International Journal of Disaster Risk Reduction 57 (2021) 102152

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: http://www.elsevier.com/locate/ijdrr

A composite inherent resilience index for Zimbabwe: An adaptation of the disaster resilience of place model

Emmanuel Mavhura [a,*], Tawanda Manyangadze [a], Komal Raj Aryal [b]

[a] Geography Department, Faculty of Science and Engineering, Bindura University of Science Education, Private Bag, 1020, Bindura, Zimbabwe
[b] Faculty of Resilience, Rabdan Academy, United Arab Emirates

ARTICLE INFO

Keywords:
Composite resilience index (CRI)
Disaster
District
Resilience
Variables
Zimbabwe

ABSTRACT

Building resilience to disasters has become a strategic goal of many risk reduction programs across the globe. This is because resilience ensures that communities develop capacities which prevent or minimise loses to disasters. In view of this, there is need to develop a baseline that tracks changes in resilience through time. This study responded to this gap in Zimbabwe by developing composite resilience indices (CRI) using 26 variables that reflected 5 subdomains of resilience: community capital, economic, infrastructure, social and health. The CRI were then used to map the spatial variation of resilience across 91 districts. The results show that the majority of the districts with below moderate resilience are mainly rural and marginalised, while the most resilient districts emerged in urban areas where service provision and infrastructure are better developed. These findings were further subjected to factor analyses which deconstructed the overall CRI and identified six latent factors behind resilience: infrastructure, health, household head, and income, access to maize and fortified food. These factors were mapped in a GIS environment to show their geographic variation in the country. Furthermore, Moran's Index and the Getis Ord Gi* statistical tests were applied to determine clusters of resilience across space. Results confirmed the spatial clustering of CRI. The results are therefore, useful in planning mitigation, response and preparedness measures across the country.

1. Introduction

Since the era of the Hyogo Framework for Action (HFA) 2005–2015, resilience has increasingly become a buzzword in various disciplines, especially in relation to development, disasters and economic downfalls [1,2]. The term resilience has also received a wide policy appeal at global level. For example, resilience is currently integral to the Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction (SFDRR), the United Nations' Agenda 2030, and the Paris Agreement [3–5]. Fundamentally, building resilience entails capacitating population groups to better deal with systematic shocks/-stressors. Every community operates as a system with many interactions and interdependencies with other systems [6]. Thus disaster induced damages in one community can cascade and result in negative effects onto related factors in the community and other systems. To many disaster management and development practitioners, resilience is a conceptual tool that is useful to understand how population groups deal with changing hazards that affect their livelihoods [7]. Inevitably, this has increased the demand for methods of quantifying resilience in different contexts across the globe.

Nevertheless, the measurement of resilience has been fraught with conceptual, technical and methodological challenges [8]. Some definitions and methodologies proposed to measure resilience are contested [9]. For example, Holling's definition of resilience emphasises on stability of systems [10], yet Bogardi and Fekete [11]'s definition focus on systems' rapidity to recovery after a hazardous event. Likewise, some scholars view resilience as a goal or outcome, but others consider it as a process to achieve a desired goal [12,13]. Also, there are some definitions which consider resilience as the opposite of vulnerability, a view that is criticised by many authors [14]. In addition, there is no agreement on the choice of indicators to use, scale of analysis, and how to recognise the localised nature of resilience [2]. Notwithstanding these challenges, there is significant interest in the use of resilience metrics across various programmes of development and humanitarian organisations [15,16].

Zimbabwe is currently on the drive to build resilience to disasters so as to ensure continued progress towards the improvement of the well-being of its citizens. This programme is being spear-headed by the

* Corresponding author.
E-mail addresses: emavhura@buse.ac.zw, edmavhura@gmail.com (E. Mavhura).

https://doi.org/10.1016/j.ijdrr.2021.102152
Received 16 December 2020; Received in revised form 19 February 2021; Accepted 20 February 2021
Available online 9 March 2021

Ministry of Agriculture with technical and financial support from the United Nations Development Programme (UNDP), European Union (EU) and the United Kingdom's Department for International Development (DFID) [17]. However, there is no baseline study that has been undertaken to benchmark the current drive to a resilient nation. Therefore, this study applied the disaster resilience of place (DROP) model to assess inherent resilience to disasters in Zimbabwe. The study provides answers to these two questions: (i) How does resilience manifest itself across Zimbabwe? (ii) What factors are driving inherent resilience in Zimbabwe? By answering these questions, this study becomes the baseline that will allow comparisons and monitoring of the progress towards building resilience across the districts in Zimbabwe. The baseline is also useful for targeted interventions in order to enhance resilience to disasters.

After this introduction, Section 2 critically examines the measurement of resilience. In Section 3, we describe the methods employed to compute the composite resilience index (CRI) before providing the results in Section 4. This will be followed by the discussion of the results, conclusion and policy implication for resilience building.

2. Understanding resilience

2.1. *Defining resilience*

Despite being a popular term, resilience is still a vague concept. The shared use of the term does not, however, signify unified concepts or definitions of resilience. Many scholars find it difficult to agree on a common definition of resilience. This is because resilience is defined in relation to risks which evolve differently in different local scenarios. As a result, there has been a dozen of definitions which reflect different research disciplines including ecology, engineering, psychology, disaster and socio-ecology [18]. In ecology, where some scholars claim the term was first coined, resilience is viewed as 'a measure of persistence of systems and their ability to absorb changes and disturbances and still maintain the same relationships between populations or state variables' [10]:14). This view aligns very well with the meaning of the Latin word resilio (to jump back) from which resilience was derived [19]. However, resilience is not about jumping back to the original position because that would reinforce the conditions that led to the disasters. Rather, resilience involves abilities to transform instead of retaining the status quo [20]. Hence, issues of persistence and change in non-linear systems have gained much traction in resilience literature.

While the ecological resilience focuses on absorbing changes induced by hazards, the engineering perspective is centred on a speed and efficient return to normality after a hazardous event [21]. It links resilience to four properties (commonly referred to as 4Rs): robustness (ability to withstand shocks), redundancy (functional diversity), resourcefulness (ability to mobilize when threatened), and rapidity (ability to contain losses and recover in a timely manner) [22]:85; [23]. Thus resilience is viewed as a form of buffering socio-technical systems against hazards [24]. However, this view is also problematic because buffering may limit or prevent certain enablers or disenabling factors of sustainable development, especially where institutions significantly participate in enhancing disaster resilience.

In psychology, resilience is interpreted as an individual's capacity to withstand stressors and not manifest psychology dysfunction [25,26]. In the disaster community, the term resilience is widely applied to system's capacity to adapt, resist or change in order to reach and maintain an acceptable level of functioning and structure when faced with hazards [20]. As a result, many disaster studies focus on the capacities of individuals, communities and nations which enable them to cope and adapt to hazards, thereby reducing potential damages and recovering quickly from a hazardous event [27]. The argument is that resilience manifests itself at the local level, and the capacities of the affected people serve as safety nets during hazardous events. However, the social-ecological systems (SES) resilience embraces dynamic cross-scale interactions of coupled human-nature systems [2]. It acknowledges the role of human agency to proactively influence the resilience of the systems under investigation. As a result, the SES resilience entails notions of learning, adaptation and transformation, which are all essential in enhancing disaster policy and practice [28].

Although there is a variation in the definition of resilience, many disciplines agree that resilience is dynamic and comprised of evolving capacities such as absorption, adaptation and transformation [22]. That is why the Organization for Economic Co-operation and Development (OECD) considers absorptive, adaptive and transformative capacities for strengthening resilience at household, community and national levels [29]. Absorption embraces minimising or absorbing the negative impacts of stresses/shocks to prevent the negative trajectories of risks [30]. Adaptive capacity entails changing ways of living in order to minimise exposure to actual or perceived hazards; diversifying and using alternative livelihood strategies to moderate potential damage [19,31,32]. Transformative capacity entails the creation of new structures (e.g. policies, infrastructure, and social networks) that enable the systems to continue functioning after disturbances [33]. In addition to these capacities, three common issues have emerged in the framing of resilience: (a) resilience enables systems to function and thrive even when subjected to disturbances; (b) resilience should manage changes and limit damages induced by shocks and stresses on systems; (c) resilience should enable a speedy recovery from hazardous events [3]. When dealing with social systems, the term resilience is widely applied to the ability of a system or population groups to thrive when subjected to stresses or shocks [7]. Resilience is generally viewed as a positive and desirable attribute that is meant to prevent falling into cycles of poverty but improve wellbeing outcomes in the face of shocks/stressors [34]. This is because resilient systems are less likely to suffer losses and have the potential to recover more quickly after a hazardous event [35]. Both at global and national levels, many organisations expect their systems, organisations, communities and individual to be resilient [36]. Thus resilience is considered as the solution to the changing landscape in the hazards facing humanity.

2.2. *Resilience approaches and frameworks*

The dozen of resilience definitions has also been accompanied by many theoretical frameworks, which fall within three broad approaches: participatory, quantitative and qualitative [35,37]. Participatory approaches are premised on the view that the at risk population groups have or may have certain capacities including knowhow, skills and access to resources they can use to define and measure their resilience [38]. As a result, the local population actively participates in resilience building activities. Examples of participatory tools include the Analysis of the Resilience of Communities to Disasters (ARC-D) [7,39], and the Flood Resilience Measurement for Communities (FRMC) [40,41]. The major strengths of participatory approaches are a reflection of locals' own and diverse views, and the ability to address the actual local needs. This makes them useful in targeted disaster risk reduction (DRR) interventions. However, participatory approaches are hardly comparable (between entities such as households, communities and areas) and are limited in scope because they focus on one specific entity. Their implementation is also highly dependent of facilitators' skills.

Qualitative approaches emerged from the social sciences and are aimed at exploring the underlying conditions which support resilience at different scales. They entail testimonies of disaster victims, and case studies where narratives are obtained through interviews, observations and story-telling [42]. The qualitative approaches have the advantages of yielding contextual resilience details including its enablers or disenabling factors on the ground and other intangible aspects of resilience [43]. The later are usually missed when quantitative tools are used in measuring resilience. Qualitative approaches also have the potential to create theoretical frameworks that can be translated in measurable variables. Therefore, the qualitative approaches can inform policy and practice. However, the qualitative approaches heavily depend on years of research and are hardly comparable and trackable over time.

