

Women's subjective resilience to climate change in informal settlements: Learning from residents in Nairobi, Kenya

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Abstract

17 This study explores women's subjective resilience to climate change in informal settlements in
18 Nairobi, Kenya, focusing on the lived experiences of women who face heightened vulnerability.
19 Informal settlements, characterized by overcrowding, inadequate infrastructure, and insecure
20 tenure, are disproportionately affected by extreme weather events such as flooding and
21 heatwaves. While existing literature highlights climate resilience at the socio-ecological systems
22 level, there is limited attention on women's personal experiences and adaptive strategies. This
23 research fills that gap by investigating how women perceive and respond to climate challenges,
24 contributing valuable insights into the relationship between individual resilience and broader
25 systems of adaptation. Using qualitative methods, the study examines the roles women play in
26 household and community-level adaptation, emphasizing their agency and the systemic barriers
27 they encounter, including poverty, political marginalization, and limited access to resources. The
28 findings reveal that women's resilience is shaped by interactions between personal assets and
29 strategies and external resources at every level of the social-ecology. These interactions both
30 reinforce and challenge broader socio-ecological resilience frameworks, highlighting the need
31 for integrated, context-specific climate adaptation. The study calls for more inclusive
32 approaches to climate adaptation that build on mutual aid and community-level initiatives in
33 informal settlements to recover, adapt and transform in the face of climate change. Ultimately,
34 this research offers a foundation for designing more effective, community-driven climate
35 strategies that center women's experiences and promote sustainable, system-level resilience.

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37

38 **1.0. Introduction**

39 Resilience, defined broadly as “the capacity or ability of someone...to anticipate,
40 accommodate, cope, adapt, or transform when exposed to specified hazards”¹—is a critical
41 priority for residents living in informal settlements, where vulnerability to climate-related hazards
42 is highly concentrated.^{1,2} Globally, approximately 1.1 billion people live in informal
43 settlements²—defined as areas that lack clean water and sanitation and are characterized by
44 non-durable construction, overcrowding, and insecure tenure.³ In Africa, about 51.3% of the
45 urban population lives in informal settlements⁴ including approximately 60% of Nairobi’s
46 residents.⁵ These settlements are often located in ecologically sensitive areas such as
47 riverbanks, floodplains, wetlands, or steep slopes placing residents at heightened risk from
48 extreme weather events (EWEs), including flooding and heatwaves.¹ Structural vulnerabilities,
49 such as poverty, political and social marginalization, insecure land tenure, and a lack of
50 essential services, further undermine climate resilience of these contexts.¹

51 Within informal settlements, women face disproportionate risks. Heightened physical and
52 mental health challenges, reduced access to healthcare and education, elevated caregiving
53 burdens and greater exposure to violence can all reduce women’s capacity to adapt to climate
54 change.^{6–8} While an established body of literature has examined climate resilience at the socio-
55 ecological systems level, and within informal settlements, limited attention has been paid to
56 women’s perspectives and experiences, or ‘subjective’ resilience, in the face of climate change.
57 Understanding subjective resilience can offer critical insight into how individual experiences both
58 reflect and shape the resilience of broader systems. This study addresses that gap by exploring
59 women’s subjective climate resilience in Nairobi’s informal settlements.

60

61 **1.1. Climate Resilience**

62 Climate resilience, broadly defined as “the capacity to respond to climate change,
63 prevent and mitigate its impacts, and prepare for ongoing and future threats”^{9(p71)} has become

64 central to discussions of how individuals, institutions, and systems respond to the intensifying
65 impacts of climate change. Rooted in ecological theories of resilience,^{10,11} climate resilience
66 literature focuses on systems-level or structural models such as socio-ecological frameworks
67 that emphasize the interdependence between human and natural systems.^{12,13}

68 Early resilience models emphasized “bounce back” capacity – the ability to return to a
69 pre-disturbance state, but have since evolved to include adaptability and transformability as key
70 components.¹⁴ Adaptability refers to maintaining system functioning under stress, while
71 transformability refers to “the capacity to evolve into a fundamentally new system when existing
72 conditions are untenable.”^{14(p66)} These elements are particularly relevant given the ongoing,
73 compounding nature of climate change, which produces continuous disruptions, such as shifting
74 temperature and precipitation patterns, rather than isolated shocks.^{13–15} Thus, effective
75 resilience frameworks must address not only coping and recovery but also adaptive and
76 transformative capacity.

77 System-level models have been adopted by leading authoritative bodies on climate
78 change, such as the Intergovernmental Panel on Climate Change (IPCC), which defines climate
79 resilience as, “the capacity of social, economic and environmental systems to cope with a
80 hazardous event or trend or disturbance, responding or reorganising in ways that maintain their
81 essential function, identity and structure while also maintaining the capacity for adaptation,
82 learning and transformation.”^{16(p5),17(p43)} These models are essential given the scale and
83 systemic nature of climate change impacts, which disrupt ecosystems, infrastructure,
84 governance institutions, and the interconnected systems that sustain human and planetary well-
85 being.¹⁸ Moreover, systems-level actors, such as governments, organizations, and institutions,
86 hold the power and resources needed to facilitate structural or transformative adaptation.
87 Without their leadership, individual efforts often fall short or risk maladaptive outcomes.¹⁹
88 However, focusing exclusively on systems can obscure the transactional dynamics
89 between individuals and the systems they inhabit. Research increasingly emphasizes the

90 importance of cross-scale effects, where processes at one level shape and are shaped by those
91 at another.¹⁴ Individual level resilience is both embedded in and influenced by broader socio-
92 ecological systems, and vice versa.²⁰ People's perceived capacity to cope and adapt in the face
93 of climate change is tied not only to their internal assets but also to their perceptions of the
94 availability and accessibility of resources within their broader socio-ecological system or
95 environment.^{21,22}

96 Exploring subjective resilience, i.e., perceptions of individuals' abilities to recover from
97 and adapt to climate threats, can illuminate these dynamics. In contexts such as informal
98 settlements, subjective resilience offers insights into how personal strategies and socio-
99 ecological conditions interact to either reinforce or undermine climate resilience. It also helps
100 surface systemic vulnerabilities that may not be visible through structural assessments alone.
101 This study contributes to that effort by exploring how women in Nairobi's informal settlements
102 experience and enact climate resilience, shedding light on both individual agency and the
103 systemic conditions that enable or constrain it.

104 **1.2. Subjective Resilience and Individual-Level Climate Adaptation**

105 Although ontological and epistemological differences pose barriers to integrating cross-
106 disciplinary models of resilience, scholars have explored perceived adaptive capacity,²¹ well-
107 being,¹⁴ and subjective resilience²² at the individual-, household-, and community-levels within
108 social-ecological systems. In this study, we explore the subjective climate resilience of individual
109 women living in Nairobi's informal settlements and examine the implications of these
110 experiences for broader social-ecological resilience. We begin by outlining the theoretical
111 framework guiding our analysis.

112 Across disciplines, 'resilience,' has been conceptualized in diverse ways. Early
113 psychological and trait-based models often defined individual-level resilience as a set of internal
114 assets, or coping styles that allowed them to maintain positive development despite adversity.²³

115 More recent theories rooted in the human and social sciences emphasize the role of external
116 supports, such as family, peers, and community resources, in shaping resilience.²⁴

117 Bronfenbrenner's bioecological theory offers a multisystem perspective, framing
118 individual resilience as a product of interactions between personal attributes (microsystem),
119 community resources (mesosystem), broader societal structures (macrosystem), and historical
120 contexts (chronosystem).²⁵ Within this model, resilience depends not only on the availability of
121 resources but also on the individual's ability to access, navigate, and negotiate those
122 resources.^{23,26} Recent adaptations have added the biosphere as a core component, reflecting
123 the interdependence between human and environmental systems.^{27,28} These integrated
124 frameworks suggest that individual resilience in the face of climate stressors emerges from the
125 dynamic interplay between personal, social, institutional, and ecological systems.

126 For this paper, we draw on Bronfenbrenner's model, however, we have modified or
127 expanded the framework in two ways: first, we incorporate insights from early psychological
128 models to account for individual assets and strategies as essential elements of subjective
129 climate resilience. Second, we reflect climate resilience as a process, encompassing recovery
130 (or coping), adaptation, and transformation (See Figure 1). While transformation, defined as the
131 capacity to evolve into a fundamentally new system, is beyond the scope of this paper, we focus
132 on coping and adaptation as core dimensions of subjective resilience. We define coping as "the
133 capacity of individuals and groups to use their existing resources to withstand and overcome
134 immediate adversities" and adaptation as "the ability of individuals and groups to maintain
135 existing levels of functioning by learning from the past, anticipating future threats, and then
136 making incremental adjustments before new impacts occur to maintain present levels of
137 functioning."^{15(p74)} This framework enables us to capture how women in informal settlements
138 draw on personal, social, and environmental resources to respond to climate change, and how
139 their individual experiences may inform and shape broader systemic resilience.

