



CLIMATE RISK ASSESSMENT

Addis Ababa, Ethiopia

JANUARY 2023

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¹ <https://worldpopulationreview.com/world-cities/addis-ababa-population>

² Dorosh, P.I., & Schmidt, E. (2010). *The rural-urban transformation in Ethiopia*, International Food Policy Research Institute. <https://www.ifpri.org/publication/rural-urban-transformation-ethiopia>

³ World Bank. Urban Population (% of Total Population) - Ethiopia | Data. <https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ET>

⁴ World Bank (2010). *The Ethiopian urban migration study 2008: The characteristics, motives and outcomes of migrants to Addis Ababa*

⁵ ReliefWeb. Ethiopia national displacement report 6, round 23: August - September 2020 - Ethiopia. Accessed November 12, 2021. <https://reliefweb.int/report/ethiopia/ethiopia-national-displacement-report-6-round-23-august-september-2020>

⁶ Resilient Cities Network (2020). *Addis Ababa Resilience Strategy*. <https://www.preventionweb.net/publication/addis-ababa-resilience-strategy>

⁷ Beshir, A.A., & Song, J. (2021). Urbanization and its impact on flood hazard: The case of Addis Ababa, Ethiopia, *Natural Hazards*, 109, 1: 1167–90. <https://doi.org/10.1007/s11069-021-04873-9>

⁸ Yohannes, H., & Elias, E. (2017). Contamination of rivers and water reservoirs in and around Addis Ababa city and actions to combat it, *Environment Pollution and Climate Change*, 1:116. <https://doi.org/10.4172/2753-458X.1000116>

Background

Addis Ababa is Ethiopia's capital and largest city. Today's metro population of 5.3 million people—already more than twice its 2000 value of 2.3 million—is projected to reach almost 9 million by 2035.¹ This is in line with broader global trends whereby half of the world's population growth through 2050 will occur in Africa. With only 21% of its population in urbanized areas, Ethiopia is in the early stages of a rural-to-urban transformation and is one of the least urbanized countries globally.^{2,3} Addis, however, has a long history of in-migration—approximately 40% of Addis inhabitants were born outside the city.⁴ This trend is expected to continue. Conflict, environmental degradation, and climate change will continue to displace people throughout Ethiopia and contribute to increased urbanization in all Ethiopian cities and towns, especially Addis.⁵

Informal settlements in Addis are the prime destination for most migrants (both internal and international). These areas are characterized by infrastructure that is either non-existent or severely lacking, and face the twin challenges of worsening climate change and poor urban environmental policy. Addis' mountainous landscape has already been degraded from deforestation and soil erosion from the ongoing proliferation of informal settlements. Such unlicensed construction is typically associated with poor drainage systems, improper waste disposal, and a loss of green spaces—further exacerbating Addis' vulnerability to shocks and stressors.⁶

In particular, such rapid urbanization and expansion of informal settlements exacerbate the city's vulnerability to flooding.⁷ The decline in green spaces alone is estimated to contribute to 40% of flooding and landslides in Addis. Public health is also negatively impacted by the footprint of informal settlements. An estimated 40% of vegetables supplied in the city are irrigated with wastewater drawn from polluted rivers.⁸ Finally, the pressures of in-migration are additional to existing climate change impacts. Already in today's climate,⁹ Addis is particularly vulnerable to drought, heat waves, and flooding—67% of the population in Addis lives in flood prone areas.¹⁰ Addressing social and climate pressures in a quickly urbanizing metropolitan area is a frontier challenge for Ethiopia and the Addis city government.

While there is broad consensus that improvements to the climate resiliency of Addis are necessary and urgent, the governance system suffers from severe limitations that impede these improvements.¹¹ As a result, climate change planning is not yet fully integrated into general urban planning activities. A recent survey of planning and administrative professionals points to several implementation issues. Almost half of respondents did not believe that Ethiopia's urban spatial planning policy documents successfully mainstreamed resilience principles, with 35% of respondents ascribing that failure to poor political commitment and lack of communication between federal, regional, and local levels.¹²

This is supported by past trends whereby climate change adaptation is implemented at the national level, not locally,¹³ and by the five local to federal agencies with planning authority for Addis.^{14,15} Informal construction practices that severely limit the enforceability of land protections and building standards are another key issue. There is some degree of public skepticism and distrust towards official planning efforts. In the recent past, that dissatisfaction culminated in public unrest, which led to abandonment of the Integrated Regional Development Plan.