On the other hand, quantitative approaches employ variables developed from observing systems and from the wider literature [2]. The variables are used to develop composite indices, scores or ranks that provide a holistic picture of an issue. One example of quantitative frameworks is the latest version of the Resilience Index Measurement Analysis (RIMA II) developed by the United Nations Food and Agriculture Organisation [44]. The scores from such frameworks simplify complex technical information into user-friendly data; and simplify systems and processes that are hard to represent with a single variable [7]. In this way, indices make resilience comparable and trackable over time and space. They are mostly based on secondary data or large-scale surveys. For example, Li et al. [23] used public secondary data to measure community resilience in south-western China following the 2008 Wenchuan earthquake. In a similar way, Yoon et al. [45] selected variables from secondary data on human, social, economic, environmental, and institutional components to quantify community disaster resilience in 229 municipalities in Korea. However, quantitative approaches are criticised for high levels of generalisation, missing intangible aspects of resilience and a bias towards outsiders including organisations, government agencies and researchers in the resilience field [2]. They also allow subjective selection of indicators across contexts as well as the weighting of the indicators [9].

While some scholars question the ways in which the resilience metrics are determined, an increasing numbers of other scholars, practitioners and policy makers favour the use of such metrics in reducing disaster risk [46]. They argue that the measurement of resilience is useful when comparing entities, identifying capacity needs and for allocating resources to different places. Many other scholars believe that resilience metrics have the potential of ensuring that disaster policies and programmes target and support the right activities and people [2].

Many frameworks have been developed to advance the resilience measurement of systems at different levels and scales [3]. Table 1 shows a sample of the resilience frameworks developed between 2005 and 2020, their strengths and limitations in translating resilience into empirically measurable outcomes. The majority of the frameworks employ capacities to monitor changes in resilience. Adaptive, absorptive and transformative capacities have emerged as the most common forms of resilience capacities. However, many countries still face numerous challenges in measuring and tracking their resilience to disasters in time and space. Key challenges relate to establishing baselines that would allow comparisons and monitoring of the progress towards building resilience. This study respond to this gap in Zimbabwe. The baseline developed in this study is also useful for planning interventions in identified places either before, during or after a hazardous event.

2.3. The disaster resilience of place model

This study adapted the disaster resilience of place (DROP) model (Fig. 1) to assess inherent resilience to disasters in Zimbabwe. In this section, we only focus on the measurement of inherent resilience as depicted in the DROP model. For a detailed description of the DROP model, the reader is encouraged to consult Cutter et al. [47].

Inherent resilience is part of the antecedent conditions and processes created by the interaction of the built environment, social and natural systems before any adversity [47]. Thus ecological, social, economic, infrastructural and institutional variables determine inherent resilience. Examples of social variables include age, gender and occupation; while those of economic dimension are income, employment and savings [48]. Infrastructural indicators include housing, transport and other lifeline and critical facilities. Resource stocks, land and water form some variables of the ecological dimension. Contigency plans, emergency services, land use zoning and standard building plans are institutional examples that can enhance inherent resilience. Lastly, community competence entails knowledge and skill to understand risks, and implement risk reduction strategies. The inherent resilience is dynamic in nature and is influenced by both endogenous and exogenous factors of the system under investigation [49]. Both absorptive and adaptive capacities of the system influence inherent resilience as they determine levels of recovery, preparedness and mitigation following a hazardous event. When a shock or stressor strikes a system, the absorptive capacity will first resist the shock. A resilient system will overcome the shock at that stage. However, there are possibilities that the absorptive capacity will be exceeded by the shock. When that happens, the individual system will then resort to its adaptive capacity, and if the adaptation fails, the system will transform to deal successfully with the shock [34]. The level of recovery and the lessons learnt during these events create feedback processes which determine the nature of social, natural and built environment systems. In this way, they influence the inherent resilience which is often used as the starting point for potential measurements of changes in resilience [14].

3. Materials and methods

3.1. Study area, Zimbabwe

Zimbabwe is a southern African country (Fig. 2) which faces a variety of hazards including drought, mid-season dry spells, crops pest and diseases, animal diseases, floods, tropical cyclones, hail storms and strong winds. Droughts and mid-season dry spells frequently occur across Zimbabwe with varying levels of severity. Notable drought episodes occurred during the 1991–1992, 1994–1995, 2002–2003, 2015–2016, and 2018–2019 seasons [50]. On another note, floods occur in low lying areas of the country, in cyclonic paths, at river confluences and downstream of major dams [51]. Furthermore, the past decades have witnessed violent storms which damaged infrastructure, property and crops and caused loss of animal and human life [52]. Table 2 shows statistics of the impacts of drought, floods, storms and extreme temperatures between 2010 and 2019. As Table 2 shows, most deaths are associated with drought and floods. In terms of economic damage, floods and storms account for about two thirds of the total economic damage. In general, the high numbers of mortalities, people affected and economic damage shown in Table 2 may suggest the need to enhance resilience across Zimbabwe.

Multiple hazards affect rural livelihoods of Zimbabwe [17]. Agriculture forms the major source of livelihoods to about 70% of the population, while contributing about 12% to the country's Gross Domestic Product (GDP) [50]. However, since 1990, Zimbabwe has experienced declining food production partly due to climate-induced hazards and poor implementation of agricultural policies [53]. As a result, Zimbabwe currently imports most of the food, yet before 1990, the country used to export food to neighbouring countries [54]. The agricultural sector is vulnerable to hydro-meteorological hazards, particularly drought, mid-season dry spells and floods, which occur with much frequency and are likely to increase due to increased climate change impacts [55]. This has led to food insecurity, increased poverty and declining economic productivity. By affecting the agricultural livelihoods, hazards also reduce the prospects of achieving the SDGs in Zimbabwe, particularly SDG1 (no poverty), SDG2 (zero hunger), and SDG3 (good health and well-being). Poverty levels in the country are high. Consequently, Zimbabwe has a low Human Development Index (154 out of 187 countries), with an average life expectancy of 59.2 years among the 16.2 million people [56]. In view of these problems, Zimbabwe has shown relative political will and commitment to building resilience to disasters by signing in to global frameworks that promote resilience such as the HFA, SFDRR and the SDGs.

3.2. Data sources and selection of resilience variables

Guide by the resilience literature including the DROP model [3,7,18,35,46,47,57], 26 variables were compiled to compute the CRI for the 91

Table 1
Few Selected Examples of Community Resilience frameworks developed between 2005 and 2020.

Framework/ Reference	Key tenets	Components capturing resilience	Key strengths	Limitations
1. The Capital-Based Approach [60]	A livelihood asset-based approach. Resilience is conceptualised in five capitals: social, economic, human, physical and natural.	Livelihood capitals (social, economic, human, natural and physical) where each asset has a set indicators used to measure resilience	Provides detailed and simplified variables for constructing disaster resilience indices by sub-component	Some of the indicators are intangible and therefore, difficult to quantify. This framework is not specific to particular shocks/ stressors.
2. Disaster Resilience of Place (DROP) [47]	Presents inherent resilience as a function of the interaction of social, natural and the built environment systems.	Ecological, social, economic, institutional, infrastructure, and community competence	Allows comparative assessments of resilience at different levels.	Model is salient on transformative capacities that are critical for resilience.
3. A Preliminary Framework for Community Resilience Assessment [52]	A conceptual framework for assessing community resilience which identifies adaptive capacity as key element of resilience which is useful for gauging the degree to which a system is resilient.	Ecological, economic, physical infrastructure, civil society, and governance subsystems.	Indices make resilience comparable and trackable over time.	Agreeing on a common set of resilience indicators has so far proven a considerable challenge.
4. Baseline Resilience Indicators for Communities (BRIC) [57]	BRIC focuses on the existing resilience capacities of a community. Resilience is often portrayed as a process, an adaptive response to adversity, in which community actors utilize community resources to adapt to changing circumstances and to moderate or avoid negative consequences.	49 indicators divided into six resilience subdomains: social, economic, institutional, infrastructure & housing, community capital, and environmental	Allows for the use of contextual and robust variables. Provides detailed simplified variables used to construct disaster resilience index by sub-component	The term 'community' is reduced to a locality, side-lining social and relational aspects of community that are of critical importance in crises. BRIC does not seek to measure community resilience as a process.
5. DFID Resilience Conceptual Framework [26]	Considers five key resilience pillars: Context (subjects and governance); Disturbance (shocks and stressors); Capacity to deal with disturbance; Sensitivity (degree to which a system will be affected by, or respond to a given shock or stress); and Reaction to disturbance (recovery ability).	Absorptive, adaptive and transformative capacities within the five livelihood assets (human, social economic, natural and physical)	Model integrates the 'asset pentagon' of the sustainable livelihoods framework with disturbance and resilience capacities. Addresses these key questions: whose resilience and at what level? Resilience to what? Resilience through what capacities? Resilience with what results? Resilience to what extent?	It approaches resilience primarily from a disaster risk reduction perspective. (This leads to short-terms cycles of funding, which limits resilience programming that promotes adaptive capacity and erosion of the structural causes of vulnerability); Does not provide specifics on how to analyse causal links and measured outcomes.
7. A common analytical model for resilience measurement [19]	Framework measures resilience in a development context with a focus on food security/economic wellbeing. Comprises six analytical components: construct assumptions, causal framework, indicators and data structure, expected trajectory, data collection, estimation procedures.	Resilience is presented as a multi-dimensional construct comprised of human, social, financial, physical and natural capitals	Categories of indicators provided; specific indicators depend on context. Use a variety of quantitative and qualitative methods. Allows a systems thinking approach across the variables.	Some of the indicators are intangible (e.g. community) and therefore, difficult to quantify.
8. Disaster Resilience Scorecard for Cities [89]	Framework provides a checklist for cities to gauge the degree to which they are resilient to the impacts of natural hazards. The list has 85 metrics (each with a suggested 5-point scoring system) relating to UNISDR's 'ten essentials'	The organization, infrastructure, response capability, environment, and recovery of cities	The framework tracks resilience across the following aspects: research; organization; infrastructure; response capability; environment; and recovery	The model is less applicable to rural communities of the developing world.
9. Analysis of the Resilience of Communities to Disasters (ARC-D) [39]	A tool that assesses the level of disaster resilience at community level through a discussion-based survey of 30 disaster resilience components. The components span four thematic areas linked to Priorities for Action of the Sendai Framework for Disaster Risk Reduction.	System of sectors including economic, health, education, environment, infrastructure, governance and culture.	Reflects locals' views; can address the actual local needs.	Hardly comparable
10. Resilience Index Measurement and Analysis model (RIMA-II) [44]	RIMA argues that resilience is a function of physical dimensions (income and food access; access to basic services; agricultural assets; non-agricultural assets; agricultural practice and technology; social safety nets; climate change; enabling institutional environment) and capacity dimensions (sensitivity; adaptive; absorptive; and transformative)	Model unpacks resilience into four pillars: Access to basic services; assets; social safety nets; adaptive capacity. Each pillar is considered a latent variable made up of range of proxy socio-economic variables	Models services as both diagnostic and evaluation tool. Ability to generate composite scores of resilience that can be readily compared across households	Rely heavily on predefined resilience characteristics and standardized indicators. Some intangible processes which drive resilience (e.g. community) cohesion are difficult to measure
11. Flood Resilience Measurement for	Measures flood resilience based on a 'systems approach' to understanding	The following capitals: human (e.g. skills and health); social (e.g. strong	Uses a systems approach to understand complex relationships,	Much of the socio-economic data (e. g. strong relationships and

(*continued on next page*)

Table 1 (*continued*)

Framework/ Reference	Key tenets	Components capturing resilience	Key strengths	Limitations
Communities (FRMC) [41]	the factors that enable communities to withstand flood-related shocks and stresses. It combines an assessment of the 5 capital assets with resilience properties of those assets (the 4Rs - robustness, redundancy, resourcefulness and rapidity)	relationships and cooperation); natural (e.g. land productivity and water); physical (e.g. infrastructure and equipment); and financial (e.g. level and diversity of income) enhance the resilience of communities to floods.	unlike linear approaches that deal with cause-and-effect relationships.	cooperation) is not available in most countries of the Global South.

