

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

Samantha C. Winter<sup>a\*</sup>, Kianna Stamps<sup>a</sup>, Anna Balakrishnan<sup>a</sup>, Haley Brown<sup>d</sup>, Gi Un Shin<sup>a</sup>, Florence Kyoheirwe Muhanguzi<sup>b</sup>, Theobald Frank Theodory<sup>c</sup>, Aishworya Shrestha<sup>a</sup>, Agness Mchome<sup>c</sup>, Hailey Hansen<sup>a</sup>, Lena Moraa Obara<sup>a</sup>, Susan Witte<sup>a</sup>

<sup>a</sup>Columbia University, New York, NY, USA

<sup>b</sup>Makerere University, Kampala, Uganda

<sup>c</sup>Mzumbe University, Morogoro, Tanzania

<sup>d</sup>Scripps Institution of Oceanography, San Diego, CA, USA

\*Corresponding author: Samantha C. Winter, 1255 Amsterdam Ave, Room 711, New York, New York, USA scw2154@columbia.edu

## Abstract

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

## 1.0. Introduction

Resilience, defined broadly as “the capacity or ability of someone...to anticipate, accommodate, cope, adapt, or transform when exposed to specified hazards”<sup>1</sup>—is a critical priority for residents living in informal settlements, where vulnerability to climate-related hazards is highly concentrated.<sup>1,2</sup> Globally, approximately 1.1 billion people live in informal settlements<sup>2</sup>—defined as areas that lack clean water and sanitation and are characterized by non-durable construction, overcrowding, and insecure tenure.<sup>3</sup> In Africa, about 51.3% of the urban population lives in informal settlements<sup>4</sup> including approximately 60% of Nairobi’s residents.<sup>5</sup> These settlements are often located in ecologically sensitive areas such as riverbanks, floodplains, wetlands, or steep slopes placing residents at heightened risk from extreme weather events (EWEs), including flooding and heatwaves.<sup>1</sup> Structural vulnerabilities, such as poverty, political and social marginalization, insecure land tenure, and a lack of essential services, further undermine climate resilience of these contexts.<sup>1</sup>

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

## 1.1. Climate Resilience

Climate resilience, broadly defined as “the capacity to respond to climate change, prevent and mitigate its impacts, and prepare for ongoing and future threats”<sup>9(p71)</sup> has become

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

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

System-level models have been adopted by leading authoritative bodies on climate change, such as the Intergovernmental Panel on Climate Change (IPCC), which defines climate resilience as, “the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.”<sup>16(p5),17(p43)</sup> These models are essential given the scale and systemic nature of climate change impacts, which disrupt ecosystems, infrastructure, governance institutions, and the interconnected systems that sustain human and planetary well-being.<sup>18</sup> Moreover, systems-level actors, such as governments, organizations, and institutions, hold the power and resources needed to facilitate structural or transformative adaptation. Without their leadership, individual efforts often fall short or risk maladaptive outcomes.<sup>19</sup>

However, focusing exclusively on systems can obscure the transactional dynamics between individuals and the systems they inhabit. Research increasingly emphasizes the

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

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

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

Although ontological and epistemological differences pose barriers to integrating cross-disciplinary models of resilience, scholars have explored perceived adaptive capacity,<sup>21</sup> well-being,<sup>14</sup> and subjective resilience<sup>22</sup> at the individual-, household-, and community-levels within social-ecological systems. In this study, we explore the subjective climate resilience of individual women living in Nairobi's informal settlements and examine the implications of these experiences for broader social-ecological resilience. We begin by outlining the theoretical framework guiding our analysis.

