3 Sustainable Infrastructure and Water Strategies for a Resilient Addis Ababa (Ethiopia)

Ruben Garcia Rubio, Alec Paulson, and Sonsoles Vela Navarro

Abstract

The capital of Ethiopia, Addis Ababa, is one of the fastest-growing cities today, experiencing rapid urbanization over the past few decades. The city's population has almost doubled from 2.7 million in 2007 to around 4 million today. With such unprecedented growth, sustainable development in the city has been compromised as existing infrastructures struggle to keep up, leaving much of the urban population with a lack of access to basic public services. With that, the network of rivers that run through Addis Ababa has deteriorated as modernization has increased pollution and the overall degradation of river ecologies. Coupled with the rising threat of climate change, inhabitants who live along those rivers increasingly suffer from flooding and other issues related to worsening weather patterns. This paper details the outcomes of the "Addis Ababa River City" research project, which seeks to resolve some of the most urgent urban issues that the city currently faces due to rapid growth. Within it, urban issues are analyzed, and holistic solutions are proposed to create a more resilient city and to improve the relationship that Addis Ababa has with its rivers. The interventions introduced in this paper serve as examples of what can be done to improve infrastructures throughout the city, applying ecological engineering with hybrid infrastructures that work in tandem to enhance sociocultural programs and reinforce the natural dynamics of the city's rivers.

Keywords

Climate change · Resilient urbanism · River management · Sustainable infrastructure · Addis Ababa

3.1 Introduction

Throughout known history, rivers have provided civilizations around the world with the ability to flourish and expand to new heights. Cities have used nearby rivers to stimulate their economies through commerce while also providing them with a water supply for irrigation, sanitation, and industry.[1] Today, the relationship between cities

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[1] Yu Fang, et al., "Globally universal fractal pattern of human settlements in river networks," *Earth's Future* 6, (2018): 1134– 1145. Jordan, Jan M., "The Uses of River Water and Impacts," in *Fresh Surface Water*, vol III, ed. James C. I. Dooge (UNESCO-EOLSS: Paris, 2009). Adeloye, Adebayo, "Rivers and Human Development," in *Fresh Surface Water*, vol III, ed. James C. I. Dooge (UNESCO-EOLSS: Paris, 2009).

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and their rivers is changing as modernization allows for unprecedented growth, affecting the ecologies and dynamics of the rivers that support them.[2] With climate change becoming an ever-pressing situation, today's cities must adapt to the increasing severity of weather patterns and natural disasters, particularly river cities where flooding occurs more regularly.[3]

The capital of Ethiopia, Addis Ababa, has expanded significantly over the past decades, both in terms of population size and land coverage. It is estimated that the city has almost doubled its population, a range between 3.6 and 4.4 million inhabitants in this millennium.[4] Also, the capital city has seen its built area increase by more than 50 percent over the last few years.[5] However, the urban's supporting infrastructure has been unable to keep up with the city's explosive growth demand. As a result, residents of Addis Ababa suffer from a series of issues stemming from the city's growth coupled with the dynamics of its unique geography.

A particular feature in Addis Ababa is the network of small rivers that weave through it. Most of them are tributaries of the Akaki River, which itself branches off into both the eastern and western areas of the city. These rivers present their own challenges to the city as Addis Ababa continues to grow around them while failing to address the inevitabilities of expanding so closely to their banks.[6] With climate change becoming a more pressing issue, the relationship between the city and its rivers only continues to deteriorate.[7] If conditions in Addis Ababa are not improved, both the city and the ecology of its environment will continue to suffer.[8]

This paper unfolds part of the Addis Ababa River City research project.[9] The methodology used for the project began with researching and identifying the major problems the city currently faces due to its explosive growth and subsequent environmental impacts and infrastructural shortcomings. The city was then mapped out to understand better the current conditions, including public transportation, neighborhood characteristics and programs, and existing infrastructure. Once the dynamics of the city were analyzed, specific areas for intervention were identified. An iterative design process followed to create new hybrid infrastructures (by exploring precedent studies and analysis of the daily lives of Addis

[2] Tewodros Tigabu, and Girma Semu, *Ethiopia: Addis Ababa Urban Profile* (Nairobi, Kenya: United Nations Human Settlements Programme 2008). Grimm, N. B, et al., "Global Change and the Ecology of Cities." *Science (American Association for the Advancement of Science)* 319, no. 5864 (2008): 756–760.

