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REVIEW ARTICLE

Sustainability of urban expansion in Africa: a systematic literature review using the Drivers–Pressures–State–Impact–Responses (DPSIR) framework

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Abstract

Rapid urban population growth in Africa has resulted in the rapid expansion of many African cities. This has important ramifications for sustainable development across the continent. However, studies systematically synthesising the emerging literature to critically comprehend the different dimensions of urban expansion in Africa, and its intersections with sustainability are lacking. We conduct a systematic review of 247 peer-reviewed papers, critically discussing the dimensions of urban expansion in Africa, using the Drivers–Pressures–State–Impacts–Responses (DPSIR) model. Despite the significant variability between contexts, urban expansion occurs through a complex mix of Drivers, including urban population growth, in-migration, housing deficits, and the complex land governance systems. Urban expansion has multiple Impacts including the loss of agricultural land and natural vegetation that catalyses livelihood shifts/loss, and social transformation in expansion areas. The literature on the Responses to urban expansion is rather limited, usually focuses on policy-oriented responses, and suggests that such policy-oriented responses are rarely implemented effectively. Overall, we observe the centrality and multi-dimensional role of land (and its governance) and demographic transitions in urban expansion processes. We also identify the severe fragmentation of the relevant literature, the disproportionate focus on urban expansion's negative Impacts, and the critical lack of studies on Responses. Arguably, there is a need for more systematic, cohesive and increasingly comparative research to both understand the different dimensions of urban expansion, as well as design effective and fit-for-purpose responses to ensure that it does not compromise Africa's sustainable development.

Keywords Urban sustainability · Urbanisation · Urban growth/expansion · Land governance · Africa

Introduction

The fraction of the global population living in urban areas has increased from 29.6% in 1950 (UN DESA 2018) to 55% in 2018 (Ritchie and Roser 2018), and is projected to reach approximately 68.0% by 2050 (UN DESA 2019). To accommodate this growing population, the physical extent of urban areas has expanded rapidly. Estimates suggest global urban extent would increase from 652,825 km^2 in 2000 (Seto et al. 2012; Gao and O'Neill 2020) to 1.2 million km^2 by 2030 (Seto et al. 2012). Studies suggest total urban areas are expected to increase by 80% between 2018 and 2030 (Mahendra and Seto 2019). These patterns are faster in developing countries, with urban area expected to increase from 300,000 km^2 in 2000, to 770,000 km^2 in 2030 and to 1,200,000 km^2 in 2050 (Angel et al. 2011).

Such growth patterns have been observed to different extents in practically all regions of the world (UN-Habitat 2016), but have been especially pronounced in Africa and Asia in the past decades (Seto et al. 2010; UN, DESA, PD 2019; Mahendra and Seto 2019). These continents are projected to have about 90% of the global urban population growth in the coming decades (UN DESA PD 2019). Population in Africa could double between 2020 and 2050, with

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two-thirds of this growth (950 million people) expected to occur in urban areas (OECD/SWAC 2020). Africa's global share of urban residents will double from 11.3% in 2010 to 20.2% by 2050 (UN-Habitat 2014). Consequently, Africa exhibits the fastest urban growth (OECD/SWAC 2020), with an annual built-up area growth rate of > 6% in the period 1990–2000 (Angel et al. 2005).

Scholars and organisations have suggested that Africa's urbanisation patterns[1] have been relatively unique (UN-Habitat 2016; OECD/SWAC 2020; UN-Habitat and IHS-Erasmus University Rotterdam 2018; Seto et al. 2011; Mahtta et al. 2022). This is because the observed patterns of population growth, rural transformation and mobility intersect in unique ways to give rise to new dynamics, urban forms and development scales which are different from past global experiences (OECD/SWAC 2020). Also, small and medium cities are a central element of Africa's urban network, with about 97% of urban agglomerations in the continent having a population of < 300,000 inhabitants (OECD/SWAC 2020). However, while urban areas in Africa, like other parts of the world, have expanded spatially to engulf peri-urban communities (Seto et al. 2010), the driving forces are relatively distinct. In other regions, urban expansion is driven by the combined outcomes of population and economic growth, but in Africa, urban expansion (on average 4.3%/annum between 1970 and 2000) is explained almost solely by urban population growth (Seto et al. 2011; Mahendra and Seto 2019). In fact, cities with urban expansion rates higher than GDP per capita and economic growth rates are concentrated in Africa (Mahtta et al. 2022).

Accordingly, Africa's urban expansion tends to be informal, often led by poorer segments of society, and continues into urban fringes (Kombe 2005; Mahendra and Seto 2019). In this sense, urban expansion in many parts of Africa is characterised by unplanned and unregulated growth (Gunneralp 2017) that engulfs farmlands (Gwan and Kimengsi 2020), often along major road networks (Adhikari and de Beurs 2017). Mostly, it gives rise to squatter settlements (Zubair et al. 2015) and neighbourhoods that are under-serviced with water, energy and road networks (Cobbinah and Aboagye 2017). As outlined above, African urban population will increase leading to concerns that this type of urban expansion will be accelerated and many African nations may face major challenges in managing its undesirable impacts (especially to the poorer segments of society). This is due to their low ability to invest in improving human and institutional capacities, poor service delivery, inadequate/unaffordable housing, and limited job opportunities, whose collective outcomes would be a series of negative sustainability impacts (UN-HABITAT 2010; UN-Habitat 2020a, b).

The above make clear the ramifications that prevailing urban expansion patterns on the continent pose for urban sustainability, and the need for efforts at ensuring sustainable urban expansion.[2] More broadly such types of urban transformation have been linked to some of the most important sustainability challenges facing Africa (Gasparatos et al. 2020a, b; Arku 2009; Cobbinah and Darkwah 2017; Arku and Marais 2021), with possibly significant consequences for achieving multiple Sustainable Development Goals (SDGs). Beyond the direct effect to SDG11, such phenomena intersect strongly with practically all other SDGs including those on poverty (SDG1), hunger (SDG2), clean water and sanitation (SDG6), clean energy (SDG7), and responsible consumption/production (SDG12). To deal with the multifaceted challenges posed by urban expansion on urban sustainability, many African countries have designed and implemented diverse policy responses and practical solutions at different levels (UN-Habitat 2020a, b; AfDB/OECD/UNDP 2016).

However, despite the large number of studies exploring different facets of urban sustainability through different disciplinary lenses, we lack a deep understanding about some of the underlying factors affecting urban expansion. First, we lack a comprehensive understanding of the drivers, impacts and responses of urban expansion, and their intersection, which is vital for enhancing urban sustainability at the local and regional level. Knowledge syntheses could offer this much needed comprehensive outlook, but this is currently missing. Indeed, while there are several studies exploring different aspects of urban expansion at the sub-city, city or even national level (e.g. Barow et al. 2019; Röder et al. 2015;

[1] Urbanisation is a multi-dimensional concept that is difficult to defined (Iossifova et al. 2017). In this systematic review, we understand urbanisation as a transformative process that encompasses multiple interacting dimensions that unfold in different ways across different global contexts. This includes, among others, demographic change (e.g. population change in cities), spatial transformation (e.g. change in city extent, reconfiguration of city spaces), economic transformation (e.g. emergence of cities as engines of economic growth and innovation), sociocultural dimensions (i.e. emergence of urban lifestyles, distributional justice), and environmental change (i.e. cities as hubs of natural resources consumption and emissions, pollution, and waste generation) (UN-Habitat 2016). In this study, urban expansion relates to some of the spatial transformation aspects of urbanisation and, in particular, to the processes related to the increase of the extent of cities (see synonyms in Methodology).

[2] In this study, we follow the United Nations Brundtland Commission definition of sustainable development as the development that meets the "needs and aspirations of the present without compromising the ability to meet those of the future" (UN 1987). In this context, we understand that sustainable urban expansion entails the spatial growth of a city in a way that when it transforms and/or revitalises urban areas and their peripheries, it improves liveability, promotes innovation, reduces environmental impacts, and maximises economic and social co-benefits in the urban and the peri-urban areas that are transformed in the process (EEA 2021).

Wolff et al. 2019), there is a lack of studies bringing this wide literature together. Second, many of these individual studies tend to focus on different aspects of urban expansion,[3] failing to provide a comprehensive picture. Third, although urban expansion has multiple interacting dimensions, individual studies tend to approach it through different theories and methodological approaches, culminating in an expansive, yet fragmented literature. In this sense, synthesis of studies on urban expansion is vital considering the great acceleration of relevant knowledge production in Africa.

This study aims to understand the current research landscape about urban expansion in Africa through critical synthesis of peer-reviewed literature. Here, it is important to delineate the concepts of urbanisation and urban expansion (see Footnote 1). Urban expansion is understood in this study as the physical growth of urban land cover, either vertically or horizontally, as one of the major outcomes of broader urbanisation processes (UNDESA, PD 2019). Beyond its academic relevance, by providing a generalised picture of urban expansion such a study can assist practitioners and policymakers. In particular, it can (a) offer knowledge about which Drivers, Pressures, State or Impact is to be expected and should be addressed to enhance sustainability of urban expansion, (b) inform about the potential outcomes of Response options seeking to mitigate the negative aspects and enhance the positive aspects of urban expansion, and (c) identify priority areas when revising existing land-use and built regulations in the context of urban expansion.

