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Research article

Factors affecting the spatial resilience of Ethiopia's secondary cities to urban uncertainties: A study of household perceptions of Kombolcha city

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ABSTRACT

The resilience measurement focuses on urban shocks and stresses, which are excluded from current spatial resilience assessments. As a result, existing literature suggests that research in secondary cities of the global south is needed to understand better spatial resilience in the face of multivariate, intersecting, and uncertain challenges. This study aims to determine the factors affecting the spatial resilience of Ethiopia's secondary cities to urban uncertainties using household perceptions of Kombolcha city. The study collected empirical data through questionnaires and key informant interviews, and then analyzed those using SPSS and the Analytic Hierarchy Process. Accordingly, seventeen environmental and physical urban problems affecting the spatial resilience of the country's secondary cities were identified. Deforestation, surface flooding, landslides, poor solid waste management, and inadequate drainage facilities were perceived as top priority urban problems in Kombolcha city with the respective values of 19.73%, 13.02%, 12.70%, 7.59%, and 6.82% of the four hundred sampled households. However, water scarcity and wind-related shocks, scoring 1.48% and 1.89%, respectively, were the least recurring urban problems. The city's spatial resilience is further limited by unsustainable material and resource consumption, a lack of infrastructure, poor transportation system conditions, poor implementation of response measures: lack of appropriate planning, and non-long-lasting biophysical measures. The household perception also showed that the urban uncertainties are severe in the city, with a 49.48% response rate. The findings also revealed a relationship and commonalities amongst the problems exacerbated by land-use zoning changes and the thriving informal settlements. The study implied that improving secondary cities' coping, adaptation, and governance systems are critical for mitigating the perceived urban problems and making cities spatially resilient. Thus, the study's spatial planning implications are that local governments in secondary cities commit to localizing international initiatives, strictly establishing and enforcing local resource utilization strategies, and improving living conditions in their cities.

1. Introduction

The concept of resilience is significant, particularly with discussions and narrations on hazards, stresses, shocks, and risks (Béné et al., 2012). It has influenced academic literature since the 1960s and became a concern of scientific discourses in ecology in the 1970s. In the 1990s, a new scientific discussion applied the concept to socio-ecological systems like cities (Brunetta and Caldarice, 2020). Accordingly, in the early 2000s, the concept was primarily supposed to create urban spaces with resilience at a local level (Taşan-Kok et al., 2013). Urban practitioners and researchers began discussing, defining, planning, financing, implementing, and measuring urban resilience in the 2010s (ICLEI, 2019).

The concept of resilience further laid a framework for analysis (Bahadur et al., 2010; Carpenter et al., 2001; Walker et al., 2006) and could consolidate various hazard contexts systematically (Béné et al., 2012). Embracing systematic methods is essential to capture many processes and elements that influence individuals and their surroundings (Adger et al., 2005).

The booming financial, social, and spatial vulnerabilities in cities coupled with resource exploitation, increased hazard events, and environmental dilapidation has prompted resilience discussions in planning paradigms. Such thinking in urban planning delivers a basis for the fundamental investigation of urban areas and their vulnerabilities (Taşan-Kok et al., 2013).

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Methodologically, our insights on how spatial structure and differences in critical factors impact resilience will help local and regional resilience measurement. Furthermore, identifying spatial patterns potentially applicable to disaster recovery is an indispensable step in assessing spatial resilience (Allen et al., 2016), with shocks and stressors in cities being debarred from current resilience measurement practices (Choularton et al., 2015). However, Rogov & Rozenblat (2018) indicated that the foci for urban resilience measurements are urban shocks and stresses, while the risks are the units of analysis. Ma et al. (2020); Sanchez et al. (2018) defined shocks and stresses as natural and man-made threats, challenges/problems, or uncertainties that a city can be vulnerable to.

However, categorizing hazards and areas prone to them is the precondition for any spatial resilience measurements (Asian Development Bank, 2013; Bansal et al., 2013; Carpenter et al., 2001). In this context, Allen et al. (2016) coined that systems with high uncertainty may require practitioners to apply scenario planning to address critical urban risks, expressing that a spatial unit may not be resilient with low consideration of redundant risks. In light of this, determining the key hazards, problems, and challenges is significant in spatial resilience (Allen et al., 2011).

Allen et al. (2016); Brunetta and Caldarice (2020) argued that the type of perturbations, environmental settings (institutions and social groups), the ability to bounce back, and the range of possible responses are at the forefront of concerns in measuring spatial resilience. On the other hand, Razafindrabe et al. (2009) indicated physical, social, institutional, economic, and natural dimensions as variables to describe the climate disaster resilience index for nine cities in Asia. Concerning country-specific practices on the factors affecting the resilience of cities, Viverita et al. (2014) applied the first four parameters in four cities in Indonesia. These authors further set that the type of hazards, environmental conditions, and level of hazards are the major factors that affect the resilience of cities to natural and man-made hazards, which have not been researched so far. Concurrently, the scholarly works of Adger et al. (2005) indicated the need for a paradigm shift that calls for new research on comprehending spatial resilience in the face of multivariate, intersecting, and uncertain risks/urban challenges.

In this vein, the concept of resilience is central to understanding the vulnerability of urban areas, and there is a particular need for research designed to address and reduce risks in secondary cities. These cities are not prepared to accommodate rapid urban expansion, and people are moving to fragile ecosystems, subject to a variety of man-made and natural hazards (Cote and King, 2017). According to Shores et al. (2019), these cities further lack the data on spatially unique urban problems, the analysis required for spatial planners and policymakers, and the resilience of these cities remains unstudied.

Therefore, this study fills this gap by determining the factors that affect the spatial resilience of Ethiopia's secondary cities to urban uncertainties, emphasizing the household perception of Kombolcha city. The paper further dwells on filling the gap left by Viverita et al. (2014) by highlighting the physical and environmental factors and responses measures affecting the spatial resilience of Kombolcha city.

The remainder of this study is structured as follows: Section 2 introduces the materials and research methods used to identify urban uncertainties affecting the spatial resilience of secondary cities and the data analysis tools used. Section 3 examines relevant literature. Section 4 summarizes the empirical research and examines the physical and environmental factors influencing the spatial resilience of secondary cities, using Kombolcha as an example. Section 5 is devoted to explaining and interpreting the results or discussion. The final section summarizes the study and discusses the research findings as well as policy recommendations.

2. Materials and methods

2.1. Ethics approval

The importance of ethics in human-centered research cannot be overstated. The authors went out of their way to be personable during the fieldwork. They realized that gaining the trust of participants was the most important aspect of conducting successful fieldwork. The familiarization visits and observations aided in establishing the authors' presence and gaining and maintaining people's trust throughout their fieldwork. According to Cohen et al. (2002), the foundation of the ethical procedure is informed consent. As a result, participants' permission was sought. The authors assured participants that their information would be used solely for academic research purposes throughout the fieldwork. They would not reveal anything about what they said to anyone they knew who might be interested in knowing what they said. The research participants offer their knowledge and share their experiences in a way that might bring positive changes. Confidentiality was maintained in reporting the information. Accordingly, informed consent was obtained from all individual participants included in the study.

2.2. Secondary cities in Ethiopia

Sub-Saharan Africa/SSA/is the fastest urbanizing region globally with a 4.1 percent annual rate of urbanization compared to the global 2.0 percent rate. It is part of the world, with significant urban development occurring in secondary cities (Githira et al., 2020). These cities are becoming home to more than 46 percent of the urban population in SSA (United Nations Department of Economic and Social Affairs, 2016). They have unique features but share commonalities in urban growth, the extent of urban problems, and future opportunities (Perry et al., 2020; Roberts and Hohmann, 2014).

However, the scholarly contribution of Song (2013) indicated the absence of a globally accepted definition of the term ‘secondary cities.’ However, it refers to the next level in the city hierarchy after the primary city. It is contextually defined in terms of the number of inhabitants, geographic extent, the political, economic, and historical significance of a system of cities lower than the primate cities within a country (Roberts and Hohmann, 2014). These authors further identified secondary cities as sub-national, city clusters, and economic corridors.

The UN-Habitat (1996) defined secondary cities as cities with a population size between 100,000 and 500,000 persons. The Ethiopian Urban Good Governance Strategy document (2014) used the same criteria and classified such cities as intermediate urban centers in regional states that are relatively fast-growing in economic activity, population size, and sociopolitics. Woldeyes and Bishop (2015) further showed that those cities that took part in Urban Local Growth Development Project/ULGDP/, except Addis Ababa city, are secondary cities. Namely; Adama, Kombolcha, Dessie, Mekelle, Bahir Dar, Gondar, Jimma, Dire Dawa, Hawassa, and Harar, Bishoftu, Shashemen, Arba Minch, Dilla, Wolayta Sodo, Adigrat, Axum, and Shire Endasellassie (Figure 1).