[3] Martin Richardson, and Mikhail Soloviev, "The Urban River Syndrome: Achieving Sustainability against a Backdrop of Accelerating Change," *International Journal of Environmental Research and Public Health* 18, no. 12 (2021): 6406.

[4] Central Statistical Agency, *Projected Population of Ethiopia—2011* (Addis Ababa: Central Statistical Agency, 2019), https://www.statsethiopia.gov.et/population-projection/; United Nations, Department of Economic and Social Affairs, Population Division, *The World's Cities in 2018: Data Booklet,* ST/ESA/SER.A/417 (New York: United Nations, 2018), 10, https://digitallibrary.un.org/record/3799524?ln=en; Elias Yitbarek Alemayehu, Imam Mahmoud Hassen, Yonas Alemayehu Soressa, and Laura Stark, "New Perspectives on Urban Transformation in Addis Ababa," in *The Transformation of Addis Ababa: A Multiform African City*, ed. Elias Yitbarek Aemayehu and Laura Stark (Newcastle upon Tyne, UK: Cambridge Scholars Publishing 2018), 2.

[5] UN-Habitat, *The State of Addis Ababa 2017: The Addis Ababa We Want* (Nairobi: UN-Habitat 2017), 73–74.

[6] Ruben Garcia Rubio and Taylor J. Scott, "Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa," *The Plan Journal*, vol. 5, no. 2 (December 2020): 473–94. Ruben Garcia Rubio, and Sonsoles Vela, "Rivers for Urban Regeneration. The Case of the Kebana River in Addis Ababa (Ethiopia)," in *Global Village, Shelter for Resilient Living, Conference Proceedings,* edited by Tatjana Mrđenović (Belgrade, Serbia: Faculty of Architecture in Belgrade), 144.

[7] Paolo Billi, Yonas Tadesse Alemu, and Rossano Ciampalini, "Increased frequency of Flash Floods in Dire Dawa, Ethiopia: Change in Rainfall Intensity or Human Impact?," *Natural Hazards* 76, no. 2 (March 2015): 1373–94; Bisrat Kifle Arsiso, Gizaw Mengistu Tsidu, Gerrit Hendrik Stoffberg, and Tsegaye Tadesse, "Influence of Urbanization-Driven Land Use/Cover Change on Climate: The Case of Addis Ababa, Ethiopia," *Physics and Chemistry of the Earth* 105 (2018): 212–23.

[8] UN-Habitat, *The State of Addis Ababa 2017*, 73.

[9] The "Addis Ababa River City" is an academic, independent, multidisciplinary, and long-term research project lead by the Assistant Professor Dr. Ruben Garcia-Rubio, which is part of the Saul A. Mintz Global Research Studios, within the Tulane School of Architecture (Tulane University—New Orleans LA, USA).

Ababa residents) to improve the city and promote its resiliency within the city.

The following text analyzes some of the critical urban issues that Addis Ababa is currently confronting while also proposing theoretical solutions for how they might be addressed. This paper aims to establish design ideas for specific interventions that can be applied in Addis Ababa through comprehensive, sustainable architecture, combating identified urban issues, and setting an example for other developing cities experiencing similar problems. Because of the range and complexity of challenges the city faces, a holistic solution is needed where conditions can be improved for both residents and their surrounding environment. The intervention described in detail later in this paper provides a solution in the form of hybrid infrastructures which address multiple of the UN's Sustainable Development Goals, overcoming issues related to a lack of mobility, flooding, pollution, and more. The resulting design sets an example of how multiple sustainability issues can be mediated as a whole to create a more resilient city.

3.2 Diagnosis and Urgent Urban Interventions for Addis Ababa

The first step in the research was a holistic analysis of the current situation in Addis Ababa.[10] This analysis unfolds several issues, five of which were determined to be the most urgent and able to be addressed through urban and architectural design.