To achieve this aim, we undertake a systematic literature review for better understanding of the underlying literature (Mallett et al. 2012) through the use of explicit and transparent methods (Gill and Malamud 2014). In particular, we systematically elicit from peer-reviewed articles (and subsequently synthesise) on urban expansion in Africa using the Drivers, Pressures, States, Impacts and Responses (DPSIR) model. First, we outline the research approach of the systematic review, and how we identify, critically appraise and elicit information from the peer-reviewed literature. Subsequently, we systematise this literature in terms of the DPSIR of urban expansion. In the next section, we seek to be comprehensive and for this reason, we outline the totality of the relevant topics related to each DPSIR dimension. Finally, we critically discuss key literature patterns, identify implications for urban sustainability, and suggest future research priorities. Here the focus is on major underlying themes that underpin multiple DPSIR dimensions.

[3] Some of the aspects covered in the literature include: (a) what drives urban expansion (e.g. Mahmoud et al. 2019; Baye et al. 2020); (b what are the environmental and socioeconomic characteristics of areas that experienced urban expansion (Cobbinah and Aboagye 2017; Fuseini and Kemp 2015); (c) what are the positive and/or negative outcomes of urban expansion (e.g. Weldearegay et al. 2021; Gwan and Kimengsi 2020); (d) what interventions and responses can be put in place to enhance the positive aspects of urban expansion and/or minimise the negative (e.g. Afriyie et al. 2019).

Methodology

Conceptual framework

To systematise evidence about the different dimensions of urban expansion in Africa, we structure our systematic review following the DPSIR framework. The DPSIR framework is a conceptual framework that allows for the description of the interactions between a phenomenon (urban expansion in this case) and socioeconomic and environmental systems (Patricio et al. 2016).

The DPSIR framework can be tracked to the Pressure–State–Response (PSR) framework by Rapport and Friend (1979). The Organization for Economic Cooperation and Development (OECD) promoted it for its environmental reporting (OECD 1993; Patricio et al. 2016). The basic reasoning underlying the DPSIR framework is that human actions put 'Pressures' on social–ecological systems causing changes ('State'), which shapes societal 'Responses' to these changes (Gupta et al. 2021). The DPSIR framework that includes the 'Drivers' and 'Impacts' dimensions was developed by the European Environment Agency (EEA) (EEA 1999; Bradley and Yee 2015). Here the 'Drivers' induce 'Pressures' that activate changes in the 'State' of a social–ecological system, resulting in positive or negative 'Impacts', which motivate societal 'Responses' to adapt, mitigate or benefit from the situation (Rodrıguez-Labajos et al. 2009; Oesterwind et al. 2016; Gupta et al. 2021). It should be noted that there is not necessarily linearity between the DPSIR dimensions, but there can be multiple feedback loops between a sub-set or all the different dimensions depending on the context of application (e.g. Balzan et al. 2019; Gari et al. 2015).

Due to its flexibility and ability to systematise and simplify complex relationships of very diverse social–ecological systems, the DPSIR framework has been applied in many geographical and thematic contexts such as climate change (e.g. Omann et al. 2009; Khajuria and Ravindranath 2012), social–ecological systems change (e.g. Bruno et al. 2020; Gupta et al. 2021), development (e.g. Carr et al. 2007; Zhou et al. 2013), and urban sustainability (e.g. Fujiwara et al. 2005; Sekovski et al. 2012; Zhao et al. 2021) among others.

Despite its popularity and extensive use, scholars have identified some limitations, including potential overlap between different dimensions of the framework (Oesterwind et al. 2016). Against this backdrop, we develop clear definitions for the different dimensions of the DPSIR framework in the context of urban expansion, drawing from Bradley and Yee (2015).

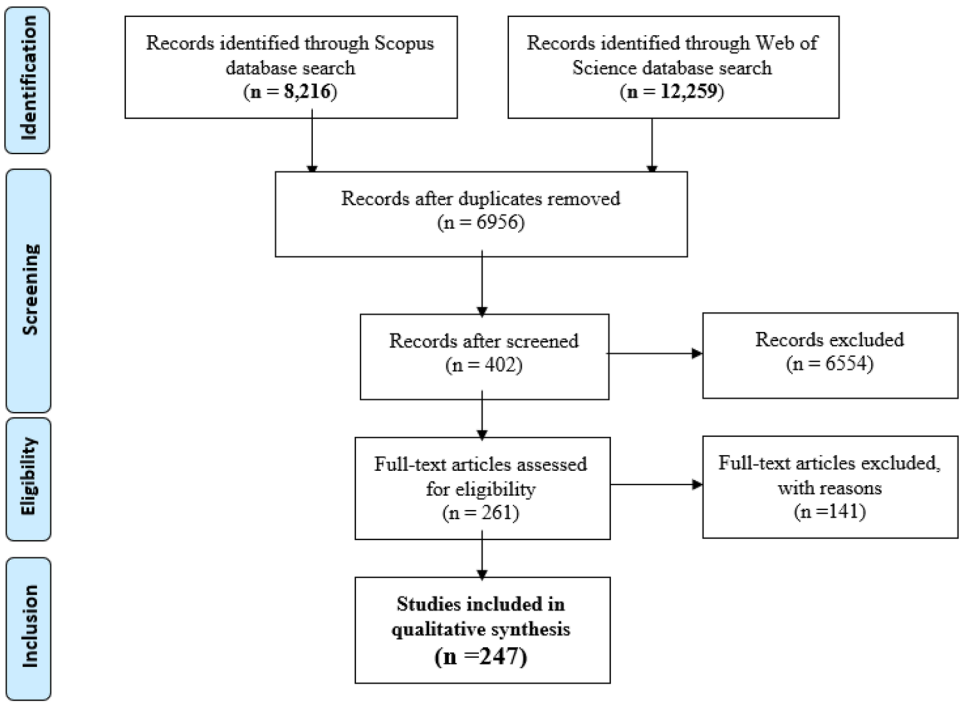

Fig. 1 PRISMA 2009 flow diagram for article inclusion in the systematic review

In this study's context, Drivers refer to forces that motivate urban expansion. Pressures are human activities resulting from the functioning of the Drivers that induce changes to the urban/peri-urban environment and/or human behaviour (EEA 2005; Maxim et al. 2009; Bradley and Yee 2015). States refers to the condition of urban systems and its components (e.g. natural/built-up land, social systems) resulting from the Pressures of urban expansion. Subsequently, Impacts are the positive or negative outcomes of urban expansion. Finally, Responses are the actions taken by individuals, groups, or organisations (e.g. governments, private sector) to avert, correct, or adapt to the Drivers, Pressures, changes in States and/or Impacts of urban expansion. There may not necessarily be linearity between the different DPSIR dimensions, but feedbacks between dimensions could be possible (see "Interactions among DPSIR dimensions" in "Discussion").

Finally, our study aims to be comprehensive in terms of identifying all main aspects of urban expansion in Africa. For this reason, we (a) adopt the full DPSIR framework rather than one of its simplified/derived versions (e.g. Gupta et al. 2021; Zhou et al. 2021; Patricio et al. 2016), and (b) in the results we present the totality of the relevant topics for each DPSIR dimensions as elicited from the literature. Conversely, in the Discussion the focus shifts to some of the major underlying themes that underpin multiple DPSIR dimensions, and can thus be considered as major characteristics of how urban expansion unfolds in Africa.

Literature identification and quality assurance

We used two sets of keywords to identify urban expansion literature in Africa. The first consisted of terms related to urban expansion as identified in reports of international organisations (e.g. United Nations [UN] 2017; UN-Habitat 2016; OECD 2018). These sources were deemed most appropriate considering the extensive and multi-dimensional work of these organisations on Africa's urbanisation. The actual keywords here are 'urban growth', 'urban expansion', 'spatial expansion', 'urban sprawl', 'suburban sprawl', 'suburbanisation', and 'peri-urbanisation'. The second were names of the 58 African countries/territories. Tables S1 and S2, respectively, in the Supplementary Material contains the search term combinations and complete list of countries/territories.

The search was conducted on the title, abstract and keywords of peer-reviewed articles. Relevant literature was identified in Elsevier Scopus and ISI Web of Science databases. A search in Elsevier Scopus database was conducted in December 2019, and repeated in February and June 2021. The search in ISI Web of Science was conducted in June 2021. Thus, the literature selection and its systematic review reflect the state of relevant literature as of June 2021.

The entire literature selection process, as outlined in Fig. 1, followed the PRISMA 2009 guidelines for systematic reviews and meta-analyses (Moher et al. 2009). In total, the literature search in Scopus and Web of Science returned 8216 and 12,259 publications, respectively. Upon review and

Table 1 Literature inclusion and exclusion criteria for the systematic review

	Inclusion criteria	Exclusion criteria
1	Article related to urban expansion	Articles unrelated to urban expansion (e.g. general urban sustainability papers)
2	Peer-reviewed journal articles	Books/chapters, reports, conference papers
3	Publication in the English language	Publications in all other languages
4	Publication related to African cities only	Publication not related to African cities, joint publication on African and non-African cities, global
5	Empirical article or review of empirical	Articles that are (a) conceptual, (b) theoretical, (c) simulations/scenarios/projections/forecasting/modelling the future, (d) methodology testing, (e) pre-colonial analysis of spatial urban phenomena (e.g. studies focusing on colonial periods, which are mostly not relevant in the current urbanisation context), (f) mere critiques of methodologies/theories/initiative), (g) toolkits for urban expansion/upgrading, (h) city profiles, and (i) urban expansion initiatives

duplicates removal, we had 6,956 articles. Subsequently, we screened the titles and abstracts of these to exclude studies unrelated to urban expansion in Africa. This scoping process resulted in a total of 402 publications that were fully read. After applying the eligibility criteria for inclusion in the systematic review (Table 1), we ended up with a total of 261 publications that were relevant for the study. This sample contained both qualitative and quantitative studies that met the selection criteria outlined in Table 1.