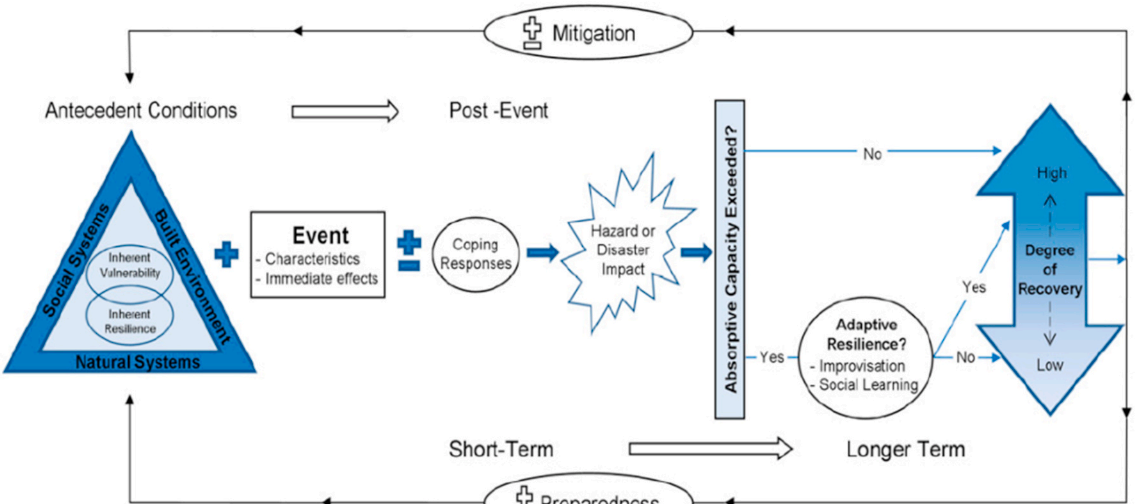

Fig. 1. Disaster resilience of place model.

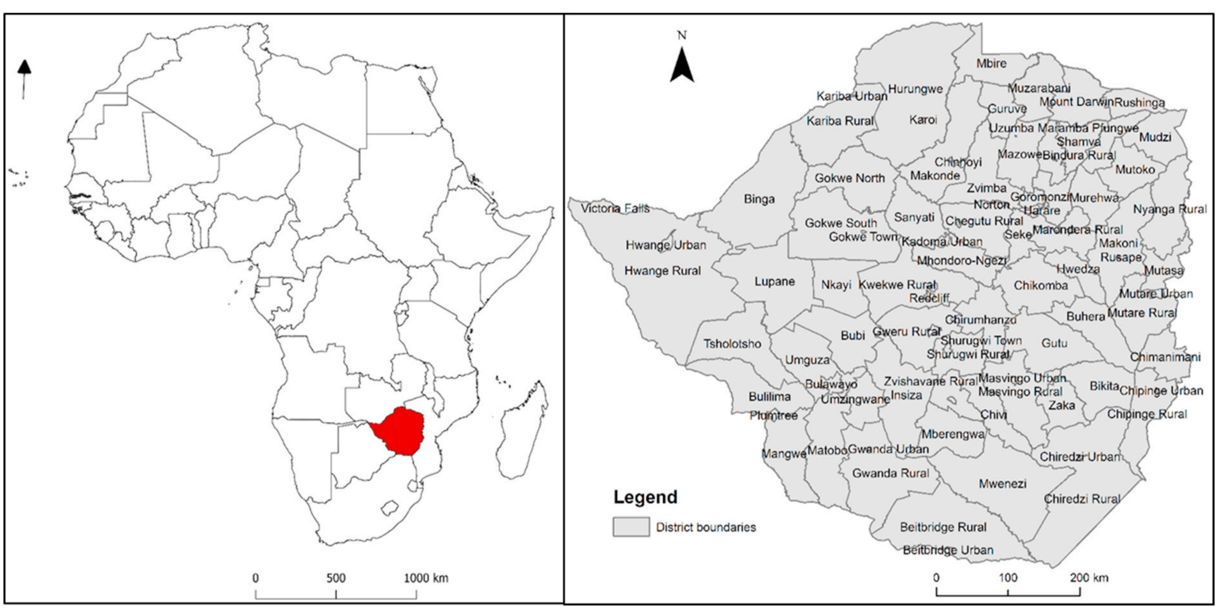

Fig. 2. Study area (Zimbabwe).

urban and rural districts of Zimbabwe. The variables ranged from social, economic, health, physical and community capital subdomains of resilience. Table 3 shows the data sources for the specific variables employed, their dimensions and impacts on disaster resilience. As shown in Table 3, we extracted resilience variable data from public sources including national census, Poverty, Income, Consumption and Expenditure Survey (PICES) and the Zimbabwe Vulnerability Assessment Committee (ZimVAC) reports. This data is reliable and comparable over time because it is collected by government specialized agencies, the Zimbabwe National Statistics Agency (ZIMSTAT) and the Food and Nutrition Council (FNC) of Zimbabwe [58,59]. We used the 2012 national census data because it was the most recent census data from the

Table 2
Cumulative hydrometeorological disaster impact in Zimbabwe - 2010 to 2019 (Source [20].

Disaster	Total deaths	Total injuries	Homeless	Total population affected	Total damage ('000 US $)
Drought	20 000	–	–	122 015 642	3 653 000
Floods	6755	9244	763 649	31 351 859	3 940 715
Storms	2712	10 258	235 671	7 551 734	3789 900
Extreme temperature	145	111	–	2 727 611	–
Epidemics (Bacterial, parasitic and viral diseases)	39 125	743 312	–	1 318 729	–
Total	**68 737**	**762 925**	**999 320**	**11 598 074**	**11 383 615**

government. Likewise, we used the most recent PICES and ZimVAC reports of 2017 and 2020 respectively. The PICES is carried out every 5 years with the aim of providing baseline data on income, consumption and expenditure disparities or patterns among socio-economic groups [60]. The ZimVAC's annual rural livelihoods assessments focus on issues such as education, food levels, crop and livestock production, child nutrition, water and sanitation, and crop post-harvest management practices [59]. In addition to the ZimVAC and ZIMSTAT reports, this study also used other reliable foreign data sources on mean night light time and access to markets and health care. Therefore, the data sources shown in Table 3 provided comprehensive data which included various subdomains of resilience. Such data was very useful in the analyses of resilience across the 91 districts of Zimbabwe. This study did not work with samples. Rather it made use of all the quantitative variable data available at the district level. The variables were carefully selected by a team of experts on disaster resilience, which took into account the impact of such variables in Zimbabwe and the availability of public sources data at district level. The experts were chosen from the Zimbabwe's National Civil Protection Committee, and included people from social welfare, agriculture, academia, health, and hydrological and meteorological agencies.

All the variables employed were relevant to assess resilience in Zimbabwe. We used community capital variables such as employed labour force and female participation in the job market to reflect increases in economic productivity that enhance resilience capabilities to disasters [61,62]. Urban population was also used because it is a key determinant of economic growth when compared to rural population especially in developing countries. Urban populations that have established public services such as transport, education, fire, ambulance and medical facilities can ride on ride on such services as a basis for resilience [63]. Likewise, population with access to water, sanitation and hygiene (WASH) facilities widely correlates directly with increasing resilience to disasters [64]. In a similar way, easy access to health facilities tends to increase the general health of the population that strengthens its resilience capabilities [35]. On another note, a higher literacy rate implies a higher capability to deal with disaster events including their prevention, mitigation and preparedness. Furthermore, cattle prices were included because cattle production is a form of wealth (economic capital) that enhance resilience among many Zimbabweans. The cattle can provide food or can be used as draught power used by smallholder farmers. Furthermore, the cattle can be disposed into different forms of capital (e.g. buying farming inputs) to cope with any threat [6]. We also included variables related to maize grain and meal prices because maize is the staple crop in Zimbabwe, with the vast majority of farmers growing it, making it a good predictor of resilience impacts on the population. Access to fortified food products was also included because it is a proxy to prevention against micronutrient deficiencies and cushions households from hunger. Another variable included is the night-light time, a

Table 3
List of variables used in resilience analysis.