3.2.1 Lack of Mobility

The Upper Kebena river suffers from connectivity issues due to insufficient infrastructure for a rapidly growing city.[11] Along the northern regions of the river, where most residents walk as their primary source of transportation, there is little access to public transportation services forcing residents to walk on roads unfit for pedestrian travel.[12] Public access to the river is waning as the city grows. Homes are built close to the river, creating barriers to water access for most of the city. Walls and fences are also being put in place along the river in addition to the already steep slopes that exist along much of it.

Bridges exist throughout the city that allow for access across the river. However, most exist downtown, where vehicle travel is predominant. Other city regions lack bridge connections, which limits the mobility of many residents to other communities across the region, particularly those on foot. Due to the overall lack of connection through the rivers, the Upper Kebena river misses opportunities for better connectivity and mobility across the city and sufficient public access to the river.

3.2.2 Flooding

Due to rapid urbanization and the unfortunate realities of climate change, Addis Ababa has been increasingly suffering from flooding issues in recent decades, which has interfered with the city's continued development.[13] Being a city full of small rivers and tributaries, Addis Ababa's urbanization has negatively impacted the natural dynamics of its waterways and the permeability of much of the city's ground surfaces, both crucial aspects of natural water management.

[10] Ruben Garcia Rubio, and Taylor J. Scott. "Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa," 477–83.

[11] Clelie Nallet, "The Challenge of Urban Mobility: A Case Study of Addis Ababa Light Rail, Ethiopia," Institut Français des Relations Internationals—Notes de l'Ifri, February 2018, https://www.ifri.org/en/publications/notes-de-lifri/challenge-urban-mobility-case-study-addis-ababa-light-rail-ethiopia.

[12] The World Bank,*Transport Systems Improvement Project* (Washington, D.C.: World Bank Group), http://documents.worldbank.org/curated/en/490361467992052159/Ethiopia-Transport-Systems-Improvement-Project.

[13] UN-Habitat, *The State of Addis Ababa 2017: The Addis Ababa We Want* (Nairobi: UN-Habitat, 2017), 73. Ruben Garcia Rubio, and Taylor J. Scott. "Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa," 473–76.

Many people in the city live in poorly constructed informal housing that is built close to the bank, mainly due to a lack of space from the rapidly growing population of the city.[14] This housing contributes to erosion along the banks and covers much of the necessary green space along the river needed for ground absorption and flood protection. Because of this, informal neighborhoods are particularly susceptible to fluvial flooding as the winding meanders of the river frequently overflow in the wet season.

3.2.3 Pollution

The natural geography and rivers flowing through Addis Ababa had historically spurred the development of settlements that eventually became the city we know as the capital of Ethiopia today. Despite this, the bodies of water responsible for the inception of civilization in the area have been neglected, becoming open trash dumps in many instances throughout the city.[15]

While the city has increased around these rivers, the waste management infrastructures have not kept pace. With an incomplete sewage network, an inadequate solid waste management system, domestic organic matter discharge, industrial leakage wastes, agricultural and washing outflow among the city's most common waste sources, rivers today have become unfit for necessary uses like cleaning, cooking, or washing.[16]

3.2.4 Water Scarcity

Addis Ababa's existing water services are also under stress because of the city's rapid growth. While over 90% of the city has water coverage, certain areas on the outskirts have only occasional access to water due to the rising demand for housing in the city.[17] Some sub-cities have access to water for only 12 h, three days a week or less.[18] With that, wastewater management is lacking, with about half of the residents using a shared pit latrine, about 18.3 percent using private pit latrines, and 26.4 percent using flush toilets, including pour flushing.[19] Much of this waste is improperly transported and disposed of due to a lack of proper desludging services, leading to significant sanitation issues.

In addition to this, Addis Ababa's sewer system is more or less obsolete, only serving about 10 percent of the population.[20] Many neighborhoods have no access to water taps with little to no infrastructure in place to support the movement of sanitary water. Due to the lack of pipes, people sometimes utilize personal wells or water towers; however, these serve as their own private water supply and do not support surrounding neighbors. The little infrastructure that does exist in the city is old and in desperate need of renovation.