To address this history of governance challenges, the Addis Ababa Climate Action Plan¹⁶ highlights a need for improved coordination between city and federal authorities and a

⁹ Today's climate corresponds to a 1°C world. Since 2000, global annual mean temperatures have averaged 1°C warmer than the 1850–1900 baseline used as a reference period for climate policy. There is already a ca. 50% chance of exceeding the Paris Agreement's 1.5°C threshold for safe bounds of climate warming in the next 5 years. The warming level in 2021 was 1.2°C, the highest level ever recorded in the instrumental era.

¹⁰ Jalayer, F., Herslund, L., Cavan, G., Printz, A., Simonis, I., Bucchignani, E., Jean-Baptiste, N., et al. (2013). *Climate change induced risk analysis of Addis Ababa city (Ethiopia)*, EGU General Assembly, Poster, 9457

¹¹ Resilient Cities Network. Addis Ababa Resilience Strategy (2020). <https://www.preventionweb.net/publication/addis-ababa-resilience-strategy>

¹² Maru, M., & Worku, H. (2022). Unpacking principles of resilience mainstreamed in Ethiopia's local urban spatial planning documents: Practices from Kombolcha, an urbanizing secondary city, *Heliyon*, 8. <https://doi.org/10.1016/j.heliyon.2022.e09137>

¹³ Pauleit, S., Coly, A., Fohlmeister, S., Gasparini, P., Jorgensen, G., Kabisch, S., & Yeshitela, K. (2015). Urban vulnerability and climate change in Africa. *Future City*, 4.

¹⁴ At the municipal level the Addis Ababa City Plan Preparation Program Office, the Land Development and Management, and the Agency and Environmental Protection and Green Development Commission are key players. The Ministry of Urban Development and Construction and the Environment, Forest and Climate Change Commission (recently renamed the Ethiopian Environmental Protection Authority) are relevant at the federal level.

need for additional training to increase the professional and technical capacity of city staff. This same planning document also describes existing priorities. The top climate concern is drought, which will affect health, hydroelectric energy production, and urban agriculture. Flooding is a major concern, particularly in the sub-cities of Kolfe Keranio, Nifas Silk-Lafto, and Addis Ketema. Landslides, driven not only by extreme rainfall but also poor urban water management and the loss of green space, will affect Gullele and Yeka in particular. Additional concerns are heat waves, extreme day and night-time temperatures, and increasingly heavy and variable rainstorms.

While the challenges in Addis are significant, similar environmental, climate, and urban planning concerns are shared by many African cities. These center on governance capacity and land use enforcement; urban stormwater management, riverine flooding, sewage management, and water provisioning; climate-change- and urban-heat-island-induced high temperatures; and contamination of air and water resources. Addis, like most African primary cities, will be better able to adapt to climate change with improved land use management and building standards, upgraded urban drainage and stormwater management infrastructure, and more urban green infrastructure. City climate adaptation plans must also incorporate the needs and experiences of migrants and those living in informal settlements, who are both particularly vulnerable to climate change and also play a role in exacerbating environmental challenges in cities.

Results

To illustrate the links between climate change, land and water management, and vulnerable populations in Addis, we examine projected changes in extreme heat, drought, and flooding. Our analysis explores how these changes have affected—and will continue to impact—informal settlements, land and water use, and development plans within the city.

Social Vulnerability

Informal Settlement Maps

Approximately 80% of Addis Ababa's population live in informal settlements.¹⁷ These settlements are known as “Chereka Bet,” and are home to the city's most vulnerable residents, including migrants and refugees. Prior attempts have been made to map these informal settlements,¹⁸ but due to the lack of comprehensive and current maps of informal settlements in Addis, bespoke maps were developed for this study.¹⁹

Vulnerability Analysis

An analysis of social vulnerability considered three variables: wealth, access to communication devices, and years of education.²⁰ Social vulnerability in Addis remains low relative to the rest of the country, likely because the urban setting is where communications, education, and wealth tend to be concentrated. However, the city is not without pockets of high vulnerability, often where informal settlements, a lack of resources, and exposure to climate hazards coincide.