According to Horst (2006), these cities are growing even faster than the primate city, Addis Ababa, but with fewer capacities to plan and manage urban development and promote employment and economic growth (Roberts and Hohmann, 2014).

2.3. Description of the case study area, Kombolcha city

Regionally, Kombolcha is located on the western escarpment part of the central Ethiopian rift. It is found in the Eastern part of Amhara Regional State and specifically in the South Wolo Zone. Geographically, it is situated in the latitude and longitude coordinates of 11°6′ N and 39°45′ E, respectively (Damtew et al., 2019; Water and Land Resource Center/WLRC/, Ethiopia, 2018) (Figure 1). According to the 2011 Structure Plan report, the city's area is 12450 ha and has six urban and six rural Kebeles/smallest administrative units in Ethiopia.

The 2020 Asset Management Plan of the city indicated that the city had 137,493 population in 2017. However, the 2013 Central Statistics Agency/CSA/projection shows that the population is estimated to reach 149,787 inhabitants in 2021 (CSA, 2013).

Kombolcha city is among the fast-growing cities in Ethiopia with rapid population increase, fast and wide-area expansion, and a massive gap in demand and supply of infrastructure and urban services. It is an industrial growth center of regional and national importance, the unique feature of the city from other secondary cities in Ethiopia (Woldeyes and Bishop, 2015). The population of the city has shown significant changes from 2007 onwards.

Table 1 depicts that the level of urbanization of the city reached above 75% in 2017. At the same time, the proportion of the city's urban population increased by close to 10% from 2007 to 2020.

2.4. Data collection

The study used both primary and secondary data, which are collected through various tools. Thus, this paper has dully applied desk studies on spatial plan reports, key-informant interviews, and household surveys.

2.4.1. Desk study

Two primary data collection instruments were used: key informant interviews and questionnaires/household surveys/. Furthermore, the 2011 City-Wide Structure Plan, the 2013 Drainage Master Plan, and the city's Asset Management Plan were used to support the results and discussion as secondary data sources.

2.4.2. Key-informant interview

The experts working at the Urban Planning, Green Development and Environmental Protection offices in Kombolcha city administration, including the city manager, form part of the key informants' interview. The total number of key informants chosen from these offices was seven among twelve. The study also collected data from urban development and planning consultants, academics, and the Urban Plan Preparation, Implementation and Follow-up/UPPIF/Bureau, including the bureau head, at the Ministry of Urban Development and Housing/MoUDH/. The interviews were conducted with sixteen experts.

The paper collected primary data from older people and former Red Cross Society Kombolcha Branch officials and employees who provided essential data on the type and form of urban problems with historical significance.

2.4.3. Household's surveys

Various data collection instruments existed to measure the perception of individuals and communities towards resilience. Allen et al. (2016) determined the characteristics of place-specific contexts of hazards through field-based sampling conducted in resilience 'of what' or systems/processes. However, OECD (2013) noted that the most preferred and authentic way is to use household surveys or questionnaires. Close-ended questions enable the amalgamation of scoring urban problems (shocks and stresses) and ease comparisons among the problems.

Accordingly, this study used closed-ended questionnaires with Likert scale measurements with five response items (Strongly disagree = 1, Strong agree = 5) and dispatched them to randomly selected households residing in different localities within Kombolcha city. Finally, each urban problem was individually compared and aggregated to form a single collective score in the Analytic Hierarchy Process/AHP/.

2.5. Samples size determination

Based on the 2020 AMP of Kombolcha city, an estimated 27,400.00 housing units were found in 2017. Therefore, for this defined population, the study applied Yamane's sample size determination Formula (Rahman et al., 2020) (Equation 1), which is applicable for the finite number of populations (Guwahat, 2013).

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

Where,

Table 1. Level of Urbanization of Kombolcha city.

No	Year	Rural Population	Urban Population	Total Population	Level of urbanization
1	2007	26,700.00	58,667.00	85,367	68.72%
2	2017	32,701.00	104,792.00	137,493.00	76.22%
3	2020	33,503.00	122,637.00	156,140.00	78.54%

Source: Kombolcha City Asset Management Plan/KCAMP/, 2020.

n is the sample size, N is the population size (i.e., 27,500), and e is the desired level of precision, usually 0.05 for 95% confidence level (Guwahat, 2013).

Thus, the sample size computed based on Eq. (1) above is

$$n_{=}\frac{27,500}{1 + 27500(0.05)^2} = 394.25$$

Hence, the total sample households selected for this study were 400.

2.6. Data analysis

2.6.1. SPSS based factor analysis

SPSS (Version 20) was applied to undertake multivariate factor analysis to determine the urban challenges. Based on Pallant (2013), the use of factor analysis is significant with the value of Kaiser-Meyer--Olkin's/KMO/measure of sampling adequacy above 0.5, the value for Bartlett's sphericity test less than 0.05, and Cronbach's alpha internal consistency test result above 0.800. In addition to these, the study applied Promax rotations since correlation exists among the factors considered. Furthermore, data extraction methods were applied to exclude the urban problems with a factor loading value below 0.500, if any.

The Kaiser-Meyer-Olkin (KMO) value for this study is 0.891, which Hutcheson and Sofroniou (1999) stated praiseworthy, indicating that the seventeen variables considered are adequate to proceed with the research. The significance (sig) value of Bartlett's test of sphericity is 0.000 (Table 2).

2.6.2. Application of AHP

Multi-attribute decision-support models are applied to evaluate households' perceptions towards urban shocks and stresses (Keeney and McDaniels, 2001). Therefore, this study deployed Saaty's decision-making support model, which enabled the researchers to apply the factor loading values indicated in Table 4. This model can be applied for studies with a maximum of twenty variables (Feng and Chan, 2004; Saaty, 1988).

However, Saaty's level of importance is subject to a grading scale applied to convert each urban risk's component factor loading values into a standard and normalized scale. Therefore, pairwise comparisons among all the urban problems can be made (Carrilho, 2015). The grading scales of 1 indicate the relatively most minor recurring urban problem and 10 for the frequently occurring urban challenges (Table 3).

The grading in Table 3 and the subsequent application of Eq. (2) below allowed the factor analysis results to fit Saaty's fundamental scale, as illustrated in Table 3. However, these grading values require further adjustments to carry out a pairwise comparison of the variables and fit Saaty's fundamental scale. Carrilho (2015) proposed applying a formula (Equation 2), which uses absolute values to avoid negative values, if any, that fit the AHP model.

$$s(a_i, a_j) = \frac{8}{9}\left|v(a_i) - v(a_j)\right| + 1 \tag{2}$$

Where

a is one cell of index i and j is the cell with index j that i, j R, I $\neq$ 1

v (a_i) and v (a_j) are the values of the cells a_i or a_j, respectively.

Table 2. Kaiser-Meyer-Olkin (KMO) and Bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.891	Cronbach's alpha Test
Bartlett's Test of Sphericity	Approx. Chi-Square	3820.534	.934
	df	190	
	Sig.	.000	

Table 4 illustrates applying the grading values depicted in Table 3 and Eq. (2) to fit the AHP model. The table further shows that the pairwise comparison of the same urban problem result is left of the empty cells. The values above the empty cells are the reciprocals of the values indicated on the left side of these cells.

3. Literature analysis

3.1. Factors affecting spatial resilience to urban uncertainties

Cities face increasing challenges and apocalyptic risks, such as climate change, which has increased the popularity of the resilience concept (Carmin et al., 2012). The concept has been positioned as a desirable goal in response to research examining who benefits from and loses from resilience regimes (Meerow et al., 2016). According to Sharifi and Yamagata (2016), urban resilience constituted five dimensions: materials and environmental resources, built environment and infrastructure, society and well-being, economy, governance and institution. Razafindrabe et al. (2009) showed physical, social, economic, institutional, and hazard frequency and density as the significant dimensions of resilience concerning the urban disaster. On the other hand, Gharai et al. (2018) claimed these as urban resilience indicators by incorporating spatial resilience focusing mainly on physical and environmental dimensions with measurable variables.

However, resilience to disaster requires safeguarding the physical integrity of the community, ensuring continuity of economic, business, and administrative operations, and ensuring the community has the resources it needs to survive (Paton and Johnston, 2001).

Table 3. Grading values of purely spatial urban uncertainties.