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

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

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

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

*[Insert Figure 1 approximately here]*

## **Figure 1. Complex and Dynamic System of Women’s Climate Resilience in Informal Settlements**

### **1.3. Vulnerability in Informal Settlements**

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

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

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

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

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

Informal settlements often function outside formal governance structures but generate their own adaptive responses through local knowledge and community cohesion. Case studies such as the Asia Coalition for Community Action,<sup>47</sup> the Kenyan Homeless People’s Federation (Muungano wa wanavijiji)<sup>1</sup> and the National Slum Dwellers Federation of Uganda<sup>48</sup> illustrate how participatory, community-driven strategies can effectively identify climate risks and deliver contextually appropriate adaptation. While external support from governments and NGOs is important, the literature emphasizes that sustainable climate resilience is most effective when communities lead their own adaptation efforts.<sup>45,49</sup>

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



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

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

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

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

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

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

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

## **2.0. Methods**

### **2.1. Study Site**

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

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

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

**Figure 2a. Map of Location of Mathare and Kibera informal settlements in Nairobi**

**Figure 2b. Maps of Mathare and Kibera informal settlements with village boundaries**

## 2.2. Study Design

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

## 2.3. Sample

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

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

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

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

#### **2.4. Procedures**

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

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

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

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

## **2.5. Analysis strategy**

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

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

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

### 3.0. Results

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

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

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

### 3.1. Coping

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

**Table IA4C. Individual Assets for Coping**

Asset	Example
<i>Acceptance</i>	"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)
<i>Perspective</i>	"That is when you realize someone else is suffering more than you are" (Amw2300_P02_1988, Ref 3)
<i>Hope</i>	"I console myself with hope. I tell the children that we will return to Umo...It's temporary." (Gmw2136_P9_1985_English, Ref 2)
<i>Emotional resolve</i>	"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)
<i>Internal strength</i>	"I have learned how to manage the stress....I always keep strong" (Amw2300_P23_1997, Ref 1)
<i>Self-encouragement</i>	"You have to encourage yourself in order to get through difficult times" (Po2285_P19_1979, Ref 1)
<i>Endurance</i>	"It is quite hard, but you have to push on" (Nwk2108_P15_1984, Ref 2)
<i>Self-reliance</i>	"So now, survival is up to the individual...You have to handle your life on your own" (Amw2300_P41_1984_REDO_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)

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

**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.

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

**Table FR4C. Family Resources for Coping**



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

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

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

**Table CR4C. Community Resources for Coping**

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

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

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

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

**Table IR4C. Institutional Resources for Coping**

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

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

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

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

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

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

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

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

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

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

## 3.2. Adaptation

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

**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)

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

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

**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

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

**Table FR4A. Family Resources for Adaptation**

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

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

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

**Table CR4A. Community Resources for Adaptation**

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

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

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

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

**Table IR4A. Institutional Resources for Adaptation**

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

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



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

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

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

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

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

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

Type of Resources	Resource
<b><i>Financial</i></b>	Changing seasons open up business opportunities for selling seasonal products (e.g., popsicles during hot weather, warm clothing in cold seasons).
<b><i>Material or Tangible</i></b>	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



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

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

#### 4.0. Discussion

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

#### 4.1. Contributions to Subjective Resilience

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

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

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

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

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

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

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

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

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

Despite women's resilience in the face of climate change, study findings corroborate research that highlights vulnerabilities inherent to informal settlements.<sup>1,45,54</sup> These include financial, material, non-material, consumable, and social vulnerabilities that intersect and

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

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

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

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

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

## **4.4 Implications for Policy & Development**

### ***4.4.1 Mutual Aid***

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

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

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

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

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

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

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

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

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



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

*[Insert Figure 3 approximately here]*

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

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

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

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

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

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

#### **4.5 Limitations**

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

#### **5.0. Conclusions**

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

## **6.0. Acknowledgements**

We thank our participants who gave their time to this study. We also want to deeply thank our sixteen community team members, Anne L. Akinyi, Anna M. Wambua, Christine A. Amollo, Cynthia A. Oyugi, Elina N. Sila, Everline Achieng, Everlyne Bowa, Gakuru M. Wambui, Jackline M. Ndambuki, Julia N. Nyambura, Lilian Simiyu, Melvine Odhiambo, Mwanaisha A. Joel, Nancy W. Kimeu, Ruth A. Otieno, and Stephanie A. Otieno, who are the heart and soul of this work. This study was funded by the Office of the Provost at Columbia University. The funder was not involved in the study design or analysis.