¹⁵Ayele, B.Y., Megento, T. L., & Habetemariam, K. Y. (2021). Governance of green infrastructure planning in Addis Ababa, Ethiopia, *Land Use Policy*, 111, 105777. <https://doi.org/10.1016/j.landusepol.2021.105777>

¹⁶Addis Ababa Environmental Protection and Green Development Commission & C40 Cities Climate Leadership Group (2021). *Addis Ababa climate action plan (2021–2025): Towards a climate resilient, inclusive, carbon neutral city by 2050*. <https://addisenvironment.gov.et/wp-content/uploads/2021/10/C-40-September-14-compressed.pdf>

¹⁷UN-HABITAT (2010). *The Ethiopia case of condominium housing: The integrated housing development programme*, United Nations Human Settlements Programme: Nairobi. <https://unhabitat.org/condominium-housing-in-ethiopia>

¹⁸E.g. Woldegerima, T., Yeshitela, K., & Lindley, S. (2017). Characterizing the urban environment through urban morphology types (UMTs) mapping and land surface cover analysis: The case of Addis Ababa, Ethiopia. *Urban ecosystems*, 20(2), 245–263. <https://doi.org/10.1007/s11252-016-0590-9>; Abagissa, G. (2019). Informal settlements in Addis Ababa: extent, challenges, and measures taken. *Journal of Public Administration, Finance and Law*, 7–8.

¹⁹As in previous studies, we inferred the location of informal settlements in Ethiopia from a combination of satellite imagery, aerial photography, and Google Streetview. Following established methods, we used visual cues such as small lots, irregular street patterns, a lack of green space, and unpaved roads to identify informal settlements from aerial and on-the-ground imagery.

²⁰Data Source: UEP Climate Migration Research Team, USAID.

Climate and Environmental Vulnerability

Extreme Heat

Although the entire city of Addis will experience warming in the future, some districts are more vulnerable to extreme heat than others. In the southern end of the city, Akaky Kaliti, Bole, and Nifas Silk-Lafto are already experiencing some of the hottest maximum temperatures across the city during the warm season (March–May), and will remain more vulnerable to extreme heat in the future as well (Table 1).

Table 1. Average warm season (March–May) maximum temperatures for 2000–2020, 2040–2060, and 2070–2090 by region in Addis Ababa (°C). *Data Source: CMIP6 data, downscaled using the CHELSA methodology.*^{21,22}

District	2000–2020	2040–2060	2070–2090
Addis Ketema	22.80	24.32	25.90
Akaky Kaliti	25.57	27.07	28.64
Arada	22.80	24.32	25.90
Bole	24.20	25.71	27.29
Gullele	22.40	23.92	25.50
Kirkos	23.47	24.98	26.56
Kolfe Keranio	23.84	25.34	26.92
Lideta	23.44	24.95	26.52
Nifas Silk-Lafto	24.70	26.21	27.78
Yeka	22.94	24.45	26.03

Extreme daily maximum temperatures, those that occur on average every 1-in-20 days, or the hottest 5% (18 days) of the year, are expected to increase by 1.7°C between 2000–2020 and 2040–2060 for Addis (Figure 1a). For the warm-season months of March, April, and May, an increase of 1.8°C is expected (Figure 1b). This means that the 18th-hottest day of the year will be, on average, around 1.8°C warmer in the future compared to the recent past. Daily maximum temperatures throughout the year are also set to increase; this can be seen in the rightward shift of the peak of the distribution curves between 2000–2020 and 2040–2060.