No	Description for grading	Grading values
1	Decision with extremely least possibility to occur	1
2	Decision with very least possibility to occur	2
3	Decision with least possibility to occur	3
4	Decision with marginally least	4
5	It is indifferent to the final decision	5
6	Decision with moderately low possibility to occur	6
7	Decision with moderately high possibility to occur	7
8	Decision with high possibility to occur	8
9	Decision with very high possibility to occur	9
10	Decision with extremely high possibility to occur	10

Source: Computed by the authors based on Carrilho (2015).

Regarding physical and environmental dimensions, Razafindrabe et al. (2009) further showed the factors/variables inherently affecting the resilience of cities against urban shocks and stresses: energy, water supply, sanitation, solid waste disposal, internal road network, housing, and land use, and community assets. The authors further determined that the type of urban shocks and disturbances for which a city is expected to be resilient, which form one pillar of spatial resilience Brunetta and Caldarice (2020), affects cities' resilience. The factors influencing spatial resilience further included the severity of urban uncertainties, environmental context, and response pathway.

Benini (2016) suggested four severity ratings of risks with significance towards measuring the perception of individuals: minor, moderate, major/significant, and severe. In the environmental context, spatial resilience depends on the ability of an urban system to suggest pioneering bottom-up concepts and practices be incorporated within consolidated institutional policies of spatial development. The ability to respond is attributed to how a system reacts to urban problems and threats.

Finally, the response pathway (coping capacity) indicated the range of possible solutions to the shocks and disturbances of an urban system. This factor considers the stages of intervention, including collapse, conservation, adaptation, and evolution (Brunetta and Caldarice, 2020). According to Folke (2016), system collapse results from an incapacity of cities to cope with shocks and stresses. Adaptation and conservation are attached to the process of anticipating and coping with urban threats and changes. On the other hand, evolution is a capacity for systems to cross thresholds and move into novel areas following emergences and development paths that may not be known beforehand.

Based on these discussions, this paper considered the following factors affecting the spatial resilience of secondary cities in Ethiopia (Table 5).

3.2. Secondary cities and spatial resilience

Many second-tier cities in sub-Saharan Africa lack adequate spatial frameworks to enable sustainable urbanization, mainly due to poor urban planning. Therefore, the spatial development of these cities has been slow since rural-urban migration has fueled poorly planned expansions and the proliferation of slums. Moreover, it is stated that the failure of services or infrastructure in secondary cities has a significant impact on the communities around them: rural and urban centers (Githira et al., 2020; Perry et al., 2020). These cities lack the data and information needed to develop national policies and plan urban spaces (Perry et al., 2020).

Thus, Cote & King (2017) argued there is a need to build resilience in secondary cities, particularly spatial resilience, to achieve national and local development objectives since these cities serve as a bridge between rural areas and large cities as traditional and industrialized economies.

In their work, Brunetta and Caldarice (2019) elaborated on spatial resilience approaches and how they engage in coordinated measures to adapt to and mitigate potential disasters. The framework also negotiates social and economic goals, considers conflicting interests, and considers sustainability targets and objectives. Accordingly, four pillars of spatial resilience Brunetta and Caldarice (2020) are essential - the type of disturbance, the genius loci, the ability to respond, and the path to recovery. These factors together define spatial resilience, as shown below.

Table 4. Illustration of Eq. (2) and factor grading to fit AHP model.

	Variables	Surface flooding (SF) (grading 8)	Erosion (E) (grading 3)	Landslide (LD) (grading 6)
A	Surface flooding/SF/(factor value 0.866)	-	Reciprocal of the value of cell ESF = 1/ESF = 1/6 = 0.1767	Reciprocal of the value of cell LDC = 1/3 = 0.333
B	Erosion/E/(factor value 0.566)	ESF = 8/9 (/grading of SF-grading of E/)+1 = 8/9 (/8-3/)+1 = 5.44 ≈ 6	-	Reciprocal of the value of cell LDE = 1/4 = 0.25.
C	Landslide/LD/(factor value 0.641)	LDC = 8/9 (grading of V-grading of LD/)+1 = 8/9 (/8-6/)+1 = 2.777 ≈ 3	LDE = 8/9 (/grading of E-grading of LD/)+1 = 8/9 (/3–6/)+1 = 3.66 ≈ 4	-

Spatial resilience is the ability of a territorial system to bounce back to desired functions after unexpected shocks and disturbances to improve its adaptive capacity intending to evolve its material and immaterial components towards a new territorial system's organization (Brunetta and Caldarice, 2020).

In Allen et al. (2016)'s perspective, the type and form of urban problems are related to hazard-related properties of specific locations. This context led Fleischhauer (2008) to identify and categorize urban problems regarding spatial resilience in the European context (Table 6).

3.3. Assessments of urban spatial resilience

The urban hazard assessment determines the planning and implementation of risk prevention and mitigation measures through suitable response and recovery measures following a disaster (UNDP, 2010). This is the first step in operationalizing and measuring resilience (Mitchell and Harris, 2012). In their studies, Berkes (2007); Obrist et al. (2010) found that the risk and resilience approach comprehensively assesses systems and their interactions, from neighborhood plots to regional and national levels.

A growing body of research suggests that resilience can be measured through qualitative and quantitative methods, participatory assessments, statistical analyses, models, and metrics (Allen et al., 2016). Measurements are, however, subject to conceptual and methodological limitations, that is, knowing what to measure and obtaining the correct data (Brunetta et al., 2021).

The Asian Disaster Preparedness Center, 2010 identified five crucial methods for these contexts in urban risk assessment. Risk evaluation included: identification, assessment, vulnerability assessment, and estimation of risk.

Nevertheless, identifying the 'of what' and 'to what' of resilience is the precondition for measuring any resilience (Carpenter et al., 2001). The 'of what' concerns of resilience are tied to place-specific or answer the 'where' question with two primary conditions: a system's spatial extents and the ranking, scoring, or prioritization of some areas' resilience. On the other hand, the 'to what' concern is attributed to the disturbances expected in an urban system to be resilient (Crown, 2011; Meerow and Newell, 2018).

In support of this, the Asian Development Bank (2013) elaborated that risk assessment measures the vulnerability of human beings, properties, and infrastructure to various disturbances to which urban areas are exposed.

The Allen et al. (2016) study identified systems and disturbances, defined spatial regimes, delineated internal and external elements associated with the scale of analysis and collected data to measure spatial resilience. The criteria are crucial elements to urban spatial resilience.

Cities form parts of social-ecological systems falling under the resilience 'of what' category while natural and man-made urban problems affecting urban lives are linked to resilience 'to what (Crown, 2011). According to Adger (2006); Allen et al. (2016); Cutter et al. (2008), resilience assessment considers the context and disruptions occurring in a city.

Two resilience assessment methods dominate the scholarly literature: the objective approach, imposed by experts, and the subjective approach, based on individuals' experiences with hazards. The approaches can be used separately or jointly (Jones, 2018, 2019; Jones and Tanner, 2017).

In describing and measuring resilience, the two measurements are interrelated (Jones, 2019). Nevertheless, subjective approaches differ from objective approaches in terms of epistemological understanding (Jones, 2018). It is a bottom-up approach to resilience and is best applied in contexts where individuals understand localized risks (Jones, 2019).

Through this assessment, individuals can gain a comprehensive understanding of what resilience entails and be in a good position to measure their risk profiles (Jones et al., 2018; Jones and Tanner, 2017; OECD, 2013).

Moreover, recent literature alluded to the increasing interest in studying the impacts of urban risks concerning spatial resilience through subjective assessments (Allen et al., 2016).

Risk analysis takes many forms in an urban setting. Accordingly, Asadzadeh et al. (2015) used factor analysis and AHP to develop disaster resilience indicators. They presented a new network process to compute the weights of recognized disaster resilience dimensions and indicators. RIMA (2016) also demonstrated the application of factor analysis. The FAO study estimated resilience pillars, calculated resilience capacity index, and estimated index values using structural equation modeling. In addition, the study noted the importance of correlation among the variables to rank.

Secondary data, field observations, and other datasets collected through community or qualitative data helped validate decisions in both studies (Asadzadeh et al., 2015) and (RIMA, 2016).

Table 5. Factors affecting spatial resilience considered in this study.

Dimensions	Factors
Type of urban problems	Type of urban uncertainties: environmental and physical factors affecting spatial resilience of cities
	The severity of urban uncertainties: critical, severe, moderate, and minor
Environmental setting of an urban center	Material and resource consumption: forest and energy resources
	Flood occurrence
Physical/Built environment and infrastructure/	Type, condition, and availability of drainage lines
	Solid waste management infrastructures
	Condition of transportation systems: traffic accidents and congestion
Response (coping capacity)	Adaptation measures: planning and biophysical measures

Table 6. Spatially relevant resilience discourses.

