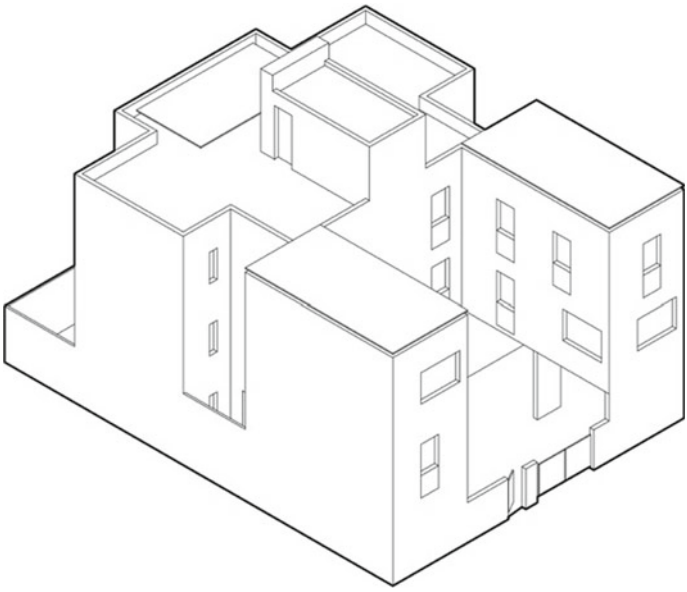

Fig. 18 Typology 3 axonometry. *Source* elaboration of the authors

climatic factors. As in the previous typologies, it favours maximum ventilation whilst protecting the facades from direct exposure to the sun. The internal height is 3 m and by using passive cooling techniques, such as the chimney effect or shading the roof, the interior habitable conditions maintain ~~a~~ good thermal comfort even when there are high temperatures such as the ones in Mogadishu (Figs. 20 and 21).

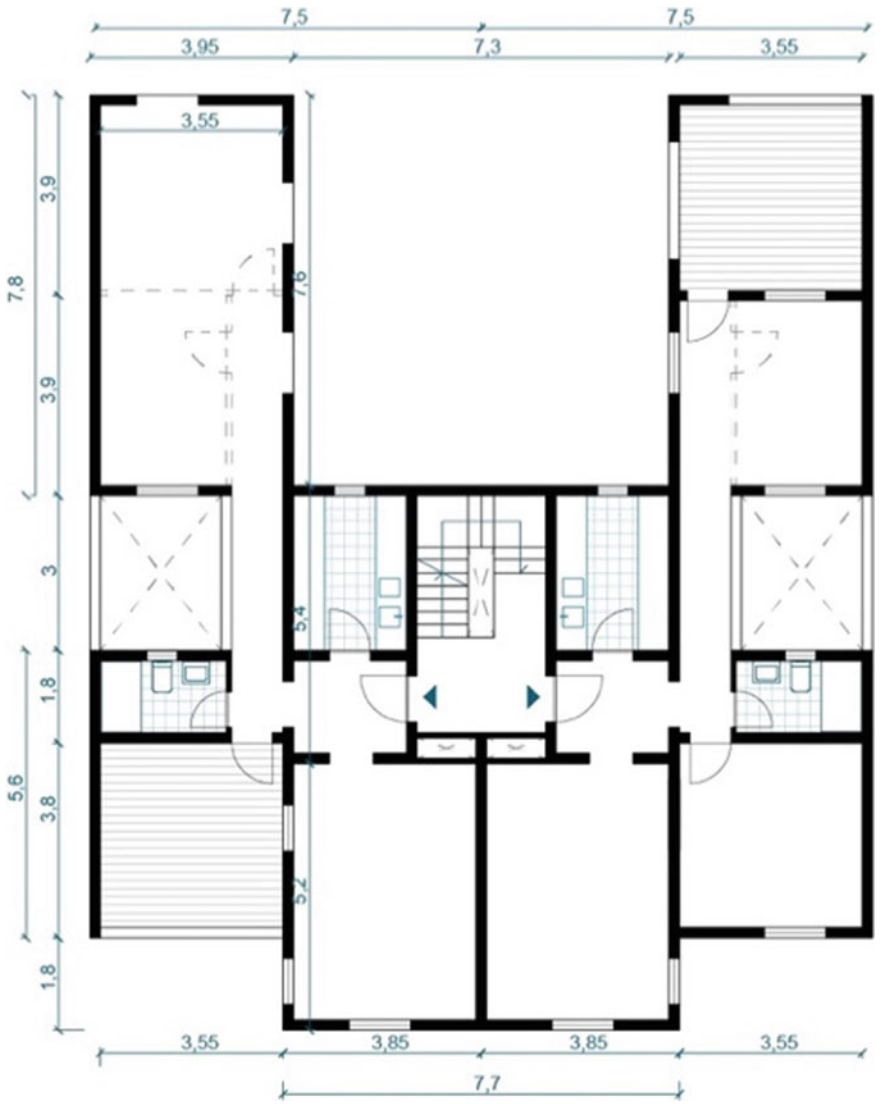

Fig. 19 Typology 3 standard floor plan. *Source* elaboration of the authors

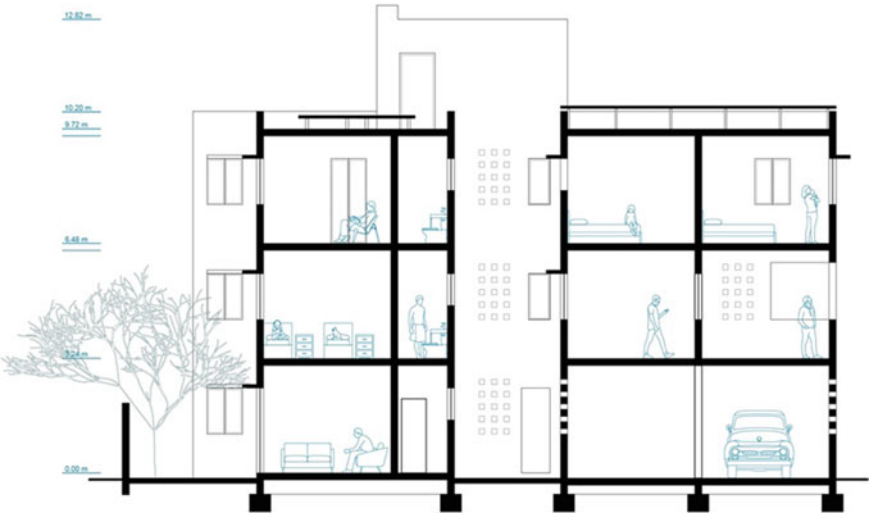

Fig. 20 Typology 3 section. *Source* elaboration of the authors

Fig. 21 Typology 3 front elevation. *Source* elaboration of the authors

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Construction Technologies and Materials for Sustainable Affordable Housing

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Abstract Within the dynamic and fragile context of developing countries, often characterized by social, political and economic uncertainty, the present chapter proposes a methodology for assessing and selecting appropriate building technologies for affordable housing, including a method for the systematic classification of building components. The aim is to investigate possible sustainable construction technologies and materials, taking a holistic perspective that allows overcoming the mere economic assessment. Hence, the chapter highlights possible perspectives for the improvement of current building solutions and practices in Mogadishu toward industrialization of construction, use of local raw materials and enhancement of construction quality through training.

Keywords Construction sector · Sustainable technologies · Environmental sustainability · Social sustainability · Mogadishu · Somalia · African countries

1 Affordability and Sustainability: Emerging Needs of Current Construction Practices in Mogadishu

The topic of affordability has been largely discussed within the construction sector over the last decades, especially when referring to developing countries (Wetzstein 2017; Dewita et al. 2018; Stephen Ezennia and Hoskara 2019; Baker et al. 2020). In these contexts characterized by high fragility and uncertainty, where the economic growth is often more urgent than sustainable (Leal Filho et al. 2018; Holmberg and Sandbrook 2019; Silvestre and Ţîrcă 2019), the challenging goal is to find a balance between sustainability and affordability, overcoming self-assembled shelter

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solutions toward the development of sustainable durable buildings (Purvis et al. 2019; Bellini et al. 2020; Atta et al. 2021). Highly debated internationally by experts and professionals in the field, this broad goal represents today an open challenge for Somalia—and other developing countries—that requires a careful reflection on the causes and implications of the current housing emergency (Grijalva-Eternod et al. 2018; Bryld et al. 2020; Avwunudiogba and Dung 2021).

Within Somali territories, the access to adequate and affordable housing represents a growing issue, as evidenced by the high number of IDPs (Internally Displaced Persons) and the large portion of the population that currently lives in slums or war-damaged buildings (CAHF 2018; Mwau et al. 2020; Proença et al. 2020; Mitlin 2020). This housing emergency is a consequence of the coexistence of various phenomena: the continuous population growth resulting in ever-higher urbanization rates, the increasing size of households (FSG 2019; Bakonyi 2021), the high level of poverty, the presence of a building share partly destroyed by the civil war and never restored, the displacement of low/no-income population, the occurrence of recurring disasters such as floods and droughts (Development Initiatives 2016; Dahie 2019), as well as the vulnerability and insecurity, typical of conflict areas (Development Initiatives 2016; FGS 2019). Approximately, 69% of the Somali population lives below the poverty line (FGS 2017, 2019). According to the Somali Poverty and Vulnerability Assessment (SPVA) by WBG (2019), almost nine out of ten Somali households are deprived of at least one fundamental right among education, access to income, water, sanitation or electricity[1] (CAHF 2018; WBG 2019; Bonnet et al. 2020). The resulting strong instability and the failure to guarantee people's basic needs risk to favor the emergence of an abrupt and rapid growth, leaving the ground for speculative actions and merely economic strategies not intended to consider environmental and social sustainability aspects (Atta et al. 2021). To handle this critical issue, alongside housing strategies an policies there is the need to promote the design and construction of durable residential settlements, recognizing the poor quality and inadequacy of slums and temporary shelter agglomerations (CAHF 2018; Atta et al. 2021) that do not ensure social integration and inclusion. Beyond the activation of social cohesion, further development plans need to be oriented toward the creation of sustainable settlements, supporting the common understanding of key environmental sustainability aspects to increase building performances and the progressive reduction of the negative impacts on the environment (FGS 2019; Purvis et al. 2019; Bellini et al. 2020).

Focusing on the construction sector, one of the worst consequences of the hasty and uncontrolled housing growth is that often, when dealing with the choice of construction technology solutions and/or materials and products, decision-makers only take

[1] This scarcity and precariousness is comparable to housing conditions in slums or refugee camps. In particular, according to Bonnet et al. (2020): "*In 2017, over 480 of these settlements were spread across Mogadishu. Most of them are located in the northwestern part (e.g. Hodan and Daynile Districts), though there are also some in the centre (e.g. Shangani) and southwest (e.g. Kaxda). Living conditions in these settlements are dire. Housing consists predominantly of corrugated metal sheet shacks or so-called bulls, temporary shelters made of sticks, plastic and fabric*" (Bonnet et al. 2020).

into consideration the economic aspects, without giving the right weight to sustainable design strategies, thus neglecting the other two pillars of sustainability. This translates directly into a narrow range of technological solutions, certainly low-cost but designed regardless of the context, and therefore, not optimal for the local climatic conditions. Given the particular features of a developing country such as Somalia, the choice of suitable construction technologies carries a strong responsibility and the related decision-making process cannot fail to follow the holistic Triple Bottom Line (TBL)[2] approach (Correia 2019; Loviscek 2020). To this end, the following paragraphs focus on construction technologies to propose an assessment tool—based on a multi-criteria analysis—useful to support decision-makers in the choice of the most suitable technological solutions according to the specificity of the developing context. The tool is based on a set of key indicators articulated into the three pillars of sustainability, seeking a balance between affordability and sustainability in the selection of construction technologies (Atta et al. 2021; UN Habitat, 2019a, b). This support tool addresses several beneficiaries at different levels with different aims (Bellini et al. 2020). Among the direct beneficiaries is possible to mention the various stakeholders of the AEC sector, e.g., construction and manufacturing firms, SMEs, social cooperatives, architects, engineers, policymakers, public institutions and NGOs. While the indirect beneficiaries are primarily the end users of sustainable affordable housing, thus the citizens, including displaced people and middle-lower classes, but also young AEC professionals looking for new job opportunities in the field of sustainable construction.

2 Construction Technologies in Mogadishu: Emerging Need of the Current Scenario

The Somali construction sector, particularly driven by the city of Mogadishu, represents a very dynamic and promising ground for the development of the local economy in the next years (UN Habitat, 2019a, b; FGS 2019; Atta et al. 2021). Mogadishu and the entire Somali country are experiencing a wave of growth within the construction industry (Mohamed et al. 2019; Nor and Masron 2019). In contrast with the declining trend of the recent past, the country is now witnessing a high number of new construction projects (ongoing and planned), which is expected to increase in the coming years (FGS 2019; Mohamed et al. 2019; Nor and Masron 2019). However, in order to produce value for the entire community, this exponential growth of the construction sector needs to be properly guided towards ensuring widespread access (without disparity and exclusions) to durable and quality buildings. To this end, the

[2] The Triple Bottom Line (TBL) of People, Planet and Profit, term coined by Elkington in 1997 (Loviscek 2020), is currently a widespread method that encompasses social, environmental and economic aspects, supporting the set up of long-term strategies for companies (Correia 2019). The transition toward sustainability is, indeed, based on three important dimensions of the sustainable development (Loviscek 2020): environmental quality, social equity and economic benefits (Correia 2019).

availability of information tools is decisive to support the inclusion of sustainability in the decision-making processes and in the definition of viable actions to implement strategic housing development plans (UN Habitat, 2019a, b; World Bank IMF 2020; IOM 2019).

The first step to realize the shift of the construction industry toward more sustainable construction processes and technologies consists of identifying alternative solutions with respect to the weaknesses of the current practice (see Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu"). In particular, the current state of the sector, outlined in Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu", thanks to the involvement of local stakeholders, has highlighted some weaknesses and potentialities of the manufacturing and construction sectors, mainly due to the fact that the cost-effectiveness of the solutions is almost the sole factor of evaluation taken into consideration in the choices related to the procurement of raw materials and products and to the definition of construction methods and tools (Bellini et al. 2020; UN Habitat 2020).

For what concern the procurement of resources, most of the raw materials used for construction processes in Mogadishu (including concrete, steel, wood and ceramic) are imported from foreign countries, mainly from China, Turkey, UAE, and India, thus limiting the growth of the local manufacturing production (CAHF 2018; IIED 2019; UN Habitat 2020; OEC 2021) . This import market is not limited only to raw materials, but also regards semi-finished and finished products, with particular reference to finishes and furniture (including tiles, sanitary fixture, windows, doors, and home furnishings) which are almost solely imported through consolidated international trade channels, without any proof of local manufacturing despite their high impact on the final selling price of buildings.[3] One of the main critical consequences of this import market lies in the fact that the variety of imported construction materials and products is very limited and narrow and, moreover, the quality is often scarce, favoring the cheapest solutions procured through equally economical (consolidated) trade channels. As a consequence, in Mogadishu—and in Somalia in general—the use of the same low quality and cheap construction solutions is currently a common and widespread practice in the field. In this outlined scenario, the main emerging needs toward sustainable improvement concern the promotion of the local sourcing of construction raw materials and the local manufacturing of building components, including the identification of key drivers for the related investments, and a campaign to raise awareness on building quality and sustainability among the local construction stakeholders.