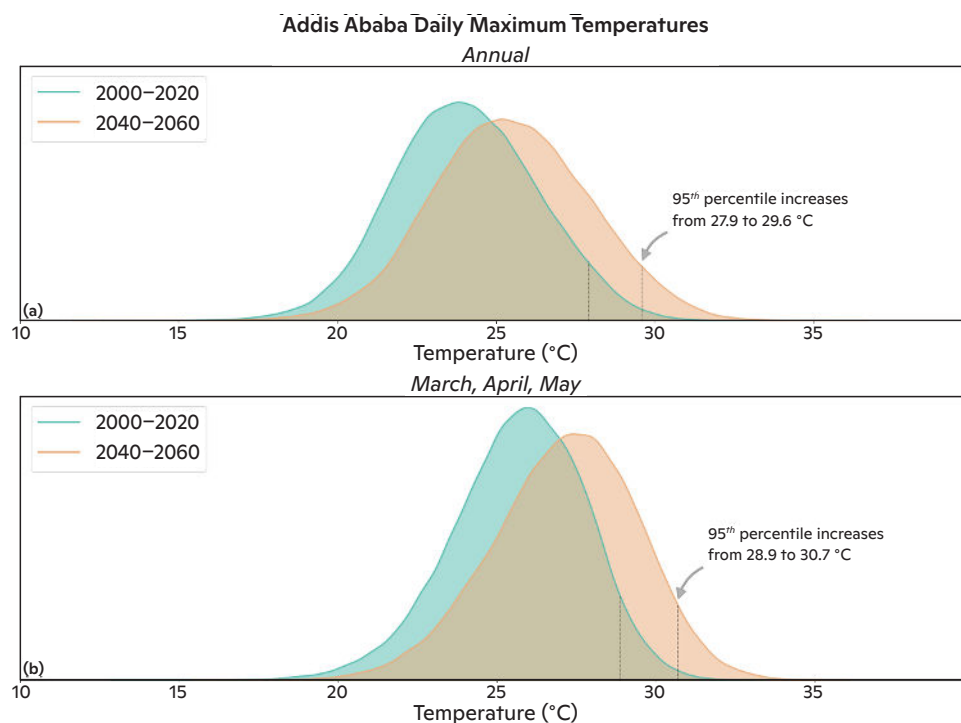


Figure 1: Daily Maximum Temperature Distributions for Addis. (a) Annual. (b) March, April, and May (warmest season). *Data source: CMIP6 data, bias-adjusted and downscaled using ISIMIP3BASD v2.5 methodology.*^{23,24}

The city of Addis has made major strides in combating malaria in recent years, and has a low incidence rate—even designated as “malaria-free”²⁵—relative to the rest of the country (Figure 2). However, climate change has the potential to expand the mosquito habitation zone and, consequently, spread of mosquito-borne diseases such as malaria.²⁶ Despite its projected warming, Addis will be somewhat immune from the climate-change-driven habitat expansion of mosquitos given its arid environment at high elevation, but malaria will remain an important health consideration moving forward.

²¹Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, P., Kessler, M. (2017). Climatologies at high resolution for the Earth land surface areas, *Scientific Data*, 4 170122. <https://doi.org/10.1038/sdata.2017.122>

²²Karger, D.N. (2022). Chelsa-cmip6 python code (Version 1) [computer program]. https://gitlabext.wsl.ch/karger/chelsa_cmip6/-/tree/master/ [Last Access: August, 2022]

²³Lange, S. (2019). Trend-preserving bias adjustment and statistical downscaling with ISIMIP3BASD (v1.0), *Geosci. Model Dev.*, 12: 3055–3070. <https://doi.org/10.5194/gmd-12-3055-2019>

²⁴Lange, S. (2021). ISIMIP3b bias adjustment fact sheet. Report. https://www.isimip.org/documents/413/ISIMIP3b_bias_adjustment_fact_sheet_GnszCO.pdf

²⁵Yalew, A.W. (2022). Achievements, gaps, and emerging challenges in controlling malaria in Ethiopia. *Front. Trop. Dis* 2:771030. <https://doi.org/10.3389/fitd.2021.771030>

²⁶Caminade, C., Kovats, S., Rocklöv, J., Tompkins, A. M., Morse, A. P., Colón-González, F. J., et al. (2014). Impact of climate change on global malaria distribution, *Proceedings of the National Academy of Sciences*, 111.9: 3286–3291. <https://doi.org/10.1073/pnas.1302089111>