140

141 [Insert Figure 1 approximately here]

142 **Figure 1. Complex and Dynamic System of Women's Climate Resilience in**
143 **Informal Settlements**

144

145 **1.3. Vulnerability in Informal Settlements**

146 Vulnerability, defined by the IPCC, is “the propensity or predisposition to be adversely
147 affected,” which includes “sensitivity or susceptibility to harm and lack of capacity to cope and
148 adapt.”^{16(p5),17(p43)} In informal settlements, vulnerability is both structural and systemic, shaped by
149 environmental exposure, inadequate infrastructure, political marginalization, and socioeconomic
150 precarity, all of which undermine climate resilience. These communities face a range of
151 interrelated challenges: overcrowding and limited public space; sub-standard housing and
152 infrastructure that increase exposure to extreme weather; limited access to clean water and
153 sanitation, especially during droughts and heatwaves; inadequate health care and public health
154 systems; unreliable electricity and drainage, minimal government investment; exclusion from
155 formal governance structures; and high levels of poverty.^{1,29,30} Furthermore, informal settlements
156 often exist outside the legal frameworks governing land tenure, planning, and public safety,
157 compounding vulnerabilities related to housing, infrastructure and services.¹ Exposure to climate
158 change-related hazards is intensified in settlements. They are often located in wetlands,
159 lowlands, or on riverbanks, and have higher levels of exposure to EWEs like flooding, heavy
160 downpours, landslides and heatwaves.^{29,31} In Nairobi, for example, over 30,000 residents live
161 near watercourses prone to flooding.³² High levels of impervious roofing, loss of natural
162 drainage, limited vegetation, and inadequate infrastructure further exacerbate localized flooding
163 and heat stress.^{33,34}

164 Women in informal settlements face heightened climate vulnerabilities due to gendered
165 roles and systemic inequalities. As primary caregivers and household managers, they are
166 disproportionately affected by disruptions to water, food, and energy systems.^{1,35–37} Their access
167 to health, mental health, and violence prevention is often limited^{6,38} as is their participation in

168 education, formal employment, and decision-making processes.³⁹ Most women rely on informal
169 labor, such as domestic work or small-scale vending, often in or near neighboring informal
170 settlements.^{40,41} After EWEs, women are also more likely than men to miss work, school, or
171 household responsibilities to manage recovery and caregiving needs, including coping with
172 water scarcity during droughts.⁴²

173 **1.4. Climate resilience in informal settlements**

174 Urban informal settlements are increasingly recognized as key to urban climate
175 resilience, given their heightened exposure to EWEs and limited institutional protection. A
176 growing body of research challenges deficit based narratives by emphasizing the adaptive
177 capacity and innovation already present in these communities.^{43,44} Scholars argue that informal
178 settlements must not be viewed solely as vulnerable spaces but as active sites of knowledge
179 production, resilience, and locally-led climate solutions.^{43–46}

180 Informal settlements often function outside formal governance structures but generate
181 their own adaptive responses through local knowledge and community cohesion. Case studies
182 such as the Asia Coalition for Community Action,⁴⁷ the Kenyan Homeless People's Federation
183 (Muungano wa wanavijiji)¹ and the National Slum Dwellers Federation of Uganda⁴⁸ illustrate
184 how participatory, community-driven strategies can effectively identify climate risks and deliver
185 contextually appropriate adaptation. While external support from governments and NGOs is
186 important, the literature emphasizes that sustainable climate resilience is most effective when
187 communities lead their own adaptation efforts.^{45,49}

188 A prominent strategy discussed in the literature in-situ upgrading.^{1,46–48,50–53} In-situ
189 upgrading focuses on improving housing, installing infrastructure, and providing services in
190 informal settlements without large-scale evictions or demolitions.^{1,51} Scholars argue that secure
191 tenure is also essential for long-term resilience, as insecure land rights discourage residents
192 from investing in durable adaptation.^{1,47} Satterthwaite et al. (2020) describe a spectrum of

193 upgrading from eviction and basic infrastructure improvements to transformative approaches
194 that involve co-produced solutions between governments and communities.

195 Several studies also highlight the role of nature-based solutions in enhancing resilience
196 in informal settlements. Strategies such as riparian restoration, rainwater harvesting, urban
197 agriculture, and greening projects offer dual benefits: they reduce environmental risk while
198 providing economic opportunities or lowering household costs.^{46,48,49,51–54}

199 Social capital is another core theme. Residents often rely on informal social support
200 networks, federations, and savings groups to buffer against shocks and meet basic
201 needs.^{37,43,45,55} Collective practices like "Harambee" (collective fundraising) and grassroots
202 infrastructure improvements contribute to adaptive capacity by fostering trust, cohesion, and
203 mutual aid,⁵⁶ while federations or collectives of savings groups push for larger-scale action like
204 tenure security.^{1,48}

205 Women are vital agents of climate resilience. Women-led initiatives foster economic
206 stability and community cohesion.⁴⁵ Their local knowledge and roles within households and
207 communities and in resource management make them critical to addressing climate risks.^{45,57–59}
208 Empowering women through inclusive decision-making and governance can enhance both
209 equity and effectiveness in climate adaptation.^{55,58}

210 Despite these strengths, the literature also underscores key limitations and gaps.
211 Scholars call for more place-based, gender sensitive research, particularly in low-income
212 countries, to better understand the lived experiences of climate impacts and the localized
213 strategies communities use to adapt.^{45,53} Community-Based Adaptation (CBA) approaches
214 emphasize "localism", recognizing that "communities possess unique and situated knowledge
215 systems, social practices, and environmental relationships that are essential for effective
216 adaptation."^{45(p5)} Yet, gender remains under examined. The roles women play in climate
217 change-related recovery and adaptation in informal settlements, in particular, is poorly
218 understood.⁵⁴ In a recent systematic review of 415 articles focused on climate-related hazards

219 and adaptation measures in informal settlements around the world, only about 18% of the
220 studies explicitly included women's participation.⁵⁴ This omission is concerning given that
221 women in informal settlements are often more vulnerable to climate impacts and are central to
222 managing adaptation at the household and community levels.^{55,60,61}

223 This study addresses these gaps by exploring women's subjective resilience in the face
224 of climate change in Nairobi's informal settlements through deep qualitative inquiry. We
225 examine how women's perceptions and strategies reveal both strengths that can inform
226 systems-level climate resilience and the systemic gaps that undermine it. In doing so, we
227 contribute to a more nuanced understanding of how individual-level resilience interacts with
228 broader socio-ecological systems, sometimes reinforcing them, but at other times revealing
229 maladaptive pressures that require structural change.

230 **2.0. Methods**

231 **2.1. Study Site**

232 Data for this study were collected in two of Nairobi's largest urban informal settlements,
233 Kibera and Mathare (See Figure 2a-2b for map). According to the 2019 census, Mathare is
234 home to 206,564 people, with 106,522 men and 100,028 women. Kibera has a population of
235 185,777, with 94,199 men and 91,569 women.⁶² These settlements are two of the most densely
236 populated areas in Kenya. Kibera has a population density of 15,311 people per square km, and
237 Mathare has a population density of 68,940 people per square km.⁶³ Kibera and Mathare are
238 characterized by high poverty levels; overcrowding; inadequate access to basic services like
239 water, sanitation, electricity, and solid waste management systems; and significant
240 environmental challenges.⁶⁴ The settlements are situated in lowlands along Nairobi's major
241 rivers, exposing residents to annual flooding and mudslides during heavy rains.^{44,65} Poor
242 drainage systems, inadequate solid waste management, and poorly constructed housing
243 exacerbate the impact of EWEs.⁶¹ In addition, these settlements experience significantly higher
244 temperatures than surrounding areas due to their dense built environment and lack of

245 vegetation, leading to frequent heat waves.^{34,45} While Mathare and Kibera share many of the
246 same structural challenges, their microclimates differ due to variations in housing density,
247 access to services, elevation, vegetation cover, and built environment. In fact, extreme weather
248 can affect one settlement without affecting the other.³⁴

249

250 *[Insert Figures 2a & 2b: Maps of Mathare and Kibera here]*

251 **Figure 2a. Map of Location of Mathare and Kibera informal settlements in Nairobi**
252 **Figure 2b. Maps of Mathare and Kibera informal settlements with village**
253 **boundaries**

254

255 **2.2. Study Design**

256 We used a qualitative, phenomenological, cross-sectional approach in the design of this
257 study. 144 women from Kibera and Mathare informal settlements participated in an in-depth
258 interview focused on the effects of climate change on women's health and well-being in informal
259 settlements and their resilience in the face of climate change. Data was collected from
260 December 2022 to February 2023. Local community health volunteers (CHVs) who were
261 residents of these settlements were hired and trained to conduct in-depth interviews with
262 participants under the supervision of the research team.

263 **2.3. Sample**

264 Participants were purposefully selected from a probability sample of 800 participants
265 involved in a longitudinal, quantitative study focused on climate change and health occurring at
266 the same time in these settlements.⁶⁶ We used a maximum variation approach to select 144
267 participants from the sample of 800 women. We aimed to capture data on a range of
268 experiences related to climate change and EWEs in informal settlements. 16 CHVs who had
269 each been collecting monthly surveys from 50 women as part of the longitudinal study were
270 asked to select 9 of their participants to invite to join this qualitative study. CHVs had extensive,

271 longitudinal knowledge about women's experiences of EWEs, the impacts of these events on
272 women's lives, and women's responses to these events.

273 To minimize gatekeeper bias in the sampling, we gave CHVs clear, structured criteria for
274 maximum variation in this study, specifically, differences in exposure to EWEs (including no
275 reported exposure); in type and level of impact from EWEs (including no reported impacts); and
276 differences in coping strategies, access to services, and supports. To minimize accessibility
277 and/or social desirability bias, i.e., only choosing participants who are easier to contact or who
278 are outspoken, we provided extra time for CHVs to complete interviews with harder-to-reach
279 participants and asked them to choose participants who were both vocal and quiet. Participants
280 had to be residents of Kibera or Mathare, over 18, and able to speak English or Swahili, the
281 lingua franca in informal settlements.