Regarding the construction sector, as outlined in Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu", most of the local firms still employ manual or semi-automated craft construction

[3] Finishing components and furniture, together with structural elements, play a significant role in the definition of the final selling price of the building, having a high economic impact on the costs in overall terms (Atta et al. 2021).

methods, using ready-to-use imported products or/and imported raw materials for on-site production of basic building components (i.e., concrete block and concrete load-bearing structures) (Atta et al. 2021). However, this trend is not due to the absence of advanced construction machineries, because excavators, bulldozers, telehandlers, etc., are present on the local market, even at low prices, but the cause behind this trend lies in the fact that these machineries require highly trained operators, who are not easy to find locally and, moreover, their hourly fee is often high and barely affordable for construction companies. Hence, local stakeholders need to be supported by proper information tools and training programs to increase their knowledge and know-how, experimenting with more appropriate and sustainable construction methods and processes, thus reaching better performance and sustainability of construction solutions.

With particular reference to the currently-used construction technologies, the cognitive processes carried out with the support of Somali construction companies and local professionals in the AEC field[4] confirmed the suboptimal quality and contextual appropriateness, as a consequence of the above-highlighted criticalities of the field. In particular, the employed technological solutions are mainly based on basic concrete blocks for walls, concrete structures for columns/beams and wood frames with metal sheets for roofs, as detailed in Table 1.[5] In order to systematically organize the technical information on traditional construction technological solutions—collected through surveys, questionnaires and interviews with local construction companies and professionals—Table 1 proposes a standardized framework for the classification and coding of the elements based on the OnmiClass international standard. In a future perspective, this expandable catalog of components

[4] The process of analysing of the technological solutions currently used in the construction practice in Mogadishu has been based on a strong interaction with local stakeholders. Interviews, questionnaires, and focus-groups with local construction companies and professionals in the field have been carried out in order to gain insights on construction processes and technologies, with particular reference to the commonly used products and materials, supply chain configurations, building site organization, construction machineries and employed workforce. Moreover, the performed analysis was also supported by documents provided by the interviewed companies, including pictures of construction phases and construction techniques, bills of quantities and cost estimations.

[5] In particular, the OmniClass "Construction Classification System" (ICS 2021) is adopted to define a common taxonomy, a hierarchical structure and a coding system useful to uniquely identify the set of building components, thus creating a reference framework able to describe in a clear and unambiguous way by using a shared language the technological solutions constituting a building asset. Particularly, the OmniClass system consists of a set of inter-related tables, not meant to be utilized all at once but allowing the selection of the ones more significant for the purposes of the analysis. In this way, it enables the creation of ad-hoc Product Breakdown Structure (PBS) (ICS 2021), tailored to the specific case. Moreover, the standard is particularly instrumental as it employs the nomenclature commonly used in construction practice within digital tools such as Building Information Modeling (BIM), providing a standardized basis for classifying information created and used by the Architectural, Engineering, and Construction (AEC) industry. In particular, the proposed hierarchical framework of building classification based on OmniClass is created by combining three different OmniClass Tables, i.e., Elements (Table 21), Products (Table 23) and Materials (Table 41).

Table 1 Framework of Somali current construction technologies

Elements (*OmniClass Table 21*)				Products (*OmniClass Table 23*)		Materials (*OmniClass Table 41*)		Specifications (*Local Construction Companies*)	
Level 1	Level 2	Code	Level 3	Code	Level 3–5	Code	Level 5	Technological	Price
Substructure	Foundations	21-01 10 10	Standard foundations	23-13 29 15 13	Grade beams	41-30 10 25 19 15	Cement	Concrete class M25 (1:1.75:3.5)	8$ for 50 kg
						41-30 10 25 19 19	Sand		65$ for 4 m^3
						41-30 20 11 14	stainless steel	High strength steel bars module 2.9 × 3.0 m	450$ for 1 module
						41-30 30 11 19 13	Hardwood timber	Wooden formwork 25 mm thick	340-360$ for 1 m^3
	Slabs-on-grade	21-01 40 10	Standard slabs-on-grade	23-13 31 11	Structural concrete	41-30 10 25 19 15	Cement	Concrete class M25 (1:1.75:3.5)	8$ for 50 kg
						41-30 10 25 19 19	Sand		65$ for 4 m^3
						41-30 20 11 14	Stainless steel	High strength steel bars module 2.9 × 3.0 m	450$ for 1 module
						41-30 30 11 19 13	Hardwood timber	Wooden formwork 25 mm thick	340-360$ for 1 m^3
Shell	Superstructure	21-02 10 10	Floor construction	23-13 31 11	Structural concrete	41-30 10 25 19 15	Cement	Concrete class M25 (1:1.75:3.5)	8$ for 50 kg

(continued)

Table 1 (continued)

Elements (*OmniClass Table 21*)				Products (*OmniClass Table 23*)		Materials (*OmniClass Table 41*)		Specifications (*Local Construction Companies*)	
Level 1	Level 2	Code	Level 3	Code	Level 3–5	Code	Level 5	Technological	Price
						41-30 10 25 19 19	Sand		65$ for 4 m^3
						41-30 20 11 14	Stainless steel	High strength steel bars module 2.9 × 3.0 m	450$ for 1 module
						41-30 30 11 19 13	Hardwood timber	Wooden formwork 25 mm thick	340-360$ for 1 m^3
		21-02 10 20	Roof construction	23-13 17 11 15	Wood rigid profiles	41-30 30 11 19 13	Hardwood timber	–	340-360$ for 1 m^3
		21-02 10 80	Stairs	23-13 31 11	Structural concrete	41-30 10 25 19 15	Cement	Concrete class M25 (1:1.75:3.5)	8$ for 50 kg
						41-30 10 25 19 19	Sand		65$ for 4 m^3
						41-30 20 11 14	Stainless steel	High strength steel bars module 2.9 × 3.0 m	450$ for 1 module
						41-30 30 11 19 13	Hardwood timber	Wooden formwork 25 mm thick	340-360$ for 1 m^3

(continued)

Table 1 (continued)

Elements (*OmniClass Table 21*)				Products (*OmniClass Table 23*)		Materials (*OmniClass Table 41*)		Specifications (*Local Construction Companies*)	
Level 1	Level 2	Code	Level 3	Code	Level 3–5	Code	Level 5	Technological	Price
	Exterior vertical enclosures	21-02 20 10	Exterior walls	23-13 21 11 11	Concrete blocks	41-30 10 25 19 15	Cement	Concrete hollow block mix cement-sand 1:3 200 mm thick	1$ for 1 block
						41-30 10 25 19 19	Sand		
						41-30 10 25 19 15	Cement	Cement mortar mix cement-sand 1:3 10 mm thick	
						41-30 10 25 19 19	Sand		
		21-02 20 20	Exterior windows	23-17 13 17 17	Plastic double hung windows	41-30 50 21 64	PVC	–	–
						41-30 10 27 17 11	Glass		
				23-17 13 13 17	Metal double hung windows	41-10 10 60 11	Aluminum	Window 1.2x1.0 m	115$ for 1 piece
						41-30 10 27 17 11	Glass		
		21-02 20 50	Exterior doors	23-13 33 21 11	Aluminum-framed entrances	41-10 10 60 11	Aluminum	–	–
	Exterior horizontal enclosures	21-02 30 10	Roofing	23-13 19 13 11 19	Solid metal sheets	41-10 10 60 11	Aluminum	–	–

Source interviews with local construction companies. Adapted from Atta et al. 2021

could be used by designers to organize technical information not yet rationalized in the common practice.

The most common construction technology employed residential buildings is the Concrete Masonry Unit (CMU), which is a standard size rectangular concrete block, extensively adopted since cheap, simple and very adaptable to compose different volumes and shapes (NMCA 2021). As described in Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu", the concrete blocks are produced with Portland cement, adding aggregates such as fine gravel, sand or ashes (from industrial waste) according to the needed level of block density (from high to low). CMU walls are reinforced, both vertically and horizontally, with steel bars to increase the structural strength. Traditional masonry is built with layers of staggered concrete blocks, usually shaped with hollow cores for improving thermal insulation performance. Currently, in the common practice of Mogadishu, the CMU is mainly formed manually, using simple compressing machines (Rometa 2021).

3 Alternative Construction Technologies and Context-Based Approaches Toward Sustainability Within Mogadishu Construction Sector

In order to support the analysis of the cost/benefit ratio for the assessment of construction technologies suitable for the peculiar context of developing countries such as Somalia, in recent years Alternative Building Technologies (ABTs) have been largely discussed in literature by several authors, including professionals, associations and NGOs (Bonsile et al. 2019; Grady et al. 2019; Odongo 2019; SAHIF 2020). Particularly, ABTs—term consolidated in literature and widely shared by many authors of the field—represent those solutions that envisage the presence of materials and products characterized by low embodied energy, local production (leading to a reduction in transportation costs) and ease of construction (Bonsile et al. 2019; Marut et al. 2020). Representing an alternative to conventional building technologies and materials, ABTs have been strongly promoted in order to increase the environmental sustainability of buildings, by encouraging the use of sustainable materials, increasing the efficiency and quality of production processes and reducing waste and emissions (CAHF 2018; Marut et al. 2020).

Among the several classifications of the ABTs recently proposed in the literature (CAHF 2018; Didiza 2018; Bonsile et al. 2019; Grady et al. 2019; Marut et al. 2020; Odongo 2019; SAHIF 2020), the most suitable ones with regard to the peculiarity of the Somali application context are the following (Atta et al. 2021):

- High Technology involves processed materials, manufactured products or systems and industrialized production processes;

- Intermediate Technology includes hybrid approaches that replace some conventional materials and products used in construction with recycled and/or other "found" materials;
- Low Technology employs traditional materials and owner-built methods (mostly used in rural and peri-urban settings).

According to this three-level classification, Table 2 proposes possible alternative construction technologies[6] for the application context of Mogadishu, identified and discussed through the dialogue with local construction companies. In particular, for what concerns the exterior walls, an alternative low technology is represented by the employment of compressed-earth stabilized block constituted of local earth, sand, cement and water. As an alternative intermediate technology, it is possible to mention the bamboo-based sandwich panels constituted of laminated bamboo fiber and wood veneer composite materials (outside), layer of rock wool insulation and bamboo OSB (inside), with a lightweight steel frame. Reaching the high technology, it is proposed the use of single or double sandwich panels consisting of a sheet of an insulating rigid closed-cell foam (with medium–high density) between two welded wire mesh finished with structural concrete on both sides.

Nonetheless, the evolution from low to high ABTs in the context of developing countries, characterized by a fragile nature as Somalia, is not instantaneous and effortless, but it is a gradual development process that requires coordinated synergic efforts by the different stakeholders involved in the building practice to reach step by step goals. In particular, the proposed "transition goals" of this gradual process of continuous improvement toward sustainable and affordable construction solutions are below introduced in the form of paradigm shifts (Atta et al. 2021):

1. From imported to local raw materials;
2. From manual to automated or prefabricated construction processes;
3. From "doing" to learn-by-doing and cross-fertilization.

The first paradigm entails the use of local raw materials instead of resorting to import. This shift implies the revamping of local producers and the creation of new markets of local raw materials, working in parallel with the already existing import markets. The employment of local raw materials represents a booster to empower the local socio-economic context, offering new job opportunities, as well as new sustainable materials. According to the National Master (NationMaster 2021), there is a wide presence of existing natural resources in Somalia, ranging from deposits of bauxite, copper, iron, kaolin, limestone, quartz, granite, silica, sandstone and sand (Yager et al. 2010; Yager 2011). Hence, performing a feasibility analysis to assess the possible use of local raw materials for construction purposes is recommended. For

[6] The alternative technologies identified in Table 2 are characterized by three levels (low-medium-high) which differ in terms of innovation, of both materials and construction processes compared to current practices. It is important to stress that while identifying alternative solutions for the specific application context of Mogadishu, it is necessary to consider the related underlying implications, both in procedural and organizational terms (including logistic, production, supply chain, training, timing, etc.).

Table 2 Possible alternative (high/intermediate/low) construction technologies for Mogadishu

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
21-01 40 10	Standard slabs-on-grade	21-01 40 10 A	Concrete slab with concrete class M25 and steel bars (diam. 9 mm). Wooden formwork (25mm thick). Finishing in ceramic tile flooring					
		21-01 40 10 B	Precast hollow core concrete slabs					
		21-01 40 10 C	Concrete platform with two welded wire mesh					
21-02 20 10 N	Non-structural exterior walls	21-02 20 10 N A	Concrete hollow blocks (400L x 300H x 200S). Concrete frame with steel bars (diam. 9 mm) and finishing in painting over a plaster of sand and cement					
		21-02 20 10 N B	Concrete hollow blocks filled with a mineral insulating foam technology, completely recyclable. Concrete frame and finishing in painting					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 20 10 N C	Cement-bonded wood fibre blocks. Concrete frame and finishing in painting					
		21-02 20 10 N D	Precast concrete hollow blocks. Precast concrete frame and finishing in painting					
		21-02 20 10 N E	Hemp-based sandwich panels constituted of: magnesium oxide board (outside), breathable foil membrane, double layer of hemp insulation and hemp particle board (inside). Concrete frame and finishing with a natural cement derived from plants and lime					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 20 10 N F	Bamboo-based sandwich panels constituted of: laminated bamboo fiber and wood veneer composite materials (outside), layer of rock wool insulation and bamboo OSB (inside). Lightweight steel frame and finishing in painting					
21-02 20 10 S	Structural exterior walls	21-02 20 10 S A	Structural concrete hollow blocks (400L x 300H x 200S) reinforced with steel bars (diam. 9 mm). Finishing in painting over a plaster of sand and cement					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 20 10 S B	Structural compressed earth stabilized block constituted of local earth, sand, cement and water					
		21-02 20 10 S C	Structural cement-bonded wood fibre blocks (single/double) reinforced with horizontal and vertical steel bars					
		21-02 20 10 S D	Structural precast concrete hollow blocks reinforced with steel bars. Availability of different colors and textures for minimizing plastering and painting cost/time					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 20 10 S E	Structural Insulated Panels (SIPs) constituted of: insulating foam core sandwiched between two structural facings, typically Calcium Silicate or Magnesium Oxide boards					
		21-02 20 10 S F	Structural single/double sandwich panels made of a sheet of polystyrene (EPS) between two welded wire mesh finished with structural shotcrete plastering in both sides					
21-02 10 20	Roof construction	21-02 10 20 A	Aluminium corrugated sheet. Wood frame					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 10 20 B	Concrete slab with concrete class M25 and steel bars (diam. 9 mm). Wooden formwork (25mm thick). Finishing in ceramic tile flooring					
		21-02 10 20 C	Precast hollow core concrete slabs					
		21-02 10 20 D	Bamboo-based sandwich panels constituted of laminated bamboo fiber and wood veneer composite materials (outside), layer of rock wool insulation and bamboo OSB (inside). Lightweight steel frame					

(continued)

Table 2 (continued)

Construction technologies (*OmniClass Table 21*)				State		Levels of innovation		
Code	Element	Code	Description	Current	Alternative	Low	Intermediate	High
		21-02 10 20 E	Polystyrene panels with reinforcing steel and concrete pured on site (both for flat and inclined solutions)					

Source elaboration of the authors

instance, the International Network for Bamboo and Rattan (INBAR) is testing—with promising results—the use of local bamboo as construction material, representing a novelty for Mogadishu.