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# Women’s Subjective Climate Resilience in Informal Settlements

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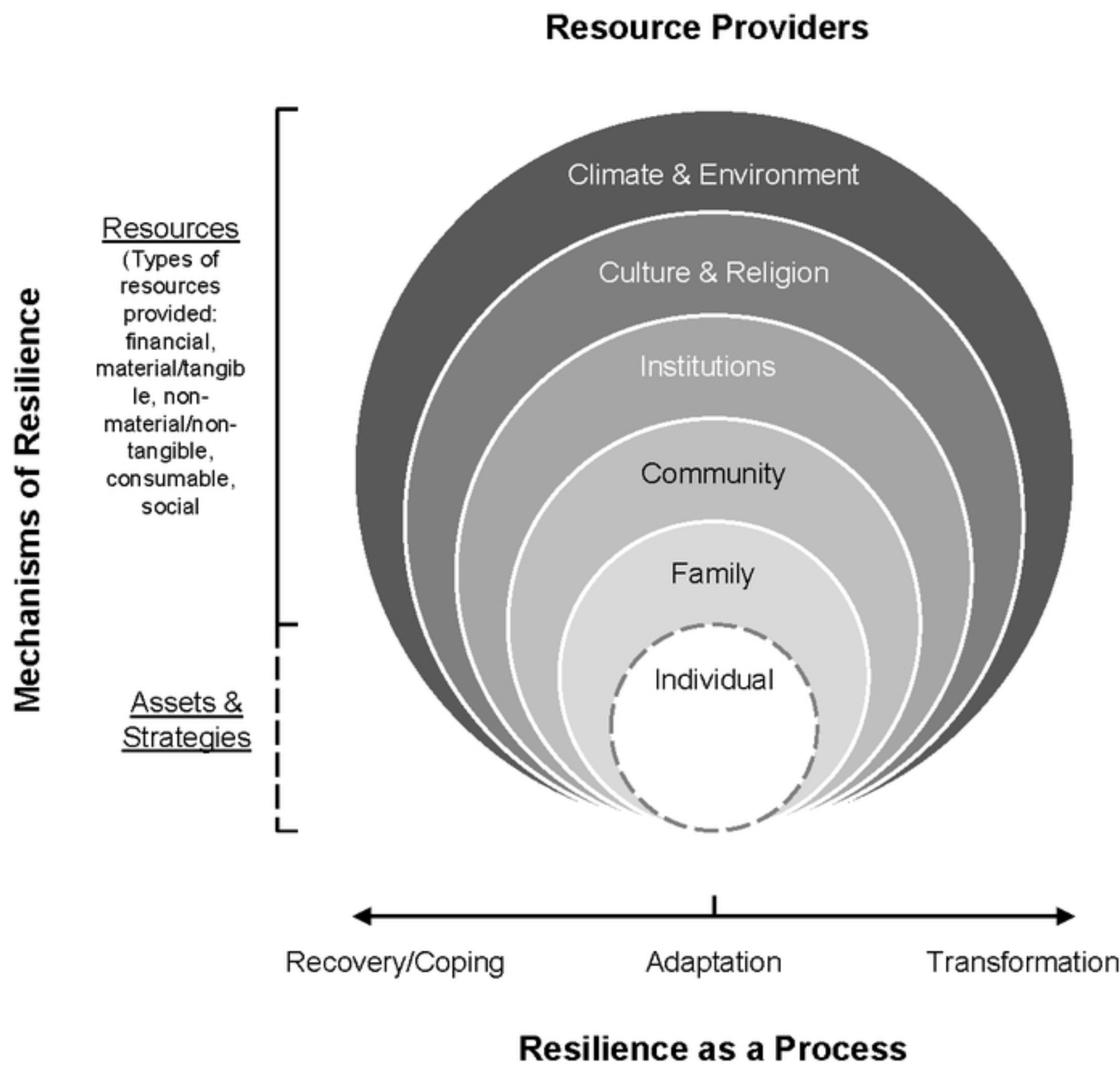