282 Women in this sample ranged from 20 to 65 years old, with the average age being 36
283 years. About 4% of the participants had never attended school, approximately 15% had
284 attended primary school, but had not completed it, about 54% had completed primary, but not
285 secondary, and about 27% completed secondary school or higher. Approximately 19% of the
286 women were unemployed or didn't work during the 30 days leading up to the interview, about
287 37% worked some during the same period, and about 44% worked nearly every day or every
288 day during the same period. Only about 3% of the participants were employed in a formal
289 position. About 31% ran a small business, sold vegetables or clothes, or worked in a small
290 shop. About 31% worked as casual laborers, and another 9% worked gigs such as washing
291 clothes or cleaning houses. About 66% of women reported experiencing extreme weather in the
292 month leading up to the interview. About 98% of those reported experiencing extreme cold.

293 **2.4. Procedures**

294 Following an interactive written informed consent process, in-depth qualitative
295 interviews, lasting approximately 90-120 minutes, were conducted in participants' homes or an
296 alternative, private location agreed upon by the participant and CHV. The interviews were audio

297 recorded with the consent of participants. To build qualitative research skills among CHVs and
298 ensure consistency and quality in the data collection, the CHVs participated in a 10-day training
299 focused on qualitative interviewing methodologies, research ethics, study protocols, and the
300 consent process. After that, each CHV observed an interview being carried out by a research
301 team member. They then conducted an interview supervised by a member of the research
302 team. Subsequently, the CHVs each carried out seven independent interviews, with ongoing
303 supervision from the research team between each interview.

304 A phenomenological approach guided the data collection. Interview questions were
305 open-ended but focused on the effects of climate change and EWEs on women's health and
306 well-being in informal settlements and their subjective/perceived resilience in the face of climate
307 change and EWEs. We focused on women's strategies for coping as well as their adaptive
308 capacity. Example questions included: "Are there strategies you/other residents use to cope
309 with EWEs?" Strategies can be internal, i.e., ways of thinking or feeling, and/or external, i.e.,
310 behaviors or practices you adopt or things you acquire. They can even be spiritual, such as
311 praying, engaging in religious/spiritual practices, or seeking spiritual advice or healing"; "Are
312 there strategies you/other residents have learned to anticipate or prepare for EWEs?"; and "Are
313 there strategies you/other residents use to cope or adapt that ensure that you and your family
314 are able to maintain the same standard of living or improve your standard of living in the
315 aftermath of these events?"

316 The study protocol was approved by the Internal Review Board at [blinded for review],
317 the scientific ethics review committee at the Kenya Medical Research Institute, and the Kenya
318 National Commission on Science, Technology, and Innovation.

319 **2.5. Analysis strategy**

320 Guided by our modified model of subjective climate resilience described in section 1.3,
321 the analysis sought to examine the range of resilience strategies and resources women use to
322 cope and adapt in the face of EWEs and climate change in informal settlements. Drawing from

323 models that suggest individual resilience is a function of the extent to which resources are
324 available or accessible and the individual's ability to navigate their way to, negotiate, utilize, or
325 transact with these resources to maintain their well-being in the face of adversity,^{23,25,26} namely
326 Bronfenbrenner's bioecological theory of resilience,²⁵ we used ecological levels of providers
327 (individual, family, community, institutional, cultural, religious, and environmental sources) to
328 organize the assets, strategies, and resources. Resources at each level were classified by type,
329 including financial, material (e.g., housing, belongings), non-material (e.g., health, spiritual),
330 consumable (e.g., food, water), and social (e.g., relationship-building). Acknowledging that
331 individual assets and strategies are potentially critical elements of individual-level climate
332 resilience, we separated out assets (internal capacities), strategies (actions), and resources
333 (external supports) in the results. Finally, we differentiated between assets, strategies, and
334 resources used for *recovery or coping*—those that help them manage the effects of extreme
335 weather and those that represent their *adaptive capacity*—those that help women anticipate and
336 reduce the negative effects of climate change.

337 Audio recordings of interviews were transcribed verbatim and then translated into
338 English. Transcripts were analyzed using NVivo qualitative analysis software. Approximately
339 10% of the transcripts were reviewed to develop a working codebook based on our model of
340 subjective resilience. A team of five then coded all of the transcripts over seven months using
341 the working codebook. The team met weekly to discuss codes, modify the codebook as
342 necessary, and reconcile discrepancies in the coding.

343 **3.0. Results**

344 Findings from this study of women's subjective resilience in the face of climate change in
345 informal settlements show that resilience is a dynamic system of individual assets and
346 strategies and multilevel resources that help women recover from and adapt to climate
347 variability and EWEs. Findings reveal that while individual-level characteristics drive many of
348 these strategies, a broader network of ecological providers of resources, including family,

349 community, institutional, cultural/religious, and climatic/environmental, is essential. These
350 resources span various types, including financial, material, non-material, consumable, and
351 social, each contributing to women's ability to cope with and adapt to climate change.

352 While we have used an organizational framework, some resources may cross ecological
353 boundaries; some individual-level assets may function as strategies; and some assets,
354 strategies, and resources may support both coping and adaptation, depending on context. This
355 dynamic system illustrates how resilience is a flexible and evolving process shaped by the
356 interaction of multiple factors across different levels and timeframes.

357 **3.1. Coping**

358 **3.1.1. Individual assets.** To cope with the immediate impacts of EWEs and seasonal variability,
359 participants draw on internal assets like acceptance of one's internal and external
360 circumstances (e.g., climate change), internal strength, and endurance. These assets help them
361 stay emotionally resilient in the face of climate change and related EWEs. Additionally, self-
362 encouragement and hope allow women to manage stress and maintain a positive outlook, even
363 during difficult times. Table IA4C describes a few examples.

364 **Table IA4C. Individual Assets for Coping**

Asset	Example
Acceptance	"I will just accept the challenge, I will accept because I don't have otherwise, it has already happened and there is no way I will run away from it so I will accept the way it came" (P02285_P24_1974_M4a, Ref 3)
Perspective	"That is when you realize someone else is suffering more than you are" (Amw2300_P02_1988, Ref 3)
Hope	"I console myself with hope. I tell the children that we will return to Umo...It's temporary." (Gmw2136_P9_1985_English, Ref 2)
Emotional resolve	"I decided I will not be entertaining a lot of stress in my heart or think too much about situations I can't handle. I will only do what I can, I will only handle what I can...." (Ala2211_P31_1989, Ref 1)
Internal strength	"I have learned how to manage the stress....I always keep strong" (Amw2300_P23_1997, Ref 1)
Self-encouragement	"You have to encourage yourself in order to get through difficult times" (Po2285_P19_1979, Ref 1)
Endurance	"It is quite hard, but you have to push on" (Nwk2108_P15_1984, Ref 2)
Self-reliance	"So now, survival is up to the individual...You have to handle your life on your own" (Amw2300_P41_1984_RED0_Translation, Ref 2)

<i>Self-control</i>	“I try very hard to have self-control” (Ala2211_P34_1995, Ref 3)
<i>Ability to ask for help</i>	“I reached a point where I decided to make some noise. Let me make some noise so that someone or two or three people can hear me and help me find a way out...I advocate for making noise” (Gmw2136_P9_1985_English, Ref 1)
<i>Faith</i>	“We only rely on God. We just let it pass. And indeed, we pray. We say that God loves us. God loves our Kibera” (Jm5492_P21_1976_English, Ref 2)

365

366 **3.1.2. Individual strategies.** Participants also describe a range of individual-level strategies
367 they employ to ensure they have the necessary resources to cope with climate variability and
368 EWEs. Women adjust their financial habits by reducing expenses or seeking alternative sources
369 of income. They also focus on maintaining hygiene and accessing healthcare when needed.
370 Other strategies include relocating temporarily, seeking emotional support from family or friends,
371 and relying on religious or spiritual practices for emotional relief. Table IS4C summarizes some
372 examples. The full set, with example quotes, is available in the supplemental materials.

373 **Table IS4C. Individual Resilience Strategies for Coping**

Type of Resource	Resilience Strategy
<i>Financial</i>	Adjusting business practices or finding temporary work to sustain income during climate disruptions (e.g., selling from home on rainy days).
	Reducing household expenditures to stretch resources during challenging seasons (e.g. “squeezing” budgets).
<i>Material or Tangible</i>	Finding temporary shelter or alternative housing during extreme weather events, such as staying with relatives or in community shelters.
<i>Non-material or intangible</i>	Seeking healthcare or spiritual guidance to manage stress or illness during and after climate events.
<i>Consumable</i>	Using alternative energy sources (e.g., kerosene lamps, solar panels) when power is disrupted.
	Reducing food or water consumption by rationing supplies during shortages.
<i>Social</i>	Offering emotional and material support to neighbors and community members, including sharing food, water, or shelter.

374

375 **3.1.3. Family resources.** Family systems also provide a range of resources the women utilize
376 to cope with seasonal changes and EWEs in informal settlements (Table FR4C). Full FR4C
377 table is available in the supplemental materials.