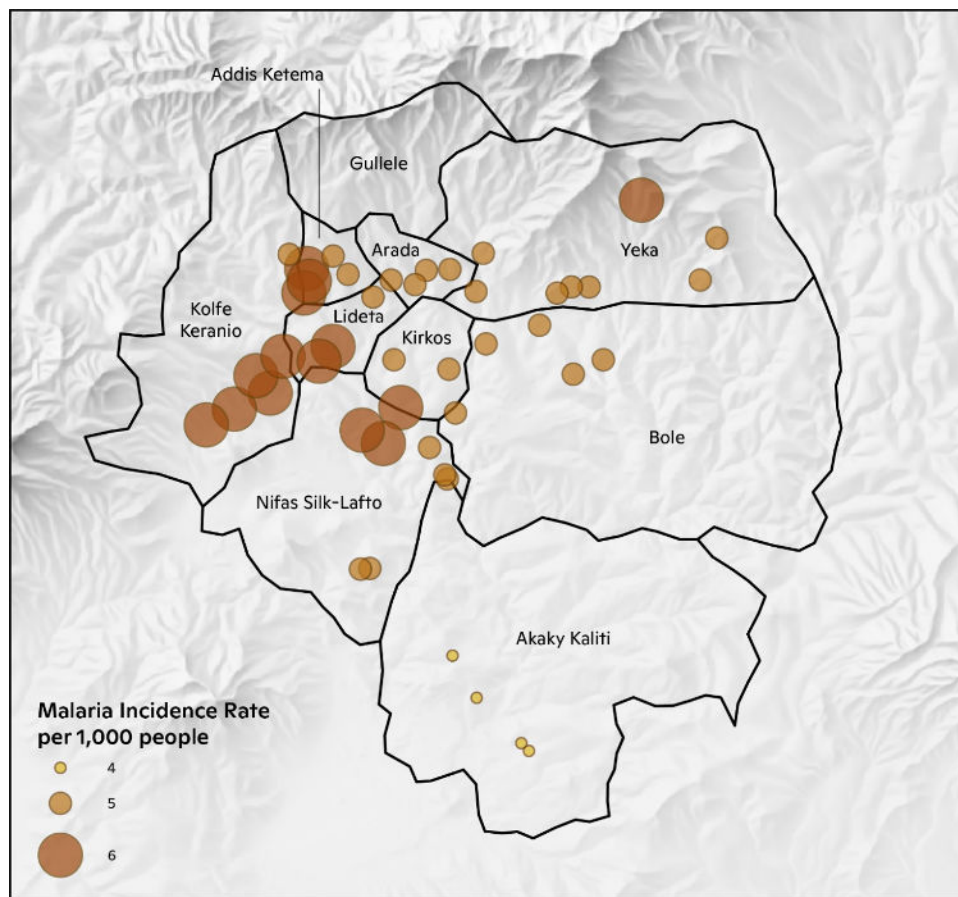


Figure 2: Observed Malaria Incidence Rates in Addis Ababa.²⁷

Drought

The frequency of extreme drought in Addis is expected to increase between 2000–2020 and 2040–2060. Drought stress is based on the Palmer Drought Severity Index (PDSI), a globally recognized standard of drought assessment.²⁸ In the past two decades, Addis experienced extreme drought, on average, around three months per year. In 2040–2060, Addis is projected to experience an annual average additional 1.6 months of extreme drought, an increase of 53%.

Land Use and Flooding

Flooding is a major environmental challenge in Addis Ababa. Flood risk is magnified by city construction around three large rivers, a weak sewage system, frequent construction excavations that exacerbate flood and landscape risk, and a poor drainage system. The number of people exposed to flood risk in Addis is increasing and water-related challenges extend beyond flooding to include procurement, treatment, and management of polluting solid and liquid wastes. Climate change will increase water-related challenges by driving variable surface river flow and groundwater replenishment, increased evaporation, increased water demand, declining water quality and associated health problems, and more.

²⁷Data Source: IPUMS Demographic and Health Surveys. <https://www.idhsdata.org/idhs>

²⁸Barichivich, J. et al. (2021). Monitoring global drought using the self-calibrating Palmer Drought Severity Index [in "State of the Climate in 2020"], *Bull. Amer. Meteor. Soc.*, 102(8), S68–S70. <https://doi.org/10.1175/BAMS-D-21-0098.1>

Too much rainfall, particularly if it occurs within a short period of time in an urban area, can lead to flooding. This poses risks in cities, as urban environments are much less equipped to deal with high precipitation. The central areas of Addis Ababa, which contain the greatest density of impervious surfaces that contribute to flood risk, have a concentration of relatively high precipitation averages. Some of the greatest flood risk occurs in the southern half of the city where the slope is relatively flatter than in the northern parts of the city (Figure 3). The Nifas Silk-Lafto region of the city has experienced considerable development in the floodplain that has exacerbated vulnerability.