No	Risk category	Disturbances	Significance
1	Hydrogeological risk	Landslides	++
		River floods	++
		Avalanches	++
2	Meteorological risk	Urban heat island and cold waves	+
		Storms	++
3	Geophysical risk	Volcanic activity	++
		Earthquakes	+
4	Climatological risk	Droughts	+
		Wildfires	+
		Tsunami	++
		Instability of West Antarctic ice sheet	+
5	Anthropic risks	Major accident hazards	++
		Hazard from Nuclear power plan	++
		Air traffic hazards	+
		Terrorism	+
		War	+
		Crime	+
		Hazards along with transport networks	+
		Long term consequences of human-induced climate changes	+
		Destabilization of the terrestrial ecosystem due to human-induced acts	+
		Change of biogeochemical cycles	+
6	Technological risks	Electromagnetic fields	+

Note ++ risks with high significance to spatial resilience; + risks with low relevance to spatial resilience.
Source: (Brunetta and Caldarice, 2020; Fleischhauer (2008)).

4. Results

This section of the paper reflects the conditions and factors indicated in Table 5 under section 3.1. Therefore, the results are presented to determine the significant factors, including the type of urban problems for the secondary cities in Ethiopia. The presentation of the household's perception towards the problems, their severity level, and the narration on the physical, infrastructural and environmental factors in the city of Kombolcha follows.

4.1. Type of urban uncertainties affecting the spatial resilience of secondary cities in Ethiopia

The urban shocks and stresses are extracted from the list of urban problems provided by the country's 2017 draft urban climate resilience strategy and the Addis Ababa city Resilience project office in 2018. The draft strategy document archives that the urban problems are an inherent characteristic of all urban centers in Ethiopia. However, the urban problems are categorized as social, economic, and political, environmental and physical; and urban problems, which lie in all dimensions (Table 7).

Table 7 reveals the results from the key informants that determined seventeen environmental and physical urban problems affecting the spatial resilience of secondary cities in Ethiopia. The Table further sets the basis for the following results of this paper by focusing on these urban uncertainties for Kombolcha city.

4.2. Households perceptions towards the environmental and physical urban challenges

The sampled households' perceptions are taken into account to reveal the most significant and recurring environmental and physical urban problems affecting the city's development and its inhabitants' well-being. The factor loading values, computed for principal component analysis, facilitated the grading of the urban problems to rank the urban challenges (Table 8), explaining the city's vulnerability to the hazards as high, moderate, and low to the related problems.

Table 8 shows that the factor loading values for all the urban problems fall under the high vulnerability of the city to all the problems identified. The highest grading score is assigned to the urban problems with the highest factor loading, and vice versa is true for the lower values. Consequently, the Table shows that poor sanitation takes the highest score with 10, followed by poor waste management and poor drainage facilities with a grading score of 9. The lower grade is constituted by deforestation and fire outbreaks with 2 and 1 grading, respectively.

4.2.1. Level of urban uncertainties in Kombolcha city

The grading in Table 8 has enabled the paper to apply Eq. (2) and provided the results shown in Table 9 to compute a pairwise comparison among the environmental and physical variables and convert the problems' grading values to fit the AHP model.

The vertical sum in Table 9 reveals the highest value to water scarcity and lowest value for solid waste management with 74.67 and 8.47, respectively, as per their order. The sum of the values for each of the urban problems corresponding to Carrilho's grading is considered for pairwise comparison made among the variables in AHP and the analysis indicated in Table 10.

A pairwise comparison made in Table 10 put deforestation, surface flooding, landslides, poor solid waste management, and inadequate drainage facilities with respective weights of about 20%, 13%, 12.70%, 8%, and 7% as the top five urban problems in the city. Lack of public parks and green spaces follow with 5.27% and 4.87% values, respectively. The Table further reveals that urban pollution (4.58%), traffic congestion (3.84%), poor infrastructure (3.66), traffic accidents (3.45%), and urban growth (3.19%) are the urban problems that the households' marked necessary next to lack of public parks and green spaces.

The Table also attests that fire outbreaks, earthquakes, and poor sanitation, are among the urban problems, with corresponding weights of 2.92%, 2.85%, and 2.20% recurring in the city. The last but not the minor urban problems ranked, based on Table 10, are wind-related and water scarcity challenges with respective recurring weights of 1.89% and 1.48%.

Table 7. Type of urban problems affecting spatial resilience of secondary cities in Ethiopia.

Social, economic, and political	Environmental and physical	Both (significance to spatial and non-spatial dimensions)
Access to Quality Education	Earthquake	Informal settlements
Access to quality Health Service	Landslide	Political instability
Economic Crisis (Inflation)	Surface flooding (Pluvial)	Infrastructure or building failure
Corruption	Urban Fire outbreak	Internally Displaced persons
Drug and alcohol abuse	Urban Pollution	Food insecurity
High unemployment	Water shortages/scarcity	Homelessness
Lack of Up-to-date and relevant data for future planning.	Traffic Accident	Energy insecurity
Economic inequality	Inadequate public parks and recreational place	Terrorism
Lack of affordable housing	Inadequate waste management systems	Poor governance regulatory Climate.
	Poor sanitation System	Environmental degradation
	High wind	Population growth (over population)
	Inadequate drainage	Poverty
	Overburdened Infrastructure	Drought
	Unprecedented urban expansion	Disease Outbreak
	Traffic Congestion	Lack of Integrated spatial Planning
	Uncontrolled growth/ lack of green space	Internal Migration
	Deforestation	Conflict
		Temperature
		Unreliable transport system

Table 8. Grading of environmental and physical urban challenges affecting spatial resilience of Kombolcha city.

No	Environmental and physical urban challenges	Factor loading values			Grading (score 1 -10)
		1	2	3	
1	Poor sanitation	.912	.060	-.270	10
2	Poor waste management	.911	-.170	.191	9
3	Poor drainage facilities	.903	.101	-.248	9
4	Urban pollution	.901	.195	-.145	8
5	Traffic accidents	.897	.082	-.199	8
6	Traffic congestion	.889	-.034	.245	8
7	Poor infrastructure	.878	-.174	.289	7
8	Urban expansion	.872	.005	-.305	6
9	High wind	.865	.158	-.151	6
10	Water scarcity	.852	-.069	-.195	6
11	Earthquake hazard	.835	-.200	.021	5
12	Flood hazard	.831	-.056	.267	4
13	Lack of green spaces	.817	-.120	-.307	4
14	Lack of public parks	.817	-.171	.282	3
15	Landslide hazard	.798	.418	.083	3
16	Deforestation	.767	.448	.087	2
17	Fire outbreak	.738	-.425	.176	1

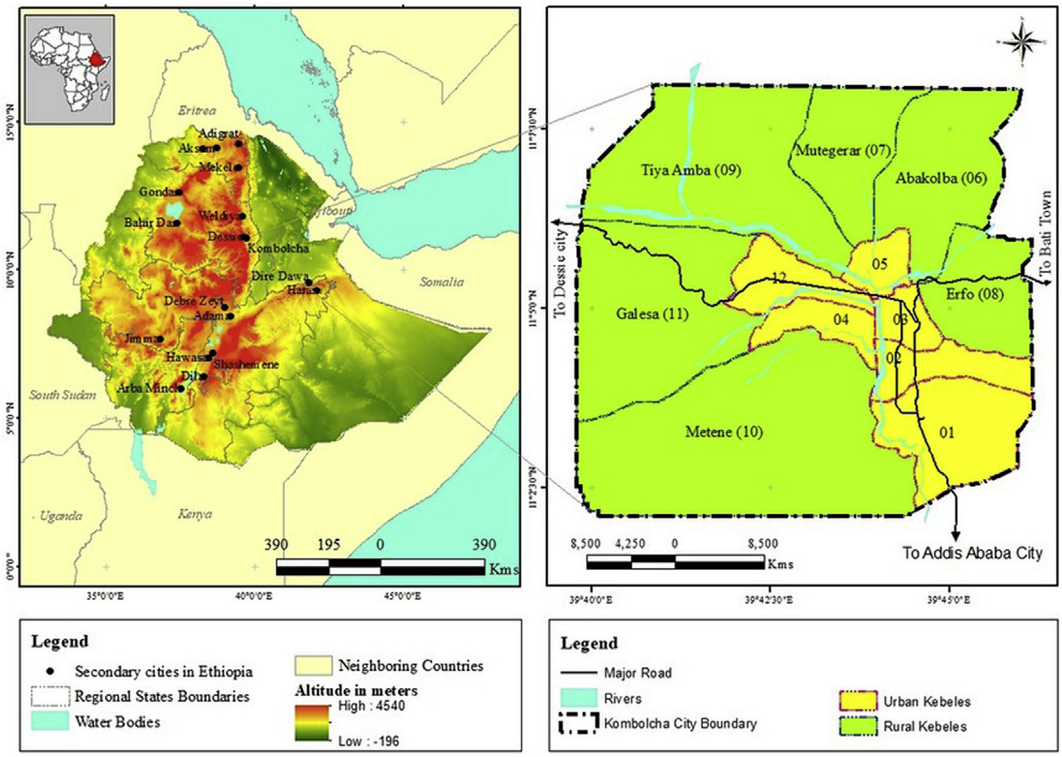

Figure 1. Location map of Kombolcha city.