378 **Table FR4C. Family Resources for Coping**

Type of Resource	Resource
Financial	Financial contributions from partners, children, or relatives to help manage income loss due to climate disruptions or seasonal job fluctuations.
Material or Tangible	Assistance with post-disaster shelter or repairs to the home or property (e.g., fixing roofs and clearing debris)
Non-material or intangible	Emotional support or counseling from family members to cope with stress following climate disruptions.
Consumable	Family members provide food, water, and other necessities during shortages caused by climate events.
Social	Family members offer emotional and practical support (e.g., taking care of children) during climate disruptions.

379

380 After climate events, family support is crucial for coping. Family members provide
381 financial assistance to manage income loss, help with home repairs, and offer temporary shelter
382 when needed. Emotional support, along with the provision of essential resources like food and
383 water, enables women and their families to recover more effectively from the disruptions caused
384 by extreme weather.

385 **3.1.4. Community resources.** Participants describe a range of community resources that help
386 them cope with climate variability and EWEs (Table CR4C). Full CR4C table is available in the
387 supplemental materials.

388 **Table CR4C. Community Resources for Coping**

Type of Resources	Resource
Financial	Community-based relief funds and employment opportunities (e.g., rebuilding infrastructure) to support recovery efforts.
Material or Tangible	Collective efforts to repair homes and infrastructure, as well as provide temporary shelter for displaced families.
Non-material or intangible	Community-based mental health support and counseling to help residents cope with the emotional toll of climate events.
Consumable	Community-organized distribution of food, water, and other essential resources in the aftermath of extreme weather.
Social	Neighbors offering practical and emotional support to each other, including checking in on vulnerable residents or offering childcare.

389

390 After climate events, communities play a critical role in recovery. They provide financial
391 support through relief funds and employment opportunities, while collective efforts focus on

392 repairing homes and infrastructure. Community-based mental health support is essential for
393 helping residents cope with emotional stress, and organized food and water distribution ensures
394 access to basic needs. Social networks offer emotional and practical support, reinforcing
395 community resilience during difficult times.

396 **3.1.5. Institutional-level resources.** Participants describe resources provided by large
397 institutions, especially the Center for Disease Control (CDC), Red Cross, Amref Health Africa
398 (previously the African Medical and Research Foundation), Doctors without Borders (MSF), etc.,
399 as well as the national and county governments that help them cope with seasonal changes and
400 EWEs in informal settlements (Table IR4C). Full IR4C table is available in the supplemental
401 materials.

402 **Table IR4C. Institutional Resources for Coping**

Type of Resources	Resource
<i>Financial</i>	Government and institutional relief funds and employment opportunities support recovery after climate events.
<i>Material or Tangible</i>	Government-supported housing repairs and temporary shelter for displaced families following extreme weather.
<i>Non-material or intangible</i>	Institution-backed mental health support and healthcare services to help residents cope with the physical and emotional impacts of climate events.
<i>Consumable</i>	Distribution of essential goods like food and water by institutions to aid communities recovering from climate disruptions
<i>Social</i>	Crisis counseling and community support programs provided by institutions help residents recover from climate-related stress and loss.

403
404 In response to climate disruptions, institutions provide support through relief funds and
405 employment opportunities to help families recover. Government programs focus on repairing
406 homes and providing temporary shelter for displaced residents, while institutional healthcare
407 services address the mental and physical health impacts of climate events. Distribution of food,
408 water, and other consumables ensures access to basic needs, and crisis counseling helps
409 residents manage the emotional toll.

410 **3.1.6. Cultural and religious resources.** Religious and cultural resources also help women to
411 cope with seasonal changes and extreme weather (Table CRR4C). Full CRR4P table is
412 available in the supplemental materials.

413 **Table CRC. Cultural and Religious Resources for Coping**

Type of Resources	Resource
Material or Tangible	Religious institutions provide temporary shelter, blankets, clothing, mattresses, etc. for families displaced by climate events.
Non-material or intangible	Spiritual guidance and prayers from religious leaders help families cope with the emotional and spiritual impact of climate events.
Consumable	Religious organizations provide food and essential items to support families recovering from climate disruptions.
Social	Religious and cultural leaders offer counseling, emotional support, and organize communal events to aid in post-disaster recovery.

414
415 Religious and cultural institutions play a significant role in helping families cope with the
416 aftermath of climate events. They provide temporary shelter, collect donations, and distribute
417 food and clothing. Religious leaders offer spiritual guidance, prayers, and emotional support to
418 help families recover from the emotional and spiritual toll of climate disruptions. Communal
419 activities organized by religious institutions further strengthen social bonds during the recovery.

420 **3.1.7. Climate and environmental resources.** Climate and environmental resources also
421 support women's coping from climate variability and EWEs (Table CER4C). Full CER4C table is
422 available in the supplemental materials.

423 **Table CERC. Climate and Environmental Resources for Coping**

Type of Resources	Resource
Financial	Climate-related businesses emerge, such as offering services to help people navigate floods or clean up after disasters.
Material or Tangible	Increasing severity and frequency of devastating climate events push governments, institutions, and landlords to make infrastructural repairs
Non-material or intangible	Post-disaster clean-up efforts reduce the spread of disease and improve hygiene, promoting community recovery.
Consumable	Communities rely on alternative food and water sources, such as rainwater harvesting and small-scale farming, to cope with disruptions.
Social	Climate events foster social solidarity, as families and communities come together to support each other in recovery.

424

425 In the aftermath of climate events, communities adapt by creating climate-responsive
426 businesses, repairing damaged infrastructure, and organizing clean-up efforts to improve
427 hygiene. Alternative food and water sources, like rainwater harvesting, ensure continued access
428 to essential resources. Social ties are strengthened as families and communities work together
429 to recover from the emotional and practical impacts of climate disasters.

430 **3.2. Adaptation**

431 **3.2.1. Individual assets.** Women described many individual-level assets that illustrate their
432 adaptive capacity in the face of climate change, including emotional and psychological strengths
433 such as self-acceptance, self-motivation, and perseverance, which help them plan for, make
434 incremental adjustments to reduce the impact of, or even take advantage of climate shifts and
435 EWEs. Faith also plays a significant role in providing emotional stability and hope, empowering
436 women to feel prepared in the face of uncertainties posed by climate disruptions. Table IA4A
437 summarizes these assets for adaptation.

438 **Table IA4A. Individual Resilience Assets for Adaptation**

Asset	Example
<i>Self-acceptance</i>	“You accept yourself and the situation to protect yourself from stress...You stay strong” (Amw2300_P02_1988, Ref 1)
<i>Self-education</i>	“We are still continuing to educate ourselves...We want to practice what we can” (Gmw2136_P20_1959_English, Ref 1)
<i>Self-motivation</i>	“You know you look at the weather... if it's sunny ... you're shining with hope and ... this is money for when ... it's going to rain” (Sao2152_P43_1995, Ref 1)
<i>Perseverance</i>	“...I have to plan myself so that my life keeps moving forward and I don't go backwards” (Ea3039_P38_1989_translation, Ref 2)
<i>Seeking support</i>	“...I will try not to let them worry me so much, especially if it is something I can share with someone, I will make sure I do that so that I don't have to be affected by it so much” (Ala2211_P31_1989, Ref 1)
<i>Faith</i>	“Am just there. God is protecting me” (Mo2924A7_m4a_Translation, Ref 1)

439

440 **3.2.2. Individual Strategies.** In addition to assets, participants described many strategies they
441 have developed to ensure they and their families have the necessary financial, material, non-

442 material, consumable, and social resources to plan for, reduce the impact of, or take advantage
443 of climate variability and EWEs. These strategies illustrate how individuals learn from and adapt
444 to anticipated challenges related to climate change, such as building up their inventory to be
445 able to switch their businesses to accommodate differences in seasons or weather events and
446 making physical adjustments to their homes to withstand extreme weather in the future. These
447 strategies include financial planning, saving money, making home repairs, and stocking up on
448 essential resources like food, water, and clothing. Women also focus on maintaining health and
449 hygiene during periods of expected or unexpected climate variations or extreme weather by
450 preparing for potential health risks associated with changing climate conditions. Table IS4A
451 summarizes these. A full set is available in the supplemental materials.

452 **Table IS4A. Individual Resilience Strategies for Adaptation**

Type of Resource	Resilience Strategy
<i>Financial</i>	Adapting businesses to seasonal changes, such as diversifying products, (e.g., selling popsicles in heat, umbrellas in rain)
	Investing in business infrastructure or protective gear to mitigate weather - related disruptions (e.g., upgrading to renting a kiosk)
<i>Material or Tangible</i>	Making home repairs to prevent flooding or protect from extreme temperatures (e.g. placing sandbags, improving insulation)
<i>Non-material or intangible</i>	Seeking preventative healthcare such as managing stress, getting counseling, talking to friends or practicing faith-based wellness rituals.
<i>Consumable</i>	Stocking up or buying food/water in bulk, before expected climate events.
<i>Social</i>	Providing community education or support to other neighbors, such as advising on mental health or disaster preparedness

453
454 **3.2.3. Family resources.** Participants described a range of resources provided by their family
455 system that help them plan for, reduce the impact of, or take advantage of climate variability and
456 EWEs (Table FR4A). As with the individual level, contributions span resource types. Full FR4A
457 table is available in the supplemental materials.

458 **Table FR4A. Family Resources for Adaptation**

Type of Resource	Resources
------------------	-----------

Financial	Financial contributions from partners, children, or relatives to support household needs or business investments.
Material or Tangible	Partners, children, or relatives contributing to home repairs or property protection to mitigate climate impacts (e.g., fixing roofs or fortifying walls).
Non-material or intangible	Emotional support from family members to manage stress related to adapting to climate change.
Consumable	Relatives send or provide food and essential consumables to support the household, especially from upcountry.
Social	Family members share responsibilities in decision-making and planning to better adapt to climate-related events.