Figure 1



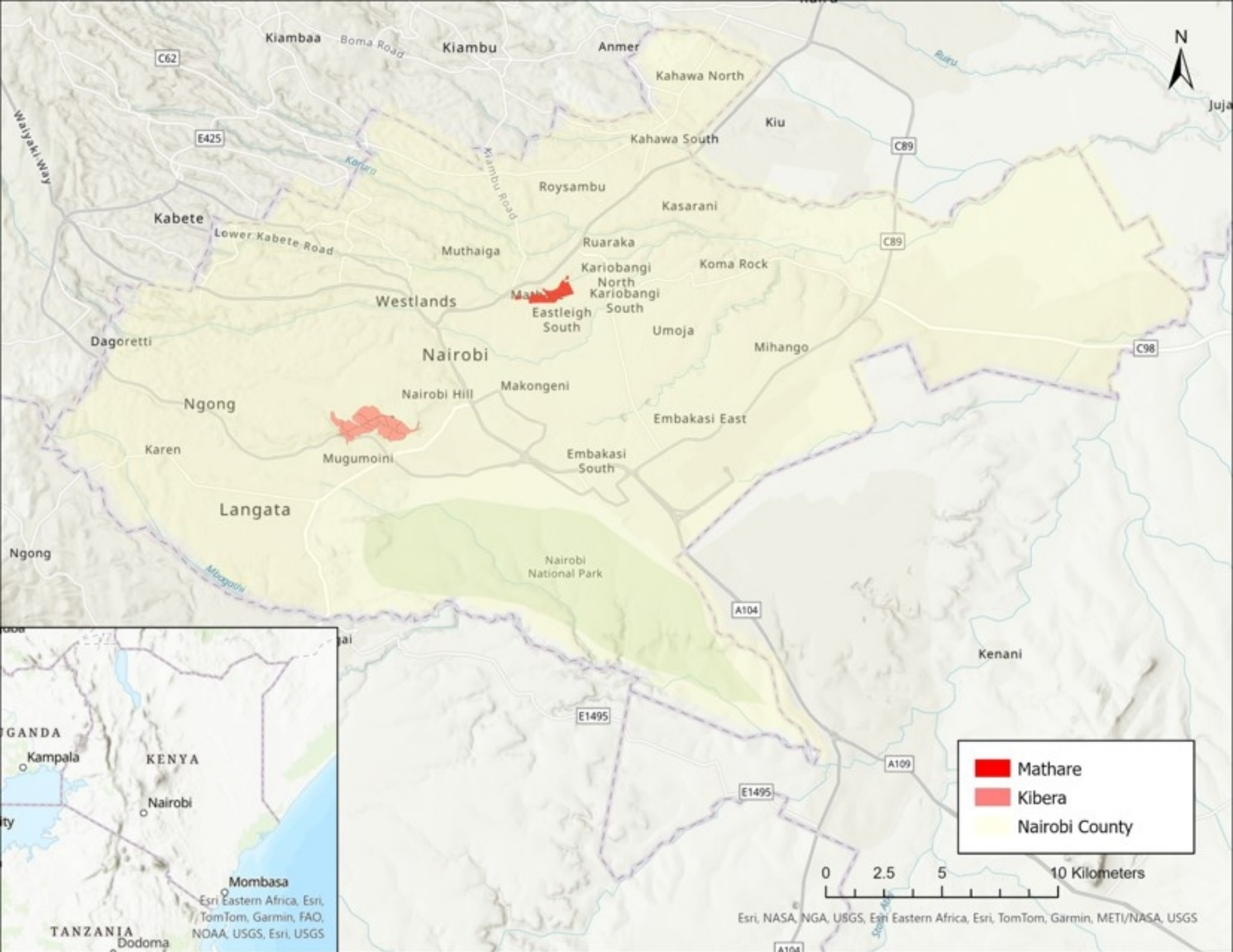


Figure 2a





Figure 2b