To ensure the quality of the systematic review, we evaluated the quality of evidence of each individual study that met the selection criteria, whether qualitative or quantitative in nature. For this purpose, we adopt the quality criteria and evidence assessment tool proposed by Mupepele et al. (2016). This 43-question checklist contains specific questions related to the internal validity of the research aim, data collection, data analysis, results and conclusions, and design-specific aspects (Table S3, Supplementary Material for the criteria). Based on this checklist, studies are categorised as having (a) very strong evidence (score: > 75%), (b) strong evidence (50–74%), (c) moderate evidence (25–49%), and (d) weak evidence (< 25%). Based on these, we omitted from the 261 publications those having weak evidence (14/261), thus keeping only those with very strong (57/261), strong (101/267), and moderate (89/267) evidence. Of these 247 articles, 236 are empirical studies using different qualitative and quantitative methods, and 11 are reviews of empirical studies as per the inclusion criteria (Table 1). Each of the publications finally included in the systematic review receives a code for easier reference. Table S26 in the Supplementary Material contains the full list of publication.

Meta-data extraction and analysis

Two broad types of meta-data were extracted from each paper. First, related to the general characteristics of each study includes the study's (a) location, (b) year of publication, (c) spatial and temporal scale, (d) research approach, and (e) data collection and analysis tools/methods. This meta-data is essentially used to categorise the different studies in major categories to understand the research landscape of the peer-reviewed literature. It is analysed through descriptive statistics and illustrated in bar charts (see "General characteristics of reviewed studies" in the "Results" section).

The second type reflects the different dimensions of the DPSIR framework covered in each study. For each dimension, data extraction followed an iterative coding process, starting with direct phrases for each DPSIR dimension, and expanding these as new versions and/or varying concepts were identified in the reviewed documents. Hence, as new DPSIR elements were identified in the surveyed literature, new codes were added. The coded elements for each DPSIR dimension are presented in bar charts (in the Results section) and in tables alongside the codes of the underlying studies for easier reference (Tables S21–S25 in the Supplementary Material).

Meta-data was elicited by the first author, in consultation with the second author on a case-by-case basis in case of inconsistencies or emerging new categories. This was to ensure the consistent elicitation of the meta-data, while at the same time allowing for an added lens for challenging cases.

Acknowledgements and limitations

Despite its comprehensive approach to understand the multidimensional phenomenon of urban expansion in Africa, our systematic review has some limitations. These include (a) language of base literature (b) non-inclusion of grey literature, (c) keyword selection, (d) possible uncertainties in data elicitation, (e) possible overlapping of DPSIR elements, and (f) inability to conduct a meta-analysis.

Regarding (a), English is legally recognised as the primary/sole official language by only 10 African countries/territories (while it is recognised as a secondary language

in 17). In this study, we consider peer-reviewed literature only written in the English language. We acknowledge that this may not represent all the evidence on urban expansion in Africa and can introduce certain biases against evidence from regions/countries where non-English languages are official or there are strong ties with other non-English speaking academic institutions/organisation (e.g. French in Western/Central Africa, Portuguese in Mozambique/Angola, Arabic in Northern Africa).

Regarding (b), the systematic review considered solely the peer-reviewed literature and excluded grey literature. The authors are fully aware that there may be relevant insights not reported in scientific peer-reviewed publication, but included in reports of international/national/local organisations. However, our focus on the peer-reviewed literature was a conscious decision to ensure both the reliability and reproducibility of the results, as well as the less-biased identification (see "Literature identification and quality assurance").

Regarding (c), even though the authors made efforts to include very diverse keywords and search terms for the selection of literature, it should be noted that they reflect the notion of urban expansion as outlined in the conceptual definition in Footnote 1. These keywords were selected as synonyms of this notion of urban expansion, based on reports from international organisation and key academic literature. However, we are aware that there may be other related keywords that reflect this process of urban expansion, considering very diverse disciplinary lenses studying the different aspects of urbanisation (Iossifova et al. 2017). However, considering the rigorous process of keyword selection as outlined above, we believe that the search terms are sufficient for properly identifying the extensive multi-disciplinary peer-reviewed literature on urban expansion in Africa.

Regarding (d) and (e), as the underlying literature did not use the DPSIR model, there might be some degree of uncertainty in eliciting information and grouping it under the different DPSIR dimensions and elements. Furthermore, we acknowledge the possible overlap between some of the DPSIR dimensions and elements for some cross-cutting themes such as land, which feature in multiple DPSIR dimensions. We have attempted to avoid such uncertainties and overlapping to the extent possible through an iterative coding process to allocate the elicited information in the correct DPSIR dimension, and divide or join elements subject to overlapping. We selected very carefully the language in the DPSIR dimensions (Fig. 9) and the different individual elements outlined in "Results". However, it is possible that some uncertainties and overlapping might persist, especially for cross-cutting issues.

Regarding (f), we adopted here a systematic review approach because most of the studies exploring urban expansion in Africa employ different qualitative/quantitative indicators for the different dimensions of the phenomenon. This makes it practically impossible for their consistent analysis through a meta-analysis approach.

Results

General characteristics of reviewed studies

Most of the reviewed studies focused on urban expansion in eastern Africa (33.2%) and western Africa (31.0%) (see Fig. 2a). There was an equally large variability on the national focus, with countries such as Egypt, Ghana, Ethiopia, Nigeria, Tanzania and South Africa being well represented (> 20 studies for each country). In terms of urban expansion typology, most focused on urban sprawl and peripheral growth (88.8%), compared to urban expansion caused by large residential- (e.g. affordable housing) (7.0%) and industrial/commercial (e.g. airports, university campuses) projects (4.2%) (Fig. 2c). Due to the spatial nature of urban expansion (see Footnote 1), most reviewed studies employed a quantitative research approach (49.6%), using predominately remotely sensed data (27.9%) (Fig. 3a, c). Other data collection methods include secondary data (12.7%), key informant interviews (12.1%), and individual/household surveys (11.0%), among others. Most studies used multiple data collection and analysis tools/methods (55.6%) (Fig. 3c), with cross-sectional and mixed-method studies using multiple data collection tools compared to longitudinal studies. Such studies also relied hugely on primary data. Only 27 studies employed a conceptual framework, with a total of 28 different frameworks identified (Table S20 in Supplementary Material). Spatial analysis was the most frequently used analytical approach (44.7% of studies) (Table S19 in Supplementary Material).

Approximately 70% of the studies were externally funded (Fig. S1b and Table S14, Supplementary Material), showing the large international interest for urban expansion research. Author affiliations were very diverse (Fig. S1c and Table S10, Supplementary Material). The reviewed research was largely collaborative between authors from diverse disciplines (45%) (Table S11, Supplementary Material).

Dimensions of urban expansion in Africa

Drivers

Approximately 39% of the reviewed studies focused on the Drivers of urban expansion (Fig. S2, Supplementary Material). Drivers are divided into four categories: (a) socio-demographic, (b) economic, (c) environmental/geographic and (d) institutional. Socio-demographic drivers are linked to population and related social aspects, whose dynamics