459

460 Family members play an essential role in individuals' adaptive capacity in the face of
461 climate change. They provide material and emotional support. Financial contributions from
462 partners, children and relatives help with household stability, and in many cases, relatives from
463 outside Nairobi send food or resources ahead of time to help reduce the impact of seasonal
464 changes and EWEs on women. Additionally, family members assist in making home
465 improvements to better protect against extreme weather in the future.

466 **3.2.4. Community resources.** Participants describe a range of community resources that help
467 them plan for, reduce the impact of, or take advantage of seasonal changes and EWEs (Table
468 CR4A). Full CR4A table is available in the supplemental materials.

469 **Table CR4A. Community Resources for Adaptation**

Type of Resource	Resource
Financial	Community savings, microfinance groups, and collective fundraising (e.g., harambees) help with climate preparedness and community investment.
Material or Tangible	Community-led efforts to protect homes and infrastructure (e.g., placing sandbags or clearing ditches to prevent flooding).
Non-material or intangible	Community-led health programs, including informal counseling and mental health support to help residents adapt to climate change.
Consumable	Community-organized food and water collection initiatives (e.g. water storage or food distribution) to anticipate and prepare for shortages.
Social	Neighbors offer strong networks to offer mutual support and advice for disaster preparedness.

470

471 Communities provide essential resources to help residents plan for, reduce the impact
472 of, or take advantage of climate challenges. These include financial support through group

473 savings and loans, collective efforts to improve housing and infrastructure, and health programs
474 that help women cultivate their emotional and physical preparedness in the face of climate
475 change. Additionally, communities organize food and water collection efforts to ensure access
476 to basic necessities in the face of EWEs and seasonal changes, while social networks play a
477 key role in building resilience through mutual support.

478 **3.2.5. Institutional resources.** Although fewer than in other categories, participants described
479 resources provided by the government or other institutions that help them plan for, reduce the
480 impact of, or take advantage of seasonal changes and EWEs in informal settlements (Table
481 IR4A). Full IR4A table is available in the supplemental materials.

482 **Table IR4A. Institutional Resources for Adaptation**

Type of Resources	Resource
<i>Financial</i>	Government or institutional savings accounts or employment opportunities for climate change adaptation.
<i>Material or Tangible</i>	Government-supported infrastructure improvements, such as housing renovations and climate-resilient infrastructure.
<i>Non-material or intangible</i>	Government or institution-backed healthcare programs focused on preventive care and climate-related health risks.
<i>Consumable</i>	Distribution of essential consumables like water or food by government or institutions to support climate preparedness.
<i>Social</i>	Public awareness campaigns and community education initiatives led by institutions to help residents prepare for climate change-related challenges.

483
484 Institutions play a critical role in women's adaptive capacity by providing financial
485 support for repairs and employing opportunities, and improving infrastructure to better withstand
486 extreme weather. Government-backed healthcare programs focus on reducing the impact of
487 future events, while institutions distribute essential resources like water aid in preparedness.
488 Public awareness campaigns help raise community knowledge about climate risks and
489 preventive actions.

490 **3.2.6. Cultural and religious resources.** Religion and, less so, culture provided resources that
491 help women to plan for, reduce the impact of, or take advantage of seasonal changes and
492 extreme weather (Table CRR4A). Full CRR4A table is available in the supplemental materials.

493 **Table CRR4A. Religious and Cultural Resources for Adaptation**

Type of Resources	Resource
Material or Tangible	Religious institutions offer community access to shared facilities, such as public spaces, during key times.
Non-material or intangible	Religious groups provide spiritual guidance, prayers, and counseling to help families mentally adapt to climate change.
Consumable	Religious groups offer material support, such as food or clothing, to help families prepare for climate events.
Social	Religious and cultural leaders promote social cohesion and community preparedness.

494
495 Cultural and religious institutions provide support to help women plan for or reduce the impact of
496 future climate events by offering material, healing, and spiritual resources. Religious institutions
497 house displaced families, while religious groups help families adapt through prayers,
498 counseling, and advising. They also provide consumables, such as food, and strengthen social
499 ties and resilience within the community.

500 **3.2.7. Climate and environmental resources.** While the climate and environment are often
501 described as the cause of participants' challenges, they can also be classified as resources that
502 help participants with a changing climate. Although climate change increases the
503 unpredictability of seasons and EWEs, participants are taking advantage of climate variability
504 (Table CER4A). Full CER4A table is available in the supplemental materials.

505 **Table CER4A. Climate and Environmental Resources for Adaptation**

Type of Resources	Resource
Financial	Changing seasons open up business opportunities for selling seasonal products (e.g., popsicles during hot weather, warm clothing in cold seasons).
Material or Tangible	Unpredictable seasons and climate events push governments, institutions, funders and landlords to strategize about policies and standards and improve housing and infrastructure for residents of settlements

Non-material or intangible	Climate changes drive improved hygiene efforts, disease prevention programs, and environmental clean-up campaigns.
Consumable	Communities adopt alternative strategies for food and water access, including rainwater harvesting and sack gardening in anticipation of changing climate and extremes.
Social	Collective efforts to clean up the environment and prepare for floods by clearing rivers and drains bring people together and strengthen social ties.

506

507 Climate and environmental changes offer both challenges and opportunities for
508 resilience. Communities and governments work together to improve infrastructure and housing,
509 while seasonal changes open up new business opportunities. Improved hygiene and disease
510 prevention programs, along with innovative strategies for food and water access like rainwater
511 harvesting, help residents reduce the impact of climate challenges. Community-based efforts to
512 protect the local environment further strengthen resilience.

513 **4.0. Discussion**

514 While it is important to acknowledge the vulnerabilities of urban informal settlements, an
515 exclusive focus on these deficits risks overlooking the strengths, agency, and resilience of these
516 communities and their residents.⁴³ While largely descriptive, our findings on women's subjective
517 resilience to climate change in informal settlements give us insights into the vulnerabilities that
518 shape climate resilience at the systems level. They also point to promising pathways for
519 strengthening the recovery, adaptive capacity, and, although it is beyond the scope of this
520 paper, transformational potential of informal settlements as social-ecological systems. We begin
521 by situating our findings within the literature on subjective resilience and discuss their relevance
522 for broader social-ecological resilience. We then examine how these findings illuminate
523 structural vulnerabilities that constrain climate resilience. Finally, we consider the implications
524 for policy and development, emphasizing the roles of mutual aid, community-led action, and
525 institutional support in bolstering climate resilience in these settings.

526 **4.1. Contributions to Subjective Resilience**

527 Our findings align with psychological and human systems' resilience theories, which
528 suggest that while individual traits are important, they are only part of the resilience
529 equation.^{20,23,26,67} In the context of urban informal settlements, women's subjective resilience to
530 climate change is shaped by promotive and protective factors operating across ecological
531 levels. Internal strengths, such as self-acceptance, self-motivation, perseverance, and
532 emotional resolve, are supported and sustained by external resources, including financial,
533 material, social, cultural, and environmental supports. These resources span relationships with
534 family and community, institutions, religious and cultural practices, and the biosphere.

535 A key dimension of resilience to climate change evident in our findings is women's
536 capacity to navigate, utilize, and negotiate access to these resources.²³ Participants
537 demonstrated both access to a wide range of supports and the agency to mobilize them
538 effectively. This demonstrates how individual-level resilience to climate change in these settings
539 is not static or innate but is co-produced through continuous transactions between individuals
540 and their broader social, political, economic, built, and natural systems.

541 **4.2 Implications for social-ecological resilience**

542 Leading climate resilience frameworks increasingly conceptualize resilience as a
543 dynamic, systems-level process encompassing three key elements or stages of resilience:
544 recovery or coping, adaptive capacity, and transformation.^{15,68,69} Our findings primarily align with
545 the first two dimensions, recovery and adaptation, capturing how women in informal settlements
546 navigate immediate adversities and engage in longer-term strategies for learning, growth, and
547 well-being in the context of ongoing climate stressors.²⁰

548 Rather than a single disruptive event, climate change presents as a continuous and
549 evolving challenge, marked by shifting seasonal patterns and more frequent and/or severe
550 EWEs.⁷⁰ In response, women in informal settlements have adapted, reflecting resilience as a
551 process. For example, lessons learned from past floods have led women to implement
552 measures, such as home repairs, sandbagging, and insulation improvements, to enhance their

553 preparedness for future EWEs. Others have developed strategies such as moving belongings
554 into temporary storage, saving money, clearing drainages, placing plastic bags on the roof,
555 stocking up on essentials, having a temporary housing or childcare plan in place, etc. before
556 EWEs even occur.

557 Our findings suggest that the distinction between coping and adaptation is often blurred,
558 with women simultaneously engaging in both. The same resources, such as financial
559 contributions from family members, NGOs, savings groups, and churches or mosques, are often
560 used to recover from past events and to take steps to reduce the impacts of future ones.
561 Environmental clean-ups similarly serve dual purposes: repairing damages, while mitigating
562 future impacts. These overlapping functions highlight this interconnection of social and
563 ecological resilience, as emphasized in system-level, systems-based models of climate
564 resilience,^{28,71} where human well-being is intrinsically linked to the health of the environment
565 and vice versa.