3.2.5 Lack of Facilities

With the lack of infrastructure throughout the city, there is also a general lack of public facilities for residents. This includes services like public restrooms, proper trash collection, etc. As these necessary facilities are rarely provided, the lack thereof contributes to other issues, such as the pollution of rivers and health problems because people have little means of properly

[14] Raffaele De Risi, et al., "From Flood Risk Mapping Toward Reducing Vulnerability: The Case of Addis Ababa," *Natural Hazards* 100, no.1 (December 2019): 387–415.

[15] Ruben Garcia Rubio, Ryan Green, and Sonsoles Vela, "Nature-Based and Hybrid Infrastructures to Build Resilient Cities through the Rivers: Two Case Studies in Addis Ababa (Ethiopia)," in *Proceedings of the ARCC-EAAE 2022 International Conference—Resilient City: Physical, Social, and Economic Perspectives*, edited by Chris Jarrett, and Adil Sharag-Eldin (Architectural Research Centers Consortium), 82–83.

[16] Tamiru Alemayehu, "The Impact of Uncontrolled Waste Disposal on Surface Water Quality in Addis Ababa, Ethiopia," *Ethiopian Journal of Science* 24, no. 1 (2001): 93–104.

[17] International Development Association, *Ethiopia—Second Ethiopia Urban Water Supply and Sanitation Project* (Washington, D.C.: World Bank Group, 2017), 1–5.

[18] Ibid.

[19] Ibid.

[20] Ibid.

disposing of waste. Additionally, a sizable portion of Addis Ababa's occupation is comprised of informal trade; however, other than a few larger markets, there are few convenient places designated for people to sell goods and produce. Affordable housing is also scarce in the city, leading many to resort to building informal housing where they can. As discussed earlier in this paper, these informal settlements further contribute to the degradation of the river ecologies.

3.3 a Strategic Plan for the Upper Kebena River and Kazanchis Neighborhood

The research proposes a strategic plan for the Upper Kebena river, which starts in the northern part of Addis Ababa (Entoto Mountains), extending from the lower-density areas north, down southward to the higher-density areas around Peacock Park close to the city center.[21] The general plan uses the river to address the identified urban issues, improving the overall relationship between the city and its bodies of water, as it focuses on the ecology, mobility, and connectivity opportunities that a river regeneration could bring to the city. One neighborhood along the river that was selected as an appropriate example of how this strategic plan works is the downtown Kazanchis neighborhood. Here, there are opportunities to improve conditions concerning the UN's Sustainability Development Goals (SDGs). More specifically, the strategy addresses clean water and sanitation; innovation and infrastructure; sustainable cities and communities; responsible consumption and production; zero hunger; decent work and economic growth, and climate action (Fig. 3.1).

The Kazanchis neighborhood lies between Kenenisa Ave and the A2 highway and is bisected by the Kebena river. Located downtown, this neighborhood was chosen as a site for further investigation and intervention due to severe flooding problems caused by the Kebena's natural meander in an area filled with informal housing settlements. The poorly constructed homes are built too close to the river and are unable to cope with the natural flooding that occurs in the area. They also contribute to the erosion of the banks, which only furthers the flooding issues over time (Fig. 3.2).

As was mentioned, due to the general lack of infrastructure throughout the city, the river acts as a barrier that divides the neighborhood. The only two bridges that span the river, both over 50 m, are busy roads designed with only vehicles in mind, making them unsafe for pedestrians. In a city where walking is the predominant means of travel, access across the river that caters to pedestrians should be essential. Moreover, as the city continues to grow, access to the river itself decreases, with homes being built too close to the river in addition to walls and fences being constructed along the banks. If people cannot use the water from the river, what incentivizes them to keep it clean?

3.4 Revitalizing the Meander, a Holistic Urban and Architectural Design

The intervention proposes the use of hybrid infrastructures in the Kazanchis neighborhood that span the Kebena river to create multifunctional points of connection across, while soft-ecological interventions such as meander diversions, gabion walls, riparian restoration, and more are strategically implemented to mitigate flooding along the river's banks. The hybrid structures are intended to serve first as-needed bridges for pedestrians that work as an extension to a proposed "green and blue" street typology strategy, discussed later in detail, while also providing additional programming where it's needed, most importantly, housing for those living in the flood-prone settlements on the banks (Fig. 3.3).