The second paradigm involves the shift from manual to automated or prefabricated construction processes as a key lever for introducing advanced sustainable technologies in the current construction practices. The adoption of automated machineries and the employment of prefabricated solutions, precast at different levels (from the single product, e.g., brick, to the whole solution, e.g., wall), have also benefits in terms of streamlining construction processes. From an economic point of view, shorter construction timeframes imply a reduction in construction costs. Focusing on social impacts, it is important to stress that if on the one hand, this scenario entails a reduction of employment, on the other hand, it allows responding to a greater share of housing demand. Nevertheless, the adoption of fully automated machineries involves further implications to be considered, such as the high purchase cost of equipment and the need of high skilled workforce. In particular, the latter implies the employment of specialized foreign technicians or the activation of specific training courses for local workers.

The third shift—from "doing" to learn-by-doing and cross-fertilization—entails the training of the local workforce at different levels (e.g., workshops, internships, and professional courses). Training can be provided by local companies but also through the cross-fertilization between local and foreign companies, with the aim of introducing new concepts, approaches, practices, techniques and tools within current Mogadishu practices. The key role of training is also recognized by the United Nations, which in the last years supported several international and national initiatives (UN 2014; FGS 2019; United Nations 2017), taking advantage of both cross-fertilization (collaboration and co-operation) among construction companies (local and not) and training of the local workforce. These initiatives set the ground for the creation of solid partnerships among companies as well as the creation of joint ventures, improving skills, know-how and reaching competitive advantages. Hence, the training of the workforce is meant as an opportunity to increase the added value and competitive advantage of local companies, enhancing the overall quality of the local construction sector.

4 Qualitative Assessment of Alternative Technological Solutions for Mogadishu

The three above-introduced paradigm shifts set the ground for the development of an information support tool, able to sustain the construction stakeholders in including, according to a holistic approach, the topic of sustainability (not only economic, but also environmental and social) within their decision-making processes toward the

identification and implementation of affordable and sustainable construction solutions. In particular, the present paragraph proposes a tool for supporting the identification and assessment of appropriate construction solutions in the context of emerging countries, improving the variety of technologies toward more sustainable alternatives. Accordingly, with the results of the on-site surveys with local stakeholders, the objective is to provide a simplified qualitative tool, useful for increasing the awareness of the key role of some sustainability issues, consisting of a basic set of indicators and related qualitative measurement criteria to fill information gaps facing the scarce availability of accurate and reliable quantitative data.

The topic of the multi-criteria tool to assess sustainability aspects is not new in literature. In recent years, several field experts have proposed methodologies and multi-criteria tools to conduct sustainability assessments, focusing on one or more pillars of sustainability, operating at different application scales (micro/ macro) with different interests, intentions and purposes (Grubert 2017; Ren et al. 2018; Khan and Kabir 2020; Streimikiene et al. 2020; Akhanova et al. 2020). However, due to the particular context of the developing countries such as Somalia, with particular reference to the unsteady nature of the city of Mogadishu, it is necessary to carry out some simplification actions, taking into consideration the current lack of official data sources and reliable context information. Therefore, the proposed tool aims to include all three pillars of sustainability, according to a Triple Bottom Line (TBL) approach (Rycroft et al. 2019; Janjua et al. 2020), while offering a simplified method with basic indicators assessed qualitatively. In fact, the objective of the tool is to find a balance between the three pillars of sustainability and not to weigh the indicators to reach a final grade. The tool aims to support decision-makers in analyzing the performance of each construction solution with respect to the proposed indicators, without providing a quantitative comparison of the marks. Furthermore, it follows a principle of gradualism, thus the tool can be enriched based on the new data and information that will become available over time.

Hence, the tool is based on a set of key indicators, divided into three sub-sets according to the three pillars of sustainability (economic, environmental and social), taking as its scope the technological solutions and the related underlying production, logistics and construction processes (Atta et al. 2021).

The complete list of indicators (Table 3) is developed starting from the review of documents available in the literature, including scientific articles (Wallbaum et al. 2012; Pullen et al. 2010; Ganiyu 2016; Shama and Motlak 2019; Tupenaite et al. 2017; Wu and Wu 2012) but also business white papers and NGOs reports (UN-Habitat 2019a, b; CAHF 2020).

Afterward, for each sub-set, the most suitable indicators for the specificity of the application context of emerging countries are selected from the list (Table 3) and thereafter validated by a multidisciplinary panel of academic experts and local professionals in the field. In particular, the academic experts belong to several disciplines, including Technology of Architecture, Sustainable Architecture, Urban Planning, Economics and Management Engineering. For what concerns the construction

Table 3 Complete list of key indicators for sustainability

Pillar	Key indicators
Economic sustainability	Cost of raw materials
	Cost of production machineries
	Sell price of product
	Cost of material transport
	Cost of material storage site/s
	Cost of construction machineries
	Cost of labor for construction
	Cost of energy and utilities in construction
	Economic share of solution on building sell price
	Cost of procurement/distribution
	Cost for maintenance/replacement processes
Environmental sustainability	Use of local raw materials
	Use of natural raw materials
	Use of raw materials of fossil origin
	Emissions of production process (EPD)
	Emissions for material transport
	Recycled content of product
	Recyclability of product
	Presence of hazardous waste
	Durability of product
Social sustainability	Involved local workforce in construction
	Involved non-local workforce in construction
	Diffusion of local workforce training programs
	Cross-fertilization among construction companies
	Spread of local market network

(continued)

Table 3 (continued)

Pillar	Key indicators
	Local value creation for new technological solutions
	Social acceptability
	Health and safety in construction
	Employment opportunity

Adapted from: Atta et al. 2021

practitioners, encompass both Italian and Somali architects, engineers and construction companies active in Mogadishu, as well as trade associations and NGOs representatives. Each of the selected indicators is assessed by the panel of experts in terms of feasibility of measurement in a context poor of information, as the one that characterizes developing countries. Hence, assessment criteria—specific to the context of Mogadishu—are proposed according to a three-level reference scale (high/medium/low) for estimating economic, environmental and social indicators.

It is worth mentioning that the proposed indicators do not constitute an exhaustive set, since other relevant factors (and/or available information) may be added over time to provide a more comprehensive assessment. They have to be considered as a minimum set to be taken into account by stakeholders of the construction industry for the selection of technological solutions in order to achieve and foster sustainable development goals.

Table 4 Basic indicators and assessment criteria for economic sustainability

Key indicators		Range	Description
EC1	Cost of production machineries	High	Fully automated complex equipment
		Medium	Semi-automated equipment.
		Low	Manual equipmen
EC2	Cost of material transport	High	Long distance (extra-continental) with new and unconsolidated trade channels; or Short distance (Africa) but poor infrastructural coverage
		Medium	Long distance (extra-continental) with consolidated trade channels
		Low	Local materials (Somalia, Kenya, Ethiopia); Short distance (Africa) with infrastructure coverage
EC3	Cost of construction machineries	High	Fully automated complex equipment
		Medium	Semi-automated equipment
		Low	Manual equipment

(continued)

Table 4 (continued)

Key indicators		Range	Description
EC4	Cost of labor forconstruction	High	Construction process characterized by short timeframe, automated equipment and specialized workers at high hourly rate
		Medium	Construction process characterized by medium timeframe, semi-automated equipment and non-expert workers at low hourly rate
		Low	Construction process characterized by long timeframe, manual equipment and unskilled workers at low hourly rate

Source Atta et al. 2021

Although the economic aspects are already the driving force of the construction industry, they are here conceived from a broader perspective, considering the entire life cycle, for supporting the shifting from a short-term vision to a long-term vision. In this way, the core is not limited to the production and construction phases, but goes beyond the operational and end-of-life phases, thus taking into account the whole building process. Hence, in Table 4 two of the economic sustainability indicators (EC1 and EC3) concern the costs incurred for purchasing and operating the machineries adopted during the manufacturing and installation of the technological solutions. Both cost of production machineries and construction machineries are assessed according to the degree of automation of the equipment used during building processes, ranging from manual, semi-automated and fully automated. Another indicator refers (EC2) to the cost of material transport from the production plant to the construction site. Given the complexity of the issues, it is evaluated by a combination of different factors, including the geographical distance (from African countries or extra-continental), the features of market channels (consolidated or unconsolidated) and the infrastructure coverage (poor or sufficient). Finally, the cost of labor for construction (EC4) is assessed by matching the timeframe of the construction process (short, medium or long), the type of equipment (manual, semi-automated or fully automated) and the skills of the involved operators (non-expert or specialized).

The proposed environmental sustainability indicators (Table 3) cover the whole product life cycle and, in particular, the production phase (e.g., use of raw materials, emissions of manufacturing process, recycled content), use phase (e.g., durability of product) and end-of-life phase (e.g., recyclability of product, generation of hazardous waste). Among them, four indicators are emphasized as particularly relevant and suitable for a qualitative assessment of the technological solutions (Table 5). Two indicators examine the composition of the product, in terms of the use of raw materials locally sourced (EN1) and resources from fossil origin (EN2). They are both assessed as a share of the whole construction product, ranging from no content to low–medium and medium–high content. Furthermore, the focus is on the emissions derived from

Table 5 Basic indicators and assessment criteria for environmental sustainability

Key indicators		Range	Description
EN1	Use of local raw materials	Medium–high	The solution consists entirely of local raw materials
		Low–medium	The solution is partially made up of local raw materials (only at component level)
		No	The solution consists entirely of imported materials, without use of local raw materials
EN2	Use of raw materials of fossil origin	Medium–high	The solution consists entirely of fossil origin materials
		Low–medium	The solution is partially made up of fossil origin materials (only at component level)
		No	The solution does not contain fossil origin materials
EN3	Emissions for material transport	High	Long distance (extra-continental) and use of means of transport by sea and road
		Medium	Medium distance (Africa) and use of means of transport by road
		Low	Short distance (Somalia, Kenya, Ethiopia) and use of means of transport by road
EN4	Recyclability of product	Medium–high	The solution is potentially fully recyclable
		Low–medium	The solution is partially recyclable (only at component level)
		No	The solution is not recyclable

Source Atta et al. 2021

material transport (EN3), considered as a combination of the distance between the production plant and the construction site and the used means of transportation (via road or sea). Lastly, promoting closed loop technological solutions, the last indicator pertains to the end-of-life scenario, with reference to the recyclability of products (EN4), ranging from not recyclable to partially or fully recyclable.

The selected social key indicators (Table 6) are useful to promote the social development of the local construction industry. In fact, the first indicator concerns the amount of local workforce involved during the construction process (SO1), looking at the country of provenance of the construction company (local or foreign). The second indicator regards the spread of workforce training programs at the local level (SO2), depending on the presence of educational programs and on the related offerings for enhancing labor skills (from apprenticeship and internship to specific training courses and academies). The third indicator refers to the cross-fertilization among construction companies (SO3), evaluating the level of collaboration and interplay between local and foreign companies (none, limited and occasional or high and constant). Finally, the fourth indicator focuses on the uptake of local market networks

Table 6 Basic indicators and assessment criteria for social sustainability

Key indicators		Range	Description
SO1	Involved local workforce in construction	Medium–high	Completely local workforce (Mogadishu construction companies)
		Low–medium	Limited number of local workforces collaborating with foreign companies
		No	Completely non-local workforce (solution imported by foreign construction companies)
SO2	Diffusion of local workforce training programs	Medium–high	Company offers academy with workshops, training courses, apprenticeship/internship, etc.
		Low–medium	Company offers apprenticeship/internship courses
		No	Company does not offer training courses
SO3	Cross-fertilization among construction companies	Medium–high	Non-local company in collaboration with local companies for construction works
		Low–medium	Non-local company with occasional collaboration with local workforce
		No	Absence of cross-fertilization between companies
SO4	Spread of local market network	Medium–high	Product sellers in Somalia, Kenya and Ethiopia
		Low–medium	Product sellers in Africa but not in Somalia, Kenya and Ethiopia
		No	Lack of local sellers of materials/products/solutions

Source Atta et al. 2021

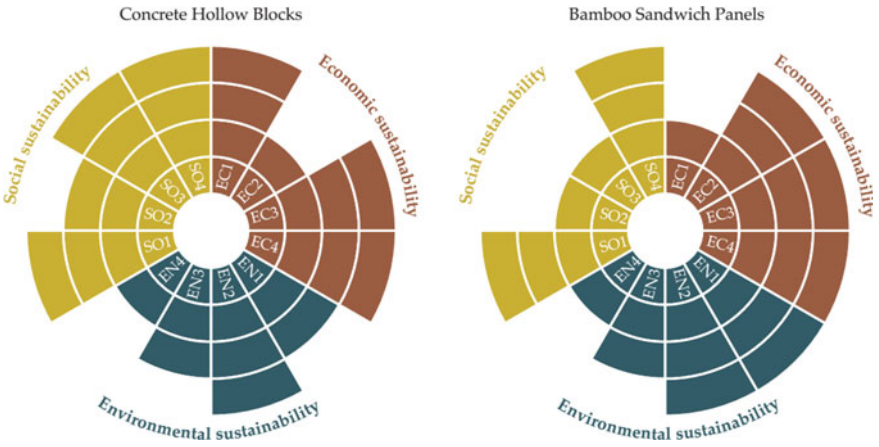

Fig. 1 Example of application of the proposed tool to assess alternative technological solutions for Mogadishu according to a TBL perspective -Diagrams. *Source* Atta et al. 2021

(SO4) and it is assessed in relation to the availability and geographical location of product sellers (East Africa or out of it).

By way of example, Fig. 1 shows the application of the tool on exterior walls. In particular, the assessment addresses two alternative solutions, namely blocks and panels, comparing a concrete hollow block wall and a bamboo sandwich panel wall.

The concrete hollow block wall represents a traditional technology. In current practices, the blocks are made up of cement that is mostly imported from Turkey and China. However, it is reasonable to envision the development of a local supply chain (Atta et al. 2021), exploiting existing local resources. Accordingly, the use of local cement allows an increase in local small–medium businesses, thus strengthening local supply chains.

The bamboo sandwich panel solution, on one side, reduces transport costs, as it is locally sourced, and it considerably limits the construction timeframe, resulting competitive in economic terms. However, on the other side, this solution decreases the number of needed workers, reducing the local occupation of operators in building construction.

On the basis of these premises, the estimation of the indicators is performed considering the equal performances of both solutions regarding thermal capacity, maintenance costs and useful life (Atta et al. 2021). The data sources needed to evaluate indicators include technical sheets of products, producer websites and online resources (e.g., performance reports, case studies, etc.) as well as, when needed, interviews with manufacturers and construction companies.

It is important to highlight that the diagrams in Fig. 1 provide for both solutions an overview of the indicator assessment according to the three pillars of sustainability, not intending to identify the best technological solution but providing a qualitative performance analysis.

5 Affordable Sustainable Buildings in Mogadishu: Considerations and Future Perspectives

Within the context of an emerging country, the proposed tool represents an attempt to support the different stakeholders of the construction supply chain to follow a more holistic approach, gaining a systemic vision of sustainability issues through a triple bottom line perspective. The tool is characterized by its simplicity of use. It is not intended to be a rigid theoretical tool that risks being of little use in a fragile and dynamic context such as that of developing countries. Contrarily, the tool is designed to be flexible and adaptable to the peculiarities of the application context, following a bottom-up development approach to properly respond to local needs, which emerged from the dialogue with local stakeholders.