4.2.2. Rating the severity of the environmental and physical factors in Kombolcha city

The city's vulnerability to the urban shocks and stresses ranked in Table 10 are also measured in terms of their severity: critical, severe, moderate, and minor (Table 11).

Table 11 shows that Kombolcha city is severely and significantly affected by urban problems specific to spatial resilience, with respective values of close to 49.48% and 36.19%. In comparison, close to 6.85% and 7.48% of the respondents recognized the moderate and minor occurrences of the urban problems, respectively.

4.3. Environmental setting as a factor affecting spatial resilience of Kombolcha city

Primary and secondary data sources are used to validate the combined results of the factor analysis and AHP. Household energy sources, building materials for constructing residential houses, data on informal settlements, solid waste management, and previous flood events in the city were prominent data used in this context.

4.3.1. Material and resource consumption: forest and energy resources

The former Red-Cross society Kombolcha branch manager notes, under oath, that Yeguf Mountain covering the Northern escarpment of the city, have lost their natural appeal due to intense cutting of trees. The agents in this regard are community members and public institutions.

Simultaneously, a study conducted by IPE Global in 2017 backs the assertions made by the key informant. The IPE study depicts deforestation and poor soil, and water conservation measures contribute significantly to severe landslides, soil erosion, and flooding challenges in the city. The construction office head elucidates that the main reasons for cutting the forest products are household cooking, heating, and construction of residential buildings.

Figure 2 depicts that more than one-third of the sampled households depend on wood, a traditional energy source, for cooking and heating purposes. However, the proportion is above this figure because the households use combined energy sources: wood with electricity and kerosene.

It is illustrated in Figure 2 the simultaneous use of both wood and electricity constitutes about 39% of the energy sources. The figure also depicts that close to 20% of the households are dependent on grid-based electricity for cooking and heating purposes.

Concerning the use of forest products to construct residential low-rise buildings, Figure 3 demonstrates that more than 80% of the sampled households use wood and straw to construct their houses. The figure also shows that only 15 percent of the households use Hollow Concrete Blocks/HCB/to construct their residential units.

Regarding the construction material for residential low-rise buildings, the key informants from the UPIF case team explain that informal settlements contribute a lot to depleting forest natural resources. The 2011 Structure Plan attests that one-ninth of the residential units in the city were informal in 2010. The city's Asset Management Plan ArcGIS document shows that close to 60.12 ha of the protected forest areas proposal of the Structure Plan are invaded and occupied by informal settlements in 2020.

The forest products are supplied with two options: purchasing and cutting trees. According to Figure 4, nearly 29% of the study participants obtain the tree products from cutting trees found in their premises, nearby mountainous areas, or villages. In comparison, more than 70% of households obtain wood from nearby markets. In this vein, the city environmental protection and urban agriculture office's key informant revealed that Kombolcha city and the adjoining rural areas are the major contributors to local forest products marketing in the city.

4.3.2. Flood occurrence

The Key informants from environmental protection, urban agriculture, UPIF case team reveal that surface flooding is another urban problem in the city. In this circumstance, the 2013 drainage master plan of the city indicates that surface flooding affects urban settlements located at the foot of the Mountains. The main consequences in these urban areas included the destruction of fences and sedimentation of

Table 9. Results of grading of environmental and physical urban challenges based on Eq. (2).

No	Urban risks	Water scarcity	Wind	Fire	Earthquake	Urban growth	Lack of Green spaces	Lack of Public Parks	Traffic accident	Traffic congestion	Poor sanitation	Urban Pollution	Poor Infrastructure	Landslide	Surface flooding	Deforestation	Poor drainage facilities	Poor solid waste management
	Carrilho Grading	6	5	1	5	6	3	4	8	8	10	8	9	3	4	2	9	9
1	Water scarcity	**0.000**	0.18	0.11	0.18	0.22	0.14	0.16	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
2	Wind	5.44	**0.000**	0.11	0.18	0.22	0.14	0.16	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
3	Fire outbreak	9.00	9.00	**0.000**	0.18	0.22	0.14	0.16	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
4	Earthquake	5.44	5.44	5.44	**0.000**	0.22	0.14	0.16	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
5	Urban growth	4.56	4.56	4.56	4.56	**0.000**	0.14	0.16	0.36	0.36	1.00	0.36	0.53	0.53	0.16	0.12	0.53	0.53
6	Lack of Green spaces	7.22	7.22	7.22	7.22	7.22	**0.000**	0.16	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
7	Lack of Public Parks	6.33	6.33	6.33	6.33	6.33	6.33	**0.000**	0.36	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
8	Traffic accident	2.78	2.78	2.78	2.78	2.78	2.78	2.78	**0.000**	0.36	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
9	Traffic congestion	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	**0.000**	1.00	0.36	0.53	0.14	0.16	0.12	0.53	0.53
10	Poor sanitation	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**0.000**	0.36	0.53	0.14	0.16	0.12	0.53	0.53
11	Urban Pollution	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	**0.000**	0.53	0.14	0.16	0.12	0.53	0.53
12	Poor Infrastructure	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	**0.000**	0.14	0.16	0.12	0.53	0.53
13	Landslide	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	**0.000**	0.16	0.12	0.53	0.53
14	Surface flood	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	**0.000**	0.12	0.53	0.53
15	Deforestation	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11	**0.000**	0.53	0.53
16	Poor drainage facilities	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	**0.000**	0.53
17	Poor waste management	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	**0.000**
	Sum	**74.67**	**69.41**	**60.44**	**55.33**	**51.10**	**43.69**	**37.61**	**36.41**	**33.99**	**39.11**	**30.93**	**31.27**	**20.27**	**13.94**	**5.50**	**9.83**	**8.47**

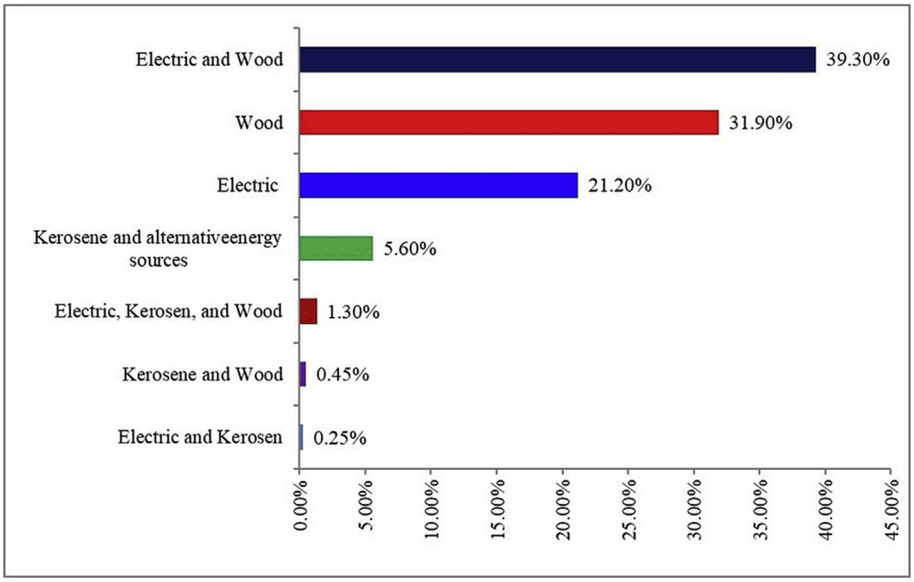

Figure 2. Proportion of energy sources used for cooking and heating purposes by the sampled households.

residential premises and buildings. In line with this, the Kombolcha city communication affairs office claims that a flooding event in April 2017 caused damages to the city's urban properties (Figure 5).

Figure 5 shows the flooding event that destroyed fences (c) and affected individual households (a, b, and d). In another setting, the Red Cross Society discloses that flooding in 2002 killed four people.