566 The interdependence was evident throughout women's accounts. Participants talked
567 about leveraging environmental resources not only to meet basic needs but also to enhance
568 economic stability and advocate for improved infrastructure. Practices such as rainwater
569 harvesting illustrate this reciprocity, providing a reliable water supply for personal and business
570 use while reducing pressure on already overutilized local systems. These findings align with a
571 budding area of research focused on nature-based solutions (NBSs) for climate change
572 adaptation and resilience in informal settlements,⁵² which point to the potential for mutually
573 reinforcing relationships between environmental sustainability and social resilience in informal
574 settlements.

575 **4.3 Vulnerabilities in informal settlements that impact resilience**

576 Despite women's resilience in the face of climate change, study findings corroborate
577 research that highlights vulnerabilities inherent to informal settlements.^{1,45,54} These include
578 financial, material, non-material, consumable, and social vulnerabilities that intersect and

579 constrain both individual and system-level resilience. Financial vulnerabilities included high
580 levels of poverty, heavy reliance on the informal or “gig” economy, the monetization of all
581 essential services (e.g., water, toilets, food, education), often at inflated pay-per-use rates.
582 Material vulnerabilities included limited sanitation and sewerage infrastructure, inadequate or
583 unsafe housing, lack of formal solid waste management, unreliable and unsafe electricity, and
584 blocked or dysfunctional drainage systems. Non-material vulnerabilities included limited health
585 services, high exposure to disease and injury, lack of green spaces and protected riparian
586 zones and water sources, limited vegetation, and significant mental health stressors.
587 Consumable vulnerabilities include water and food insecurities, exacerbated by climate-related
588 shortages and variable costs. Social and political vulnerabilities included insecurity,
589 inappropriate or infeasible building and development policies, limited or inequitable
590 enforcement, government disinvestment, limited social service provision, and deep structural
591 inequalities related to class, gender, ethnicity, citizenship, and geography (e.g., residence in
592 informal settlements).

593 These vulnerabilities often intersect. For example, tenure insecurity and state
594 disinvestment have led to repeated, widespread demolitions of homes and infrastructure. In
595 2024, for example, thousands of homes along Nairobi’s riverbanks were demolished following
596 catastrophic flooding.⁷² These evictions were carried out with minimal warning and no
597 resettlement planning, displacing tens of thousands.⁷² Although legal, the root problem with
598 forced evictions such as these lies in the absence of context-specific, appropriate policies
599 governing development and protections (e.g., legal tenure) for residents in informal settlements,
600 alongside inequitable enforcement of existing regulations.

601 Participants reported that despite legal prohibitions against building within 30 meters of
602 the highest watermark of a riverbank in Kenya,⁷³ houses are routinely constructed directly next
603 to or on top of rivers and drainages. This has severe health implications, especially when raw
604 sewage and solid waste are concentrated in these water bodies during periods of high-heat and

605 drought and then mobilized and pushed into people's homes and/or businesses during floods.
606 While women frequently described participating in clean-up efforts, the lack of formalized solid
607 waste management and sanitation infrastructure also degrades local ecosystems. These
608 regulatory and development gaps exacerbate inequalities: poorer residents are often unable to
609 afford health insurance; yet, they are more likely to live in flood-prone, hazardous areas due to
610 cheaper rents. They are also more often housed in non-durable structures that offer minimal
611 protection from extreme weather. Thus, these residents face higher health risks and exposure to
612 climate change-related risks but have fewer resources to cope and adapt.

613 Our findings also suggest that some individual-level coping and adaptive strategies may
614 reduce overall climate resilience and unintentionally undermine socio-ecological resilience. For
615 example, some women reported disposing of garbage, used menstrual products, and human
616 waste into rivers and drainages. Most of these strategies are used because there is a lack of
617 adequate, formalized systems of solid waste and sanitation management in these settlements.
618 Unfortunately, while such strategies may offer immediate protection from disease at the
619 household level because they remove waste from the immediate environment of the family, they
620 harm the broader ecosystem and heighten community-level health risks. These practices reflect
621 what the IPCC defines as maladaptation, i.e., short-term responses that fail to address root
622 causes and ultimately increase systemic vulnerability.¹⁷ To move into transformative climate
623 resilience, it is essential to move beyond individualized responses and invest in system-level
624 solutions, particularly adequate water and sanitation infrastructure and solid waste
625 management, to prevent maladaptive coping strategies and support sustainable, equitable
626 adaptation.

627 **4.4 Implications for Policy & Development**

628 **4.4.1 Mutual Aid**

629 Our findings highlight the importance of mutual aid in women's subjective climate resilience and
630 the broader resilience of the social-ecological systems in informal settlements. Perhaps

631 because of intersecting vulnerabilities in these communities, especially political and institutional
632 marginalization, as well as collectivist cultural norms in Kenya and other African contexts,
633 where the philosophy of Ubuntu (“I am because we are”), interdependence, solidarity, and
634 mutual support are very prevalent in these settlements.⁷⁴ Women described engaging in a wide
635 range of mutual aid practices, including organizing environmental clean-ups; pooling resources
636 to build shared infrastructure (e.g., toilets, water points, sack gardens); sharing essentials like
637 food, water, clothing; and providing health-related support such as informal counseling,
638 caregiving, and collective fundraising (harambees) for medical expenses. Economic mutual aid
639 involved microfinance, table-banking, shared household income, and material support.
640 Participants also described collective responses to displacement and crisis, offering shelter,
641 childcare, emotional support, and collective advocacy and security, especially in response to
642 EWEs.

643 In these settlement contexts characterized by social marginalization and systemic
644 neglect, mutual aid plays an essential role in community recovery and adaptation.^{43,45}
645 Recognizing and supporting these networks is critical. Actions to promote and bolster mutual aid
646 could include funding community-led initiatives, like microfinance and table-banking; proving
647 small-cash payments to the most vulnerable households when an EWE is expected (e.g.,
648 forecast-based financing) or bigger grants for climate adaptation efforts such as in-situ home
649 upgrading (e.g., installing solar, updating materials, adding shared sanitation and water
650 amenities); providing resources for grassroots events, trainings and emergency response, like
651 tools and personal protective equipment for community clean-ups and emergency
652 food/clothing/bedding for displaced/affected community members; and promoting partnerships
653 between emergency management agencies (e.g., the Red Cross or Kenya Defense Forces) and
654 mutual aid groups to strengthen context-relevant disaster preparedness and response.

655 **4.4.2 Supporting Community-Level Initiatives.** Women in this study described drawing on a
656 diverse array of community-level resources to support their recovery and adaptation to climate

657 change. These included services coordinated by local government actors (e.g., chiefs, MCAs),
658 such as clean-up efforts, information sessions (e.g., barazas), informal counselling, mediation,
659 employment opportunities, and community policing (e.g., Nyumba Kumi). Participants also
660 identified support from non-governmental organizations (NGOs) and community-based
661 organizations (CBOs) delivering health, water, sanitation, education, emergency response,
662 social services; improvements made by landlords (e.g., household repairs and amenities); social
663 enterprises (e.g., FreshLife, Sunking, Delight) offering fee-based services like solar lighting and
664 improved sanitation; religious institutions providing shelter and psychosocial support; traditional
665 healers; public health programs and their networks of CHVs; private businesses, such as
666 chemists; and community-based savings and microfinance groups. Together, these resources
667 contribute to women's resilience in the face of climate-related challenges.

668 Given the range of responses from women, from stating there were no accessible
669 resources to detailing a wide range of supports, it is clear that gaps in awareness exist. This
670 suggests a need for community-wide information campaigns and a centralized, accessible
671 database of services. One promising channel for dissemination is the existing network of CHVs
672 affiliated with public health clinics. Each clinic in these settlements engages 30-100 CHVs, who
673 receive small stipends (KES 6,000 per month or ~ USD 50) to conduct home visits with 50+
674 houses each. CHVs routinely share health information, make referrals, and promote resources
675 and campaigns.⁷⁵ Leveraging and bolstering supports for this established infrastructure could
676 significantly expand outreach and enhance climate resilience, especially if CHVs are well
677 equipped and supported.⁷⁵

678 Locally-driven, in-situ upgrading may be another way to build climate resilience in
679 informal settlements. According to scholars, supporting residents and community organizations
680 to work with local governments on "upgrading" initiatives is both cost-effective and impactful.^{1,51}
681 These efforts span a spectrum, from government-led eviction for development and rudimentary
682 interventions like community taps and toilets to transformative upgrades that reduce

683 settlements' carbon footprints.¹ Central to the success of in-situ upgrading are CBOs, savings
684 groups, and collectives^{1,47,48,51} and community-driven, co-produced adaptation
685 approaches.^{44,45,48} Our findings reinforce this, illustrating the critical role of local governments,
686 institutions, and collectives in supporting women's resilience to climate change. While
687 participants did not refer directly to "upgrading", they emphasized the need for locally-relevant
688 development standards, such as requiring landlords to maintain basic amenities and structurally
689 sound housing, and the role of local actors in holding developers and landlords accountable.
690 Currently, building codes and permitting processes are established and enforced at the national
691 and county levels, which often renders them impractical in informal settlements due to factors
692 like insecure land tenure and ecological vulnerability (e.g., location of settlements in riparian
693 zones or wetlands or on unstable slopes). Participants' narratives corroborate suggestions from
694 the climate resilience literature that highlight the need for co-produced, locally-relevant
695 standards and in-situ upgrading strategies that reflect the lived realities of informal settlement
696 residents as a pathway to greater climate resilience.⁴⁵