The tool[7] addresses different categories of stakeholders with diverse expected benefits, including project designers, construction companies, promoters and investors, as well as public policymakers. In particular, the tool supports designers and construction companies to enlarge the range of offered technological solutions, opting for local materials and inclusive construction processes (including local workforce training) toward the provision of sustainable and affordable buildings. Moreover, the tool also supports promoters and investors to gain a wider awareness of sustainable construction technologies by critically assessing their overtime impacts, considering not only the economic aspect, but also social (e.g., local employment) and environmental (e.g., emissions and pollution related to the supply and logistics of materials/products) issues, according to an all-encompassing vision. Lastly, by supporting the integration of social and environmental sustainability aspects within current strategic development plans, the tool assists policymakers to foster local businesses and local employment, reducing social disparities toward a more sustainable growth of the country.

Targeting these benefits, it is important to stress that the proposed tool does not intend to replace the decision-maker by identifying the best solution, instead, its purpose is to unveil the "black box" that currently underlies decision-making processes in the construction field by analyzing and assessing alternative construction technologies according to a triple bottom line approach. Furthermore, the tool is strongly affected by information accessibility and availability of the specific application context. Indeed, the success of its application is conditioned by the presence of reliable information sources and updated accurate data. Therefore, a structured and systematic approach to information sources management and data collection is necessary—representing almost an enabling prerequisite in the context of developing countries—to set the ground for proper integration of environmental and social issues within current choices of construction solutions.

[7] The propose tool can be integrated within an IT system or developed as a simplified Excel file, according to the level of complexity and digital maturity of the particular context of application.

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Estimation of Construction Costs: From Technological Solutions to the Settlement Scale

O. E. Bellini and D. di Summa

Abstract The problem of construction cost control, together with the availability of land, is the most important issue for the realization of affordable housing within the Mogadishu area which is therefore limited in its development. The research carries out an estimation of construction costs, overcoming information inaccuracy and ranging from building to settlement scale. The scarcity of data regarding the realization of housing settlements has represented one of the main hurdles for the research. Hence, the Bill of Quantities (BoQ) methodology was adopted as a tool to appraise the overall expenses for the three different housing typologies investigated by BECOMe.

Keywords Economic aspects · Construction cost · Technological solutions · Tool · BoQ methodology

1 Barriers to the Economic Estimation of Current Construction Costs

High construction costs, together with the scarcity of land, are the strongest barriers to the realization of affordable housing in the Mogadishu area and represent, at the same time, a limit to the development of the entire zone. Comparing the monthly local salary, which amounts to US$ 225 (after taxes), as outlined by a survey of the Center for Affordable Housing Finance (CAHF) (CAHF 2018), with the cheapest housing price in Somalia, that amounts to US$ 100,000 (CAHF 2018), it is possible to outline the problem of affordability that must be faced by the local government. This is to respond to the housing demand by providing solutions that are not only economically accessible, but also characterized by quality standards that are appropriate for the Somali context. Moreover, the average monthly rental cost for a house, which amounts to US$ 769 (CAHF 2017a, b), is significantly higher than the monthly income previously mentioned, with the consequence that nowadays only a small

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percentage of the Somali population has the possibility of accessing a house. In such a context, the main problem is the containment of rents and consequently the containment of construction costs.

Some considerations about the cost items on which to act are necessary. Kayizzimugerwa (2013) stated that the construction cost itself represents the main part of the overall housing prices in Africa. In Kenya, for example, they constitute 60% of the total amount, while land acquisition and infrastructures make up another 20%. Besides, within the continent, these percentages can vary substantially: by way of example, South Africa's construction cost amounts to 38% of the overall housing cost. This uncertainty within the country is also due to endogenous factors: the cost of a 40 m^2 house in a suburb of Kenya, is quite different from a similar-sized house in Niger. This is because of the differences in terms of climate, availability of materials and the various levels of efficiency of construction companies. In this framework, the dependence of the local construction sector on supplies from abroad, whose prices are deeply affected by geopolitical factors, must be emphasized.

Despite the peculiarity of the Somali context, the estimation of construction cost is anyway always a complex exercise due to the high uncertainty of the design and construction processes. Additionally, clients and contractors are very often informed about the technical specification of the project too late during the design and construction building phases. Other main causes that make the estimation process challenging are: (1) the data used to estimate the bid; (2) the absence of a national database for prices to rely on; (3) the lack of experienced estimators; (4) the presence of honest mistakes. A study developed by Aljohani et al. (2017) also identified the quality of the tendering documents as a cause of cost overrun in thirteen out of seventeen assessed case studies. According to the authors, this framework is due to: (1) the involvement of the designer as a consultant; (2) the communication gaps occurring between the contractor and the designer; (3) the scarce accuracy in the detailed drawings; (4) the lack of coordination between the stakeholders. Moreover, another problem is represented by the inadequate material management. Patel and Vyas (2011) defined the materials management as "the system for planning and controlling all of the efforts necessary to ensure that the correct quality and quantity of materials are properly specified in a timely manner, are obtained at a reasonable cost, and are available at the point of use when required". Thus, the consequences of inappropriate material management are not only the late delivery, but also the risk of purchasing at higher prices. Besides, if the number of construction project in a localized area is consistently increasing, the local market will not be able to satisfy the demand for building materials with a consequent increase in the material prices. For this reason, the fluctuation of the latter, as well as the inappropriate material management, were identified as one of the main causes of cost overrun in most of the assessed case studies. Regarding the Somali context, the interviews with local stakeholders, together with the review of international reports, (CAHF 2018; UN-Habitat 2016; IIED 2019) outlined that most of the materials are imported from China, Turkey and India with continuous growth of the sector of finishing components and materials such as tiles, windows, doors, plumbing, sink and toilet. Other construction materials such as cement, concrete, steel, wood or ceramic are imported from foreign countries through international trade routes (Trade Map a-b, accessed in 2021a, b).

However, the Somali construction market, considered as also comprehensive of the infrastructures, is seen as a vital driving force for the development of the economy of the country due to the need to secure not only a place to shelter, but also adequate means to move (Omar et al. 2020; Sheikh et al. 2020; Uranga 1999). Additionally, not only the pronounced variability of the rates, but also the absence of specifics referred to projects like the one assessed within this research, represent a limit to get reliable data. This critical issue is also clearly outlined in the work by Omar et al. (2020) in a review of the Somali construction sector. There it is reported that most of the projects still under development, or already completed in the recent past, are mixed-use building projects with offices, apartments, hotels, educational facilities, and commercial spaces, completely different from the BECOMe case study. To this, it must be also added the heterogeneity of the construction sector. In this regard, Omar et al. detailed both the private and the public sectors into which the Somali construction industries are divided (Omar et al. 2020). More specifically, the public sector is mainly focused on infrastructure and road works supported by UKaid, the Ministry of foreign affairs of Denmark and the Kingdom of the Netherlands (Ali 2012). On the other side, the private sector is characterized by a large number of local and international private companies with different classifications ranging from constructing to consulting. What above mentioned, together with the absence of building codes and regulations (with the consequent construction industry self-governed by building owners and construction stakeholders) (Omar et al. 2020), makes the construction cost estimation activity really challenging. Therefore, since the latter is a key factor to set up a proper investment plan to realize an affordable settlement like BECOMe proposal for Mogadishu. This research investigated the use of the Bill of Quantities (BoQ). It is a standard technique worldwide used to estimate the construction expenses by adding the overheads to the sum of the product of quantity and unit price, for all the developed activities. The methodology was already employed in the African context as for the Heliwa IDP housing scheme, developed in 2019 (UN-Habitat 2020) and in the city of Addis Ababa. In the last case, it was used for the construction of large scale standardized condominiums, enabling, at the same time, not only to better manage the contracts with the involved stakeholders, but also to continuously check the related costs throughout the work execution (Kayizzi-mugerwa 2013). The BoQ technique is here used to overcome all the difficulties previously mentioned as better detailed in the next chapters.

2 Information Sources on Current Technological Solutions in Mogadishu

The lack of data regarding the construction of housing settlement like the BECOMe proposal, represents one of the main problems for the construction cost estimation. To overcome this critical gap, as a first step, the report by CAHF on Benchmarking

Housing Construction Cost Across Africa (Gardner and Pienaar 2019) has been investigated to evaluate most of the construction cost indicators in Africa. The benchmark chosen is a house of 46 m^2 characterized by two bedrooms, one bathroom, and a 9 m^2 balcony, with a total built area of 55 m^2 built on a plot of 120 m^2. The house is provided with the necessary facilities like the plumbing system as well as the electricity supply and the road connections. The cross section and the layout of the house are presented in Figs. 1 and 2, respectively.

For this specific case study, it is possible to observe that construction costs are characterized by a pronounced variability of over two and half times among the thirty African cities. More specifically, the highest cost of US$ 63,241 is ascertained in Nairobi (Kenya), while the lowest is observed in the case of Kitwe (Zambia) with US$ 24,971 in total. However, since the city of Mogadishu is not included in the CAHF report, it is necessary to make some considerations on the most comparable cities, i.e. the closest ones. These are Nairobi, Mombasa, Kampala, Wakiso, Arusha and Dar Es Salaam which registered US$ 1,149/m^2, US$ 836/m^2, US$ 958/m^2, US$ 694/m^2, US$ 509/m^2 and US$ 486/m^2 of construction costs, respectively. Therefore, to understand such differences among the latter, the overall cost is broken down into a number of sub-components/elements of construction: (1) land; (2) infrastructure; (3) compliance costs; (4) construction costs and (5) other development costs. This is also because, to build a more reliable cost database, it is important to consistently rely on what is included in an element or unit, then allowing to use the unit rate benchmark to the quantities of the project being evaluated. This analysis allows to start a robust investigation of the costs of building houses across the continent and to understand, at the same time, the specificity of the African construction market. Table 1 presents the breakdown of construction costs just for the case of Nairobi,

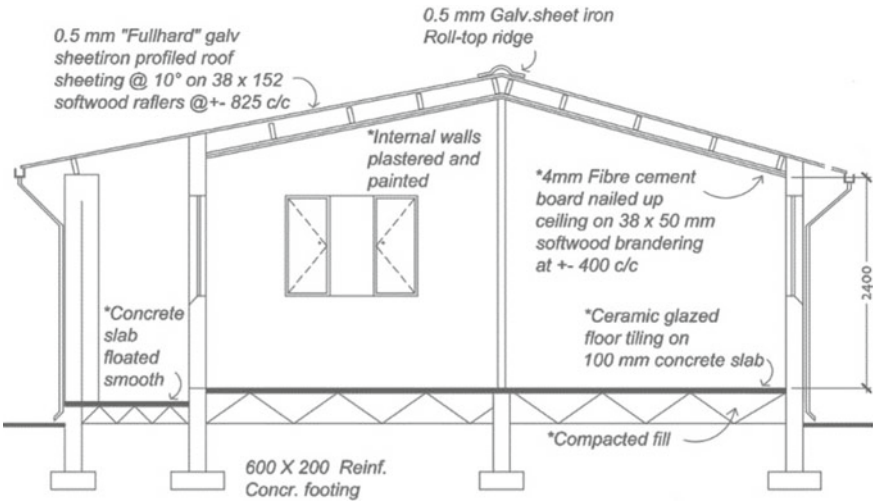

Fig. 1 Cross section of the benchmark house according to Gardner and Pienaar. *Source* Gardner and Pienaar (2019)

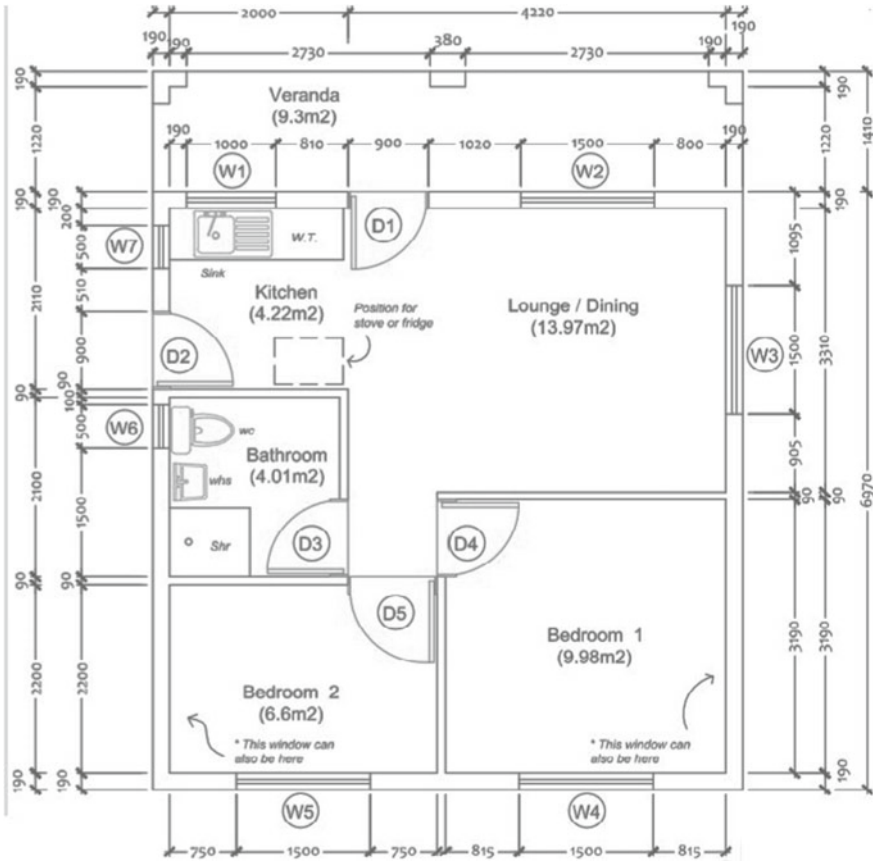

Fig. 2 Layout of the benchmark house according to Gardner and Pienaar. *Source* Gardner and Pienaar (2019)

Table 1 Breakdown of the construction costs for the case of Nairobi redrafted according to Gardner and Pienaar. All the costs are reported in US$. *Source* Gardner and Pienaar (2019)

City	Land costs	Infrastructure costs	Compliance costs	Construction costs	Other development costs	Total
Nairobi	$14,826	$9,142	$1,385	$26,186	$11,702	**$63,241**

Source Gardner and Pienaar (2019)

the geographically closest city to Mogadishu assessed in the CAHF report. Table 2 provides further detailed breakdown of labour and material costs for the same city.