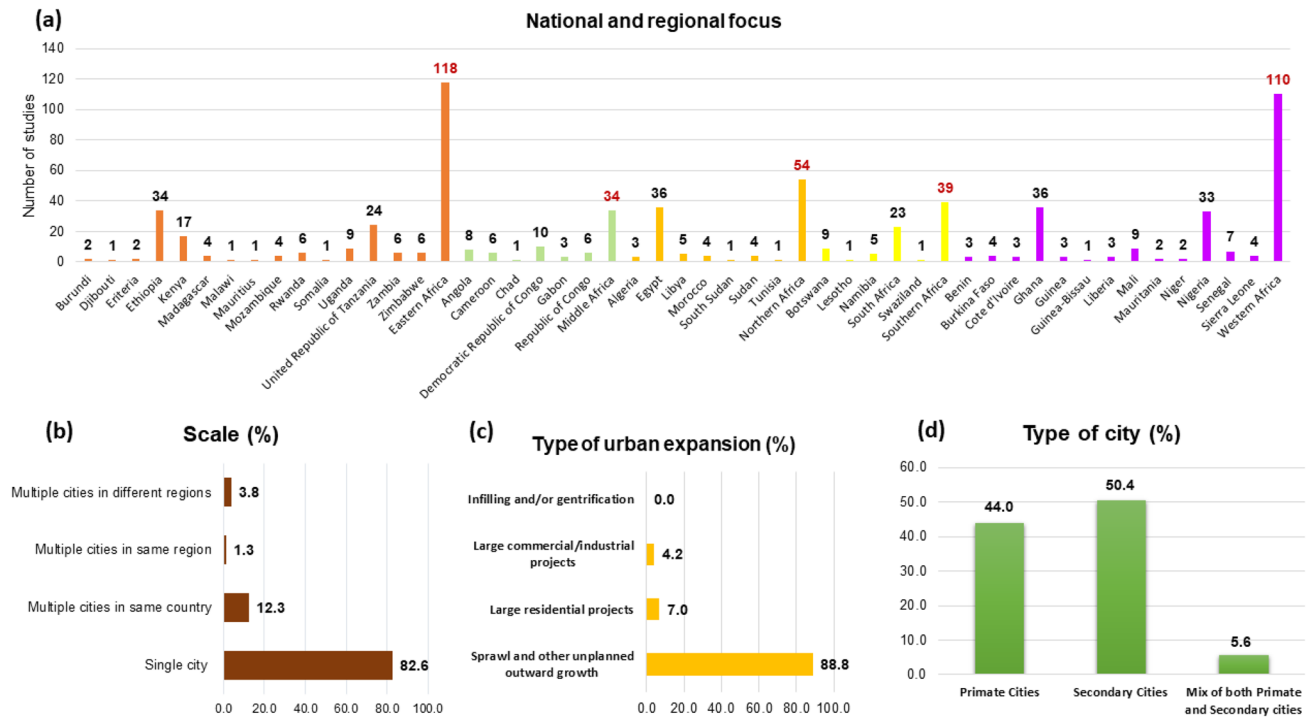

Fig. 2 Focus of reviewed studies

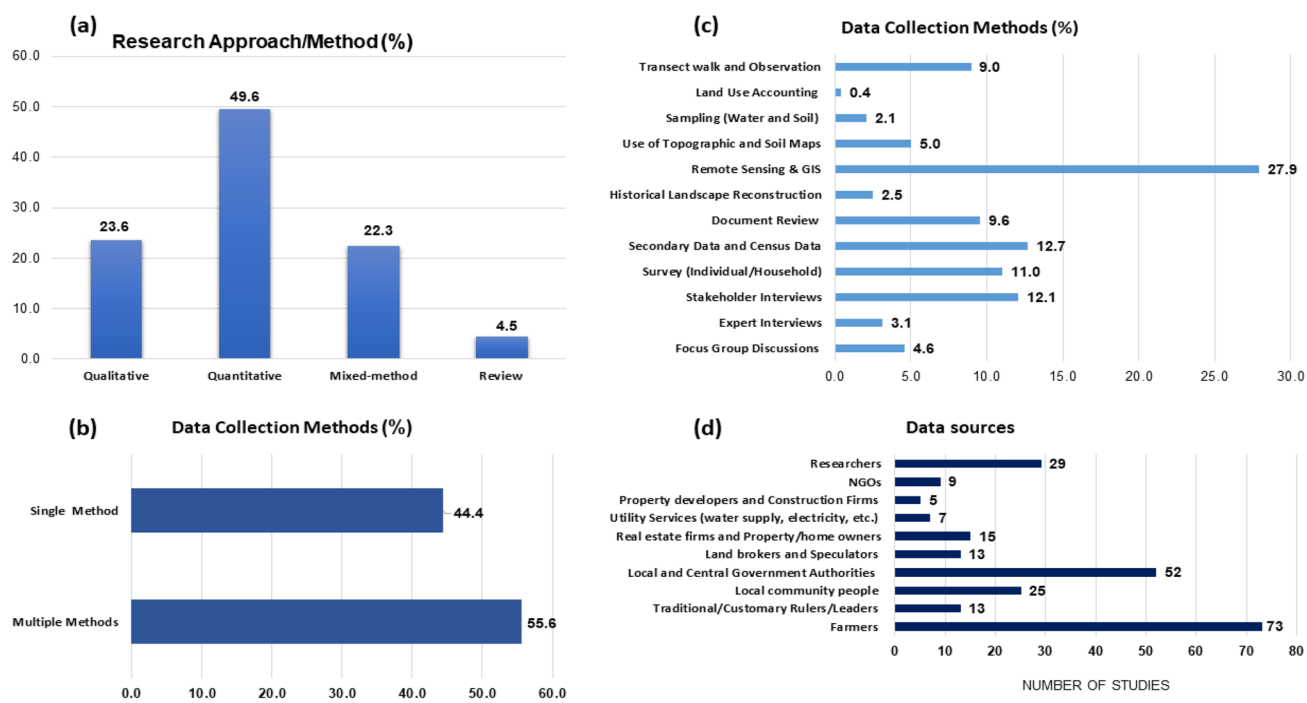

Fig. 3 Methods and data collection approaches of reviewed studies

influence urban expansion. Economic drivers include financial motives of urban expansion. Institutional drivers encompass policy and management issues that promote urban expansion, while environmental/geographic drivers include factors related to land and soil that favour/hinder urban expansion. Socio-demographic and institutional drivers

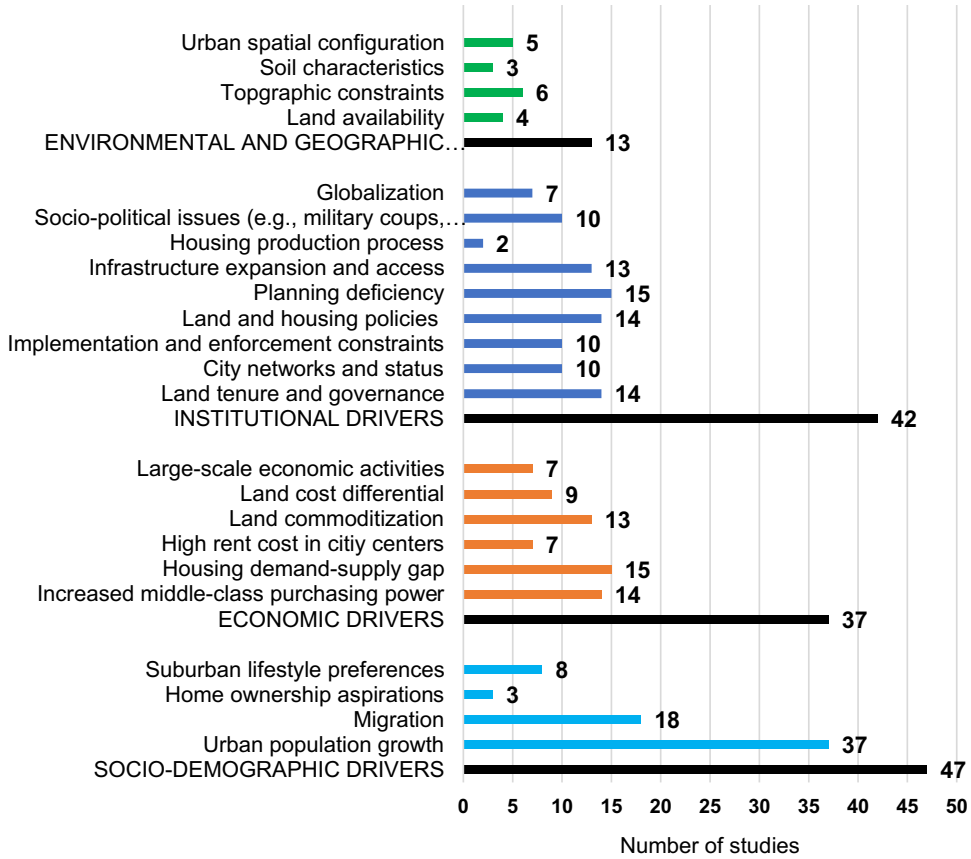

Fig. 4 Drivers of urban expansion

were the most prevalent (47 and 42 studies, respectively), with economic and environmental/geographic drivers less well represented (37 and 13 studies, respectively). Figure 4 visually represents the number of studies focusing on each Driver, and Table S21 and Fig. S3 (Supplementary Material), respectively, mention all relevant studies and display a tree map of drivers.

Urban population growth (a socio-demographic driver), was the single most prevalent direct driver of urban expansion, recorded in 37 studies. For example, studies at the national (Adhikari and de Beurs 2017) and city level (Baye et al. 2020) have outlined how population growth essentially drives the expansion of African cities. Rural–urban migration in search of opportunities was another major socio-demographic driver (Badmos et al. 2018; Msuya et al. 2021). Two other quite interrelated socio-demographic drivers of urban expansion include the emerging preferences of some urban residents towards suburban lifestyles (Almatarneh 2013) and home-ownership aspirations (Andreasen et al. 2017).

Economic drivers include demand–supply deficit in housing, which offers economic incentives for planned/unplanned expansion into city peripheries to meet housing demand (Jenberu and Admasu 2020; Bartels 2019). Another potent economic driver of urban expansion is the increasing purchasing power of the middle class, which, for example, allows for certain lifestyle decisions (e.g. car ownership, desire for bigger houses) that drives certain types of housing development in new areas (Almatarneh 2013). Other economic drivers are land commoditization in the city periphery (Msuya et al. 2021; Osman et al. 2016a, b) and the large land cost differential between vacant land within the city and peri-urban areas, which incentivizes development in the city periphery and influences urban residents to move to new and more affordable housing in the periphery (Baye et al. 2020; Andreasen et al. 2017).

The most prevalent institutional driver is planning inadequacies such as weak planning approaches (Berbache and Hadjab 2020), poorly planned development (Mahmoud et al. 2019) and outdated plans (Ngoran and Xue 2015), among others. Land tenure rules[4] also affect how urban expansion unfolds. For example, through unclear and contrasting land ownership in urban fringes (Nkambwe 2003) or the multiple

[4] Land tenure rules include the system of formal and informal rules and practices dictating land ownership (e.g. how it is accessed, used, disposed by whom, for what purpose), and the dual nature of land governance in many African contexts (i.e. chiefs and traditional leaders as fiduciary of land and government as planners of land development).