Dimension	Indicator/Variable description	Data Source	Impact on Resilience
Community Capital	Employed labour force	ZIMSTAT PICES 2017 Report	Positive
	Female labour force participation	ZIMSTAT PICES 2017 Report	Positive
Economic	Av Maize grain price (Local currency per kg)	ZimVAC 2020 Report	Positive
	Av Maize Meal price (Local currency per)	ZimVAC 2020 Report	Positive
	Cattle prices (Local currency per kg)	ZimVAC 2020 Report	Positive
	Average Remittances	ZIMSTAT PICES 2017 Report	Positive
	Urban Population	ZIMSTAT PICES 2017 Report	Positive
	Access to markets (estimated mean travel time to the nearest city of 50 000 inhabitants)	EU Science Hub https://forobs.jrc.ec.europa.eu/products/gam/	Positive
	Mean Night Lights	NOAA National Centers for Environmental Information (https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html)	Positive
	Average income	ZIMSTAT PICES 2017 Report	Positive
Infrastructure	Households with access to electricity	ZIMSTAT PICES 2017 Report	Positive
	Households with access to tap water	ZIMSTAT PICES 2017 Report	Positive
	Households with access to proper sanitation	ZIMSTAT PICES 2017 Report	Positive
	Owner-occupied housing units	ZIMSTAT Census Report, 2012	Positive
Social	Non-elderly population	ZIMSTAT Census Report, 2012	Positive
	Households headed by males	ZIMSTAT Census Report, 2012	Positive
	Women of child bearing age consuming iron rich foods except	ZimVAC 2020 Report	Positive
	Children Receiving Minimum Acceptable Diet	ZimVAC 2020 Report	Positive
	Households with Cereal Security	ZimVAC 2020 Report	Positive
	Households with Access to Fortified foods	ZimVAC 2020 Report	Positive
	Literacy Rate	ZIMSTAT Census Report, 2012	Positive
	Households headed by none single parent	ZIMSTAT Census Report, 2012	Positive
	Population without disability	ZIMSTAT PICES 2017 Report	Positive
	Non-retired population (below 60 years of age)	ZIMSTAT Census Report, 2012	Positive
Health	Access to health care (Mean walking time to nearest health Care)	Malaria Atlas Project https://malariaatlas.org/research-project/accessibility-to-healthcare/	Positive
	Access to health care (Mean Travel Time by motor to nearest Health Care)	Malaria Atlas Project https://malariaatlas.org/research-project/accessibility-to-healthcare/	Positive

satellite data which is widely used as a proxy for local economic growth. The increase in night light intensity is a surrogate for increased economic activities [65,66] that correlates very well with increased resilience. Although some variables employed in the DROP Model (e.g. institutional indicators and those related to social capital such as car ownership and telephone use) could have added value to this study, we left them out because of unavailability comprehensive quantitative data across the districts of Zimbabwe.

3.3. Data analysis

Using the Statistical Package for the Social Sciences (SPSS) software - Version 22, this study primarily employed a principal component analysis (PCA) method to quantify resilience, and a factor analysis (FA) technique to identify the key underlying drivers of inherent resilience. The data for the 26 variables were first standardized using z-scores to improve comparability across the unit of analysis [67]. Then, we conducted the Kaiser-Meyer-Olkin (KMO) of sampling adequacy and the Bartlett's Test of Sphericity (BTS) (with $p < 0.05$) to determine if the selected variables were adequate for the PCA. In general, KMO values range from 0 to 1, but for the variables to be accepted, their KMO value should be equal to or greater than 0.6 [68]. While running the PCA, we applied a Kaiser Normalization to extract factors with eigenvalues greater than one [69]. Variables with correlations greater than 0.5 and less than −0.5 were assumed as the key drivers of each component. We further applied a Varimax Rotation to minimise the number of resulting factors and maximize the sum of the variances they represent [18]. The PCA method and FA technique worked very well because of massive data that comprised various subdomains of resilience.

The PCA distilled the 26 variables into six underlying factors that best accounted for the total cumulative variance. It further generated six factor loadings (FL) or components for each district, each one based on the dominant characteristics of the variables. Each FL was assigned either a positive (+) sign for increased resilience, or a negative (−) one for reduced resilience. To determine the CRI, we applied an additive approach with an equal weighting of the six FL ($CRI_{district} = FL_1 + FL_2 + \ldots + FL_6$). This approach was the best because there was no empirical evidence to support differential weighting for the multiple hazards affecting the 91 districts. Therefore, the study did not make any *a priori* assumption about the weight of each factor in the overall CRI. The final CRI were categorised into six classes depending on their standard deviation from the mean. However, in order to show the geo-spatial variation of inherent resilience across the 91 districts, ArcMap10.4 Geographical Information System (GIS) tool was then used to map the CRI scores and their key drivers at the district level. In this way, districts that were more or less resilience to hazards were identified. The results were further subjected to the Global Moran's Index, LISA and the Getis Ord Gi* statistical tests to determine the extent to which resilience was clustered or not across space. Thus, the tests calculated autocorrelations among the districts and determined similarity and dissimilarity patterns of inherent resilience [67]. Strong positive and negative) spatial autocorrelation were shown by values close to 1 and -1 respectively, while randomness was indicated by close to 0 [70]. In this way, the study improved the reliability of the CRI scores.

4. Results

Results of the KMO and BTS tests showed that the variables were suitable for further analyses. The KMO yielded a value of 0.86, a figure that was well above 0.6, which is the recommended minimum, while the BTS was highly significant - (df = 325; Sig. = 0.000). The PCA extracted communalities ranging from 0.424 to 1.662, which represented very well the variables because the majority of them (23 of 26) were higher than 0.5 [$h \geq 0.5$].

Then, the PCA extracted six factors that explained about 75% of the total cumulative variance. The factors include infrastructure, health, household head, income, maize and fortified food. Fig. 3 shows the spatial variation of CRI in Zimbabwe. About 62% of the districts are in the very low to moderate resilience categories, while only 19% are categorised as having very high resilience. Table 4 presents the ranking of the ten most and least resilient districts in Zimbabwe. All the 10 least resilient districts are rural and 70% of them (Bulilima, Tsholotsho, Mangwe, Lupane, Hwange Rural, Beitbridge Rural and Gwanda Rural) are from Matebeleland North and South provinces. These provinces are semi-arid and marginalised in terms of development. The ten most resilient districts are mainly urban (90%). With the exception of Chiredzi Urban and Kariba Urban, the rest of the ten most resilient districts come from agro-ecological regions 2 and 3 which form the bread basket provinces of Zimbabwe.

The extracted factors became the latent drivers of resilience in Zimbabwe. Table 5 shows a summary of the resilience factors, their percentage variances explained and the dominant variables. The first factor, infrastructure accounted for the most variance (47%), while other successive factors accounted for less and less variances. Table 5 also shows that four dominant variables contributed to the infrastructure factor: households with access to electricity, tap water, and proper sanitation, as well as owner-occupied housing units. In Zimbabwe, infrastructure to electricity, tape water and proper sanitation is concentrated in urban areas. As shown in Fig. 4(a), 57 districts (68%) in Zimbabwe are in the very low to moderate categories of infrastructure factor. Of these districts 56 of them are rural except Epworth a shanty town close to the capital, Harare. The least developed districts in terms of infrastructure include Rushinga, Guruve, Buhera and Hwedza. This means more than 60% of the Zimbabwean population which lives in rural areas, does not have access to electricity and proper WASH facilities. Wood fuel is major source of power for domestic purposes and curing tobacco in farming areas. On another note, housing service is very poor even in urban areas where most people in high density areas live in crowded areas. As a result, the four variables have contributed to about half of the variance explained of resilience in Zimbabwe.

The second factor is health which accounted for about 8% of the variance. Fig. 4(b) shows that the majority of the districts in Zimbabwe (62%) have below moderate access to health care. Very remote and marginalised districts with the worst access to health care include Hwange Rural, Kariba Rural, Bubi, Umguza, Hurungwe and Binga. In fact, access to quality health care in Zimbabwe is a privilege of those who have the means to do so. Fig. 4(b) also shows about 12% of the districts with very easy access to health care. The districts include Gwanda Town, Norton and Harare Urban and Harare Rural. As shown in Table 5, two variables that contributed to the health factor include the time needed to access the nearest health centre by either walking or driving. In Zimbabwe, many households in rural areas travel long distance to access the service.

The third factor driving resilience in Zimbabwe is household head which has 6% of variance explained. This encompasses the demographic characteristics of the family head as evidenced by the dominant variables shown in Table 5. When acquiring farming inputs, securing financial and other capitals for the family to survive with, households that are headed by males are in a better position than those headed by females. The same applies to non-single families. Widowed and the child-headed households are among the most vulnerable groups to wide range of disasters including floods, storms and drought. Fig. 4(c) shows that about half of Zimbabwean districts (49%) have above high numbers of households headed by males and non-single parents. This is concentrated in northern half of the country (e.g. Harare Rural, Epworth, Muzarabani, Mbire and Makonde), while the southern part (e.g. Bulilima, Mangwe, Matobo, Tsholotsho, Gwanda Rural and Umzingwane) is dominated by widowed and female headed families.

The fourth factor behind resilience in Zimbabwe is income (5% of variance). Income inequalities are very high in both rural and urban districts of Zimbabwe, leading to high poverty levels among the majority of the population. Fig. 4(d) shows that most districts (78%) have very