Table 2 Detailed labour and materials breakdown of construction costs redrafted according to CAHF, Gardner and Pienaar. *Source* CAHF (2020), Gardner and Pienaar (2019)

	Works breakdown	Price (US$)
"Gross" shell labour	Foundations	638
	Ground floor construction	904
	Superstructure walls	1,489
	Roof construction	372
	Roof covering	266
	Roof sundries	213
Labour: house finishes	General finishes	88
	Finishing carpentry	34
	Fittings	63
Labour: service installation	Electrical installation	400
	Plumbing and drainage	1,001
	Water heating	97
Materials: gross "shells"	Foundations	170
	Ground floor construction	152
	Superstructure walls	330
	Window & door frames	193
	Roof structure	102
	Roof covering	374
	Roof sundries & rainwater	629
Materials: house finishes	Plaster & floor	242
	Ceilings	309
	Wall tiling	107
	Painting	800
	Floor finishes	401
	Finishing carpentry	168
	Fittings	230
Materials: service installations	Electrical	479
	Plumb & drain	210
	Hot water	429

Source CAHF (2020), Gardner and Pienaar (2019)

With regard to the materials, their incidence constitutes the largest proportion of construction costs followed by labour and indirect cost. The cost of the materials is almost constant across the African countries even though there is a significant variation in terms of impacts on the overall expenses. The data shows that its incidence is included between 25% and 35% of the total unit cost when land infrastructure and labour are also taken into account. Excluding land, service and

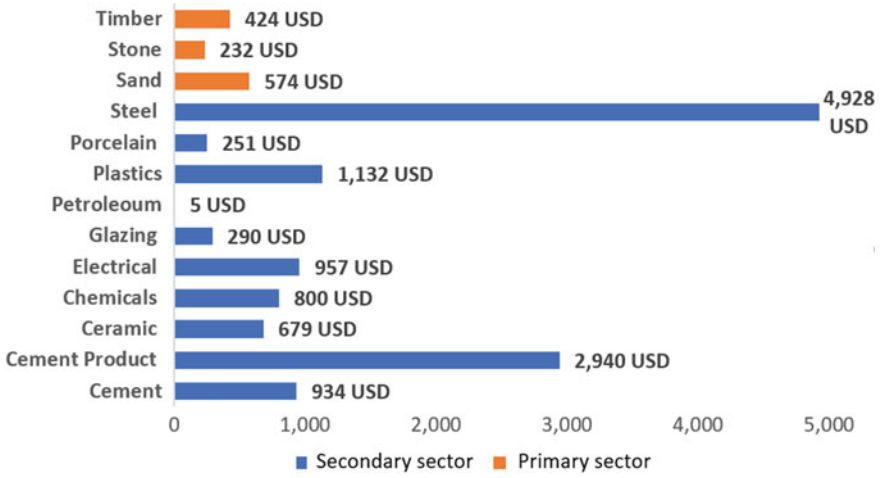

Fig. 3 Building materials costs per material type for the case of Nairobi redrafted according to Gardner and Pienaar. *Source* Gardner and Pienaar (2019), CAHF (2020)

other costs, the percentage is comprised between 41% as in the case of Monoravia (Liberia) and 75% of building cost, as in the case of Yaounde (Cameroon), with most of the other countries that registered a value between 50 and 60% (Gardner and Pienaar 2019). Therefore, to better understand the housing economic value chain, the composition of the materials cost was analyzed for the benchmark house. Only a few material cost components come from the primary sector (such as agriculture, mining and quarrying) due to the use of sand, stone and raw timber, while the more relevant contribution is due to steel and manufactured steel products, followed by cement-based materials. This overview clearly shows which building materials must be reduced in their use in favour of different choices more in line with the economic affordability goal for the construction of settlements in Mogadishu. Figure 3 presents an overview in this regard.

Then, the second step of the research consisted of a market survey for the specific case of Mogadishu to create a database to be used for the appraisal phase. In this regard, mainly due to the scarce availability of BoQ for similar projects developed within the city, a form to fill in was sent to the biggest construction companies identified as operative in the African market with a consolidated know-how in the field of the affordable housing sector. There it was asked to indicate, according to their know-how, not only the most commonly used technologies, but also the cost for each work category later summarized in Table 7. Furthermore, since the research investigated also the use of innovative components such as self-bearing panels with a core in polyethylene or wood fibre, several manufacturers with an acquired expertise in the area were contacted as well (Del Pero et al. 2021). Table 3 gives more detail about the companies involved in the scope of this research.

With regard to labour, whose cost has also been estimated, it must be stressed that within Mogadishu area, most of the activities, are still manual due to the lack of proper

Table 3 List of the companies contacted for the scope of the research

Company	Headquarter
Company n. 1	Somalia
Company n. 2	Somalia
Company n. 3	Italy
Company n. 4	Italy
Company n. 5	Ruanda

Source elaboration of the authors

machinery. The related costs depend on their nature, intensity and complexity and whether they are skilled or not (Somalia Manual Labor cost, accessed in 2021). Table 4 reports the range of labour costs.

Moreover, since the use of the most traditional technological solutions is here compared to the potential use of the self-bearing panels (with a EPS or wood fibre core), it was asked to the manufacturers to appraise the realization of a local production plant to ensure the employment of the local manual workers and more qualified personnel trained at the Mogadishu University which counts on faculties of Architecture, Civil and Electronic engineering (University of Somalia, accessed in 2021). Table 5 presents the quote received for the production of EPS self-bearing panels,

Table 4 Range of the labour costs according to (Somalia Manual Labor cost, accessed in 2021)

Mogadishu—Type of labour	Daily rate (US$)
Daily general worker (semiskilled)	10–15 daily
Daily general worker (unskilled casual worker)	10–15 daily
Skilled labour	10–15 daily

Source elaboration of the authors

Table 5 Quote for the realization of a self-bearing panels plant in Mogadishu

Plant components	Price
– Polystyrene block production plant – Panel production plant	2,105,460 €
– Installation and start-up – Software and training packages – Additional items (set of raw material for first testing: intranet network etc.) Accessories Plant networks	488,240 €
Total prices ex. works	**2,593,700 €**
Transport charge and insurance	**42,142 €**
Total price CIF (cost, Insurance, Freight) port of Mogadishu, Somalia	**2,635,842 €**

Source elaboration of the authors

where the machinery, the equipment and the support of the specialists during the start-up phase, as well as the training of the local personnel in a period of 6 months, are included. The plant there presented is supposed to be characterized by a nominal capacity of 2,000 m^2 per 8 h of shift. The latter must be intended as an example since the possibility to integrate more sustainable cores, like the wood fibre, would inevitably lead to some changes in the production process which BECOMe research has only begun to analyze, assessing the technical feasibility (Del Pero et al. 2021). Therefore, the use of a core different than the EPS could lead to cost variations in comparison to those of Table 5.

3 A Tool for Assessing Infrastructure and Building Construction Costs

After having developed a proper market survey, the BoQ methodology was then adopted as a tool to appraise the overall expenses since it seemed the best way to overcome all the difficulties previously mentioned, such as the variability of prices due to endogenous and exogenous factors. Therefore, following this approach, the construction was divided into its constituent elements, summing the costs of each part to obtain an estimation for the whole work. The potentiality of the BoQ methodology is also stated by Lee et al. in a work where by analyzing each part of the quantity surveying activity, they highlighted how, even if it is an estimation, it becomes a tender document and for which the contractor agrees to carry out the work according to what described into the bill (Lee et al. 2021). The methodology is then here intended as a cost control tool as well, for both the owner and the contractor. As matter of fact, cost estimation could be useful for owners to plan long-term actions in time, allowing costs to be regularly monitored until the completion of the work while the contractor could benefit of it to estimate the budget needed for the construction financing.

Moreover, proper cost predictions allow us to know in advance the reachable target of the population with those costs and it could be used as a feasible and practical approach to be considered by governments undertaking standardized housing construction. The BoQ plays a key role also during the tendering phase in a context as complex as the Mogadishu one, reason why it was used for the scope of this research. In fact, each contractor, bidding for a project, could estimate the cost of the work with a minimum effort and giving rise to the fairest type of competition (Lee et al. 2011) thus potentially opening a new phase for the construction market in Africa and attracting more interested stakeholders.

As usually done, the procedure was divided into two main steps: (1) the measurement of the dimensions and the contemporaneus analysis of the technical characteristics of the individual components; (2) the compilation of the BoQ. In this specific case, since not all the needed prices were obtained through the market survey, it was necessary to develop a preliminary price analysis for the case of "External walls: 200 mm thick non-load bearing walls of cement blocks" and "Internal walls:

Table 6 Scheme of the price analysis used for the case of 1 m^2 of wall made with 200 mm thick blocks

Category	Description	Unit	Quantity	Price ($)	Total ($)
Labour cost	General worker	h	0.5	1.87	0.94
Materials	200 mm thick blocks	m^2	1	15.00	15.00
Total					**15.94**

Source elaboration of the authors

100 mm thick non-load bearing walls of cement blocks". The scheme reported in Table 6 was adopted. This step could be defined as the analytic study necessary to define a new construction cost broken down into its components. To define the price, it was, therefore, necessary to calculate the labour work, the materials and the possible rental of specific equipment. The materials cost was considered as inclusive of the purchase price, and the transport to the worksite. More specifically, the total cost was obtained by adding the costs of the needed materials for 1 m^2 as well as the cost of a general worker supposed to involve half an hour to realize 1 m^2. Then, all the prices, obtained through the price analysis, as well as the market survey, were used for the estimation phase. Table 7 details all the rates collected and used within the BECOMe research.

4 Assessing Settlement Construction Costs

Before assessing the construction costs obtained for the three different typologies investigated in the framework of the BECOMe research, it must be highlighted that the affordable housing scheme was adopted as the main goal to increase the percentage of the Somali population able to pay the housing rent. Inline with what was stated in 1.2, the aim was to pass from a value of 4% as outlined in a review of the African housing finance market (CAHF 2020) in 2020 up to, at least, 25%. This 25% corresponds, according to the same review document, to the part of the population which receives an annual income between US$ 3,600 and US$ 5,000. Therefore, considering an average value of US$ 4,300, taking into account a residual of 30%, it was assumed that 1,290$ could be designated for home purchase/rent. The latter corresponds to a maximum purchase price of $500/$m^2$ assuming an average size apartment of 60 m^2 (in the case of single income households), or a 120 m^2 house (in the case of larger families with multiple incomes). The calculation was done based on a 25-year loan (Del Pero et al. 2021). Table 8 gives an overview of the mortgage situation for most of the African countries highlighting how low is, nowadays, the mortgage demands in Somalia, probably due to the economic impossibility of buying a house because of the high prices.

Hence, given the importance of obtaining reliable construction cost estimations, after obtaining all the rates listed in Table 7, it was possible to calculate the overall

Table 7 List of the construction costs obtained for the scope of the research

Urbanization works	Excavation under normal ground conditions	6.00	m^3
	Backfilling works using materials available in the work site area	6.00	m^3
	Ground levelling and soil compaction	13.00	m^2
	Road surfacing work	102.00	m^2
	Water system pipeline—supply and installation	10.00	m
	10 hp pump—supply and installation	2,000.00	item
	Wastewater system pipeline—supply and installation	10.00	m
	Septik tank—supply and installation	7,700.00	Item
	Electrical system—connection to public supply	10.00	m
	Electrical cabinet—supply and installation	200.00	Item
Foundations and superstructure	Casting of concrete for foundations	145.00	m^3
	Casting of concrete for superstructure	171.10	m^3
	Casting of lean concrete	130.00	m^3
	Supply and installation of wooden formworks for casting activities	15.00	m^2
	Concrete vibrator	8.00	m^3
	Supply and installation of steel reinforcement bars for foundations and floors	88.00	Quintal
	Supply and installation of steel reinforcement bars for superstructure, including stairs	103.84	Quintal
	External walls: 200 mm thick non load bearing walls of cement blocks	15.94	m^2
	Internal walls: 100 mm thick non load bearing walls of cement blocks	13.44	m^2
	Supply of self-bearing precast panel with polystyrene core	11.43	m^2
	Supply of self-bearing precast panel with wood-fiber core	14.17	m^2
Finishing works	Plaster application	8.50	m^2
	Painting works	7.00	m^2
	Supply and installation of floors	15.00	m^2
	Waterproofing works	8.00	m^2
	Supply and installation of internal doors	250.00	Item
	Supply and installation of external doors	350.00	Item
	Supply and installation of windows	90.00	Item
	Supply and installation of corrugated sheet for roofing	8.00	m^2
	Steel galvanized scaffolds	10.00	m^2
Systems	Water pipeline—supply and installation	10.00	m

(continued)

Table 7 (continued)

	Supply and fixing of tank for toilet basin	60.00	Item
	Supply and fixing of hand wash basin	150.00	Item
	Supply and fixing of the shower tray	50.00	Item
	Supply and installation of the toilet	150.00	Item
	Water tank—supply and installation	220.00	Item
	Hp pump—supply and installation	350.00	Item
	Wastewater pipeline—supply and installation	10.00	m
	Intdoor electric system—wiring	12.00	m
	Electrical cabinet—supply and installation	260.00	Item
	Supply and installation of ceiling fan	50.00	Item
	Supply and installation of electrical junction box	15.00	Item
	Supply and installation of switch	5.00	Item
	Light point installation	10.00	Item
	Supply and installation of socket	10.00	Item

Source elaboration of the authors

Table 8 Mortgage lending 2020, redrafted according to CAHF

	BDI	ERI	ETH	KEN	RWA	SOM	TZN	UGA
Nr. of mortgage providers	12	1	1	33	16	3	34	5
Average mortgage term in years	10	25	18	10	15	20	20	10
Average percentage of the down payment on a mortgage if required	20%	n/a	23%	15%	30%	20%	10%	20%

Source CAHF (2020)

economic investment for each of the three typologies. Tables 9, 10 and 11 report the calculation developed for typology 1, typology 2 and typology 3, respectively. For each of them, not only to include climate-responsive solutions such as the self-bearing panels, but also to highlight which technology is more suitable for the affordability purpose, the total cost was calculated by supposing both the use of the conventional solution as well as the panel with EPS or wood fibre core. As it is possible to observe, taking as an example typology 1, the standard technological solution implies a cost of around 703 US$/m^2 including the urbanization costs. The incidence of the structure itself is assessed at around 31% with 180 US$/m^2, highlighting the need to identify alternative solutions to obtain economic savings. The urbanization charges, calculated as 13 US$ per square meter of the plot area, include the connection to the electricity grid, the water and wastewater district systems and the landscaping of the surrounding area to make it accessible to vehicles. A soil compaction, without a road pavement layer, was considered. Comparing such costs to the ones of the self-bearing precast panels with concrete and wood fibre layers, it is possible to observe an economic saving of 39% with thefinal overall expenses of 426 US$/m^2.

Table 9 BoQ developed for the typology 1

	Conventional technological solution		EPS panel		Panel with wood fibre core	
	($)	(€)	($)	(€)	($)	(€)
Excavations and foundations	9,894	8,212	9,894	8,212	9,894	8,212
Structure	26,016	21,594	11,606	9,633	14,392	11,945
Opaque envelope	5,570	4,623				
Finishes and interior works	25,222	20,935	11,714	9,722	11,714	9,722
Windows	2,000	1,660	2,000	1,660	2,000	1,660
Electric systems	2,700	2,241	2,700	2,241	2,700	2,241
Photovoltaic plant	2,400	1,992	2,400	1,992	2,400	1,992
Water and wastewater systems	2,500	2,075	2,500	2,075	2,500	2,075
Total (Including 10% of unexpected costs)	**83,934**	**69,665**	**47,096**	**35,536**	**50,160**	**41,633**
Price per m^2	**688**	**571**	**386**	**291**	**411**	**341**
Total urbanization costs (Including 10% of unexpected costs)	**1,908**	**1,584**	**1,908**	**1,584**	**1,908**	**1,584**
Price per m^2	**16**	**13**	**16**	**13**	**16**	**13**

Source elaboration of the authors

Analyzing the obtained results, according to the US$ 500/m^2 threshold previously commented, it is possible to observe how not convenient, for the affordability goal, is the use of conventional construction technologies. More specifically, for the case of typology 1, they lead to a cost of around US$ 700/m^2, which is more in line with the upper-to-middle income houses around the city. However, the use of alternative solutions like the precast panel with wood fibre insulations, with a cost assessed at around US$ 400/m^2, even including the overheads and the financial charges, ensures to better reach the target of the research. Furthermore, according to what was outlined by Del Pero et al. (Del Pero et al. 2021), this solution also guarantees better thermal performance with good indoor comfort conditions. This, in addition to the potential inclusion of spaces for small business activities (on the ground floor) together with the production of free power from solar energy, supports the holistic sustainability concept of the project. Such technologies, which can be produced in a local industrial plant, could also favour the current entrepreneurs, reducing the uncertainties of construction cost and favouring the employment of local workers. What described above highlights the potentiality of the entire BECOMe project aimed to also achieve several Sustainable Development Goals (SDGs), i.e., 3 (good health and wellbeing), 7 (affordable and clean energy), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities) and 13 (climate action).