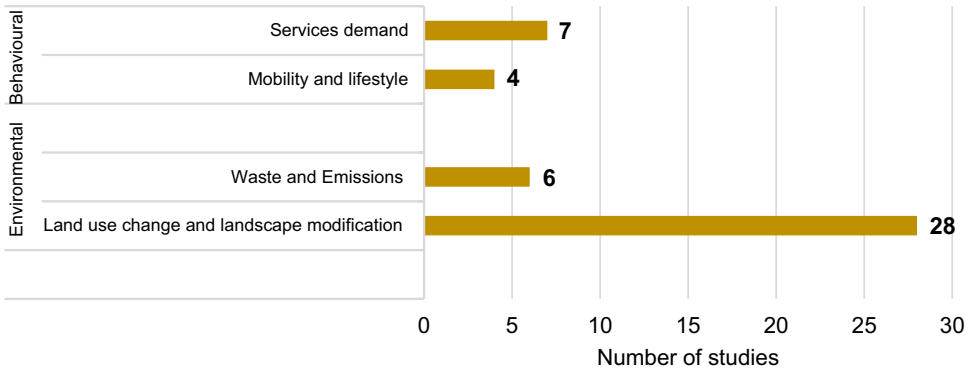

Fig. 5 Main pressures of urban expansion in Africa

and disproportionate power of stakeholders to make land allocation decisions (often through their own motives) (De Boeck 2020; Wamukaya and Mbathi 2019). Another closely linked driver is land/housing policies, including policies offering incentives for certain types of urban expansion (Msuya et al. 2021; Todes 2017), as well as the challenges in implementing and enforcing existing policies (Ngoran and Xue 2015; Terfa et al. 2020). The efforts to extend city infrastructure and access to services can be another vital driver of urban expansion, e.g. mapping land and pavement of road network into peri-urban areas has sometimes driven urban expansion (Osman et al. 2016a, b; Marondedze and Schütt 2019). In some countries, housing formalisation processes start with the self-building of homes (usually initially as squatters), without required monitoring from relevant agencies, and progressively expanding to a documented home (Bartels 2019; Agbola 1988) with legality secured later via quiet encroachment and consolidation (Bartels 2019).

Geographic drivers include topographical constraints (e.g. fragmented landscape due to complicated agro-ecological patches, hills or wetlands) that play a major role in how urban expansion unfolds (Osman et al. 2016a, b; Terfa et al. 2020). The spatial configuration of cities (e.g. location of well-drained higher elevation) (Braimoh and Onishi 2007) or proximity of surrounding peri-urban communities to roads/highways (Salem et al. 2019; Cobbinah and Aboagye 2017), among others, positively influence urban expansion into such peri-urban areas. Finally, land availability for residential and commercial development (Appiah et al. 2014) makes its acquisition easy (Adedire 2018), often without bottlenecks especially where centralised traditional authorities are responsible (Cobbinah and Aboagye 2017).

It is noteworthy that these Drivers unfold differently under varying African contexts (local socioeconomic, institutional and environmental circumstances). Furthermore, Drivers tend to intersect at different spatial and temporal levels, creating synergies or trade-offs in driving certain types of urban expansion. In this sense, how these Drivers affect urban expansion is highly variable and not always straightforward to delineate, requiring thus a good understanding of the local contexts.

Pressures

Pressures are human activities resulting from the functioning of Drivers that induce further change in the areas experiencing urban expansion that eventually manifest in States and Impacts (see next sections). Approximately 9% of reviewed studies focused on Pressures brought about by urban expansion (Fig. S2, Supplementary Material). From two major categories, environmental and human behaviour Pressures, we identified four Pressures (a) land use change and landscape modification, (b) waste and emissions, (c) shifts in service demand, and (d) shifts in mobility and lifestyle. Figure 5 visually represents the number of studies for each Pressure, and Table S22 (Supplementary Material) identifies all relevant studies.

In terms of environmental Pressures, urban expansion is a major cause of land use change and landscape modification, as it converts agricultural/forested land, and aquatic ecosystems, among others, to built-up land (Hegazy and Kaloop 2015; Kasim et al. 2021). Several studies have shown how urban expansion puts pressure on agricultural systems, forests, and river basins through land use change (Jenberu and Admasu 2020; Ackom et al. 2020), physical agroecosystems damage (Appiah et al. 2014), or direct peri-urban landscapes modification (Willkomm et al. 2021; Mohamed and Yacout 2019). Other environmental Pressures relate to increasing levels of waste generation (Cobbinah and Aboagye 2017), and water pollution (Saber et al. 2020; Bulti and Abebe 2020) from the increased population and lifestyle changes in peri-urban areas.

In terms of behavioural Pressures, urban expansion puts Pressures on social–ecological systems via shifts in mobility and lifestyles. These tend to be associated with changes in the distance between home and workplace (Cobbinah and Aboagye 2017) and requirements for travel cost minimization (Poku-Boansi 2021; Taiwo 2021). Similarly, Pressures relate to changes in service demand from the increasingly

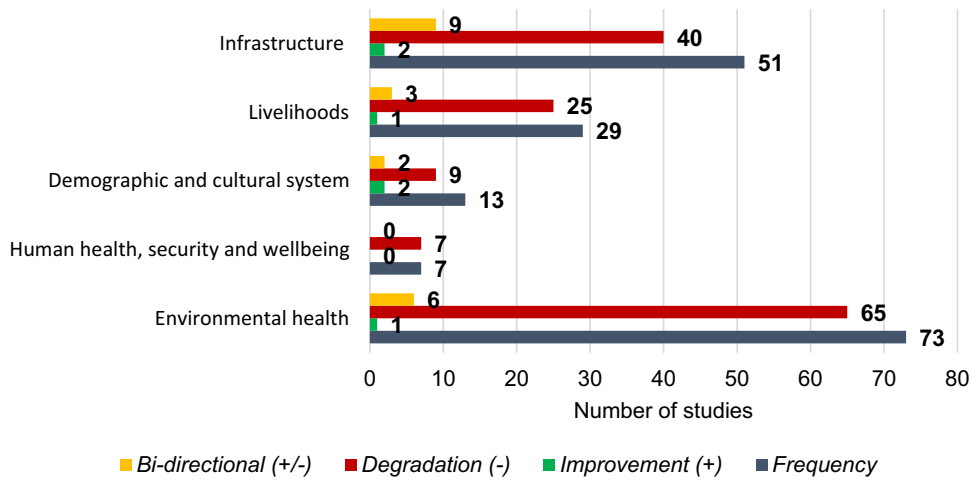

Fig. 6 State of social–ecological systems in the context of urban expansion. The bi-directional bar indicates that the study observed both an improved State in some parts of the studied urban system and a degraded state in other parts

larger and more urbanised population, including increasing demand for tree planting to stabilise the converted landscape (Tossou et al. 2014), or attracting formal institutional services, co-financing of service extensions and lobbying public service provision (Andreasen and Møller-Jensen 2016; Bartels 2019).

State

State reflects the condition of urban systems and its components resulting from urban expansion Pressures. Approximately 24.7% of the reviewed studies focused on the State of peri-urban/urban social–ecological systems (and/or the change therein) (Fig. S2, Supplementary Material). The main categories identified are State of (a) environmental health (b) human health, security and wellbeing (c) demographic and cultural make-up (d) livelihoods and (e) infrastructure. Figure 6 highlights the number of studies for each State, and Table S23 (Supplementary Material) identifies all relevant studies.

Environmental health is the most commonly covered State, with the 73 identified studies touching on different aspects of environmental health (mainly negative). These are usually associated with changes in the State of the social–ecological system through the fragmentation and loss of natural landscape elements such as forests (Deribew 2020; Larsen et al. 2019), agricultural land (Adam 2020; Abd-Elmabod et al. 2019), aquatic ecosystems (including wetlands) (Onanuga et al. 2021) and open green spaces (Abass et al. 2020). Such changes in the State of social–ecological systems are linked to increased vulnerability to hazards such as floods (Abass et al. 2020; Tiepolo and Galligari 2021) or ability to provide the ecosystem services upon which local communities rely (Abass et al. 2020; Cumming et al. 2014).

Many studies also observe major changes in the State of the demographic and cultural make-up of the areas experiencing urban expansion, as non-native populations move in and local communities get diluted in the overall population (Cobbinah and Aboagye 2017). Although this might increase diversity, it can also erode the values and moral systems that bind local communities (Hanlon et al. 2019; Martínez-Quintana and Cáceres-Morales 2016), and eventually change the cultural make-up of the areas.

The State of infrastructure was also very prevalent in the literature, with 51 identified studies, largely portraying changes in the provision of services in newly urbanising peri-urban environments (Fig. 6). Over three quarters of studies (40/51) observed poorly serviced peri-urban areas (Msuya et al. 2021; Onaiwu and Onaiwu 2019) due to reactionary public service and infrastructure delivery that lags behind the pace of urban development and responds to political pressure from constituents (Andreasen and Møller-Jensen 2016; Cobbinah and Aboagye 2017). This results in settlements characterised by informality and squatting, especially during the initial phases of urban expansion (Zubair et al. 2015).