697 Additional funding and resources are needed to strengthen community-level initiatives
698 that fall within the spectrum of in-situ upgrading recommended by climate resilience
699 scholars^{1,45,51} and already support women's climate resilience in these settlements. This could
700 include government- and non-government-funded grants and tax incentives for NGOs, CBOs,
701 social entrepreneurs, local businesses, and community collectives engaged in climate-related
702 activities. Participants highlighted the importance of the Constituency Development Fund (CDF),
703 which has supported infrastructure improvements such as toilets and post-disaster housing
704 repairs. Support should also extend to microfinance groups and federations such as Muungano
705 wa Wanavijiji and Slum/Shack Dwellers International, which collaborate with local governments
706 to co-produce contextually grounded policies and interventions for in-situ upgrading and,
707 relatedly, climate resilience.^{1,47,48}

708 **4.4.3 Institutional support.** Institutional-level actors across all levels of urban governance play
709 a central role in building climate resilience.¹⁶ Findings from our study point to a multi-level
710 governance eco-system, spanning national-, county-, and community levels, which currently
711 finances and coordinates a range of programs supporting climate resilience in informal
712 settlements. Figure 3 illustrates this governance ecosystem, developed from women's accounts
713 of the institutions and resources they described as shaping their adaptive capacity. While
714 community-level supports, such as those provided by chiefs, MCAs, CDF, and public health
715 facilities, are critical, institutional-level resources also contribute significantly to residents'
716 resilience.

717 [Insert Figure 3 approximately here]

718 **Figure 3. Examining Urban Governance and Associated Resources in Informal**
719 **Settlements Based on Resident's Examples of Climate Resilience**

721 Women described a range of national and county-level programs that already contribute
722 to climate resilience in their communities. These include essential services such as water and
723 electricity provision, maintenance, and oversight, managed by the Ministry of Water, Sanitation
724 and Irrigation and the Ministry of Energy via Kenya Power and Lighting. Other supports included
725 youth employment programs (e.g., the National Youth Service's Slum Improvement initiative
726 and Kaazi Mtaani); national health insurance (NHIF); subsidized maternal healthcare (Linda
727 Mama); and emergency response led by the Ministry of Defense. County governments were
728 also noted for coordinating drought-related water tank installations, trash collection, and health
729 campaigns. Beyond government programs, participants highlighted critical support from
730 international NGOs (INGOs), such as health services provided by Amref and MSF (Doctors
731 without Borders), and emergency aid from the Red Cross.

732 While community-level resources were identified as the most vital to women's climate
733 resilience, our findings also point to a strong demand for more robust institutional and
734 government support, particularly initiatives that integrate environmental sustainability with

735 livelihood opportunities. Participants emphasized the value of programs like Kazi Mtaani and the
736 National Youth Service's Slum Improvement Initiative, which are government-led efforts that
737 provide employment while addressing environmental degradation.⁶¹ These programs engage
738 women and youth in activities such as garbage collection, drainage, and river clean-up, and
739 construction of toilets and sewage systems. These or similar programs have been highlighted in
740 other studies focused on resilience in these communities.^{44,52,61} While participants critiqued
741 these programs for being inconsistently implemented, they also viewed their expansion and
742 stabilization as key strategies for strengthening climate resilience in informal settlements by
743 tackling both environmental and structural vulnerabilities.

744 Our findings also highlight the potential for government and institutional programs to
745 rebuild trust and foster collaboration between formal and informal sectors. Residents of
746 Nairobi's informal settlements have historically faced exclusion from formal services, political
747 exploitation, and home demolition carried out under the guise of climate adaptation, contributing
748 to deep mistrust of government initiatives.^{1,76} Although women did not explicitly mention tenure
749 insecurity or fear of eviction, this remains a significant concern. As mentioned above, the
750 government demolished homes in informal settlements located within 30 meters of rivers
751 following severe flooding that affected people nation-wide in 2024.^{72,77} While the demolitions
752 were inhumane and deeply problematic, especially because they concentrated on the most
753 vulnerable residents in informal settlements, the resulting open riparian zones offer an
754 opportunity for environmentally and socially beneficial initiatives. If, for example, programs were
755 put in place to employ former residents to restore and maintain these areas by implementing
756 projects like community gardens or parks, there is the potential for transformative resilience.
757 Such programs could simultaneously support financial resilience, reduce flood risk, strengthen
758 social cohesion, and enhance local ecosystems. Sustainable investment in community-driven
759 programs, whether newly designed or scaled from existing models like the NYS Slum
760 Improvement Initiative, can offer a pathway toward integrated social and environmental

761 resilience. However, these efforts must be accompanied by mechanisms for accountability and
762 equitable resource distribution to be truly transformative.

763 **4.5 Limitations**

764 While this study expands existing climate resilience models by providing critical insights
765 into the assets, strategies, and resources that support women's climate adaptation in urban
766 informal settlements, it is not without limitations. The cross-sectional and phenomenological
767 nature of the data, collected only in Mathare and Kibera, limits the generalizability of our
768 findings. Additionally, while the community-based research approach fostered trust between
769 participants and researchers, it may have introduced social desirability bias, as participants may
770 have been hesitant to disclose information that could be perceived negatively by their peers.⁷⁸
771 Lastly, future research should include stakeholders at different levels of the social-ecology to
772 enhance cross-scale insights for climate resilience in these settlements.

773 **5.0. Conclusions**

774 This study shows that women's subjective resilience to climate change in urban informal
775 settlements is shaped by continuous transactions between personal assets and external
776 resources across ecological levels. These interactions offer a foundation for designing more
777 effective climate adaptation policies and interventions for vulnerable urban populations.
778 Resilience in these settings is not a linear outcome, but a dynamic process, that requires
779 integrated models accounting for recovery and adaptation. Environmental resources, such as
780 rainwater harvesting, climate-responsive infrastructure, adaptive business strategies, and
781 community clean-ups, serve dual functions: enhancing individual well-being while promoting
782 environmental sustainability. Persistent barriers to accessing resources highlight the need for
783 stronger institutional investment and more equitable support systems, particularly for mutual aid
784 and community-driven interventions. Programs, like the Slum Improvement Initiative and Kazi
785 Mtaani, and community collectives (e.g., federations and women's groups) illustrate the promise
786 of integrated programs that strengthen social and environmental resilience while building trust

787 between government institutions and residents of informal settlements. However, their long-term
788 success depends on sustained government accountability and efforts to ensure context-
789 appropriate protections of residents (e.g., tenure security and locally-relevant and enforced
790 development standards) and truly co-produce solutions with communities. While women in
791 urban informal settlements demonstrate resilience in the face of climate change, the burden of
792 adaptation cannot disproportionately burden them. Addressing structural inequities and
793 improving access to resources are essential to achieving sustainable, system-level resilience in
794 urban informal settlements.

795 Ultimately, this study advances socio-ecological models of climate resilience by
796 centering the lived experiences of women in urban informal settlements, illustrating how their
797 resilience emerges through ongoing interactions between individual assets and multilevel
798 external resources. By documenting how these interactions support both coping and adaptation,
799 and at times lay the groundwork for systems-level transformation, it offers a grounded base for
800 designing climate strategies that are both community-driven and structurally-responsive.

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809 **7.0. References**

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Women's Subjective Climate Resilience in Informal Settlements

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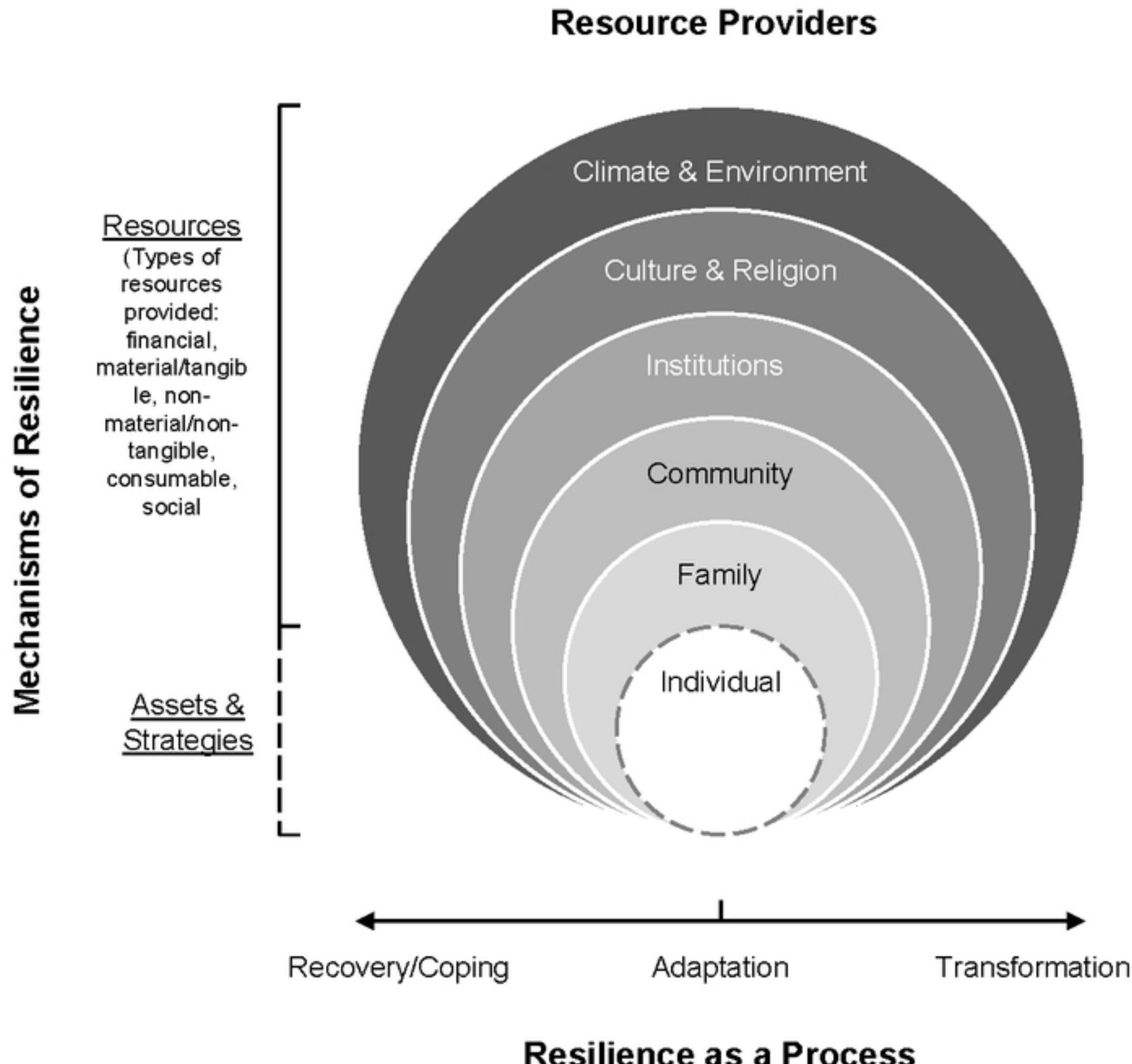