Table 10 BoQ developed for the typology 2

	Conventional technological solution		EPS panel		Panel with wood fibre core	
	($)	(€)	($)	(€)	($)	(€)
Excavations and foundations	39,152	32,496	39,152	32,496	39,152	32,496
Structure	192,514	159,787	126,723	105,180	157,137	130,424
Opaque envelope	67,680	56,174				
Finishes and interior works	143,069	118,747	100,615	83,510	100,615	83,510
Windows	11,970	9,935	11,970	9,935	11,970	9,935
Electric systems	23,018	19,105	23,018	19,105	23,018	19,105
Photovoltaic plant	33,600	27,888	33,600	27,888	33,600	27,888
Water and wastewater systems	13,900	11,537	13,900	11,537	13,900	11,537
Total (Including 10% of unexpected costs)	**577,394**	**479,237**	**383,877**	**318,618**	**417,332**	**318,618**
Price per m²	**477**	**396**	**317**	**263**	**345**	**263**
Total urbanization costs (Including 10% of unexpected costs)	**12,227**	**10,148**	**12,227**	**10,148**	**12,227**	**10,148**
Price per m²	**11**	**9**	**11**	**9**	**11**	**9**

Source elaboration of the authors

Table 11 BoQ developed for the typology 3

	Conventional technological solution		EPS panel		Panel with wood fibre core	
	($)	(€)	($)	(€)	($)	(€)
Excavations and foundations	25,869	21,471	25,869	21,471	25,869	21,471
Structure	68,242	56,641	31,393	26,056	38,927	32,310
Opaque envelope	13,491	11,198				
Finishes and interior works	33,826	28,076	25,090	20,825	25,090	20,825
Windows	3,600	2,988	3,600	2,988	3,600	2,988
Electric systems	7,500	6,225	7,500	6,225	7,500	6,225
Photovoltaic plant	12,00	9,960	12,00	9,960	12,00	9,960
Water and wastewater systems	3,950	3,279	3,950	3,279	3,950	3,279
Total (Including 10% of unexpected costs)	**185,326**	**153,820**	**120,342**	**99,884**	**128,630**	**106,763**
Price per m²	**467**	**387**	**303**	**252**	**324**	**269**
Total urbanization costs (Including 10% of unexpected costs)	**3,816**	**3,167**	**3,816**	**3,167**	**3,816**	**3,167**
Price per m²	**10**	**8**	**10**	**8**	**10**	**8**

Source elaboration of the authors

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Appropriate Tools for Decision-Makers: Proposal of a Decisional Support System (DSS)

D. Chiaroni and L. Sgambaro

Abstract The main goal of this chapter is to present the Decision Support System (DSS) adopted in the context of Mogadishu to explain the different choices to put in place about three main issues: (i) the structure and input data, (ii) the setting of alternative scenarios, and (iii) the broadening of the perspective to include a strategic view for the decision maker. The developed DSS aims to support decision-making processes towards the affordable settlements in Mogadishu and the achievement of their long-term sustainability.

Keywords Decision support system · DSS · Input data · Contextual data · Costs · Revenues · SWOT analysis

1 Introduction

Taken the original definition of DSS (Little 1970), we refer to DSS as a "model-based set of procedures for processing data and judgments to assist a manager in his decision making". The decision maker we are supporting is sitting in a real estate company, willing to evaluate an investment in residential settlement in Mogadishu, but he/she is also sitting in a bank or investment fund, willing to understand the fit for its investment portfolio, and he/she is also sitting in a policy making position, willing to understand whether and how favourable conditions for a residential settlement have to be created or strengthened in order to impact the society.

All these decision makers have in common that they should base their initial judgment on the financial performance of the investments, measured accordingly to the traditional models for investments evaluation.

$$Payback\ period: \frac{\text{Initial Investment}}{\text{Average Net Cash Flow per year}} \text{(expressed in number of years)}$$

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The payback time is a comprehensive financial indicator to measure the attractiveness of an investment decision (characterised by "one time" costs at the beginning, followed by subsequent benefits). This is the case of a constructions: indeed, they imply a quite relevant initial spending (Moschetti and Brattebø 2016). This, in turn, should lead to returns in the subsequent marketing and operating phase. It is important to measure the time needed for the benefits to counterbalance the initial spending. Given the uncertainty of the forecasted benefits (which depend on a number of exogenous factors), a quite short payback period would make the investment more appealing (Scuderi 2019). Of course, a sensitivity analysis should be performed in order to analyse to what extent the payback time depends on possible changes in the context variables.

$$NPV: \quad -\text{Initial Investment} + \sum \frac{\text{Net Cash Flow}(t)}{(1+k)^t}$$

The payback time is not an "absolute" measure of the return of an investment, and it cannot be used to compare alternative options. Due to the fact the initial investment can vary according to the kind of technical solutions adopted), it is also important to conduct as assessment of the best alternative through the Net Present Value criterion (Christersson et al. 2015).

$$IRR: \quad \sum_t \frac{\text{Net Cash Flow}_t}{(1+IRR)^t} - \text{Initial Investment} \; = \; 0$$

The Internal Rate of Return (IRR) is an indicator used to assess the profitability of potential investments. The Internal Rate of Return is the discount rate that makes the net present value (NPV) of all cash flows equal to zero. Therefore, IRR is the annual rate of growth expected to be generated by an investment. An investment is typically considered economically feasible when the Internal Rate of Return (IRR) is equal or above the Weighted Average Cost of Capital (WACC), i.e. the cost of the capital (both equity and debt) used for sustain the investment. Hence, a project is considered profitable when its IRR is greater than its cost of capital.

Once the financial performance of the investment is assessed and the decision maker is ensured there is a fundamental rationale for the investment itself (or this rationale can be found by acting on some of the available levers, e.g. incentives in the case of policy makers) a broader strategic evaluation of the investment should be taken into account.

Indeed, even if in the '90s, DSS are supposed to be semi-automatic tools in some cases able to "take the responsibility" of the decision (Sauter 1997). Current understanding is that "work system concepts might be applied to understand decision support in real world settings, and decision support can come from many sources other than technical artifacts such as DSS" (Alter 2004).

2 Setting the DSS Structure and Input Data

The first challenge to be solved refers to the selection of input data and their coherent structuring in a business plan like manner, i.e. identifying and matching cost components and revenue components and "contextual" components.

In a context characterised by high volatility and low reliability of information, like the one of Mogadishu, the main point was to complement and triangulate the information collected with a number of direct interviews performed to local players (end users, companies).

There are three main input categories to the business plan, as mentioned above:

1. "Contextual" data
2. Costs
3. Revenues.

In the following paragraphs each category will be described.

"Contextual data"

This category includes different data related to the setting of the context where the investment is made, such as data related to the extension of the project area and the area dedicated to residential, "business" and "welfare" buildings, etc., as represented by the Table 1.

It is worth noticing these data reflect the "base-case" for the settlement investment as defined also in previous chapter. The choice of the "base-case" is definitely of relevance, but it is also needed to prepare the ground for the definition alternative solutions, to be further evaluated to test the results of the financial performance through the DSS. In this respect we already consider that alternative solutions might

Table 1 Contextual data

Description	Data	Measurement unit
A = Total area	63,024	m^2
PR = Residential plot area	37,200	m^2
PW = Welfare plot area	6,000	m^2
R0 = Residential area ground floor	17,224	m^2
R1 = Residential area 1° floor	15,384	m^2
R2 = Residential area 2° floor	8,184	m^2
R3 = Residential area 3° floor	2,412	m^2
W = Welfare area	1,530	m^2
Number of apartments	320	No. apartments/units
Number of buildings	202	No. buildings
Number of shops B1 (typology 1)	180	No. shops (typology 1)
Number of shops B2 (typology 2)	24	No. shops (typology 2)

Source elaboration of the authors

be related to a different mix of the typology of the area, i.e. a different percentage related to residential, commercial and welfare buildings, as well as to a different design of the buildings, i.e. a different composition in terms of available floors.

These two main dimensions along which to define alternatives are reflected directly in the choice of the contextual data, thus allowing for the DSS to be used in a parametric way.

At the same time, it is worth mentioning that contextual data are presented in the unit of measure (number and square meters) that better relate to the costs and revenues composition, thus allowing for a clear, but distinct, transformation from a quantitative data to a monetary value.

Costs

As far as the costs are concerned, as for any investment, two main cost categories have to be considered: (i) investment costs, i.e. cost occurring at the beginning of the project and related to the actual implementation of the project, (ii) running annual costs, i.e. costs occurring each year, related to the annual maintenance and operation of the project.

Investment costs

Investment costs in the project refer to 4 main categories:

Land cost: represents the cost item related to the purchase of the land where the project will be implemented. It is measured in dollar per square meter.

Infrastructure cost: represents the cost item related to the construction of various infrastructure, functional to the proper implementation of the project itself, e.g. roads, sewerage system. This cost is measured in dollar per square meter.

Construction cost: represents the cost item related to the construction of the different buildings that will establish the actual implementation of project. This cost is measured in dollar per square meter, and it has been estimated based on the type of building that will be built.

Residential buildings: the residential construction cost is related to the construction of residential buildings which include both residential apartments at the upper floors and shops at the ground floor.

"Welfare" buildings: the "welfare" construction cost is related to the construction of "welfare" buildings (e.g. school).

Photovoltaic cost and data: presents the cost item related to the installation of photovoltaic modules on the rooftops of the different types of buildings. This cost is measured in dollar per watt. This cost includes also data related to photovoltaic modules such as the photovoltaic installed power, the annual productivity and the self-consumption rate.

The different investment costs are reported in the Table 2.

As it appears from the Table 2, data for investment costs are collected using a mix of monetary data (e.g. the land or infrastructure cost) and "technical" data (e.g. PV plant productivity of self consumption rate of energy for buildings). This approach is of particular relevance as it reflects, on the one side, the fact that these data are related to the investment decision (e.g. the productivity of PV plant is related to the

Table 2 Investment costs

Description	Data	Measurement unit
Land cost	30	$/m^2
Infrastructure cost	13	$/m^2
Construction cost R0 (ground floor)	400	$/m^2
Construction cost R1 (first floor)	300	$/m^2
Construction cost R2 (second floor)	300	$/m^2
Construction cost R3 (third floor)	300	$/m^2
Construction cost W	400	$/m^2
PV cost	1.5	$/W
PV productivity (h eq.)	1960	kWh/kW
PV m^2	7	m^2/kW
PV R	688	kW
Self-consumption rate R	50	%
PV W	76	kW
Self-consumption rate W	50	%
Useful life	20	Years

Source elaboration of the authors

localisation but also the quality of the plant itself allowing to perform accordingly to the target) and, on the other side, the assumptions made on the utilization of the area. Again it is worth mentioning, we are using a separate line of input data for different typologies of buildings (residential and welfare) as well as we are keeping the distinction of investment costs for the different potential floors of the buildings, thus allowing for a truly parametric relation with the contextual data seen in the previous paragraph.

Last but not least, it is needed to say that these data, particularly, are the result of the triangulation process mentioned before, in the attempt to make their reliability as higher as possible. Indeed, if the volatility of the data can be hardly controlled (if not with the sensitivity analysis we are further describing later), the reliability of the data has to be controlled at this stage of the DSS by putting in place all the effort needed to find a convergence among the different sources of data. Even if this is costly in term of time and resources to be used for setting the DSS, the impact of such reliability is of paramount importance for having it truly supporting the decision maker.

Annual costs

Annual costs in the project refer to 3 main categories:

Infrastructure maintenance cost: represents the cost item related to the annual maintenance of various infrastructure, functional to the proper implementation of the project itself, e.g. roads, sewerage system. This cost is measured in dollar per square meter per year.

Energy cost: represents the cost item related to the annual provision of electricity for all the various buildings typologies present in the project. This cost is measured

in dollar per kilowatt-hour consumed from the grid (i.e. the electricity produced by the photovoltaic panels installed on the buildings' rooftop which is self-consumed is not included in this cost item). The "energy cost" item has been estimated based on the type of energy users present in the project distinguishing between residential, welfare energy users and business energy users.

Other utilities cost: represents the cost item related to the annual provision of utilities other than electricity (e.g. water) for all the various buildings typologies present in the project. This cost is measured in dollar per cubic meter, and it has been assumed equal for all the building typologies present in the project.

The different annual costs are reported in Table 3.

Table 3 Annual costs

Description	Data	Measurement unit
Infrastructure maintenance cost	0.6	$/($m^2$*year)
Energy cost R W	0.48	$/kWh
Energy cost B	0.40	$/kWh
Other utilities cost (i.e. water)	1.3	$/$m^3$
R water consumption (per household)	200	m^3/(year*apartment)
B1 water consumption (per shop)	20	m^3/(year*shop)
B2 water consumption (per shop)	40	m^3/(year*shop)
W water consumption	300	m^3/(year*school)
Energy consumption R (per household)	700	kWh/(year*apartment)
Energy consumption R (total)	224,000	kWh/year
Energy consumption R+B (total)	240,620	kWh/year
Self-consumption	120,310	kWh/year
Energy Bought from the grid	120,310	kWh/year
Energy sold to the grid	1,228,170	kWh/year
Energy produced by PV	1,348,480	kWh/year
Energy consumption B1 (per shop)	75	kWh/(year*shop)
Energy consumption B2 (per shop)	130	kWh/(year*shop)
Energy consumption B1 (total)	13,500	kWh/year
Energy consumption B2 (total)	3,120	kWh/year
Energy consumption W	1,000	kWh/year
Self-consumption W	500	kWh/year
Energy bought from the grid W	500	kWh/year
Energy sold to the grid W	147,900	kWh/year
Energy produced by PV W	148,400	kWh/year

Source elaboration of the authors

Also in this case, it is worth recalling data that have been kept at the same level of details required by the two dimensions along which to define alternatives. Triangulation of data also applies to increase the reliability of information.

Revenues

The sources of revenues for the project belong to two categories:

- Buildings rent: represents the revenue item related to the rental of the various buildings' typologies present in the project. This revenue is measured in dollar per square meter per month, and it has been estimated based on the type of building present in the project and on the affordability of the population.
- Energy selling: represents the revenue item related to the electricity produced by the photovoltaic panels installed on the buildings' rooftop, which is not self-consumed and, consequently, is sold to the grid. This revenue is measured in dollar per kilowatt-hour sold to the grid. As for the "energy cost" item, the "energy selling" revenue item has been estimated based on the type of energy users present in the project distinguishing between residential, welfare energy users, and business energy users.

Sources of revenues are reported in Table 4.

Again sources of revenues are presented taking into account the different mix of typologies of buildings and reflecting the types of settings recalled in chapter "Settlement Strategy Towards New Business Ecosystems". In this respect we also are taking into consideration the sustainability of the rent level with respect to the population we are targeting.

The affordability of the residential apartments by the Somali population has been considered in order to define the residential apartments rent, which is an input of the business plan.

Table 4 Sources of revenues.