4.4. Physical/built environment and infrastructure/as a factor affecting spatial resilience of Kombolcha city

4.4.1. Type, condition, and availability of drainage lines

The city is provided with open and closed ditches that facilitate the movement of rainwater. The 2020 Asset management Plan of the city reveals that only 30% of the roads in the city have either closed or open ditches. The open ditches account for about 64% of the drainage lines in the city. The conditions of the existing drainage lines are depicted in Figure 6.

Figure 6 reveals that close to 40% of the drainage line in the city are in poor condition, and about 43% are in good condition.

4.4.2. Solid waste management infrastructures

Flooding is also attached to poor solid waste management and inadequate drainage facilities, claim the key informants from the city environmental protection office. Accordingly, a study conducted by Construction Design Share Company/CDSCo/in 2005 reveals that the city's solid waste collection efficiency is only 15%. The remaining wastes are dumped into open spaces, drainage lines, and river channels.

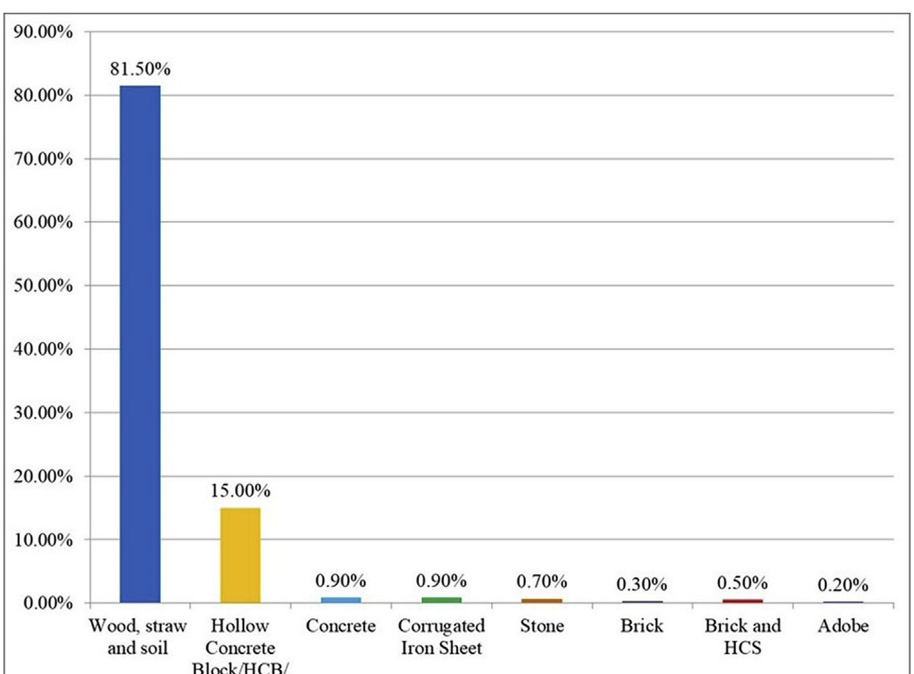

Figure 3. Proportion of construction materials used for constructing low-rise residential houses by the sampled households.

Table 10. Pairwise comparison and ranking of the environmental and physical urban challenges affecting spatial resilience of Kombolcha city.

No	Urban uncertainties Hazards	Water scarcity	Wind	Fire	Earthquake	Urban growth	Lack of Green spaces	Lack of Public Parks	Traffic accident
1	Water scarcity	**0.000**	0.003	0.002	0.003	0.004	0.003	0.004	0.010
2	Wind	0.073	**0.000**	0.002	0.003	0.004	0.003	0.004	0.010
3	Fire outbreak	0.121	0.130	**0.000**	0.003	0.004	0.003	0.004	0.010
4	Earthquake	0.073	0.078	0.090	**0.000**	0.004	0.003	0.004	0.010
5	Urban growth	0.061	0.066	0.075	0.082	**0.000**	0.003	0.004	0.010
6	Lack of Green spaces	0.097	0.104	0.119	0.131	0.141	**0.000**	0.004	0.010
7	Lack of Public Parks	0.085	0.091	0.105	0.114	0.124	0.145	**0.000**	0.010
8	Traffic accident	0.037	0.040	0.046	0.050	0.054	0.064	0.074	**0.000**
9	Traffic congestion	0.037	0.040	0.046	0.050	0.054	0.064	0.074	0.076
10	Poor sanitation	0.013	0.014	0.017	0.018	0.020	0.023	0.027	0.027
11	Urban Pollution	0.037	0.040	0.046	0.050	0.054	0.064	0.074	0.076
12	Poor Infrastructure	0.025	0.027	0.031	0.034	0.037	0.043	0.050	0.052
13	Landslide	0.097	0.104	0.119	0.131	0.141	0.165	0.192	0.198
14	Surface flood	0.085	0.091	0.105	0.114	0.124	0.145	0.168	0.174
15	Deforestation	0.109	0.117	0.134	0.147	0.159	0.186	0.216	0.223
16	Poor drainage facilities	0.025	0.027	0.031	0.034	0.037	0.043	0.050	0.052
17	Poor waste management	0.025	0.027	0.031	0.034	0.037	0.043	0.050	0.052
	checksum	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**

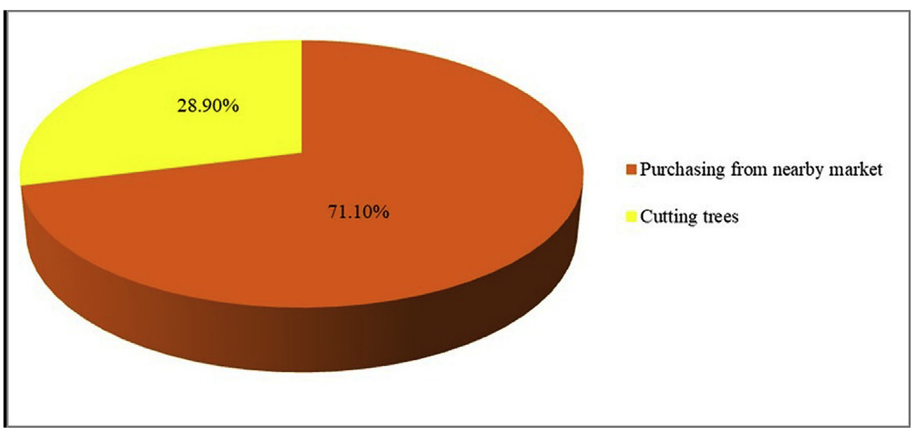

Figure 4. Proportion of options available to obtain the forest products in Kombolcha city.

Figure 8 reveals that riverbanks and open spaces in the city serve as waste disposal sites. Solid wastes have clogged the inadequate drainage lines, which have aggravated the flood problem in the city. The existing drainage lines, particularly the open ditches, are the elements of poor solid waste management practices (Figure 7a). The solid waste dumping site or the substandard landfill site is also an open field with no systems for handling the solid wastes (Figure 7b). Based on Figure 7(c), the riverbanks are sites for locating substandard waste transfer stations. The figure further reveals the layers (Figure 7d) created by poor solid waste management, affecting the riparian ecosystem.

4.4.3. Condition of transportation systems: traffic accidents and congestion

The 2011 Structure Plan of the city indicated that the location of the open market, bus station, and livestock market in the city center are generating high traffic in the city. Furthermore, the key informant from the UPIF case team and the city residents acknowledged that the industrial park, the new dry port, and the airport had become a new hub for traffic accidents and congestion in Kombolcha city. This key informant further claims that the land-use changes made by the regional and federal institutions have contributed a lot in introducing the unanticipated urban problem. The informant notes that the 2011 city's structure plan proposals had been highly compromised due to such intervention and imposition. It is raised that the mixed-use and residential proposal were changed into industrial and dry port functions in 2016 and 2017 (Figure 8).

Figure 8 reveals that three major land uses of the 2011 Structure Plan proposals, Mixed-use, Pure Residence, green recreation, and forest areas, have been converted into industrial parks and dry port sites. The Water Service enterprise of the city has also declined to accept the changes made due to the waterlogging nature of the areas where major boreholes are located. The head fears that the city may be non-water resilient shortly.

The key informant from the infrastructure case team notes that these urban functions have overburdened the existing road networks, which are not redesigned and upgraded to accommodate the demand generated from these uses. The problem is further aggravated by poor and inadequate infrastructure, such as narrow and unpaved roads.