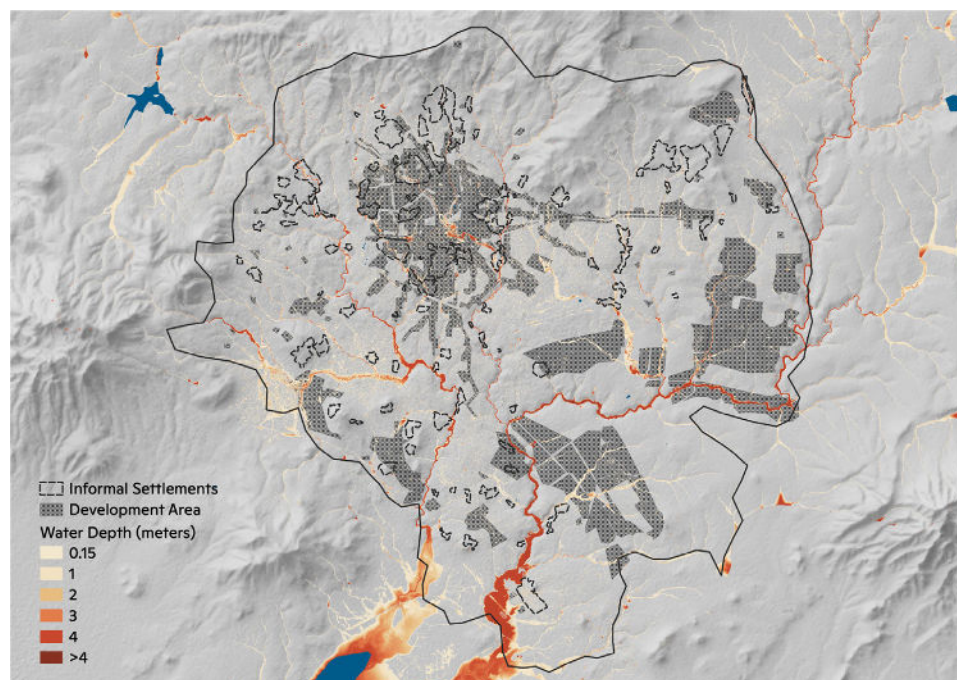


Figure 3: Present-day flood depths for the 1-in-100 year flood event. Informal settlements and future development areas are overlaid.

Table 2. Number of buildings impacted by floodwaters.

	Present	2050	2080
Informal Settlements (Total: 89,960)	9,436 (10.1%)	10,758 (12.0%)	11,514 (12.8%)
Non-Informal Settlements (Total: 584,822)	55,616 (9.5%)	62,393 (10.7%)	65,760 (11.2%)

An analysis on whether informal settlements face a disproportionate level of flood risk compared to the rest of Addis Ababa was conducted by calculating the number of buildings that would be impacted by floodwaters during the 100-year flood event. Because the buildings dataset represents present-day development, these results are underestimates of future building exposure given that construction will only continue as the population in Addis Ababa increases. The results of the analysis (Table 2) show

that informal settlements face a higher level of risk based on the metric of buildings impacted. The disparity also grows through the 21st century: presently the percentage difference is 0.6%, and this will grow to 1.3% by 2050, and 1.6% by 2080. We conclude that informal settlement communities will likely face greater disproportionate flood risk through the 21st century. Moreover, floods have the propensity to disproportionately impact under-resourced communities due to a lack of insurance and the resources to rebuild in their aftermath.

Green Space

Loss of green spaces in Addis Ababa due to current development practices and changing urban land use is exacerbating landslides and flooding within the city. Figure 4 shows the change in urban land cover from 2000 to 2020 with a clear trend in expansion. Preservation of green spaces, then, is an important resilience strategy for the city. Two major barriers to the preservation of green spaces in Addis Ababa are the lack of adherence to plans and institutional structures that impede coordination and collaboration among city agencies and those across municipal and federal bounds.

Much of the new development in Addis Ababa is replacing cropland areas. Figure 5 shows that many areas where urban space has taken hold from 2000 to 2020 were previously croplands. Furthermore, some development has occurred in the existing floodplain. Ten percent of the newly built-up area within the last decade has been in the present day 100-year floodplain. As Addis Ababa continues to grow, it is expected that development will progress and that there will be further encroachments into the floodplain. As a result, flood risk to both people and structures will only grow in the future in the face of climate change.