Description	Data	Measurement unit
Rent R—Type 1	2	$/(m^2*month)
Rent R—Type 2—A	2	$/(m^2*month)
Rent R—Type 2—B	2	$/(m^2*month)
Rent R—Type 2—C1	2	$/(m^2*month)
Rent R—Type 2—C2	2.5	$/(m^2*month)
Rent R—Type 3—D	2.5	$/(m^2*month)
Rent R—Type 3—E	2	$/(m^2*month)
Rent B (Business area)	3.5	$/(m^2*month)
Rent W (Welfare area)	2.5	$/m^2*month
Energy revenue R W	0.24	$/kWh
Energy revenue B	0.2	$/kWh

Source elaboration of the authors

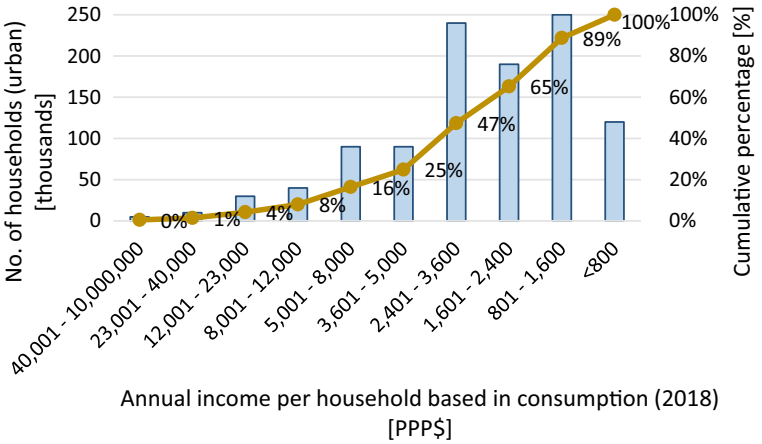

Fig. 1 Annual income per household based in consumption [PPP$] (reference year: 2018) (rework from CAHF 2019). *Source* elaboration of the authors

The Fig. 1 shows the distribution of the Somali households based on their annual income.

According to the Centre for Affordable Housing Finance in Africa, the monthly rent of a newly built house in an urban area amounted to an average of 350 $/month in 2018, for a 65 m^2 apartment (CAHF 2019).

Considering the distribution of the Somali households based on their annual income, only 4% of all households can afford a monthly rent equal to 350 $/month (CAHF 2019).

The project residential apartments rent has been defined in order to enlarge the share of household that can afford to rent an apartment.

Table 5 identifies, for the different project residential apartments typologies, the monthly rent and the share of households that can afford that rent.

Table 5 Monthly Rent and affordability of the different residential typologies available in the project

		Rent ($/month)	Share of household that can afford those rent (%)
Typology 1	Unit 1	196	16
Typology 2	Unit A	94	25
	Unit B1/B2	126	16
	Unit C1	156	16
	Unit C2	232.5	8
Typology 3	Unit D	225	8
	Unit E	130	16

Source elaboration of the authors

The majority of the project residential apartments will be affordable by the 16% of households. The affordability is maximized for one residential apartment typology (i.e. typology 2—unit A) that will be affordable for the 25% of households. Two residential apartment typologies (i.e. typology 2—unit C2, typology 3—unit D) will be affordable for the 8% of households.

Hence, the project can offer a six fold affordability (i.e. up to 25% of households) compared to the average affordability (i.e. 4% of households).

Project economic sustainability: the financial performance

In order to assess the economic sustainability of the project, we use two out of three of the indicators listed at the beginning of this chapter: the Internal Rate of Return (IRR), which assess the internal rate of return of the investment, and the Not-discounted Pay-Back Time (PBT), which assess the time required to recover the investment.

The project economic sustainability has been firstly assessed in the base-case. The base-case scenario is a full-equity investment scenario in which the project will be implemented with no debt. The Weighted Average Cost of Capital (WACC) is calculated as follows, reflecting the contribution of equity and debt to the investment:

$$WACC = \frac{Equity}{Equity + Debt} * k_e + \frac{Debt}{Equity + Debt} * k_d$$

As a consequence of the above decision about the base-case, however, the calculation of WACC is almost immediate (being only related to the cost of equity) (Table 6).

It is worth mentioning that the approach of using a full-equity calculation as a base-case, even if not always applied, is of particular relevance in our case. Indeed, given the high turbulence in the Mogadishu context, testing the financial performance in a case where only equity is involved, creates the condition for understanding the results of the investment without the effect of the leverage. In other words, the IRR and PBT resulting from this analysis are reflecting the "pure" value of the project, not considering the financial leverage effect.

Table 6 Base-case: financing data

Description	Data
WACC	5%
ke	5%
kd	0%
Total investment	$18.298.771
%E	100%
%D	0%
E	$18.298.771
D	$0

Source elaboration of the authors

Table 7 Base-case financial performance

Results	Data	Measurement unit
IRR	2	%
PBT	17	Years

Source elaboration of the authors

At the same time, this information is of paramount importance for:

- the decision maker in the real estate company, acknowledging the "value" of the project and therefore having the chance to find the better sources of financing for it;
- the decision maker in the bank, acknowledging the maximum value of return on the capital that makes the condition for the investors to proceed, and therefore finding in case the better sources of capital for supporting this investment;
- the policy maker, having a clear measure of the distance between the "value" of the project so far and the "value" considered acceptable by the investors, having therefore the chance to "measure" (or at least initially assess) the amount of incentives (or similar measures) to be put in place to sustain the settlements.

The output of the calculation in the base-case are reported in Table 7.

The IRR is positive, even though it is lower than the WACC, and the PBT is equal to 17 years, meaning that seventeen years are needed to reach a break-even point.

Both these results are posing serious challenges to the project. Indeed, given the already mentioned high volatility of the Mogadishu context, a PBT of 17 years can be far from acceptable, unless it is supported by some forms of external guarantee of the sources of revenues. Also the 2% IRR is well below the 5% cost of capital considered for an equity investment, and again is rather low if applied in a context of high volatility.

Nevertheless, as a true DSS is supposed to do, the financial performance resulting from the analysis is supporting a number of reasoning from the decision maker, about the risk level of the investment as well as on the potential sources of financing.

It is fairly evident that, only for the sake of example, the access to a non-repayable loan for a certain amount of the capital needed will reduce significantly the PBT and lowering (on a relative perspective due to the fact that now one part of the WACC requires no remuneration) the distance between the project IRR and the WACC.

Despite the above considerations, an effective DSS should support the decision maker also by offering a better understanding of the variables, among those affecting investment costs, annual costs and revenues, mostly explaining the financial performance.

This is possible through the running of a sensitivity analysis (Quin et al. 2011) to assess the impact of the above mentioned variables on the financial performance. In the choice of the variables to variate in the sensitivity analysis it is worth mentioning we focus on those decisions we assume are in the hands of the decision maker and can be controlled before the investment start.

The selected variables are the following 4:

A. Buildings rent: the revenue related to the buildings rent has been increased by 10% (so-called "Scenario A"). We are indeed assuming there is a chance for the investor to define an higher price for the rent, reducing the available market, but still being able (please refer to Table 5) to fill in all the buildings after the construction;
B. Construction cost: the cost related to the construction of the buildings has been decreased by 10% (so-called "Scenario B"). We are here assuming a more strong contractual power from the investor can reduce the cost of construction, also changing the mix of materials or the supply chains involved (please refer also to Chapter "The Fragmented and Heterogeneous Nature of Manufacturing and Construction Sectors in Mogadishu");
C. Photovoltaic data: the photovoltaic installed power has been maximized in order to cover all the available buildings' rooftop space (so-called "Scenario C"). We are here assuming the investor has the chance to act as a landlord imposing the presence of the plant on the rooftop and using the excess power to generate additional sources of revenues to pay back the investment. The odd of adverse reaction from the customers has been considered irrelevant in the specific case.
D. Energy selling: the revenue related to the electricity produced by the photovoltaic panels has been increased by 10% (so-called "Scenario D"). We are here assuming the presence of favourable policies for renewables (whose first attempts are already in place in the area) will positively affect the annual revenues coming from the electricity production. Again we consider this additional revenues can be credited to the investor.

The sensitivity analysis economic sustainability output results (i.e. IRR and PBT) compared to the base-case results and reported in Fig. 2.

Three scenarios out of four, namely scenario A, B and C, have an improved financial performance compared to the base-case.

Scenario A and scenario B have similar financial performance results with IRR and PBT equal respectively to 3% and 16 years. It is worth however mentioning that

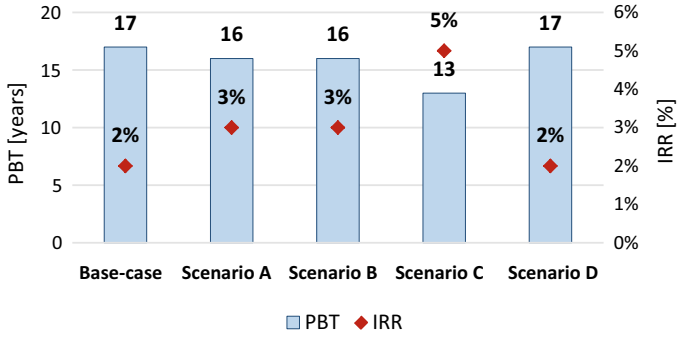

Fig. 2 Base-case: sensitivity analysis of financial performance. *Source* elaboration of the authors

in the case of scenario B (reduction of the construction costs) the improved financial performance is more certain, being achieved at the moment of the investment, whereas in scenario A (increase of rent) the benefit can be truly monetize only if we assume the higher rent will stay for the whole period.

Scenario C is the most attractive with an IRR equal to 5% and PBT equal to 13 years. It is worth mentioning this scenario offers many arguments to the decision maker. First of all, as in the case of scenario B, it can be controlled since the beginning with the decision to exploit the rooftop for photovoltaic plants. Second, scenario C is more dependent on the action of the investor rather than on other external players, whereas in scenario B the reduction of the construction costs stays on the construction suppliers. Third, this scenario is peculiar of the design foreseen for the settlement and in this respect further confirms that exploiting the local distributed production of energy is a key component of the project.

If the photovoltaic installed power is maximized, the project economic sustainability improves.

3 Definition of the Alternative Scenarios for Mogadishu

Considering the results of the base-case and its sensitivity analysis it appears clearly that the financing strategy, i.e. the way the project is funded, is of paramount importance to grant its feasibility.

Having structured the DSS in a parametric way, with particular regard to the calculation of WACC, allows us to define alternative scenarios for the financing of the project to further check its financial performance.

Considering the peculiarity of the context, and the presence of special funding options (e.g. those made available by the World Bank, or the financing scheme unveiled by the Somalian government to support the return of Somalian citizens who left the country in the past) it is possible to imagine two alternative cases for the project.

1. Alternative-case 1. In this case, the project financing strategy is based on an equal distribution between equity and debt (setting however at null the cost of debt). The capital raised through the debt, however, has to be fully repaid in the time period of the investment.
2. Alternative-case 2. In this case, the project financing strategy is based on an equal distribution between equity and debt. The debt, however, other than having the cost of debt set to null, it is also in the form of a non-repayable loan, i.e. it is not required to repay the capital raised.

The results of the financial performance in the 2 alternative cases is reported in the Table 8.

Obviously the alternative case 2 dominates the case 1, due to the fact that it is not requiring the repayment of debt. It is worth, however, considering the DSS as a support for the decision maker, to further investigates the values. The base case IRR

Table 8 Alternative-cases: financial performance

Results	Alternative-case 1		Alternative-case 2	
	Data	Measurement unit	Data	Measurement unit
IRR	4	%	10	%
PBT	15	Years	9	Years

Source elaboration of the authors

equals 2%, in the alternative 1 IRR is 4%, and in alternative 2 IRR is 10%, with a PBT below 10 years.

In other words, the effect of diluting the equity with a noninterest-bearing debt (alternative 1) is to double the financial performance. The impact of a non-repayable loan, on the contrary, is to generate 5 times the performance for the equity investor.

It is fairly evident that finding a form of financing like the one in alternative 2 appears the best option for the project. Furthermore, it is also clear the impact of the financing is of a magnitude far higher than the impact of potential interventions on the project definition (e.g. the rental price, the construction costs, …).

To better clarify the above point and offering an additional view on the project, it is possible to run a sensitivity analysis, like the one discussed in the previous paragraph.

The four scenarios considered are therefore:

A. Buildings rent: the revenue related to the buildings rent has been increased by 10% (so-called "Scenario A"),
B. Construction cost: the cost related to the construction of the buildings has been decreased by 10% (so-called "Scenario B"),
C. Photovoltaic data: the photovoltaic installed power has been maximized in order to cover all the available buildings' rooftop space (so-called "Scenario C"),
D. Energy selling: the revenue related to the electricity produced by the photovoltaic panels has been increased by 10% (so-called "Scenario D").

The four scenarios of sensitivity analysis applied to alternative case 1 led to the results presented in Fig. 3.

Not surprisingly it is the scenario C, the one including the optimization of the area for the photovoltaic plant, to be the best among the options. The IRR in this scenario reaches 8%, and the PBT is 10 years.

A similar analysis conducted on the alternative case 2 shows even more interesting results. According to Fig. 4, the optimization of the area for the photovoltaic plant (scenario C) allows the project to go above the threshold of the "double digit" IRR, reaching a value of 14%. At the same time, as a consequence, the PBT is reduced to 7 years.

Even if these results are subject to the assumption of a 50% nonrepayable loan, it is worth recalling that these are numbers fully compatible with an investment, even considering the risk associated with the peculiar environment of Mogadishu.

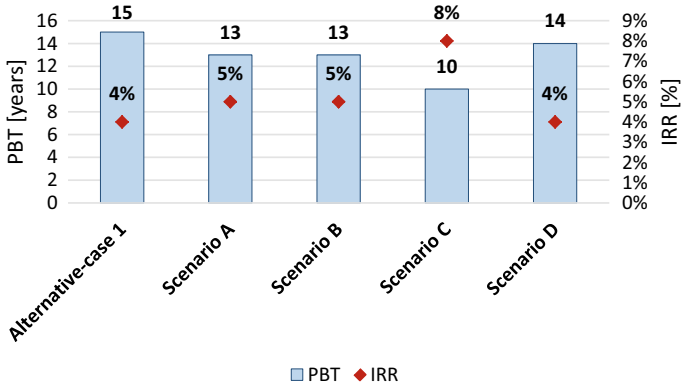

Fig. 3 Alternative-case 1: sensitivity analysis. *Source* elaboration of the authors

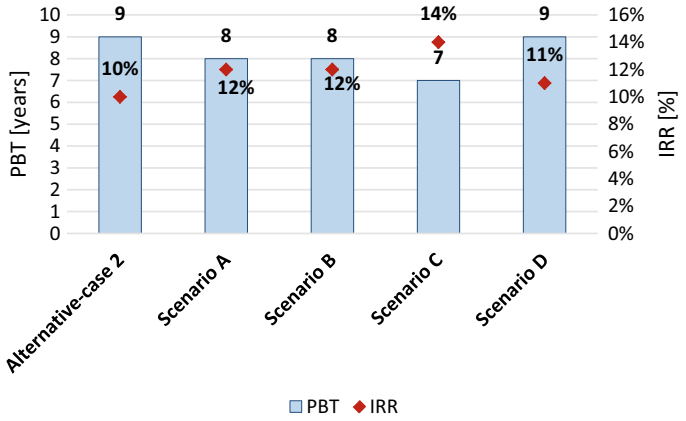

Fig. 4 Alternative-case 2: sensitivity analysis. *Source* elaboration of the authors

4 Development of a DSS for Settlement Feasibility Studies

The analysis done so far with the DSS we have designed for the project are showing that there is indeed a potential, at certain financing conditions, for the project to be effectively pursued by an investor.