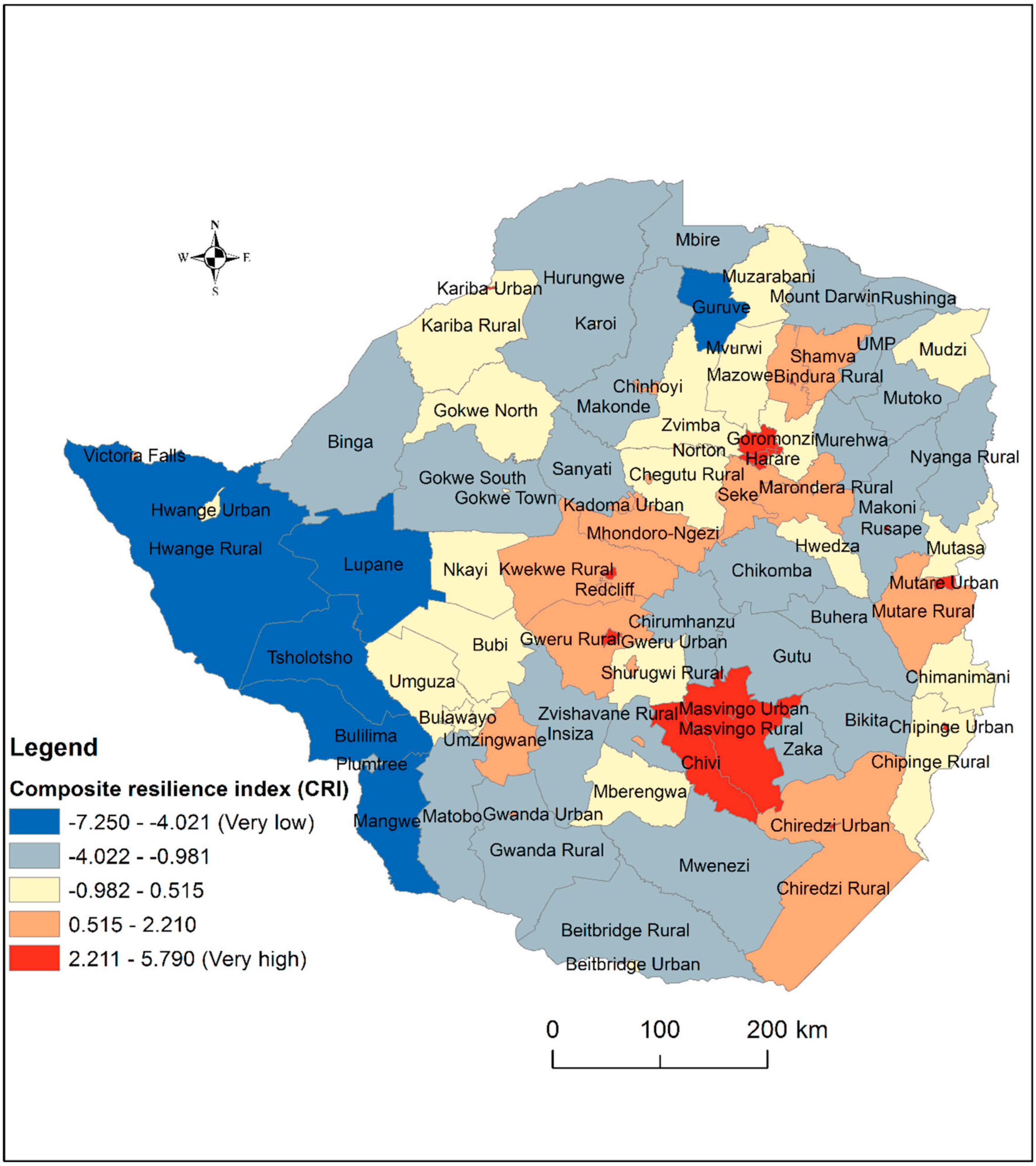

Fig. 3. Spatial variation of CRI in Zimbabwe.

Table 4
The ten (10) most and least resilient districts in Zimbabwe.

	Ten least resilient districts		Ten most resilient districts	
Rank	District	CRI	District	CRI
1	Guruve	−7.25021	Harare Rural	5.7902
2	Bulilima	−6.71972	Harare Urban	5.28108
3	Tsholotsho	−5.5958	Gweru Urban	4.6181
4	Mangwe	−4.46035	Chiredzi Urban	4.31971
5	Lupane	−4.04973	Ruwa Local Board	3.70998
6	Hwange Rural	−4.02072	Epworth	3.54135
7	Hurungwe	−3.48705	Chitungwiza	3.39932
8	Mwenezi	−2.99574	Mvurwi	3.31121
9	Beitbridge Rural	−2.94142	Kariba Urban	3.11557
10	Gwanda Rural	−2.47928	Rusape	2.89422

low to moderate income or purchasing power. Districts with the least income include Mbire, Gwanda Urban, Binga, Zaka and Muzarabani. Only the district of Harare Urban has very high income. Consequently, most people in Zimbabwe cannot afford to prepare for, recover quickly from and or mitigate against disasters due to low disposable income.

The fifth factor is maize, the staple food of most Zimbabweans. This factor is dominated by the average price of the maize grain and maize meal. Where the staple food is affordable, it allows for a healthy and active life style. Fig. 4(e) shows that the price of the maize products is below low level in 36 districts (40%) including Plumtree, Beitbridge Rural, Chirumanzu, Bulilima and Harare Rural. The last factor driving resilience in Zimbabwe is fortified food. It has one dominant variable contributing 4% of variance: household with access to fortified food. In Zimbabwe, food enrichment is a public health policy meant to reduce deficiencies in diet within the substitute foods. Fig. 4(f) shows that 49 districts (54%) have households below moderate access to enriched food. Notable districts in this category include Guruve, Epworth and

Table 5
Resilience factors and variance summary.

Factor #	Resilience influence	Factor Description	%Variance Explained	Dominant variable(s)	Component Loading
1	Increase	Infrastructure	46.707	Households with access to electricity	.851
				Households with access to tap water	.852
				Households with access to proper sanitation	.856
				Owner-occupied housing units	-.850
2	Increase	Health	8.388	Mean walking time to nearest health Care	-.873
				Mean Travel Time by motor to nearest Health Care	-.867
3	Increase	Household head	5.952	Households headed by males	.731
				Households headed by none single parent	.917
4	Increase	Income	5.274	Average income	.823
5	Increase	Maize	4.739	Av Maize Meal price (Local currency per)	.818
				Av Maize grain price (Local currency per kg)	.442
6	Increase	Fortified Food	4.390	Households with Access to Fortified foods	-.671
	Total Variance explained		**75.449**		

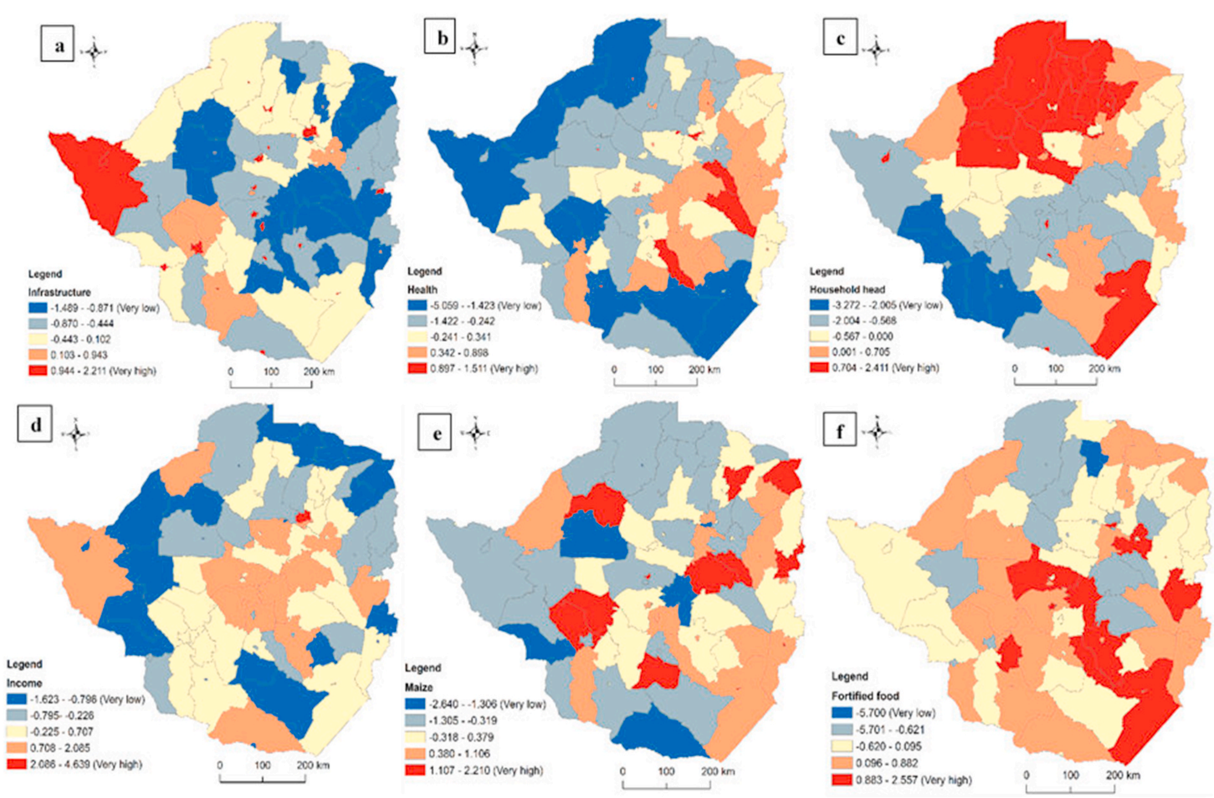

Fig. 4. Factors driving resilience in Zimbabwe.

Chikomba. On the contrary, 40 districts (44%) have high to very high access to fortified food.

The Global Moran's Index confirmed the spatial clustering of CRI (Moran's $I = 0.437$, Z-score = 7.449; p-value <0.001.). Fig. 5(a) shows the variation of the CRI based on Getis Ord Gi* while Fig. 5(b) shows CRI hotspots or clusters based on local Moran's *I*. Getis ord* identified cold spots of CRI to the south western part of Zimbabwe including Plumtree, Bulilima, Mangwe, Matobo, Hwange and Lupane districts. This is a region of low resilience i.e. a district of low resilience is surrounded by districts with low resilience as well. The LISA identified two types of clusters of CRI that were significant (p-value<0.05): Low-Low (LL), High-High (HH), and Low-High (LH) outlier. Two LL clusters were observed to the south western part of the country as also noted in the Getis ord* and the other one to the northern part including Mbire district. The HH cluster was observed in the central part of the country including Harare, Seke and Goromonzi district. This is the region of high resilience. Murehwa district was observed as the LH outlier indicating that it is surrounded by the districts characterized by high resilience.

5. Discussion

This study applied the DROP model to assess inherent resilience to disasters in Zimbabwe. It used 26 variables that ranged from the social, economic, health, physical and community capital subdomains of resilience to run the PCA and FA techniques. The variables were distilled into six factors whose loadings enabled the development of CRI that provided a holistic picture of resilience disparities for the entire country. The CRI becomes the starting point for future measurements of changes in resilience levels across the districts of Zimbabwe. It helps to explain why some districts are more or less resilient to disasters than others and identify where resources can be channelled in order to enhance resilience of the district. In this way, the CRI also makes resilience in Zimbabwe comparable and trackable over time and space. Therefore, this study provides a useful tool that will guide a theory of change either

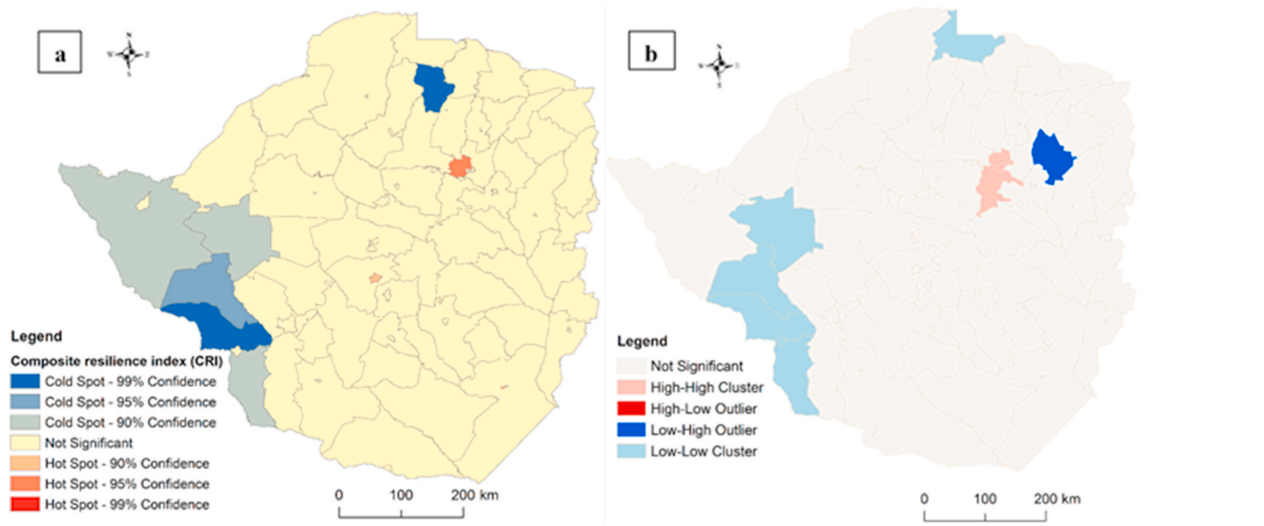

Fig. 5. Spatial variation of the CRI based on a) Getis Ord Gi* (b) local Moran's I.

by monitoring the progress towards building resilience in the country, or by ensuring that disaster policies and programmes target and support the right activities and the people in need [2]. Likewise, Yoon et al. [45] used variables of similar subdomains in order to quantify community resilience in 229 municipalities in Korea that became the basis for measuring changes in resilience.