[21] Ruben Garcia Rubio, and Taylor J. Scott, "Designing for Sustainable and Resilient Neighborhoods: The Case of Peacock Park in Addis Ababa (Ethiopia)," in *2020 AIA/ACSA Intersections Research Virtual Conference: Carbon*, edited by Corey T. Griffin and Erica Cochran Hameen (Washington: ACSA Press), 82–89.

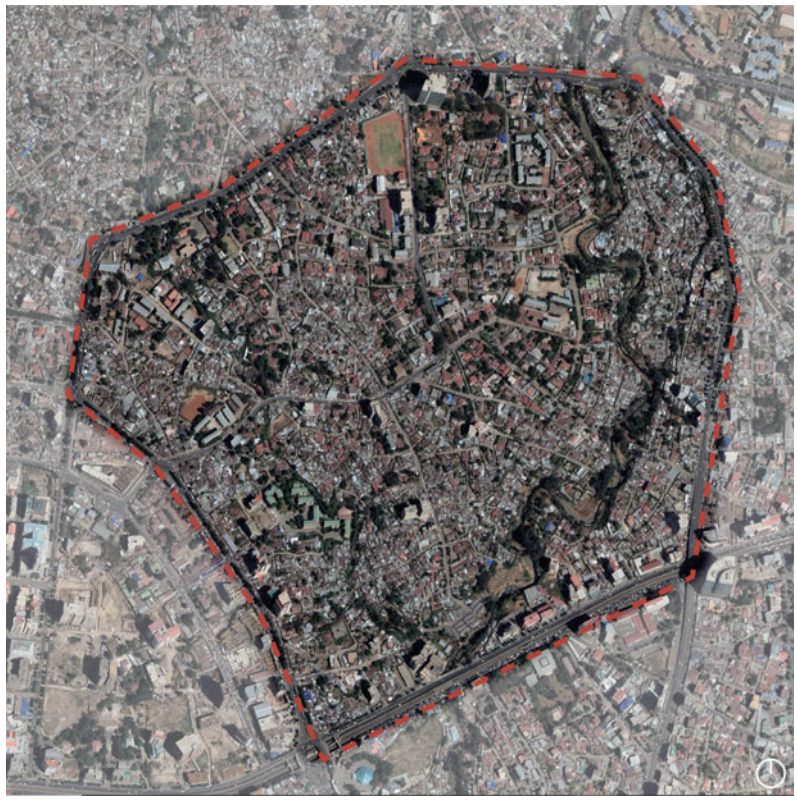

Fig. 3.1 Kazanchis neighborhood. Google Map (February 2022), edited by "Addis Ababa River City" (henceforth AARC)

Fig. 3.2 Strategic plan for Kazanchis neighborhood: Connection, Housing, and Flooding. Connection diagram (left): potential bridge connections across the river in red. Housing diagram (center): plans for new hybrid bridges in black, with proposed housing and other amenities. Flooding diagram (right): areas of predominate flooding along the river meander in blue. AARC

At a larger scale within the neighborhood, multiple structures are proposed at specific points along the river, determined to have the most opportunities considering the surrounding street layout and planned green street strategy. These nodes not only connect both sides of the river but also provide some form of amenities and/or utilities accessible to the public within the

Fig. 3.3 General axonometric, the extent of all interventions included within a hybrid bridge structure. AARC

structures. These include markets, public facilities, waste collection, compost, urban agriculture, and recreational green space to improve water-ground retention. By providing these needed programs at the connection points across the river, more significant interaction and access to both the connections and included programs are reinforced. Along with a slow mobility path that follows the river and strings them together, this network would enhance the walkability and usage for pedestrians who currently have limited access across the river.

At the building scale, one of these hybrid infrastructures was further designed as an example. The location was chosen where a large bend in the river creates about a five-meter disparity in elevations of each bank, causing significant flooding issues for the surrounding area. On the higher side, a steep drop to the river makes access to water challenging. On the lower side, poorly constructed homes frequently flood during the wet season due to a shallower bank and a lack of permeable ground. The proposed structure would become a multilevel bridge spanning the river, creating a seamless connection between selected streets on either side (Fig. 3.4).