When it comes to the State of livelihoods and human health/security/wellbeing (mainly of peri-urban communities), the former relates to the fact that many peri-urban communities affected by urban expansion depend on land and ecosystems for their livelihoods. Most studies covering this theme focused on the negative effects of urban expansion on livelihoods (Fig. 6), usually via the loss/transformation of agrarian livelihoods and production systems (Afriyie et al. 2020; Agyeman 2018). Conversely, the State of human health, security and wellbeing is deteriorated through weakened community cohesion (Kepe et al. 2015), and undersupply of infrastructure and services (Andreasen and Møller-Jensen 2016; Cobbinah and Aboagye 2017).

Impact

The Pressures imposed by urban expansion and the resulting changes in the State of the social–ecological system bring

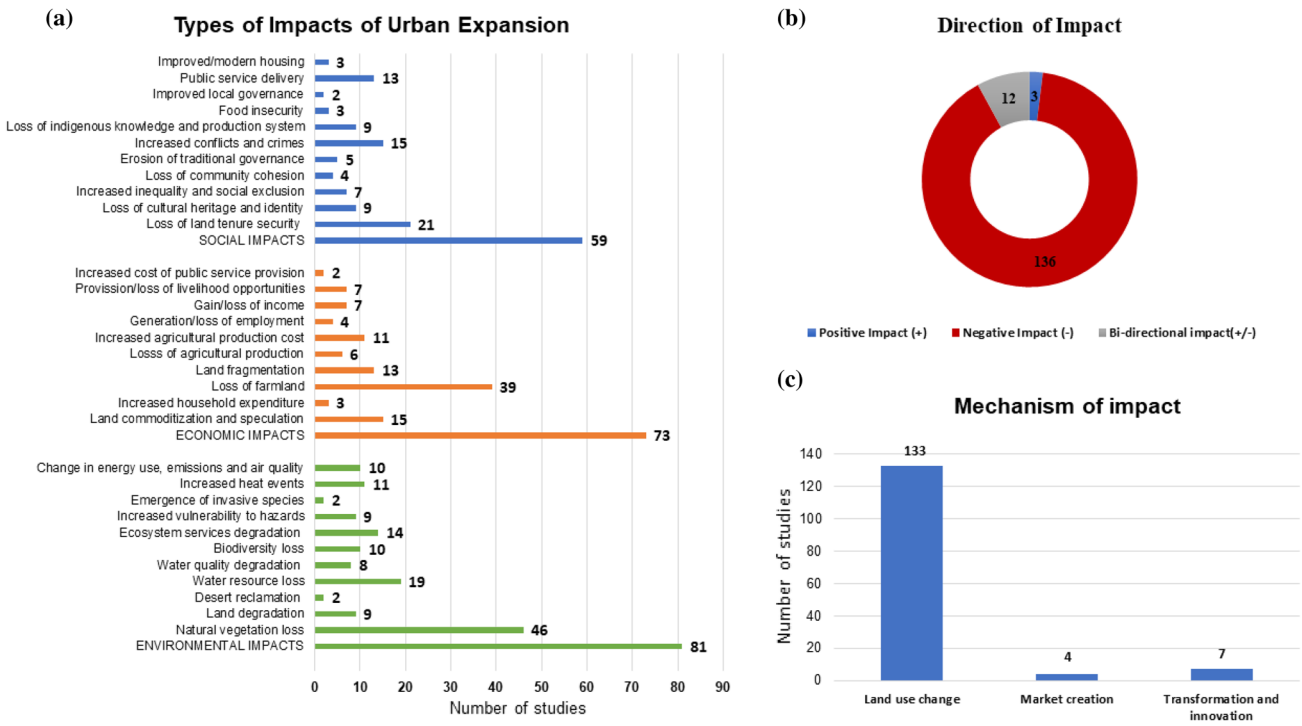

Fig. 7 Types, direction, and mechanisms of the Impacts of urban expansion

about a series of environmental, economic, and social Impact (Fig. 7a). Impact constitutes the most covered DPSIR dimension in the reviewed literature with 39.4% of studies discussing at least one Impact (Fig. S2, Supplementary Material). A critical look at how Impacts unfold indicate that land use change is the main mechanism (in 92% of studies covering Impact) (Fig. 7c). Although Impact can have a negative, positive or bi-directional effect on individuals, society or the environment, about 90% of the Impact-related studies report negative Impact (Fig. 7b). Table S24 (Supplementary Material) identifies all relevant publications discussing Impacts of urban expansion. Generally, environmental impacts are the most prevalent category (53% of studies) followed by economic impacts (48%) and social impacts (39%). Figure 7 summarises the different types of Impacts and Table 24 (Supplementary Material) shows the complete list of studies.

A prevalent environmental impact is natural vegetation loss (e.g. forest, grassland) resulting from their conversion into built-up land (Mansaray et al. 2016; Yankson and Gough 1999). The second most prevalent environmental impact is the loss of water resources (Onanuga et al. 2021), such as wetlands (Wasswa et al. 2018), during the development of housing (Oiro et al. 2020; Moyo and Rapatsa 2015) or industrial activities (Mteki et al. 2017; Robbins 2015). Less prevalent impacts were ecosystem service degradation (Dapilah et al. 2019; Jaligot et al. 2018) and biodiversity loss (Jeffery and Buschke 2018; Rija et al. 2014).

Prevalent economic impacts include farmland loss (39/73 studies of economic Impacts), land commoditization and speculation (15/73), land fragmentation, and increases in agricultural production cost. Farmland is lost for farmers who switch cultivation to urban open space (Vermeiren et al. 2013; Maxwell et al. 1999) and peri-urban areas (Kuusaana and Eledi 2015a, b; Haregeweyn et al. 2012) mostly without adequate compensation (Admasu et al. 2019; Baye et al. 2020). Land commoditization/speculation is usually observed through the purchase of multiple plots of land (e.g. Neimark et al. 2018; Becker 2013). Land fragmentation is exemplified by the ever-declining size of agricultural plots due to appropriation of agricultural land for residential and commercial purposes in peri-urban areas (e.g. Willkomm et al. 2021; Keita et al. 2021). Agricultural production costs may also increase as farming is pushed further away from the city periphery which increases transportation time and cost (Vermeiren et al. 2013).

The most prevalent social impact relates to land tenure insecurity, especially among community members depending on land for their livelihoods. The starting point here is the fiduciary control of land by traditional leaders (e.g. chiefs, clan and family heads) and the subsequent use by local communities through an usufruct right system (see "Drivers"). In this land tenure context, land competition from urban expansion sometimes transforms how land is accessed and tenure is secured by local communities, leading to land tenure and governance

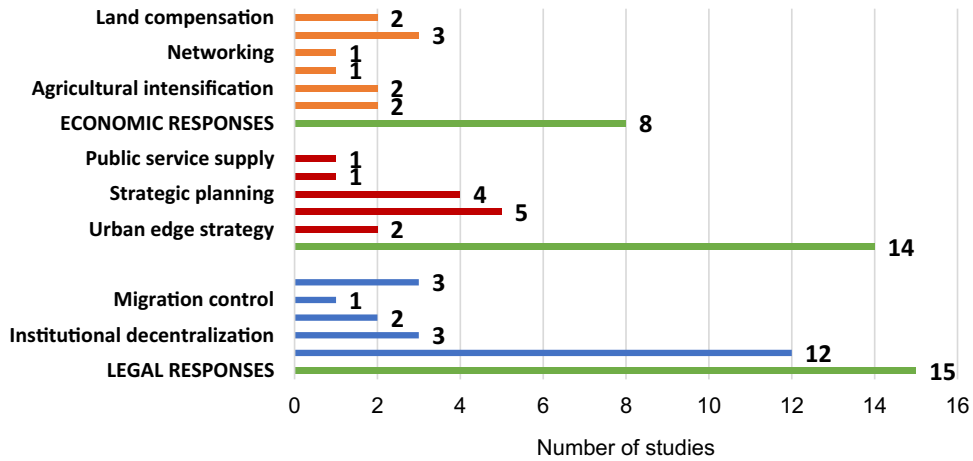

Fig. 8 Responses to/for urban expansion. PPP stands for Public–Private Partnership

transformation (Fuseini 2021; Agegnehu et al. 2015). In many cases, this results in the dispossession of community members (Fogelman 2017; Admasu et al. 2019) without adequate compensation (Baye et al. 2020). This is sometimes the starting point of the second most reported social impact of urban expansion, namely increased conflicts (Kepe et al. 2015) and crimes (Breetzke and Cohn 2013; Spocter 2021). Other prevalent social impacts relate to public services delivery, in that the delivery of essential services and infrastructure for decent living conditions, are mostly lagging behind the pace of urban expansion (Cobbinah and Aboagye 2017; Olvera et al. 2003). However, there is also literature reporting the gradual increase in the delivery and quality of such services (Adedire 2018;), most in response to pressure from local communities (Bartels 2019; Andreasen and Møller-Jensen 2016).

Responses

Responses are the least covered DPSIR dimension (5.2% of studies, see Fig. S2, Supplementary Material). The literature broadly identifies three main types of Responses to urban expansion, namely legal ($n = 15$), economic ($n = 8$), and infrastructural ($n = 14$) (Fig. 8). Table S24 in the Supplementary Material identifies all relevant studies discussing the different Responses to urban expansion in Africa.