The study revealed districts with very low to very high CRI where targeted interventions are needed in order to enhance or maintain resilience to disasters. The majority of the districts below moderate level of resilience are mainly rural, which are highly prone to drought and dry spells. They include the districts of Bulilima, Tsholotso and Mangwe where drought and dry spells contribute between 35 and 44% of the mean district hazard index [17]. The least resilient districts also have little potential for agricultural production since they fall under agro-ecological IV and V that are characterized by too low and erratic rainfall (less than 650 mm per year) [71]. Such districts are virtually unsuitable for crop production unless irrigation facilities are fully exploited. This observation confirms the fact that farming is the backbone of the economy of Zimbabwe which has a bearing on resilience to disasters [50]. Unfortunately, the farming sector is subsistent and rain-fed, characteristics which make it very sensitive to drought and dry spells [55]. In addition to this, the least resilient districts are marginalised in terms of development. In fact, uneven development characterise the Zimbabwean districts, leading to differences in resilience to disasters that are reflected in housing, wealth, water, sanitation and access to food and other services [72]. Affluent urban districts have better social service that enhance their resilience than rural ones that are poor, and have inadequate utility infrastructure and health services [73, 74]. Thus, the most resilient districts in Zimbabwe are mainly urban areas including Harare Urban, Gweru Urban, Chitungwiza and Chiredzi Urban.

Six latent factors emerged as the key drivers of the different levels of resilience across Zimbabwe. These include infrastructure, health, household head, income, maize and fortified food. Infrastructure of utilities including water, electricity and housing as well sanitation is the major latent factor driving resilience in Zimbabwe. Such infrastructure is better developed in major urban areas including the resort town of Victoria Falls and Kariba Urban than in rural areas. Accordingly, resilience levels are higher in towns than they are in under-developed districts such as Gokwe South and Sanyati. Good infrastructure service can address specific risk to disasters and enhance resilience [75]. Fekete [76] demonstrated the cascading effects of critical infrastructure in enhancing disaster resilience. Likewise, Zhang et al. [77] argued that improving the resilience of infrastructure can lead to the sustainability of communities that are faced with hazardous events. However, most rural districts of Zimbabwe lack such infrastructure, a condition that has led to low levels of resilience among most districts. Unlike our study, Sung and Liaw [78] who used the same PCA and FA techniques to analyse the geographic pattern of resilience in Taiwan, found no influence of infrastructure on the baseline resilience in that country. This may suggest that the influence of infrastructure on resilience is contextual. Hence the need to need to use context-specific variables when measuring resilience of communities to disasters.

Apart from infrastructure, access to health in Zimbabwe is very problematic, especially in rural and marginalised districts. There are very few health care centers in rural districts such as Hurungwe, Kariba Rural and Mwenezi. People have to travel long distances on foot in order to access health care. Where the health care institutions exist, the majority have limited drugs and are usually manned by nurses alone [73]. Consequently, the doctor-patient ratio in most rural areas is very high, a situation which limits population access to quality health. Yet access to health is critical when a community experiences disaster injuries, disease outbreaks and allergies during hazardous events [79]. That is why some global frameworks such as the SFDRR and the SDGs promote access to health as a way of building resilience to disasters [80]. Collins et al. [81] demonstrated that inadequate access to health is a significant predictor of the negative impacts of floods among the Hispanic population group in the USA. Therefore, there is need to enhance access to health care in marginalised districts of Zimbabwe.

Demographics of the household head is also a key issue in the geographic variation of resilience in Zimbabwe. Households that are headed by males and non-single parents dominate the northern districts of the country, and consequently improve the resilience of those places. On the contrary, southern districts of Zimbabwe are affected by migration of males to South Africa and Botswana in search of employment [82, 83]. Although this might be improving household income, the migration on its own has affected household variable. Hence southern districts scored very low to low resilience scores. This observation is consistent with literature that male headed families and marriages improve the economic status of the households in Africa and Asia by enhancing wealth accumulation [85,86]. In a similar way, Keys et al. [87] also observed that the adaptive capacity of one-parent households in South East Queensland, Australia was lower than that of couple families due to their limited incomes, poor rates of home ownership, and reduced labour force participation.

On another note, income, maize and fortified food are also driving disparities in resilience that characterise most districts. Very few people in Zimbabwe earn above subsistence wage, a situation that lowers their capacities to increase resilience. Low disposable income also limits the capabilities of many households to recover quickly from disasters or mitigate and prepare for them [88]. It also prevents some families from accessing descent shelter, health, the staple food (maize) and other fortified foods, as well as farmers' adaptive capacity to climate and weather related hazards [89,90]. The UNDP also reported that many households in Zimbabwe consume very few iron fortified foods, which is a key developmental challenge [91]. All these conditions reduce the resilience to disasters.

However, this study has two limitations. First, although the study used comprehensive data that reflected various subdomains of resilience, census data of 2012 was not current. The variables derived from census data could have changed for the better or worse. Nevertheless, the use of the 2012 census data was unavoidable because census is usually conducted after about ten years in most countries including Zimbabwe [58,92]. The next census data in Zimbabwe will be available sometimes in 2022. Second, not all resilience variables were captured in this study. We excluded some intangible and other tangible aspects of resilience because of the unavailability of quantitative data at district level [43]. Yet such variables could have yielded useful contextual resilience details on the ground.

6. Conclusion

Disaster impacts are increasing in most countries including Zimbabwe. Reactive approaches which focus on disaster response, recovery and reconstruction are an expensive and inefficient strategy to deal with disasters. Instead, building resilience of communities and nations is a proactive and cost-effective way of using resources. This can be achieved through an understanding of inherent resilience in places and people. Therefore, this study adopted five subdomains of resilience from the DROP model developed by Cutter et al. [47]; and used the PCA as a data reductionist method, and FA technique to assess inherent resilience in Zimbabwe. Twenty-six variables were used because resilience is a complex and multi-dimensional construct that cannot be measured by a single variable. The variables were distilled into six factors which were used to develop CRI that measured relative resilience among 91 districts. Results showed that the majority of the districts below moderate level of resilience are mainly rural and marginalised. On the other hand, the most resilient districts emerged as mainly urban areas where service provision and infrastructure are better developed than in rural areas. The use of a data reductionist technique, PCA allowed for a robust and consistent set of variables which can be monitored over time and space to assess any changes in resilience. The technique can also facilitate the replication of the variables at other spatial scales, thus making the data compilation more efficient. Key drivers of resilience emerged as infrastructure, health, household head, income, access to maize and fortified food. These results form a baseline for targeted interventions in order to enhance resilience to disasters in different districts of the country. The interventions can either be at lower level or at the identified latent factors driving resilience. This would improve communities' preparedness and response to disasters.

This study contributes to contemporary literature and the debate on resilience in four ways. First, it constitutes, as far as the authors are concerned, the first comprehensive attempt to model district-level resilience to disasters in Zimbabwe. In this way, it provides a geospatial and visual picture of inherent resilience across the 91 districts of Zimbabwe. Second, this study forms a baseline that will guide a theory of change towards building resilience in the country. The CRI developed in this study becomes the starting point for future measurements of changes in resilience across the districts of Zimbabwe. Third, it also forms the basis for further research in order to inform disaster policy and practice. Fourth, the pattern exhibited by the CRI confirmed that inherent resilience to disasters varies from one place to another. Hence, there is need to understand its key drivers in each place in order to better deal with disasters.

Declaration of competing interest

We hereby declare that there is no conflict of interest whatsoever related to this manuscript.