The hybrid bridge is intended not only to function as a bridge but also as a neighborhood amenity, becoming a hub for pedestrian activity. On one side of the bridge, a marketplace is proposed as an entry point continuous with the existing street. While on the other, new housing relocates those prone to flooding. Additional arms extend off the bridge to further enhance connectivity along with the proposed mobility path, which stretches along the river. In addition, different ecological interventions are used throughout and around the site, including existing streets, to combat flooding in the area while cleaning the river.

The design of the regulated structural system allows for a variation in a form where multiple programs can be freely housed. Because informal trade is prevalent throughout the city, the market was chosen as the additional program to support the housing on the other side. According to a study conducted by the Ethiopia Microfinance Institution in 2002, about 50% of the active labor force in Addis Ababa was employed in the informal sector.[22] Coupled with the agricultural field proposed adjacent to the bridge, the marketplace creates an opportunity for those residents to sell locally grown produce, among other goods, at a central location. Together, the market

[22] Tekle Bekele Tekle, "Management of Informal Traders in Public Spaces: A Case Study of Megenagna Square, Addis Ababa, Ethiopia" (Research Project—Master of Urban Management, University of Nairobi, Nairobi, 2021), 12.

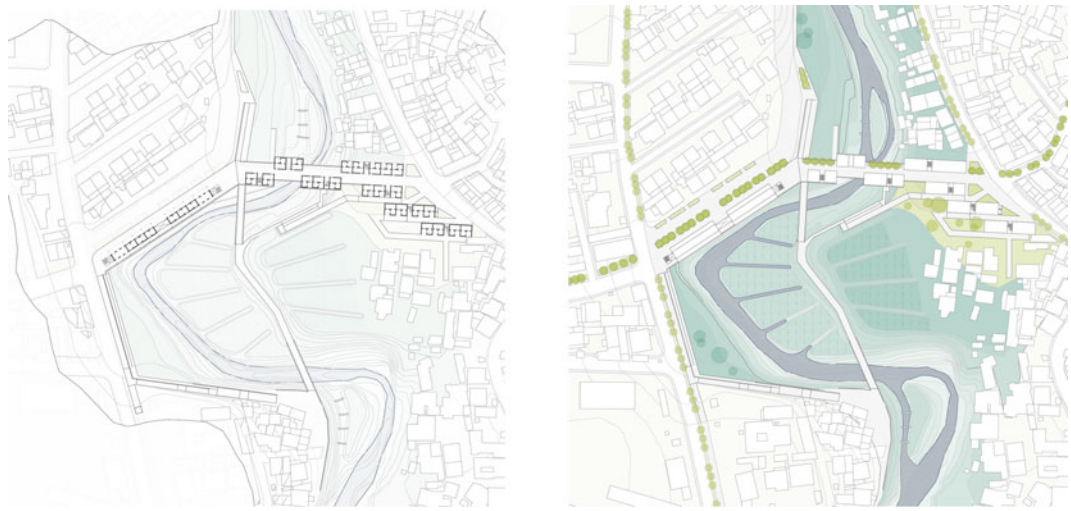

Fig. 3.4 General ground plan and flooding plan. Ground plan (left): the floor plan of housing and marketplace along with the river during normal conditions. Flooding plan (right): the site plan of the hybrid bridge structure and all included interventions shows the river during flooded conditions. AARC

and local agriculture work to enhance responsible consumption and production, zero hunger, a decent job, and economic growth.

The housing is intended to relocate those living in the informal settlements near the river, freeing up much-needed green space for water absorption and retention along the banks. These new homes would be more accessible to residents and of much greater construction quality, being built into the bridge's structure. Providing locals with proper housing that is safe from flooding and restoring the necessary green space for flood protection is an example of how the sustainability of the city and community can be reinforced throughout Addis Ababa.