It is however needed also to extend the scope of the DSS beyond the numeric evaluation of the financial performance to include also a more strategic perspective (Power et al. 2011). The choice of investing in Mogadishu in a kind of settlements like the one in the project, indeed, goes beyond the mere maximization of the financial performance and requires to consider also the strategic implications.

The addition of this perspective in the analysis is done through the run of a SWOT analysis (Leigh 2009).

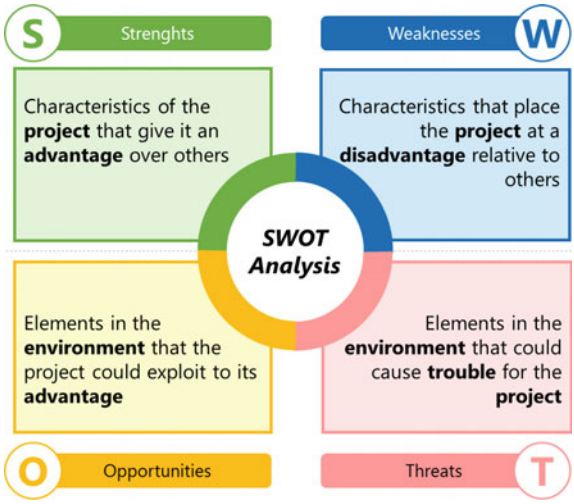

Fig. 5 SWOT analysis framework. *Source* elaboration of the authors

The SWOT analysis is a strategic planning tool aimed at identifying strengths, weaknesses, opportunities, and threats related to a project. Hence the SWOT analysis aims at identifying the internal and external factors that are favourable and unfavourable to the project.

The SWOT analysis assumes that strengths and weaknesses are internal factors, while opportunities and threats are external factors (Fig. 5).

Applying the SWOT analysis to the project, it is possible to recognise some relevant strategic implications.

First of all about the strengths connected to the project as it is drafted in this book. The main strength of the approach we have followed in this project stays into the social inclusion, i.e. in the chance to allow an increasing number of citizen to access residential buildings in our settlements due to the match between the expected rental price and the available salary.

As a consequence, the project holds the advantages of affordable housing projects, granting access to a certain quality of living to potentially a relevant number of citizens in Mogadishu.

Another clear strength of the project is the fact that is not just intended to provide a place where to live but also to create a favourable and integrated environment for local businesses, hence creating a local offer of jobs to be meet by the demand of workers in the families living in the settlement. Moreover, social services (e.g. schools, medical services, …) are expected to be part of the area, thus again offering to families living there additional improvement to their quality of life. The presence of businesses and social services close to residential buildings also is a key condition for the establishment of a truly local community that is so coherent with the local culture to be considered a sort of pre-requisite for the settlement to be really in place.

Last but not least, from a techno-economic point of view, the project is designed for being scalable, i.e. to be expanded or generally adapted to the size of the area

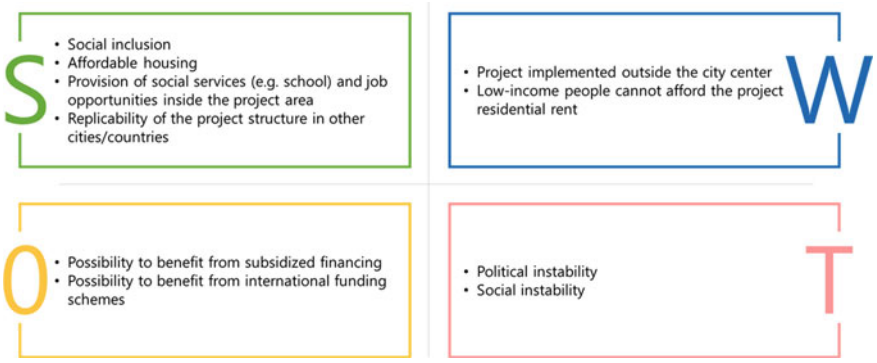

Fig. 6 SWOT analysis related to the BECOMe project. *Source* elaboration of the authors

where is it intended to be developed, and replicable, i.e. to be replicated in any areas with conditions similar to those analysed in the case of Mogadishu.

Besides these strengths the project has also some weaknesses. First of all, it requires a kind of "virgin" area to be applied and this has as a consequence that it is expected to be in place outside the city centre. Even if the concept of creating satellites areas around the city centre it is not new, it is expected the same to create a barrier for those citizens having reached a certain income level and willing to rent a residential place for their families.

At the same time, despite the effort put to reduce the rental price, the project is not able to reach the goal to make also low income people able to access the settlements. Therefore, still a significant part of the population is expected to be untouched by the project results (Fig. 6).

As far as the external environment is concerned, it is clear that the project is in line with the opportunities opened by international funding schemes and subsidized financing that is growing in relevance in the Somalian country and particularly in Mogadishu. Examples of such sources of financing can be the World Bank, the EU Investment Bank (EIB), the African Investment Bank, and European Investment Funds specialized in Real Estate in Africa and Somalia like the Actis Africa Real Estate Fund (CDC), Taaleri Impact Investing, Grit Real Estate, and Centum Real Estate.

The political and social instability, however, represent a threat, particularly if we consider that, despite the difference among alternative scenarios, the time needed to pay back the investment is at best around a decade: a time frame where potential significant changes in the context pose relevant risks.

The SWOT analysis offers definitely a different perspective for the different decision makers the DSS is supporting.

The decision maker is sitting in a real estate company, willing to evaluate a investment in residential settlement in Mogadishu, for example, is expected to consider of particular relevance some of strengths of the project. The social inclusion is indeed expected to be considered more broadly as part of a responsible investment strategy,

might be coherent with the ESG criteria (environmental, social and corporate governance factors) that are increasingly considered a must-have for companies willing to solicit the global market. At the same time, replicability is a key pre-requisite for a real estate company, that can therefore further profit from the chance to adapt the design (and the related costs of investment) in other investments opportunities. At the same time, the threat posed by the political and social instability are of particular relevance for this decision maker, knowing that its capital is at stake at least until the project reaches the PBT.

The decision maker sitting in a bank or investment fund, willing to understand the fit for its investment portfolio, might, on the contrary, consider the opportunity of invest in an affordable housing project in an area where several funds and institutional investors are actually looking. The replicability and scalability of the project can be at the same time favourable characteristics allowing to adapt the project to the size of investment.

The decision maker sitting in a policy making position, willing to understand whether and how favourable conditions for a residential settlement have to be created or strengthened in order to impact the society, can eventually look at the social inclusion and provision of social services as the key strengths of the project. At the same time concerns might arise due to the fact that low income people still do not have the chance to benefit from the project.

Regardless of the position of the decision maker, it is clear the DSS is supporting a more consistent decision about the project, whose financial performance is also rather clear.

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Conclusion

This book reports some of the results of the multidisciplinary research titled BECOMe dealing with affordable housing in East Africa. BECOMe has pursued some practical objectives: the experimentation of methods for the investigation and interpretation of some complex East Africa contexts; the definition of models of settlements deepened in the functional, typological and technological aspects; the development of tools for supporting decision makers and various categories of stakeholders. At the same time, it has given the opportunity for a wider analysis, aiming to define some interpretative keys of the role of affordable housing for the development of an original approach to social equity connected to economic development and to environmental issues, with a particular attention to the specific characteristics of the context.

The research starts from an observation of the wide and complex scenario of the East Africa region, characterized by potentialities and contradictions and where everything coexists with its opposite: extraordinary boost for growth with the risks related to an uncontrolled use of the natural capital and speculative phenomena in territorial development processes; large flows of money and persistent pockets of poverty; interest from foreign investors, huge amount of resources (row materials and people) and difficulties in the development of local enterprises and models of production, marketing and consumption appropriate to the context; widespread presence of international observers for humanitarian issues and economic development and generalized lack of information; many young people and little qualification; extensive territories and congested cities.

In such a region, where political instability creates a condition of constant uncertainty, informality is a pervasive characteristic dealing with so many aspects of society (production and marketing of goods, economic trade, urban development and construction, use of natural resources, etc.). On one side, informality represents a strength as an autochthonous capacity for the self-organization and resilience of the social ecosystems; on the other side, it is the black hole able to hide the actual scale of phenomena such as social iniquities, corruption, unsustainable urban, and economic growth.

O. E. Bellini et al. (eds.), *Innovative Approach for the Development of Sustainable Settlements in East Africa*, Research for Development,
https://doi.org/10.1007/978-3-031-00284-7

Urban settlements are a tangible evidence of informality. One of the challenges for the region is to build the conditions to overcome these problems, preserve resilience, improve the quality both of the inhabitants life and the built environment, support decision makers through share knowledge and appropriate models of processes.

In this perspective the challenge is to experiment, on the reality of the specific contexts, the triad equity-sustainability-affordability, searching for new and appropriate models of building and living.

BECOMe has identified Somalia, and in particular Mogadishu, as a very interesting field of experimentation, that in a paradigmatic way represents potentialities and needs for growth, risks, housing emergencies, informality, uncertainty but also vitality and desire of recovery.

The Somali scenario—and in particular Mogadishu as a specific application context—represents a highly complex and challenging test for such a kind of research: the political instability has limited the development of an affordable social housing and in the past the protracted conflicts have gradually destroyed the local Architecture, Engineering and Construction (AEC) firms as well as the manufacturers of construction materials and components. Furthermore, housing demand has been increased overtime by the intense growth of population, the high levels of poverty, the destruction of the building stock, the displacement of population, and the insecurity of the area as result of the civil war. Nowadays the construction sector is on the rebound mainly for what concerns the high-level housing, but not for the affordable housing, whose demand remains unsatisfied. Indeed, the business dynamics concerning low- and medium-level housing are highly affected by the context specificities and the uncertainty conditions that discourage both local and foreign investments.

BECOMe has assumed some basic interpretive hypotheses:

- the development of a model of housing that integrates spaces for local crafting/manufacturing activities, development environments (learning by sharing) and social services as key factor to facilitate, support, and stimulate the local micro-entrepreneurship of Mogadishu;
- the integration of on-site renewable energy production (at no cost for housing units and at an affordable cost for local entrepreneurs and social and business services) as an enabler of optimization and innovation of energy production and management practices, as well as promoter of new sustainable and high-performance technological solutions;
- the revamping of the local building sector with the manufacture of construction materials/components and the creation of new appropriate supply chains and training strategies as a mean to make the most of local resources and boost the local construction sector.

In this context, BECOMe proposes a new business ecosystem for sustainable settlements, developed through an integrated model that embraces affordable housing, local entrepreneurship and social facilities, also exploring the exploitation of local loops in a circular economy approach. Therefore, the research outlines:

- a set of possible scenarios able to stimulate new investments within the building sector, ensuring a balance between all three pillars of sustainability;
- a methodology for evaluating, for each scenario, feasibility conditions (economic, legislative, social), assessing direct and indirect benefits and risks.

From the social point of view, the proposed affordable housing model is designed to target a predefined housing price that can be affordable for a large part of the population, through the optimization of the entire construction process and the use of the local renewable energy. From the economic and financial point of view, it suggests an investment plan, leveraging financial aids for local entrepreneurs and renewable production as well as showing the potential for sustainable intervention by external investors. From the environmental point of view, it strives to offer a high energy and comfort performance buildings through climate-responsive design and the exploitation of most appropriate construction materials and techniques. In addition to these three main sustainability goals, BECOMe has a broader purpose: it involves the use of bottom-up actions to increase in the new generations the civil maturity and responsibility in order to overcome the ethical, economic, and environmental challenges of the future.

At the same time, BECOMe aims to raise awareness of the local government on the potential for providing affordable housing solutions to a larger part of the population, creating—through the involvement of local entrepreneurs—a lively and almost self-sustaining environment and local community.

BECOMe follows a multidisciplinary approach involving the deep interaction among four key disciplines, considered as fundamental for developing the proposed business ecosystem of sustainable settlements adopting a holistic perspective: architectural design (typological/functional aspects and the relation with the context); building technology (construction technologies, process organization, and supply chain management); energy and building physics (energy design and integration of photovoltaic systems); management engineering (business ecosystem models and their economic sustainability assessment). BECOMe involves in several ways the main categories of local stakeholders and assigns them key roles as partners, sources of information, and privileged interlocutors.

The result is a business ecosystem suited to the social/economic context and issues, able to activate a new housing market and to attract and engage different stakeholders. For this purpose, the research defines the conditions of pre-feasibility of the proposed business ecosystem and it suggests the methodological framework and tools for drawing and assessing possible scenarios of development. Starting from this main objective, BECOMe proposes:

1. a model of modular settlements, to integrate low-cost houses, business units for artisans/small local enterprises and social services. The settlements are characterized by predefined housing prices affordable for at least the 25% of the population and typological schemes appropriate to the local culture;
2. a set of scenarios of possible actions, related to the development of the business ecosystems on large scale, aiming to create local enterprises and to stimulate foreign investors for the revamping of the national AEC sector and of the related

industries. The scenarios are methodologically defined by linking in a matrix form the different topics, such as the production approaches (from artisanal and traditional production to industrialized processes), the types of construction materials, theirs sources (local resources, resources from outside, recycled local war debris), the types of building components, the local and foreign stakeholders and the forms of business relationships;

3. a methodology for evaluating, for each scenario, economic feasibility conditions, through assessing direct and indirect benefits and risks. Financial instruments (e.g. mortgages and loans) and available financial aids programs supporting economic feasibility) have been investigated.

More in details, by proposing solutions for meeting the demand of low- and medium-level housing, BECOMe addresses the needs of the local vulnerable segment of the population. The population that currently lives in shelters could benefit from the opportunity to move into houses that are no longer improper and temporary but adequate and durable, increasing their conditions of hygiene, safety and well-being and, in general terms, ensuring a higher quality of life. At the same time, the population that presently lives in low-level housing could have the opportunity to upgrade its conditions moving into medium-level housing, with the chance to integrate micro entrepreneurship spaces as a support for their business development. In addition, the actors of the local AEC sector may strongly benefit from the definition of a model of modular settlements, where different alternatives and chains of supply have been already analyzed and grouped. This "plug and play" model will help them in the evaluation of practical business opportunities and in establishing tighter relationships along the supply chains. The potential for creating a circular economy approach exploiting the local presence of specific materials has been also explored.

Moreover, BECOMe has the aim to provide an impact throughout the entire life of the settlements. Indeed, the idea of creating a local community of entrepreneurs, offering services to the inhabitants of the settlements and to the local community is one of the key point of the proposal and has led to the addiction of some facilities, such as—among others—the office/SMEs dedicated spaces in the buildings and the renewable energy production plants. Local entrepreneurs can benefit from the above-mentioned facilities and from a dedicated training and documentation aimed at helping them understanding the potential for the use of such facilities. The emergence of local services for the support of the life cycle of the settlements, such as electric maintenance and refurbishment construction materials supply, has the potential to create a virtuous circle helping the settlements becoming an almost self-sustaining ecosystem within the local community.

BECOMe, proposing alternative settlement models, sets the ground for the integration of the Sustainable Development Goals promoted by the United Nations in the Agenda 2030 (e.g. Goal 1—End of poverty; Goal 3—Good health and well-being; Goal 7—Affordable and clean energy; Goal 11—Sustainable cities in communities) within the transformation of the built environment in East Africa.