Acknowledgements

The authors would like to express heartfelt gratitude to team of experts who carefully selected the disaster resilience variables that were used in this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2021.102152.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] ISDR, International Strategy for Disaster Risk Reduction (ISDR), (2005) Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters, Kobe, Hyogo, 2005.
[2] L. Jones, T. Tanner, 'Subjective resilience': using perceptions to quantify household resilience to climate extremes and disasters, Reg. Environ. Change 17 (2017) 229–243, https://doi.org/10.1007/s10113-016-0995-2.
[3] L. Jones, E. Samman, P. Vinck, Subjective measures of household resilience to climate variability and change: insights from a nationally representative survey of Tanzania, Ecol. Soc. 23 (1) (2018) 9, https://doi.org/10.5751/ES-09840-230109.
[4] W.S.A. Saunders, S. Kelly, S. Paisley, L.B. Clarke, Progress toward implementing the Sendai framework, the Paris agreement, and the sustainable development goals: policy from aotearoa New Zealand, Int. J. Disaster Risk Sci. 11 (2020) 190–205, https://doi.org/10.1007/s13753-020-00269-8.
[5] C. Wamsler, Å. Johannessen, Meeting at the crossroads? Developing national strategies for disaster risk reduction and resilience: relevance, scope for, and challenges to, integration, Int. J. Disaster Risk Reduct. 45 (2020) 101452, https://doi.org/10.1016/j.ijdrr.2019.101452.
[6] E. Mavhura, Applying a systems-thinking approach to community resilience analysis using rural livelihoods: the case of Muzarabani district, Zimbabwe, Int. J. Disaster Risk Reduct. 25 (2017) 248–258, https://doi.org/10.1016/j.ijdrr.2017.09.008.
[7] A. Clark-Ginsberg, B. Mccaul, I. Bremaud, G. Caceres, D. Mpanje, S. Patel, R. Patel, Practitioner approaches to measuring community resilience: the analysis of the resilience of communities to disasters toolkit, Int. J. Disaster Risk Reduct. 50 (2020) 101714, https://doi.org/10.1016/j.ijdrr.2020.101714.
[8] T. Tanner, A. Bahadur, M. Moench, Challenges for Resilience Policy and Practice (No. 519), 2017, https://doi.org/10.13140/RG.2.2.30130.30402. London.
[9] R. Gregorowski, A. Dorgan, C. Hutchings, Resilience Measurement - MEL Approaches in Practice: Challenges and Lessons in Operationalizing Resilience Measurement Frameworks – Experience and Lessons from CoP Stakeholders, 2018 (London).
[10] C.S. Holling, Resilience and stability of ecological systems, Annu. Rev. Ecol. Systemat. 4 (1) (1973) 1–23.
[11] J.J. Bogardi, A. Fekete, Disaster-related resilience as ability and process: a concept guiding the analysis of response behavior before , during and after extreme events, Am. J. Clim. Change 7 (2018) 54–78, https://doi.org/10.4236/ajcc.2018.71006.
[12] M. Abdulkareem, H. Elkadi, From engineering to evolutionary, an overarching approach in identifying the resilience of urban design to flood, Int. J. Disaster Risk Reduct. 28 (2018) 176–190, https://doi.org/10.1016/j.ijdrr.2018.02.009.
[13] S.B. Manyena, The concept of resilience revisited, Disasters 30 (4) (2006) 434–450, https://doi.org/10.1111/j.0361-3666.2006.00331.x.
[14] S.L. Cutter, Resilience to what? Resilience for whom? Geogr. J. 182 (2) (2016) 110–113, https://doi.org/10.1111/geoj.12174.
[15] K. Forbes-Genade, D. van Niekerk, GIRRL power! Participatory Action Research for building girl-led community resilience in South Africa, Action Res. 17 (2) (2019) 237–257.
[16] P.S. Villanueva, V. Sword-Daniels, Routes to Resilience: Insights from BRACED Year 2, 2017 (London).
[17] UNDP, Mapping of Selected Hazards Affecting Rural Livelihoods in Zimbabwe: A District and Ward Analysis, United Nations Development Programme, Harare, 2016.
[18] S.K. Aksha, C.T. Emrich, Benchmarking community disaster resilience in Nepal, Int. J. Environ. Res. Publ. Health 17 (2020) 1985.
[19] Y. Lei, J. Wang, Y. Yue, H. Zhou, W. Yin, Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective, Nat. Hazards 70 (2014) 609–627, https://doi.org/10.1007/s11069-013-0831-7.

[20] T. Quinn, W.N. Adger, C. Butler, K. Walker-Springett, Community resilience and well-being: an exploration of relationality and belonging after disasters, Ann. Assoc. Am. Geogr. 111 (2) (2021) 577–590, https://doi.org/10.1080/24694452.2020.1782167.
[21] A. Fekete, G. Hufschmidt, S. Kruse, Benefits and challenges of resilience and vulnerability for disaster risk management, Int. J. Disaster Risk Sci. 5 (2014) 3–20.
[22] A. Keating, K. Campbell, M. Szoenyi, C. Mcquistan, D. Nash, M. Burer, Development and testing of a community flood resilience measurement tool, Nat. Hazards Earth Syst. Sci. 17 (2017) 77–101, https://doi.org/10.5194/nhess-17-77-2017.
[23] X. Li, N. Lam, Y. Qiang, K. Li, L. Yin, S. Liu, W. Zheng, Measuring county resilience after the 2008 wenchuan earthquake, Int. J. Disaster Risk Sci. 7 (4) (2016) 393–412, https://doi.org/10.1007/s13753-016-0109-2.
[24] D.G. Angeler, C.R. Allen, A. Garmestani, K.L. Pope, D. Twidwell, M. Bundschuh, Resilience in environmental risk and impact assessment: concepts and measurement, Bull. Environ. Contam. Toxicol. 101 (5) (2018) 543–548, https://doi.org/10.1007/s00128-018-2467-5.
[25] J.M. Rodriguez-llanes, F. Vos, D. Guha-sapir, Measuring psychological resilience to disasters: are evidence-based indicators an achievable goal? Environ. Health 12 (2013) 1–10.
[26] M. Welsh, Resilience and responsibility: governing uncertainty in a complex world, Geogr. J. 180 (1) (2014) 15–26, https://doi.org/10.1111/geoj.12012.
[27] W.C. Chuang, A. Garmestani, T.N. Eason, T.L. Spanbauer, H.B. Fried-Petersen, C. P. Roberts, C.R. Allen, Enhancing quantitative approaches for assessing community resilience, J. Environ. Manag. 213 (2018) 353–362, https://doi.org/10.1016/j.jenvman.2018.01.083.
[28] E. Carabine, E. Wilkinson, How can local governance systems strengthen community resilience? A social-ecological systems approach, Polit. Govern. 4 (4) (2016) 62–73, https://doi.org/10.17645/pag.v4i4.746.
[29] OECD (Organisation for Economic Co-operation and Development), Guidelines for Resilience Systems Analysis, 2014. Paris. Retrieved from, www.oecd.org/publishing/corrigenda.
[30] V. Proag, Assessing and measuring resilience, Procedia Econ. Finan. 18 (2014) 222–229, https://doi.org/10.1016/S2212-5671(14)00934-4.
[31] T. Heikkila, A.K. Gerlak, A.R. Bell, S. Schmeier, Adaptation in a transboundary river basin: linking stressors and adaptive capacity within the Mekong River Commission, Environ. Sci. Pol. 25 (2013) 73–82, https://doi.org/10.1016/j.envsci.2012.09.013.
[32] ODI, and CoP, Analysis of Resilience Measurement Frameworks and Approaches, The Resilience Measurement, Evidence and Learning Community of Practice (CoP), London, 2016. Retrieved from, www.measuringresilience.org.
[33] R. Berman, C. Quinn, J. Paavola, The role of institutions in the transformation of coping capacity to sustainable adaptive capacity, Environ. Develop. 2 (2012) 86–100, https://doi.org/10.1016/j.envdev.2012.03.017.
[34] E. Serfilippi, G. Ramnath, Resilience measurement and conceptual frameworks: a review of the literature, Ann. Publ. Cooper. Econ. 89 (4) (2018) 645–663, https://doi.org/10.1111/apce.12202.
[35] S. Scherzer, P. Lujala, J.K. Rod, A community resilience index for Norway: an adaptation of the Baseline Resilience Indicators for Communities (BRIC), Int. J. Disaster Risk Reduct. 36 (2019) 101107.
[36] S. Davoudi, Resilience: a bridging concept or a dead end? Plann. Theor. Pract. 13 (2) (2012) 299–307, https://doi.org/10.1080/14649357.2012.677124.
[37] IFRCRCS, 2016 World Disasters Report: Resilience: Saving Lives Today, Investing for Tomorrow, The International Federation of Red Cross and Red Crescent Societies, Geneva, 2016. Retrieved from, www.ifrc.org/wdr2016.
[38] K. Rus, V. Kilar, D. Koren, Resilience assessment of complex urban systems to natural disasters: a new literature review, Int. J. Disaster Risk Reduct. 31 (2018) 311–330, https://doi.org/10.1016/j.ijdrr.2018.05.015.
[39] B. McCaul, A. Mitsidou, Analysis of the Resilience of Communities to Disasters - ARC-D Toolkit User Guidance Manual, 2016.
[40] C. Pettengell, C. McQuistan, M. Szonyi, A. Keating, F. Laurien, F. Ianni, R. Bold, Project Set up, Study Set up, Data Collection, and Grading, 2020. Zurich. Retrieved from, www.floodresilience.net/FRM.
[41] Zurich Flood Resilience Alliance, The Flood Resilience Measurement for Communities (FRMC), 2019. Zurich, https://forobs.jrc.ec.europa.eu/products/gam/. (Accessed 16 September 2020). https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html (Accessed September 19, 2020). https://malariaatlas.org/research-project/accessibility-to-healthcare/(Accessed September 13, 2020).
[42] N. Mock, C. Béné, M. Constas, T. Frankenberger, Systems Analysis in the Context of Resilience. Resilience Measurement Technical Working Group, 2015. Technical Series No. 6. Rome. Retrieved from, http://www.fsincop.net/fileadmin/user_upload/fsin/docs/resources/FSIN_TechnicalSeries_6.pdf.
[43] A. Chacowry, L.J. Mcewen, K. Lynch, Recovery and resilience of communities in flood risk zones in a small island developing state: a case study from a suburban settlement of Port Louis, Mauritius, Int. J. Disaster Risk Reduct. 28 (2018) 826–838, https://doi.org/10.1016/j.ijdrr.2018.03.019.
[44] FAO, Resilience Index Measurement and Analysis - II (RIMA 2), United Nations Food and Agriculture Organisation, Rome, 2016. Retrieved from, http://www.fao.org/3/a-i5665e.pdf.
[45] D.K. Yoon, J.E. Kang, S.D. Brody, A measurement of community disaster resilience in Korea, J. Environ. Plann. Manag. 59 (3) (2016) 436–460, https://doi.org/10.1080/09640568.2015.1016142.
[46] L. Jones, M. D'Errico, Whose resilience matters? Like-for-like comparison of objective and subjective evaluations of resilience, World Dev. 124 (2019) 104632, https://doi.org/10.1016/j.worlddev.2019.104632.
[47] S.L. Cutter, L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, J. Webb, A place-based model for understanding community resilience to natural disasters, Global Environ. Change 18 (4) (2008) 598–606, https://doi.org/10.1016/j.gloenvcha.2008.07.013.
[48] L. Siebeneck, S. Arlikatti, S.A. Andrew, Using provincial baseline indicators to model geographic variations of disaster resilience in Thailand, Nat. Hazards 79 (2) (2015) 955–975, https://doi.org/10.1007/s11069-015-1886-4.
[49] J. Mochizuki, A. Keating, W. Liu, S. Hochrainer-stigler, R. Mechler, An overdue alignment of risk and resilience? A conceptual contribution to community resilience, Disasters 42 (2) (2018) 361–391, https://doi.org/10.1111/disa.12239.
[50] J. Frischen, I. Meza, D. Rupp, K. Wietler, M. Hagenlocher, Drought risk to agricultural systems in Zimbabwe: a spatial analysis of hazard, exposure, and vulnerability, Sustainability 12 (2020) 752, https://doi.org/10.3390/su12030752.
[51] B. Mucherera, E. Mavhura, Flood survivors' perspectives on vulnerability reduction to floods in Mbire district, Zimbabwe, Jàmbá - J. Disaster Risk Stud. 12 (1) (2020) a663, https://doi.org/10.4102/jamba.v12i1.663.
[52] E. Mavhura, Learning from the tropical cyclones that ravaged Zimbabwe: policy implications for effective disaster preparedness, Nat. Hazards 104 (3) (2020) 2261–2275, https://doi.org/10.1007/s11069-020-04271-7.
[53] J. Twigg, M. Calderone, Building Livelihood and Community Resilience: Lessons from Somalia and Zimbabwe (No. 545), 2019 (London).
[54] SADC, SADC Regional Vulnerability Assessment and Analysis Synthesis Report 2015: State of Food Insecurity and Vulnerability in the Southern African Development Community, 2015. Gaborone. Retrieved from, www.sadc.int/fanr/aims/rvaa.
[55] World Bank, Zimbabwe: Agriculture Sector Disaster Risk Assessment, 2019.
[56] UNDP, Zimbabwe Human Development Report 2017, United Nations Development Programme, Harare, 2017.
[57] S.L. Cutter, C.G. Burton, C.T. Emrich, Disaster resilience indicators for benchmarking baseline conditions, J. Homel. Secur. Emerg. Manag. 7 (1) (2010) 1–22, https://doi.org/10.2202/1547-7355.1732.
[58] ZIMSTAT, Zimbabwe Population Census Report: 2012, Zimbabwe National Statistical Agency (ZIMSTAT), Harare, 2012.
[59] ZimVAC/FNC, *ZimVAC-2019-Rural-Livelihoods-Assessment-Report*. Zimbabwe Vulnerability Assessment Committee (ZimVAC)/Food and Nutrition Council (FNC) of Zimbabwe, Harare, 2019. https://www.google.co.za/url?sa=tand rct=jand q=and esrc=sand source=webandcd=3anded=2ahUKEwiQo4yR0JLoAhWwyYUKHRVYAvUQFjACegQIAxABand url=http%3A%2F%2Ffnc.org.zw%2Fwp-content%2Fuploads%2F2019%2F02%2Fzimvac-2019-lean-season-assessment_final.pdfand usg=AOvVaw0v7hXntHpSllxuPNt344ql. Accessed August 2020.
[60] ZIMSTAT, Poverty, Income, Consumption and Expenditure Survey (PICES) 2017 Report, Zimbabwe National Statistical Agency (ZIMSTAT), Harare, 2018.
[61] A. Altuzarra, C. Gálvez-Gálvez, A. González-Flores, Economic development and female labour force participation: the case of European Union countries, Sustainability 11 (2019) 1–18, https://doi.org/10.3390/su11071962.
[62] J.Y. Koyuncu, R. Tilmaz, M. Unver, The relationship between female labor force participation and divorce: panel data analysis, Int. Refereed Acad. Soc. Sci. J. 6 (18) (2015) 237–250, https://doi.org/10.17364/iib.2015189755.
[63] S. Sarker, A. Khan, M.M. Mannan, Urban population and economic growth: south Asia perspective, Eur. J. Govern. Econ. 5 (1) (2016) 64–75, https://doi.org/10.17979/ejge.2016.5.1.4316.
[64] Å. Johannessen, A. Rosemarin, F. Thomalla, Å. Gerger, T. Axel, G. Vulturius, Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: the role of public private partnerships, Int. J. Disaster Risk Reduct. 10 (2014) 102–115.
[65] L. Bhandari, K. Roychowdhury, Night Lights and Economic Activity in India: a study using DMSP-OLS night time images, Proceed. Asia-Pacific Adv. Netw. 32 (2011) 218–236, https://doi.org/10.7125/apan.32.24.
[66] J.K. Galimberti, Forecasting GDP growth from outer space, Oxf. Bull. Econ. Stat. 82 (4) (2020) 697–722, https://doi.org/10.1111/obes.12361.
[67] S.K. Aksha, L. Juran, L.M. Resler, Y. Zhang, An analysis of social vulnerability to natural hazards in Nepal using a modified social vulnerability index, Int. J. Disaster Risk Sci. 10 (2019) 103–116, https://doi.org/10.1007/s13753-018-0192-7.
[68] A. Fekete, Spatial disaster vulnerability and risk assessments: challenges in their quality and acceptance, Nat. Hazards 61 (2012) 1161–1178, https://doi.org/10.1007/s11069-011-9973-7.
[69] I. Armas, D. Toma-Danila, R. Ionescu, A. Gavris, Vulnerability to earthquake hazard: bucharest case study, Romania, Int. J. Disaster Risk Sci. 8 (2) (2017) 182–195, https://doi.org/10.1007/s13753-017-0132-y.
[70] V. Cerchiello, P. Ceresa, R. Monteiro, N. Komendantova, Assessment of social vulnerability to seismic hazard in Nablus, Palestine, Int. J. Disaster Risk Reduct. 28 (2018) 491–506, https://doi.org/10.1016/j.ijdrr.2017.12.012.
[71] Government of Zimbabwe, Revision of Zimbabwe's Agro-Ecological Zones, 2020 (Harare).
[72] J. Manjengwa, C. Matema, D. Tirivanhu, Understanding urban poverty in two high-density suburbs of Harare, Zimbabwe, Dev. South Afr. 33 (1) (2016) 23–38, https://doi.org/10.1080/0376835X.2015.1116376.
[73] L. Muchabaiwa, L. Chigusiwa, S. Bindu, V. Mudavanhu, D. Damiyano, B. E. Mushanyuri, Feasibility and sustainability of community based health insurance in rural areas. Case study of musana, Zimbabwe, Expert J. Finan. 5 (2017) 73–85.
[74] UNDP, Executive Summary - Zimbabwe Human Development Report 2017: Climate Change and Human Development: towards Building a Climate Resilient Nation, United Nations Development Programme, Harare, 2017.
[75] D. Dodman, H. Leck, M. Rusca, S. Colenbrander, African urbanisation and urbanism: implications for risk accumulation and reduction, Int. J. Disaster Risk Reduct. 26 (2017) 7–15, https://doi.org/10.1016/j.ijdrr.2017.06.029.