The streets on either side that the bridge links are converted into "green and blue streets" that fit into the greater network of street typologies established at large throughout the strategic plan to improve clean water and sanitation and promote sustainable cities and communities. The blue street typology is proposed for larger main roads and focuses on wastewater management through above-ground sewer systems. Green streets are comprised of smaller streets that branch off the more significant blue streets. A portion of the street is allocated toward green space that takes the form of bioswales and other plantings, which are used for water filtration and managing runoff. The green streets are continuous over the bridge structure, providing ecological benefits while establishing a visual continuity across the river. The street connection across becomes the trunk of the bridge with secondary paths, then branching out into the surroundings. Certain routes connect to the lower levels of the structure where the slow mobility path intersects before continuing up the river. There is public access to the river on the lowest level, where locals can use the water (Fig. 3.5).

In the center of the river bend, a field of urban agriculture serves as the primary flood mitigation strategy at the river meander. When the river rises, water floods the trenches between the plantings, both retaining and filtering the water heading downstream while also irrigating the crops. A diverse range of crops would need to be used to create effective resiliency. After analyzing more than 150 experiments worldwide, the Union of Concerned Scientists determined that for the most outstanding efficiency, agricultural fields need to incorporate perennial crops in addition to

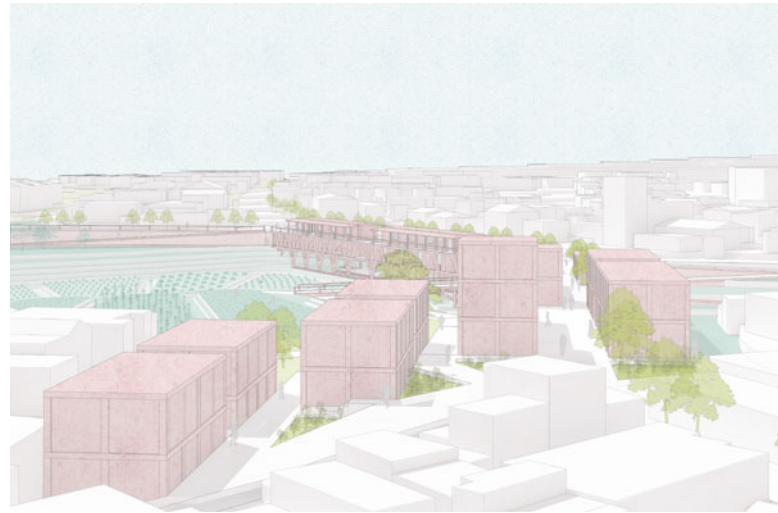

Fig. 3.5 Aerial general view, a perspective of the hybrid infrastructure from the housing. AARC

grasses and cover crops to ensure permanent land cover.[23] This increases crop water use efficiency by reducing runoff and contributing to soil improvements that create more water storage, in turn enhancing resilience to flooding.

River diversions are strategically placed at either end of the meander, bookending the agricultural field in the center. These diversions help to redirect water when the river rises to keep it from flooding the banks. While they only redirect the water when it reaches a certain level, the riparian buffer is restored within the diversions to enhance the deteriorating river ecosystem. According to the European Environment Agency's platform Climate-ADAPT, riparian vegetation alongside bodies of water reduces vulnerability to floods by protecting against sediment and pollutant runoff and increasing groundwater recharge.[24] This natural vegetation improves water quality and slows water flow during wet seasons. Additionally, gabion walls are employed at the meander diversions to filter the water further and prevent more significant pollutants from collecting. These walls are beneficial for erosion control and dissipating river energy during flooding (Fig. 3.6).

Using ecological interventions as simple as the examples above not only prevents flooding and erosion but also goes a long way toward promoting clean water and sanitation for residents in the city. Being a mostly "river city," Addis Ababa should look to its rivers not as obstacles to be built around but as opportunities to be integrated.

3.5 Conclusion

As urban issues are complex, multi-faceted solutions are necessary to address the problems emanating throughout our cities. Today, climate change has become one of the greatest threats to our future, impacting populations globally. Precisely, developing nations and those adjacent to bodies of water are predicted to see the most considerable negative impacts with weather patterns becoming more severe. As climate change worsens, further aggravating already existing urban issues, a rapidly growing city like Addis Ababa must become more resilient as it continues to expand. On top of that, with the unexpected COVID-19 pandemic that persists today, the need for well-designed public spaces is only

[23] "Turning Soils into Sponges. How Farmers Can Fight Floods and Droughts," *Union of Concerned Scientists*, August 7, 2017, https://www.ucsusa.org/resources/turning-soils-sponges.