The city transport office asserts that traffic congestion is attributed to the daily high volume of freight transport vehicles originating and departing from the dry port and various industrial establishments and warehouses. On-street parking of heavy items trucks also aggravated the urban problems. The traffic accident and congestion problem are further exaggerated by the absence of an alternative bridge on the Borkena

Traffic congestion	Poor sanitation	Urban Pollution	Poor Infrastructure	Landslide	Surface flood	Deforestation	Poor drainage facilities	Poor waste management	Weights of recurrence	
									Values	Percentages
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.015	1.48%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.019	1.89%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.029	2.92%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.029	2.85%
0.011	0.026	0.012	0.017	0.026	0.011	0.022	0.054	0.063	0.032	3.19%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.049	4.87%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.053	5.27%
0.011	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.035	3.45%
0.000	0.026	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.038	3.84%
0.029	**0.000**	0.012	0.017	0.007	0.011	0.022	0.054	0.063	0.022	2.20%
0.082	0.071	**0.000**	0.017	0.007	0.011	0.022	0.054	0.063	0.045	4.52%
0.056	0.048	0.061	**0.000**	0.007	0.011	0.022	0.054	0.063	0.037	3.66%
0.212	0.185	0.233	0.231	**0.000**	0.011	0.022	0.054	0.063	0.127	12.70%
0.186	0.162	0.205	0.203	0.312	**0.000**	0.022	0.054	0.063	0.130	13.02%
0.239	0.207	0.262	0.259	0.400	0.582	**0.000**	0.054	0.063	0.197	19.73%
0.056	0.048	0.061	0.060	0.093	0.135	0.343	**0.000**	0.063	0.068	6.82%
0.056	0.048	0.061	0.060	0.093	0.135	0.343	0.192	**0.000**	0.076	7.59%
1.000	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**100.00%**

River. The Structure Plan attests that multiple types of transport modalities: inter-regional, inter and intra-urban buses, trucks, mini-buses, taxis, three-wheeler cars/Bajajs, and carts share the same, few, and narrow streets with pedestrians.

4.5. Responses to the urban problems: adaptation measures

4.5.1. Planning measures

Enhancing the spatial resilience of Kombolcha city through various intervention mechanisms is the ambition set on the vision state of the 2011 Structure Plan. They include delineating specific areas for protected forests and provisions of recommendation for the preparation and implementation of supportive plans, such as drainage master plans. Accordingly, the drainage master plan of the city had been prepared in 2013 with major shifts in increasing the proportion of drainage lines in the city and enhancing their capacity to handle surface runoffs.

The plan notes the spatial attributes of resilience through runoff coefficients, representing the integrated effects of many drainage basin parameters, determined by land use, soil groups, and land slope. The plan is based entirely on the city's existing land use/morphology and indicates the interventions for gully formation by demonstrating four gully fall and one chute outfall structure.

Figure 5. Households (a,b,d) and fences (c) affected by flooding and clearing the mud sediments (a,b).

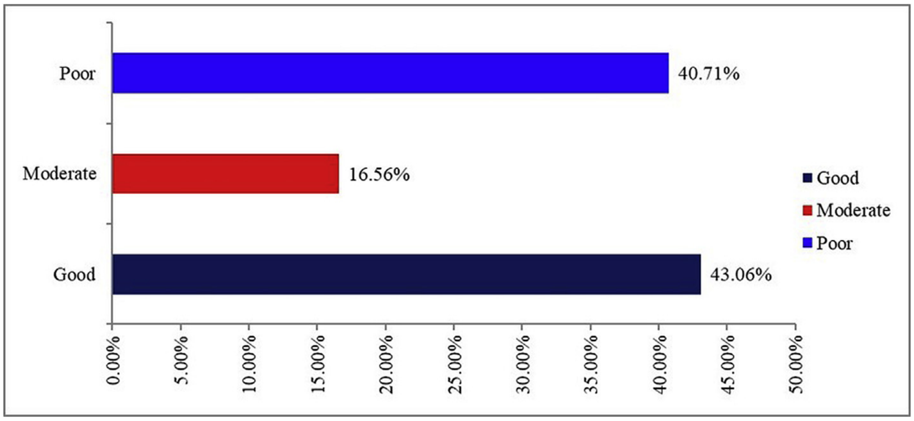

Figure 6. Proportion drainage lines conditions in Kombolcha city.

4.5.2. Biophysical measures

The sampled households perceive that the urban problems in the city did not force them to evacuate from their area of residence, and they attempt to adapt through the various mechanisms. Accordingly, close to 54% of them reply that they are prepared to adapt to the urban problems. In comparison, about 40% reveal that they are not prepared for any existing and potential future threats, natural and man-made, that the city is facing. Those households who reveal their preparedness assert three forms of disaster adaptation measures: particularly the bio-physical measures (Table 12). However, they do not assert the marking of evacuation routes and early warning systems.

According to Table 12, about 28.70% of the sampled households perceived the application of physical measures: gabions and retaining walls along river banks, elevated lands, and gully formations. On the other hand, close to 45% of the households reveal that the biological measures constituting tree planting were implemented to restore degraded mountainous areas. According to the South Wollo Zone agriculture office (2019), these areas are one of the spatial locations to implement terracing and trench activities in Kombolcha city, along with agricultural fields and gully formations.

In this context, the office asserts that the respective rehabilitation of 4.2, 10.1, and 13.6ha of land contributes to making the city spatially resilient. However, the office discloses that the terracing activities in the city lack supportive and compulsory works such as drainage lines, water retention ponds, soil and water conservation strategies, and channelization of gully formations.

The physical measures, which are the component of the terracing activity, had been implemented to protect the river systems from erosion. In this vein, the city Asset Management plan shows about 10.5 km of masonry retaining walls and 2.5km of meshed gravel-based gabions. All gabions are constructed along river banks and are affected by flooding. The retaining walls along river banks constitute only about one-fourth of the total length constructed, and 75% are erected to avoid land subsidence from mountainous areas (Figure 9).

Figure 7. Solid waste management in Kombolcha city: landfill site (a), open dumping (b), transfer station(c), and solid waste layers along river banks (d).

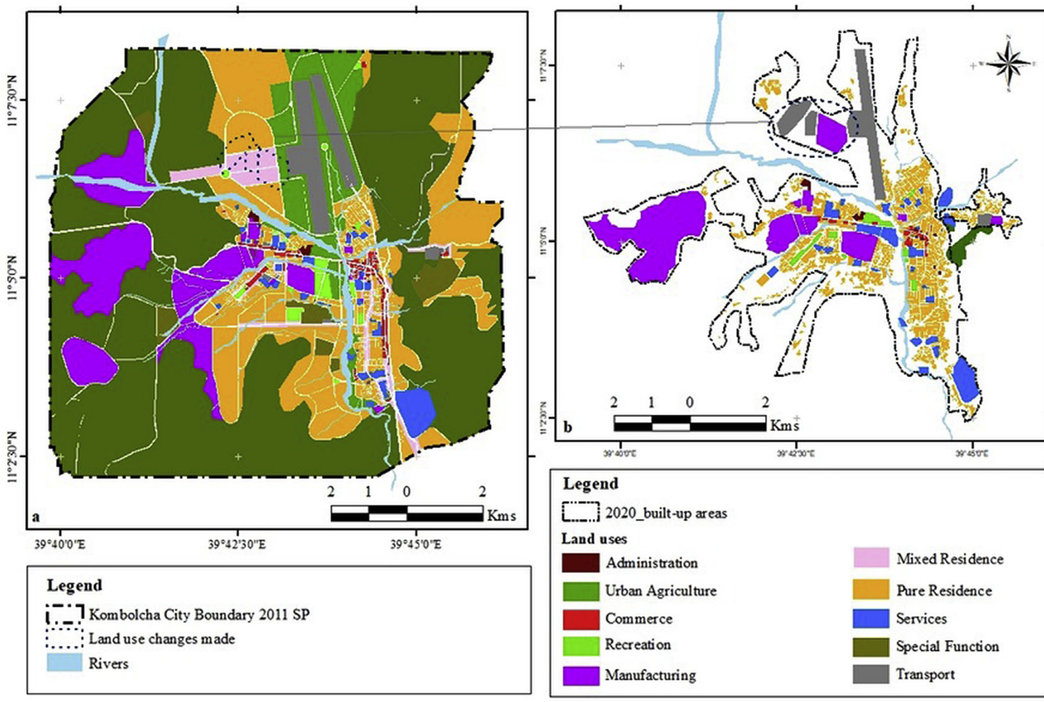

Figure 8. The 2011 Structure Plan land -use proposals (a) and 2020 existing land-uses (b).

Figure 9. Retaining wall constructed to protect soil subsidence from mountainous areas (a) and river banks (b).