[76] A. Fekete, Critical infrastructure cascading effects. Disaster resilience assessment for floods affecting city of Cologne and Rhein-Erft-Kreis, Int. J. Flood Risk Manag. 13 (2) (2020), e312600, https://doi.org/10.1111/jfr3.12600.
[77] C. Zhang, J. Kong, S.P. Simonovic, Restoration resource allocation model for enhancing resilience of interdependent infrastructure systems, Saf. Sci. 102 (2018) 169–177, https://doi.org/10.1016/j.ssci.2017.10.014.
[78] C.H. Sung, S.-C. Liaw, A GIS approach to analyzing the spatial pattern of baseline resilience indicators for community (BRIC), Water 12 (2020) 1401, https://doi.org/10.3390/w12051401.
[79] A.T. Boyd, S.T. Cookson, M. Anderson, O.O. Bilukha, M. Brennan, T. Handzel, M. Gerber, Centers for disease control and prevention public health response to humanitarian emergencies, 2007-2016, Emerg. Infect. Dis. 23 (2017) 196–202.
[80] R. Maini, L. Clarke, K. Blanchard, V. Murray, The Sendai framework for disaster risk reduction and its indicators — where does health fit in? Int. J. Disaster Risk Sci. 8 (2017) 150–155, https://doi.org/10.1007/s13753-017-0120-2.
[81] T.W. Collins, A.M. Jimenez, S.E. Grineski, Hispanic health disparities after a flood disaster: results of a population-based survey of individuals experiencing home site damage in El Paso (Texas, USA), J. Immigrant Minor. Health/Center Minor. Public Health 15 (2) (2013) 415–426, https://doi.org/10.1007/s10903-012-9626-2.
[82] C. Madebwe, V. Madebwe, Contextual background to the rapid increase in migration from Zimbabwe since 1990, Inkanyiso, J. Hum. Soc. Sci. 9 (1) (2017) 27–36.
[83] P. Thebe, G. Maviza, The effects of feminization of migration on family functions in Tsholotsho district, Zimbabwe, Adv. Soc. Sci. Res. J. 6 (5) (2019) 297–306, https://doi.org/10.14738/assrj.65.6462.
[85] P. Brown, A.J. Daigneault, E. Tjernström, W. Zou, Natural disasters, social protection, and risk perceptions, World Dev. 104 (2018) 310–325, https://doi.org/10.1016/j.worlddev.2017.12.002.
[86] K.R. Lekobane, T.B. Seleka, Determinants of household welfare and poverty in Botswana, 2002/2003 and 2009/2010, J. Poverty 21 (1) (2017) 42–60, https://doi.org/10.1080/10875549.2016.1141381.
[87] N. Keys, M. Bussey, D.C. Thomsen, T. Lynam, T.F. Smith, Building adaptive capacity in South East Queensland, Australia, Reg. Environ. Change 14 (2014) 501–512, https://doi.org/10.1007/s10113-012-0394-2.
[88] E. Mavhura, B. Manyena, Spatial quantification of community resilience in contexts where quantitative data are scarce: the case of Muzarabani district in Zimbabwe, Geo: Geogr. Environ. 5 (2) (2018), https://doi.org/10.1002/geo2.65 e00065.
[89] K. Campbell, F. Laurien, J. Czajkowski, A. Keating, S. Hochrainer-stigler, First insights from the Flood Resilience Measurement Tool: a large-scale community flood resilience analysis, Int. J. Disaster Risk Reduct. 40 (2019) 101257, https://doi.org/10.1016/j.ijdrr.
[90] N. Muzamhindo, S. Mtabheni, O. Jiri, E. Mwakiwa, B. Hanyani-Mlambo, Factors influencing smallholder farmers' adaptation to climate change and variability in Chiredzi district of Zimbabwe, J. Econ. Sustain. Dev. 6 (9) (2015) 1–9.
[91] UNDP, Climate Change and Human Development: towards Building a Climate Resilient Nation. Zimbabwe Human Development Report 2017, United Nations Development Programme, Harare, 2017.
[92] K. Jan, The challenges of the population census round of 2020. Outline of the methods of quality assessment of population census data, Statist. Trans. New Ser. 18 (1) (2017) 115–138.

Further reading

[84] UNDP, Community Based Resilience Analysis (CoBRA) Conceptual Framework and Methodology, 2013. Retrieved from, http://bit.ly/1FB5uqi.