[24] "Establishment and Restoration of Riparian Buffers," Climate ADAPT—European Environment Agency, September 3, 2016, https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/establishment-and-restoration-of-riparian-buffer-s.

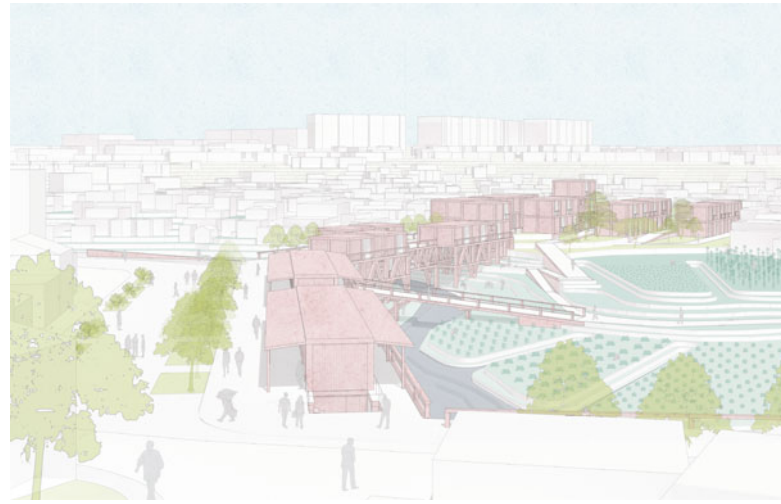

Fig. 3.6 Aerial general view, a perspective from the marketplace. AARC

becoming more apparent. Climate change or COVID-19 should not be seen as hindrances in future design but as opportunities to curb environmental and public health issues before they become emergencies. Efforts to create healthier cities for both their inhabitants and their environment should be prioritized as the new standard in design.

The objective of this paper is to outline proposed design measures resulting from the research done for the Addis Ababa River City research project. The specific intervention detailed in this paper for the Kazanchis neighborhood serves as an example of integrated designs that can create better-functioning, more sustainable cities while focusing on much-needed climate action. As existing systems fail to keep up with the demands of a growing city, Addis Ababa must look toward ecological infrastructures to remediate the pressures it has put on its environment and hinder the worsening effects of climate change. Specific measures, like the ones detailed in this paper, can be taken to curb issues relating to flooding, pollution, water scarcity, mobility, etc., while enhancing the public realm for city residents. Using hybrid-programing, multiple infrastructural and programmatic needs can be met where they are currently lacking and necessary, all within an active node that extends into its surroundings. Incorporating the rivers into design allows for passive strategies in cleaning polluted water bodies and enriching soils for farming, making them an essential part of urban living. Having these interventions work with the natural dynamics of Addis Ababa's landscape and waterways, rather than fighting against them, improves access throughout the city for those who need it, reduces the adverse effects that modernization and growth have had on the environment, and creates a more productive, resilient city for the future.

The ideas proposed in this paper are justifiable for progress in Addis Ababa. However, such comprehensive designs are primarily based on theory. For actual development to occur, greater political and economic strategies for implementation would be necessary. The residents of Addis Ababa would be unable to execute on their own so government involvement would be required. As land in the city is predominantly state-owned, a viable first step could include government action in terms of constructing new bridges spanning the river. Because hybrid infrastructures are at the center of this proposal, this would be the necessary catalyst for developing the sustainable strategies detailed in this paper. At worst, new bridges that enhance connectivity in Addis Ababa would be created, connecting neighborhoods across the river. At best, funding through the private sector could

take the next step to improve these bridges, making them genuinely hybrid and allowing other programs that have been described above to be included, such as housing. Because the government presumably lacks adequate funds to conceive the entirety of this project, private institutions would likely be necessary. For example, affordable housing rent could generate income to continue the development of hybrid bridges and gradually include more interventions over time, such as the marketplace, agricultural fields, and other ecological infrastructures. Such inclusive involvement could bring the ideas of this project into fruition, steadily improving the resiliency, sustainability, and overall conditions of Addis Ababa and achieving progress toward the UN's Sustainability Development Goals in the city.

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