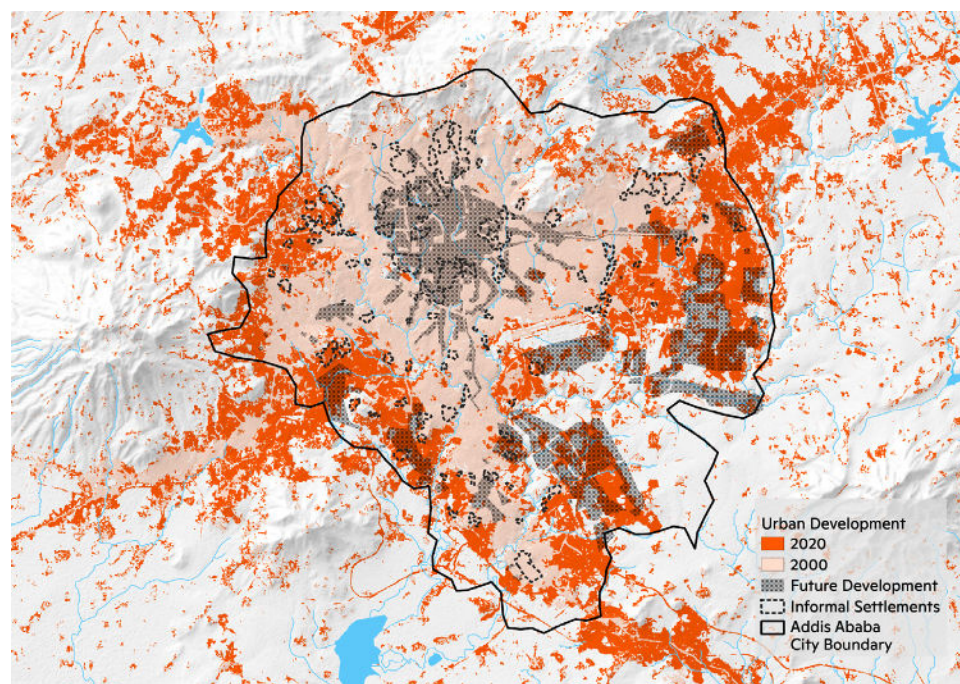


Figure 4: Change in urban land cover in Addis Ababa from 2000 to 2020.²⁹

²⁹Land cover data is from the Global Land Analysis and Discovery Laboratory at the University of Maryland. <https://glad.umd.edu/dataset/GLCLUC2020/>. Future development areas are from the Addis Ababa city structure plan: Draft final summary Report (2017-2027). https://www.c40.org/wp-content/static/other_uploads/images/2036_Addis_Ababa_Structural_Plan_2017_to_2027_original.pdf?1544193458