Figure 1

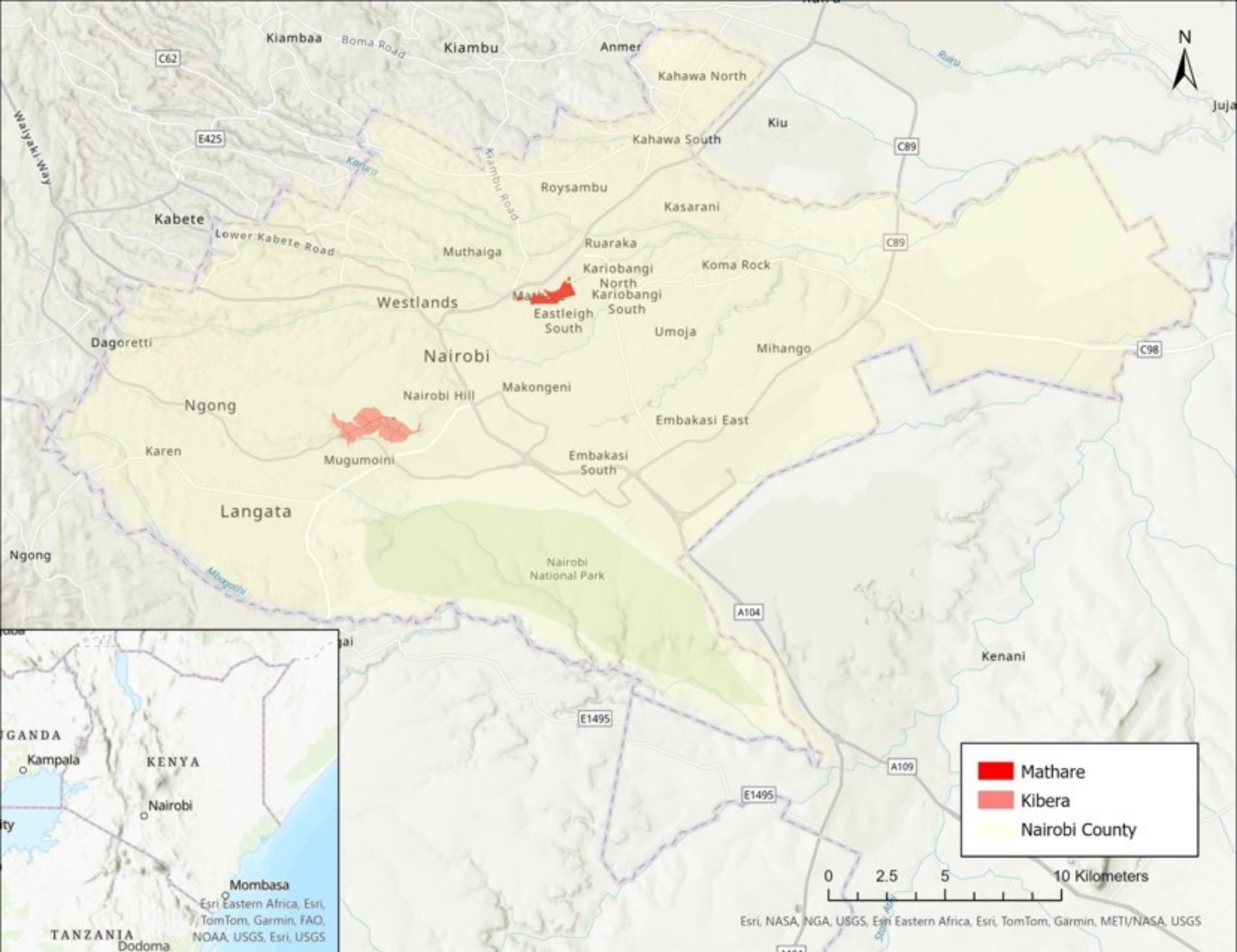


Figure 2a



Figure 2b

Examining Urban Governance and Associated Resources in Informal Settlements Based on Resident's Examples of Climate Resilience

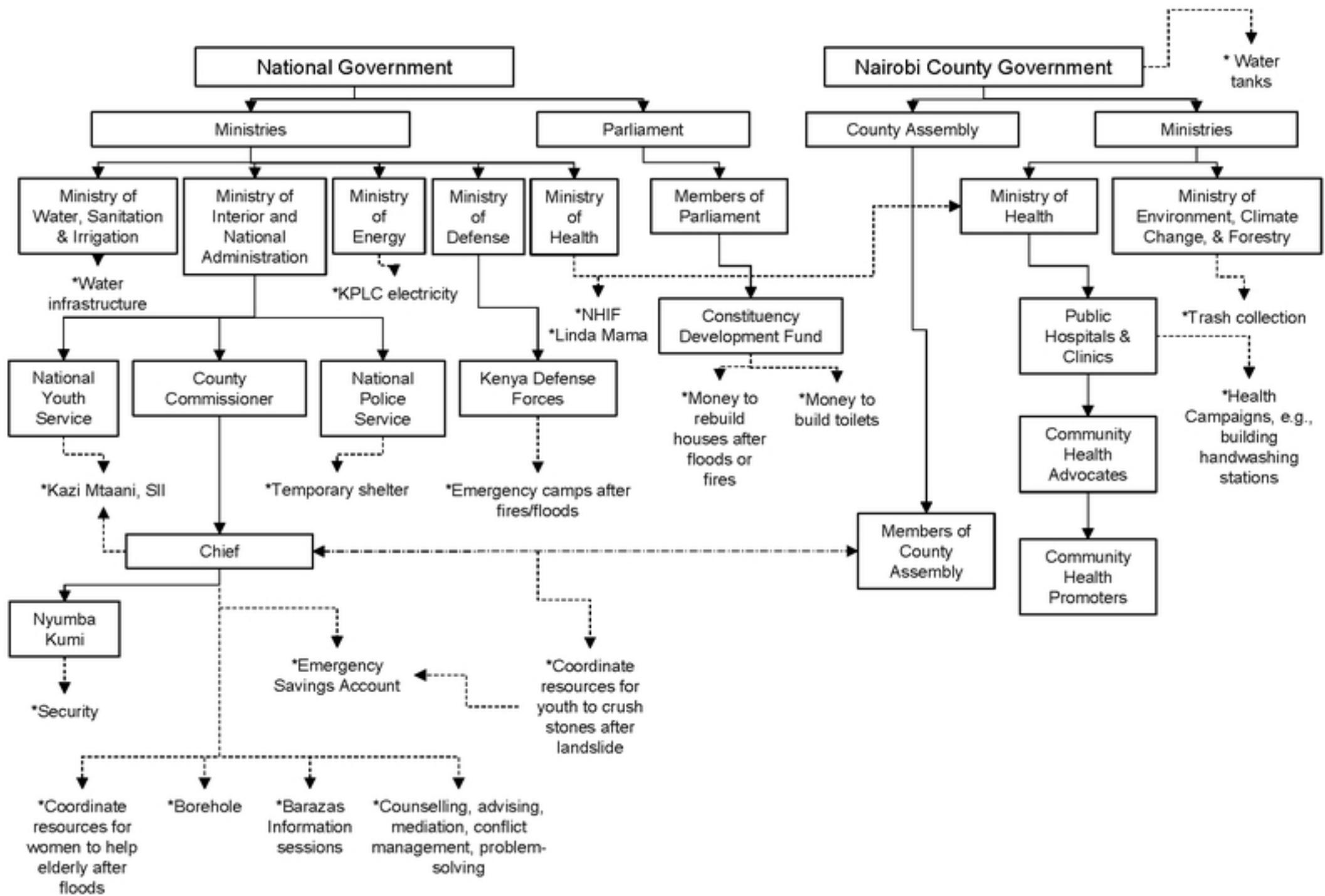


Figure 3