Legal responses include policies, laws, bye-laws and suggestions seeking mainly to improve housing supply (Braimoh and Onishi 2007) and land governance by regulating land use (Agegnehu et al. 2015; van Rensburg and Campbell 2012), protecting land rights (e.g. Jenkins et al. 2002; Agegnehu et al. 2015), and ensuring actions against irresponsible land use and disregard for central and local regulations (Areola et al. 2014; Afriyie et al. 2019). Some key examples include (a) formulation and enforcement of policies on housing, land, and the environment (Cash 2014; Brian 2016; Muzorewa 2020), (b) institutional coordination and decentralisation (Bidandi and Williams 2020; Batisani and Yarnal 2011), (c) formalisation and incorporation of customary land practices into formal instruments (Jenkins et al. 2002; Agegnehu et al. 2015), and (d) participatory land governance (Adam 2020; Muzorewa 2020).The physical/infrastructural Responses are largely government planning institutions' strategies for urban practitioners. These include strategic planning focusing on ensuring spatial equity (Todes 2012), checking sprawl (Brian 2016) and coordinating the development of urban areas in a sustainable manner (Ramiaramanana and Teller 2021). Some studies also focused on urban edge zoning to minimise urban sprawl while protecting the environment, increase the compactness of cities, and improve the effective use of large-scale infrastructure (Van Rensburg and Campbell 2012; Cash 2014). Responses related to public housing and supply services focused on delivery of serviced and affordable land for an upgrading scheme within low-income areas to limit negative environmental impact (Areola et al. 2014).

Finally, most of the economic Responses are at community level and are essentially adopted by the people negatively affected by urban expansion. Economic responses usually seek to help the affected people adapt to impacts of urban expansion, and have included among others: (a) networking and economic collaboration to provide the needed services (Gwan and Kimengsi 2020), (b) intensification of agricultural production to offset land loss (Afriyie et al. 2019; Gwan and Kimengsi 2020), (c) diversifying livelihoods into high-value crop production (Afriyie et al. 2019; Gwan and Kimengsi 2020), and (d) monetary compensation for land loss (Areola et al. 2014; Agegnehu et al. 2015).

Discussion

Interactions between DPSIR dimensions

Figure 9 systemises the connections between the DPSIR dimensions (see "Results") and the multiple phenomena

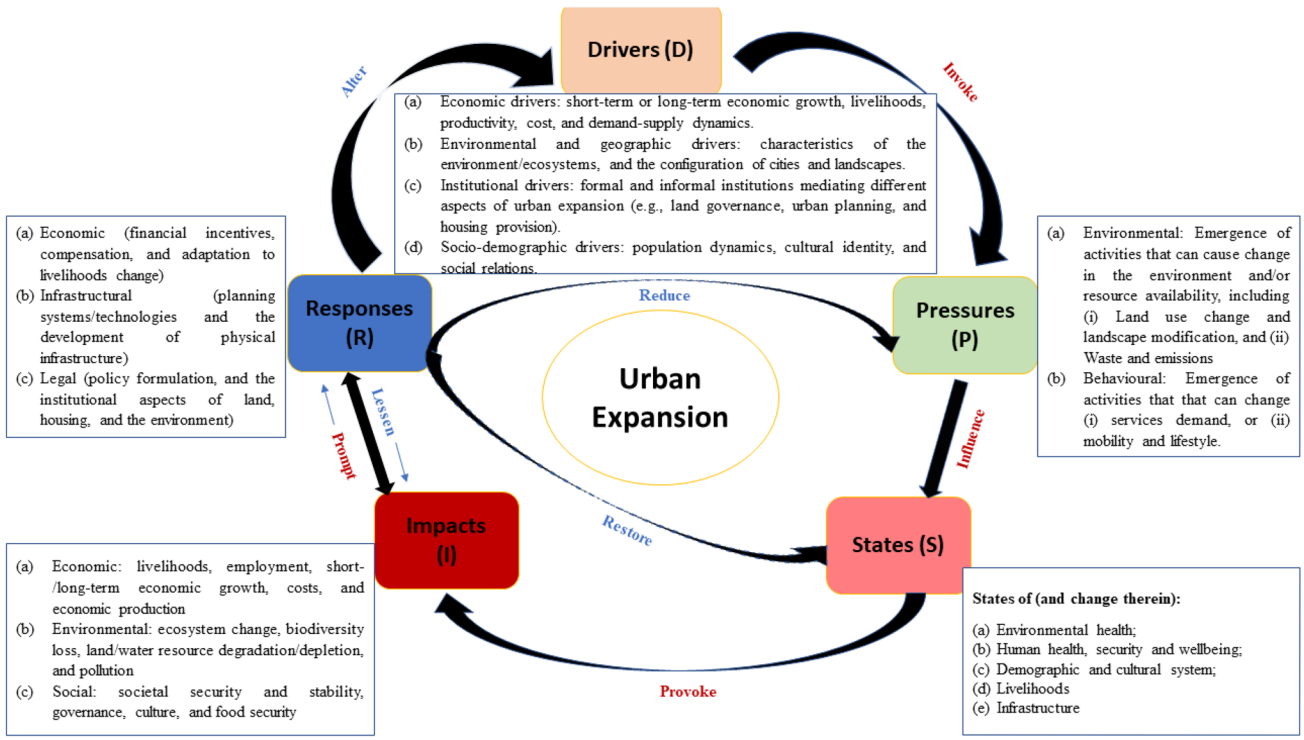

Fig. 9 Interactions among the DPSIR dimensions. Due to the fragmentation of the literature, it is not possible to create a figure showing the linkages between all individual Drivers, Pressures, States, Impacts and Responses as presented in "Results". Such a full causal map is not possible as each of the reviewed studies did not capture all DPSIR dimensions or aspects, or they might not have been present in their specific city context. Source: Adapted from ISTAT, Costantino, Falcitelli, Femia, & Tuolini, 2003; UN Environment 2018

underpinning the sustainability of urban expansion in Africa. The possibility of different feedbacks between DPSIR dimensions is noteworthy, and indicative that these dimensions do not unfold linearly.

Overall, multiple factors such as population growth, planning inadequacies, or land tenure interact in complex ways to drive urban expansion in Africa ("Drivers" box, Fig. 9). These interactions generate multiple Pressures (P) that influence the State (S) of the environment and socioeconomic system in urban areas and their peripheries. Major Pressures include land use change, emissions, and behavioural changes ("Pressures" box, Fig. 9), that culminate in States characterised by alterations of environmental health, human health and wellbeing, and demographic and cultural characteristics ("States" box, Fig. 9). Such alterations translate into various undesirable economic, environmental and social Impacts ("Impacts" box, Fig. 9).

Considering that multiple factors are involved in urban expansion, different Responses (R) can be implemented to reduce the negative aspects of urban expansion or improve the positive ones. These include economic, infrastructural or legal/policy Responses ("Responses" box, Fig. 9) that target and/or affect the Drivers, Pressures, States or Impacts. Arguably, understanding the interlinkages in Fig. 9 can help develop and implement appropriate, acceptable, and targeted Responses to promote urban sustainability.

Centrality of land use change and land governance

Most of the reviewed studies focused on spatial expansion, reflecting the observation that Africa's urban extent has been rapidly increasing compared to global patterns (Anderson et al. 2013. A fairly consistent narrative emerges that African urban expansion engulfs and displaces peri-urban land compromising traditional livelihoods, changing the customary land rights (Teklemariam and Cochrane 2021), via development by dispossession (Fogelman 2017).

An underlying issue is that access to land and land tenure are complex, contentious, and intersect with various competing/conflicting land uses that reflect diverse stakeholder interests (Aprioku 2004; Balestri 2019). Consequently, land governance is riddled with weak and corrupt institutions (Koechlin et al. 2016; Chiweshe 2021) that more often than not operate against the interest of marginalised communities (Bradshaw 1988).

This narrative, combined with the fact that land features in each DPSIR dimension (see "Results", Fig. 9) demonstrate the centrality of land (and its governance) in urban

expansion discourses. Below we provide a brief synthesis of the different guises that land-related issues assume in the context of urban expansion.

When looking at land (and its governance) as a Driver of urban expansion (see "Drivers"), we must consider the (a) inherent complexity brought by the duality of land governance systems, (b) perceived land availability that makes land easily disposable, (c) informality and imperfection of land markets and (d) huge value differential between land in the Central Business Districts and in peri-urban communities.

Under the customary system, land is a non-marketed asset held in trust by traditional leaders (Chimhowu 2019; Yakubu et al. 2021). Although customary rules underpin much of land governance across Sub-Saharan Africa (Wily 2012), land use planning is performed by formalised local/central government institutions (Bidandi and Williams 2020; Kuusaana and Eledi 2015b). However, traditional institutions have commoditized land in many local contexts (Becker 2013; Amanor 2008), sometimes directly selling land without coordination with the local/central government responsible for planning and services delivery (Fuseini and Kemp 2015; Cobbinah and Aboagye 2017). This has often catalysed the displacement of vulnerable indigenous/local communities, and pastoralists/peasants, from communal property held under usufruct sometimes without or with meagre compensation (Ubink 2008; Moreda 2017; Baye et al. 2020).

This duality in land governance has arguably constrained the effective implementation of land use policies (see "Responses"), with direct consequences for urban sustainability (Enoguanbhor et al. 2021). Furthermore, it has complicated large-scale land acquisitions, taking a toll on the systematic planning of urban expansion (Nkambwe 2003; Wamukaya and Mbathi 2019). These, in conjunction with the relatively low value of peri-urban land, abuse of chiefs' fiduciary power, and growing ability of powerful players (and increasingly the middle class) to purchase land (sometimes for speculative reasons) (Mahmoud et al. 2019; Baye et al. 2020), contribute to the uncoordinated fashion of urban expansion,.