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

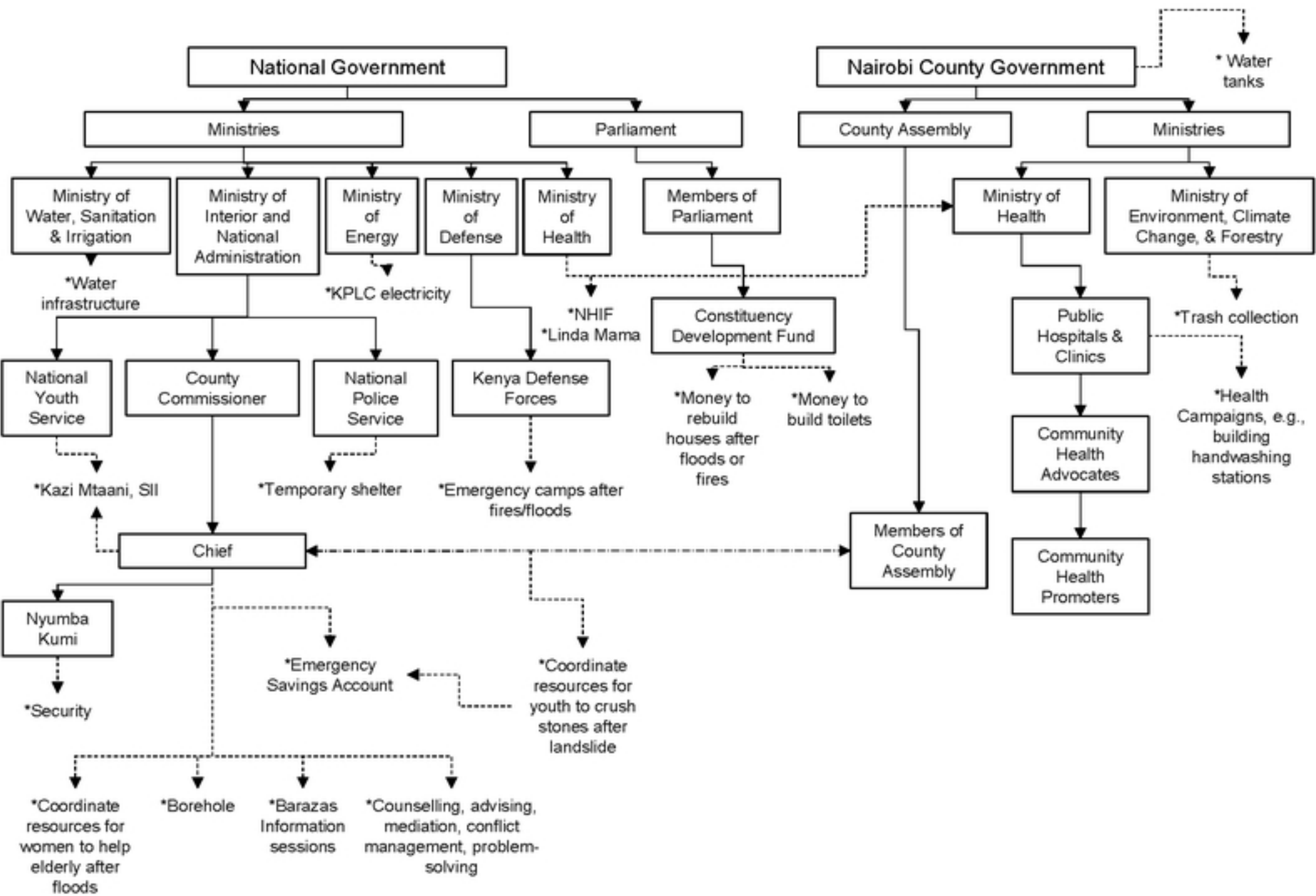


Figure 3