5. Discussions

The inadequate capacities of local governments in secondary cities of SSA to localize international initiatives and develop local resource utilization policies have deteriorated the living conditions of their constituencies (Christiaensen and Kanbur, 2017). Therefore, assessing natural and man-made hazards for these cities is expected to abridge complex experiences of disasters to help make decisions. It also makes people's perceptions more substantial by assisting decision-makers in understanding the multiple risks communities face (Dickson et al., 2012; UN-Habitat, 2007).

Accordingly, this study determined seventeen environmental and physical factors/urban problems affecting the spatial resilience of secondary cities in Ethiopia. Furthermore, resource consumption, lack of appropriate and adequate physical infrastructures, and poor adaptation responses to the urban problems have exacerbated the urban problems in the city. The factor analysis revealed the correlation among the seventeen urban problems, and the households survey response revealed the susceptibility of Kombolcha to all the identified problems.

Popa and Diaconu (2019) disclosed that deforestation, affecting the forest resources, is one factor that potentially triggers flooding and landslides, which is a combined hazard triggered by seismicity and recurrent surface flooding (Highland and Bobrowsky, 2008). Concurrently, using wood as an energy source and constructing houses in secondary cities of Ethiopia Githira et al. (2020), including Kombolcha city, inevitably made flooding and landslide hazards defining features of the cities.

Flooding in SSA secondary cities is further aggravated by settlements along river banks, booming informal settlements, poor housing, and solid waste dumping in drainage channels (Agbola et al., 2012). In this context, the eastern escarpment or Mountainous areas of Kombolcha city lack adequate drainage facilities that aggravate surface runoff, eroding the topsoil. Subsequently, this had made surface flooding, apparently, a concern for settlements found at the foot and plateau/plain lands below the mountains. The drainage lines found within the neighborhoods are inadequate to carry the discharges from the overtopping rainwater. Furthermore, the lines within the settlement areas are filled with solid wastes, a global concern attached to environmental degradation

Table 11. Decision criteria to determine the severity of the environmental and physical urban challenges affecting spatial resilience of Kombolcha city.

No	Decision criteria	Water scarcity	Wind	Fire	Earthquake	Urban growth	Lack of Green spaces	Lack of Public Parks	Traffic accident
1	Severe	67%	12%	46%	54%	33%	49%	47%	48%
2	Major/significant	33%	40%	31%	46%	36%	40%	40%	29%
3	Moderate	0%	26%	13%	0%	17%	6%	6%	15%
4	Minor	0%	22%	10%	0%	15%	5%	7%	7%
	Sum	100%	100%	100%	100%	100%	100%	100%	100%

(Ferronato and Torretta, 2019), dumped irresponsibly. The river systems and scant open spaces are also spatial locations for solid waste disposal.

In this vein, the waste transfer stations in the city are by far substandard and contribute toward making the entire city, particularly the river system, non-resilient in spatial and socio-economic perspectives. According to Ferronato and Torretta (2019), such uncontrolled solid waste disposal causes significant pollution and health risks. The lack of a proper waste transportation system in the city exacerbated the problem of solid waste management.

According to Ganin et al. (2017), transportation in general, part of an urban system in secondary cities, is highly susceptible to different shocks and stresses, including traffic accidents and congestion. As a critical concern of traffic management, congestion is attributed to the mismatch between travel demand and road capacity (Aftabuzzaman, 2007).

Accordingly, the recently introduced urban land uses such as the industrial park, the new dry port, and the airport have become a new hub for traffic accidents and congestion in Kombolcha city. Moreover, incompatible existing land uses have also aggravated the problems in the city. The contribution of informal settlements in this regard is immense. The newly added urban functions were added to the existing road networks without proper improvement or upgrading on their right of way width and the quality of pavement materials. The problem is aggravated by poor and inadequate infrastructure, such as narrow and unpaved roads overburdened by the new economically significant urban functions.

Traffic congestion is inevitable due to the daily high volume of freight transport vehicles originating and departing from the dry port and various industrial establishments and warehouses in the city. On-street parking of heavy items trucks also aggravated urban risks associated with traffic congestion (IPE Global, 2017).

In addition to transportation systems, urban green infrastructures are indispensable in creating resilient and sustainable cities (Reinwald et al., 2019). Concurrently, the city residents acknowledge this concept and reiterated that a lack of green areas and public parks might introduce the social dimension of a non-resilient city like drug addiction due to the absence of leisure spaces.

The household survey responses reveal that urban expansion, which converts productive arable lands and forest areas to urban functions, inexorably aggravates the level, frequency, and magnitude of spatially relevant urban risks in Kombolcha city. The disturbances may include the flourishing of informal settlements, overburdened existing infrastructures, conflict may arise on the right to use land, and the transport system may be unreliable.

Table 12. Percentage of the household perception of the biophysical measures deployed.

No	Adaptation Measures	Percentage of the household perception on the measures deployed
1	Planting Trees	45.30%
2	Physical measures	28.70%
3	Terracing	26.00%
	Sum	100.00%

The local community's perception towards evacuation route marking and early warning systems to respond to the urban challenges is affected by poor planning. Thus, the execution of very few biophysical measures: retaining walls, gabions, and terracing influence the adaptation measures introduced.

5.1. Implications for planning resilient and sustainable cities

This research plays a vital role in urban resilience discourses at global, regional, and local levels by providing empirical evidence to create resilient and sustainable secondary cities in a spatial planning context. Furthermore, it will serve as a milestone to work on factors affecting the spatial resilience of cities, addressing the physical and environmental urban problems relevant to spatial resilience. It would open arguments during urban local spatial planning, policy, strategy, and plan formulation and revision. In addition, the output of this paper would fill some gaps of the existing scholarly contributions and indicate the need for an integrated spatial planning approach to identify, adapt and mitigate urban hazards proactively.

6. Conclusions

Every discipline, development goal, and measurement endeavor has adopted the concept of resilience. It is a promising approach to understanding how communities identify and respond to urban risks. It has social, environmental, physical, political, economic, and spatial implications with a positive and negative effect on the spatial resilience of cities. The type of hazards, institutional setting, severity of urban shocks and stresses, and response pathway are among the factors that potentially affect the spatial resilience of cities. However, this paper is limited to empirical studies on the physical and environmental dimensions and remedies applied to offset the disturbances. The paper also noted differences in spatial discourses between urban and rural settings, which provided input into local spatial planning interventions.

Concerning the urban spatial context, this research looked at the factors that influence the spatial resilience of secondary Ethiopian cities to urban challenges, using empirical data of household perception from Kombolcha city. Consequently, it deliberated on seventeen physical and environmental urban problems affecting the country's spatial resilience of second-tier cities, for all of which the case study area is vulnerable to and severely affected by the urban problems. The problems are further exacerbated by a lack of appropriate planning and the unsustainability of deployed biophysical measures. The study findings may contribute to the advancement of resilience theory in a spatial context, particularly in the global south. These findings have significant implications for spatial planning, which can aid in making decisions that improve the quality of life in secondary cities. As a result, improving secondary cities' coping, adaptation, and governance systems are critical for mitigating the perceived urban problems and making cities spatially resilient. In this vein, it is important to mark evacuation routes and deploy early warning systems with the active involvement of the communities.

Besides, this study is supposed to help local, regional, and national governments better understand urban uncertainties with pure significance to spatial resilience. It also implies that devising policies,

Traffic congestion	Poor sanitation	Urban Pollution	Poor Infrastructure	Landslide	Surface flood	Deforestation	Poor drainage facilities	Poor waste management	MMULT (Water scarcity: poor solid waste management (sum of the row in) Table 11, ($ water scarcity: $ poor waste management (a fixed sum of weights column in Table 10)	
33%	62%	14%	63%	59%	51%	70%	11%	47%	49.48%	Highest is recommended
36%	38%	37%	37%	41%	35%	30%	40%	37%	36.19%	
17%	0%	18%	0%	0%	4%	0%	28%	5%	6.85%	
15%	0%	32%	0%	0%	10%	0%	21%	10%	7.48%	
100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

strategies, and spatial plans appropriate to the adaptation and mitigation of the problems is indispensable. The intervention should be achieved by the commitment of local governments to localize, adapt and adopt international environmental protection laws and enforce local resource utilization policies.

The paper further suggested that the focus of future research should be on developing strategies, instruments, and plans that mainstream spatial resilience's essential characteristics into resilient-spatial planning practices at a national, regional, and local level. Besides, researches can be conducted to identify and determine the distribution of spatially relevant multiple hazards at an urban or a neighborhood level.

Declaration

Author contribution statement

Mulugeta Maru: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Hailu Worku: Conceived and designed the experiments; Wrote the paper.

Joern Birkmann: Analyzed and interpreted the data.

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Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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