Land through the lenses of States, Pressures and Impacts (see respective sub-sections in "Results") is inherently linked with the huge effects of urban expansion on land use change and transformation. As understood in this study, urban expansion is a spatial process usually occurring in city peripheries (see "Introduction"), that entails the conversion of agricultural land and natural vegetation, catalysing agrarian transformation and environmental/ecosystem degradation in the process (Berbache and Hadjab 2020; Hammond et al. 2015; Schlesinger and Drescher 2016). When this happens, the communities/groups/individuals relying on these resources for their livelihoods are dispossessed (Fogelman 2017; Moreda 2017), transforming or destroying livelihoods (Coulibaly and Li 2020; Gwan and Kimengsi 2020).

At the same time, many of the newly built-up areas on the urban periphery are characteristically leapfrogged, unplanned, and fragmented development (Cobbinah and Aboagye 2017; Zubair et al. 2015) that eventually densifies, with native populations adopting new housing styles leading to the further alteration of urban fringe communities (Osumanu and Akomgbangre 2020).

The influx of new residents (with different socioeconomic status to local communities; see "Drivers") causes heterogeneity in the urban fringe. At the same time, dispossessed local communities often fail to benefit from the capital inflow (Moreda 2017), but are prone to experience large livelihood impacts in the short, medium and long terms (see above). Apart from general increases in the cost-of-living (Afriyie et al. 2019; Olvera et al. 2003), native residents can experience (a) extra costs for purchasing land and other inputs (e.g. fertilizer, water) to retain their livelihoods (Dadi et al. 2016; Vandercasteelen et al. 2018), or (b) increased travel distances to further away communities to engage in new livelihood activities (Kuusaana and Eledi 2015a; Admasu et al. 2019).

Although the above phenomena might manifest in different ways and to different extents across Africa, the literature is very consistent in emphasising the central role of land (and its governance) for sustainability in the context of urban expansion. Here, the strong intersections with the four core dimensions of urban sustainability (i.e. social, economic, environmental and spatial), which are necessary for the sustainable urban and peri-urban development (UN-Habitat 2020a, b) are noteworthy.

Disproportionate focus on negative impacts

Our review suggest that the Impacts of urban expansion are primarily negative. Land use change and poor land governance are major pathways through which these negative impacts manifest. Prevalent negative environmental impacts include vegetation conversion, water resources depletion, and ecosystem degradation (Jaligot et al. 2018; Hammond et al. 2015), which collectively contribute to biodiversity loss (Rija et al. 2014; Jeffery and Buschke 2018). Economic impacts associated with farmland loss (Gwan and Kimengsi 2020; Radwan et al. 2019) and land commoditization (Becker 2013; Gemeda et al. 2019), often catalyse negative social impacts such as unequal access to land (De Boeck 2020; McGregor and Chatiza 2019) and natural resources (Tati 2016; Dapilah et al. 2019). In turn, land dispossession often causes social conflicts over access to land and its resources (Kepe et al. 2015; McGregor and Chatiza 2019), which in the long-run degrades local communities' cohesion (Becker 2013; Neimark et al. 2018).

The inadequate delivery of public services is another major pathway to several negative sustainability impacts of urban expansion. Here, the underlying trigger is the lack of capacity of many national and local governments to develop appropriate, functional and resilient infrastructure, especially when urban expansion is rapid (Barofsky et al. 2016; AfDB/OECD/UNDP 2016). This has diverse negative environmental and health-related impacts linked to flooding, water pollution, inadequate waste management, and lack of access to sanitation and drinking water (Tiepolo and Galligari 2021; Penrose et al. 2010). In this context, already burdened formal institutions are facing increased pressure to deliver the lacking infrastructure and services, further adding to their financial strain (Onaiwu and Onaiwu 2019; Robbins 2015). Sometimes, social dissatisfaction with the delivery of infrastructure and related services creates distrust, low citizen participation, and even causes social conflicts, as local residents in areas of unplanned urban expansion feel left out (Becker 2013; McGregor and Chatiza 2019).

In this context of mostly negative impacts, studies' Responses to urban expansion are fragmented and superficial (see "Responses"), often reaching the distressing conclusion that these Responses are mostly poorly implemented (Grant et al. 2019; Cash 2014) or inefficient (Gutman and Patel 2018; Baye et al. 2020). For example, the implementation of National Urban Policies (NUP) that are critical for preventing/mitigating many of urban expansion's negative sustainability impacts are usually constrained by (a) human and financial deficits, (b) policy siloes and institutional fragmentation, (c) inadequacies in technical expertise and (d) lack of political will or policy continuity (UN-Habitat 2021).

Research gaps and future directions

First, most reviewed studies focus disproportionately on single cities (Fig. 3), land tenure regimes and DPSIR dimensions/elements. Despite the need to appreciate the local contexts of urban expansion as many DPSIR dimensions/elements manifest very differently across localities, the lack of comparative studies across city types (e.g. primary vs. secondary cities/small towns) and land tenure regimes prevents our comprehensive understanding of how different DPSIR elements emerge from (and intersect with) different city characteristics and tenure regimes. Furthermore, studies, without exception, focus on a small sub-set of DPSIR dimensions/elements in a given locality. Although such detailed studies offer valuable insights about urban expansion processes, they fail to provide a complete snapshot. Comprehensive empirical studies of DPSIR dimensions/elements can help better comprehend the interconnectedness of DPSIR dimensions/elements, and better design and implement appropriate Responses to achieve sustainable urban expansion.

Second, most reviewed studies focus on the negative Impacts of urban expansion, with few on positive Impacts or Responses (Fig. 7, Fig. S2, Supplementary Material). Despite having several serious negative impacts, urban expansion also has some positive Impacts, e.g. infrastructure development and improved service delivery (Bett et al. 2011; Gwan and Kimengsi 2020), or improved housing quality (Tati 2016). However, it is not clear whether this evidence imbalance is due to a preferential research focus on the negative aspects of urban expansion, or whether indeed urban expansion has few positive Impacts in Africa. Similarly, it is not clear whether the comparatively low number of studies on Responses reflect there are few actually implemented Responses or it is an under-researched topic. Whatever the underlying reasons are, we need more research on the positive Impacts of (and Responses to) urban expansion as the current skewed focus might prevent opportunities to capitalise on the possible benefits of urban expansion or hinder the development and implementation of effective Responses to steer the (possibly) unavoidable urban expansion to a more sustainable path.

Third, we generally lack studies exploring actors dynamics (e.g. which stakeholders are involved, how they are linked, how they influence expansion, and eventually how they benefit/lose from urban expansion). Arguably, without good understanding of such dynamics and the underlying institutional landscape, it is unlikely that urban expansion studies would unravel sufficiently the Drivers and Impacts of urban expansion, and thus influence appropriate Responses.

Fourth, land is central in historical and ongoing urban expansion processes as attested both by the numerous studies exploring land-related aspects of urban expansion and their visibility in multiple DPSIR dimensions. Despite our relatively good understanding of the intersections between land, environment and livelihoods in urban expansion (e.g. processes of land use change and its impacts on ecosystems and livelihoods), we still lack understanding of some institutional aspects such as intersections between the multiple land tenure systems in urban peripheries (Lall et al. 2017; Mahendra and Seto 2019), or land speculation and unregulated land sales (Simon et al. 2004).

Finally, as African urbanisation exhibits some quite unique aspects compared to other regions of the world ("Introduction"), urban expansion patterns might be equally unique. As most African countries are at comparatively earlier stages of their urban transition than other global contexts, it would be useful to understand whether the currently observed urban expansion patterns in Africa reflect those of other regions. This can help identify promising Responses from other parts of the world that could enhance the sustainability of future urban expansion in Africa. Systematic

reviews, similar to the one presented here, for other global regions could help build this evidence base.

Conclusions

This systematic review of the peer-reviewed academic literature identified and synthesised the main dimensions of urban expansion in Africa, using the DPSIR model to structure the elicited information. Overall, African cities are rapidly expanding spatially, primarily driven by demographic and socioeconomic transitions, and assisted by the underlying institutional and governance landscape (Drivers). These Drivers induce Pressures in peri-urban social–ecological systems such as land use change, landscape modification, pollution and associated changes in lifestyles and demand which in turn affect their environmental health, infrastructure, demographic/cultural make-up and livelihoods (States). These processes cause mostly negative sustainability Impacts including farmland and natural vegetation loss, water resources depletion, ecosystem services loss, biodiversity loss, land tenure insecurity, and agrarian livelihoods transformation. Despite some efforts to put in place different legal, economic, and infrastructure-based Responses to mitigate the negative aspects and/or increase the sustainability of urban expansion, these tend to be poorly implemented.

Collectively this systematic review finds strong effect of demographic transitions on urban expansion, as well as the centrality of land (and its governance) in the observed patterns and processes of urban expansion. We observe the disproportionate focus of the literature on the negative Impacts of urban expansion, and a rather limited literature on Responses. We argue for the need for a more comprehensive and inclusive research on urban expansion, if we are to both understand properly this multi-dimensional phenomenon in Africa and put in place appropriate interventions to enhance urban sustainability across the rapidly urbanising continent.

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Author contributions KY and AG: conceptualisation and/or study design; KY and EBD: methodology—literature search and extraction; KY: methodology—data analysis and meta-data generation; KY: writing—original draft preparation; AG and EBD: writing—review and editing.

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Data availability The data in support of our study findings are available upon reasonable request to authors.

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