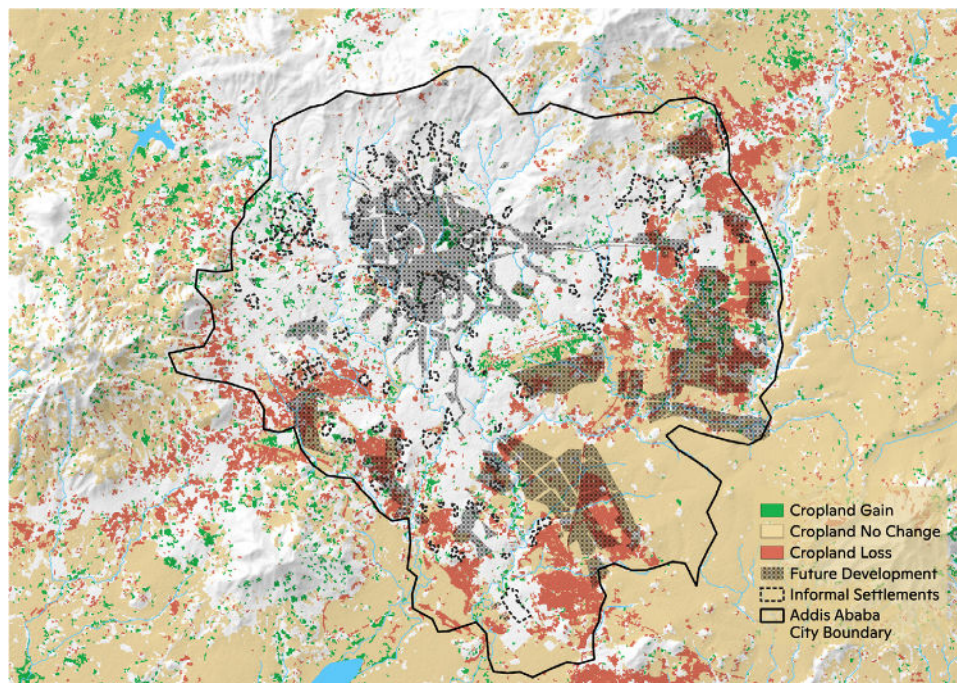


Figure 5: Cropland land cover change from 2003 to 2019 in Addis Ababa.²⁷

Housing

Rapid urban growth is exacerbating environmental challenges in Addis Ababa but is also a product of climate change itself. More severe droughts in Ethiopia are making traditional farming unsustainable and causing farmers to move to the city in search of different livelihoods, thus driving urban expansion. Within the city of Addis Ababa, flooding is a major environmental challenge. Informal settlement growth along riverbanks is decreasing flood resilience by reducing the riverbanks' capacity to buffer storm surges and leading to contamination of the river system from household waste.

Waste Management

Solid waste management is a continuing concern for Addis Ababa. Solid waste is often left in residential neighborhoods or collected but not properly treated. These issues pose threats to human health but also can exacerbate city flooding and environmental concerns as unmanaged waste clogs natural and constructed drainage infrastructure. All resilience plans for Addis Ababa aim to increase the quantity of recycled and composted goods.

Conclusions and Policy Recommendations

To address impending climate risks—especially to Addis Ababa’s most vulnerable communities—appropriate policy responses and actions can increase the city’s climate resilience. Specific recommendations include:

- 1. Need for effective land management.** The city’s planners understand the greater need for the incorporation of climate and resilience concerns—including the use of green space for flood control and heat mitigation—into land-use planning. We recommend that green space regulations are better clarified and better enforced, to enhance effective land management and green space preservation.
- 2. Need for climate-resilient housing.** Although the extent to which the City has developed housing is laudable, the location of these projects on wetlands and having limited transportation access is less than ideal. Housing development policy interventions such as the consideration of flood risks, the implementation of resilient construction practices, and the prioritization of urban mobility and transportation access would improve Addis Ababa’s climate resilience.
- 3. Need for improved water management.** Water management will continue to be heavily affected by land use enforcement and green space protection processes. Furthermore, those in informal settlements along riverbanks face the catch-22 of lacking access to running water (for drinking and sanitation) and are therefore dependent on the rivers they are forced to pollute. Our flood risk mapping demonstrated how projected flooding will adversely impact the city’s most vulnerable residents in informal settlements. An integrated water management plan may be the best way to address the multiple water-related challenges in Addis Ababa and their associated equity concerns.
- 4. Need for greater public trust and transparency.** Government plans can earn greater public trust through transparency and continuous stakeholder consultation and engagements. Despite its robust plan of urban land use and implementation practices, Addis Ababa’s Draft Structural Plan—which did not directly address displaced residents’ needs and interests and instead emphasized the development of luxury hotels, playgrounds, and golf courses—faced resistance from the public, and the current City administration walked away from the plan. Moving away from top-down models of governance and regulation and including a greater awareness of local dynamics would aid equitable climate resilience efforts. However, issues including bureaucratic red tape, some degree of corruption, lack of coordination, and institutional misalignment persist.
- 5. Need for a responsible city agency.** Although Addis Ababa has its Resilient Project Office, an effective response to the depth and breadth of climate impacts necessitates the existence of a robust, agile, and independent agency. Accountability is needed and a designated agency should be empowered to prioritize public interests and to tackle government challenges in order to effectively plan and implement climate resilience policy.



Front cover: Approach into Addis Ababa in the late afternoon / photo by Hansueli Krapf (CC BY-SA 3.0)

Back cover: Churchill Avenue, Addis Ababa, Ethiopia / photo by Radosław Botev (CC BY-3.0-PL)



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