Mitig Adapt Strateg Glob Change (2024) 29:42
https://doi.org/10.1007/s11027-024-10136-2

ORIGINAL ARTICLE

A framework for assessing social structure in community governance of sustainable urban drainage systems: insights from a literature review

Simon Peter Muwafu[1] · Lena Rölfer[3] · Jürgen Scheffran[2] · María Máñez Costa[1]

Received: 2 August 2023 / Accepted: 12 April 2024 / Published online: 25 April 2024
© The Author(s) 2024

Abstract
The utilization of Sustainable Urban Drainage Systems (SUDS) as Nature-based Solutions (NBS) holds significant promise for enhancing resilience against climate change-induced flooding and promoting community well-being in urban areas of Sub-Saharan Africa. While existing research predominantly emphasizes technical aspects within the NBS framework, understanding the socio-governance dynamics at the community level is equally imperative, particularly given the decentralized nature of SUDS. This study aims to complement the prevailing technical focus by examining the social dimensions of community governance related to SUDS implementation. Through a literature review, key determinants of social structure influencing successful community governance in SUDS management are identified, and categorized into actors, resources, discourses, and rules of engagement. An innovative assessment framework comprising 65 indicators is proposed to evaluate these determinants, offering a comprehensive tool for scholars and practitioners. By integrating social considerations into SUDS management practices, this research seeks to inform policy formulation and strategies tailored to Sub-Saharan African cities, facilitating equitable and participatory urban stormwater management initiatives crucial for addressing climate change challenges.

Keywords Urban Stormwater Management · Green Infrastructure · Sub-Saharan Cities · Adaptation · Policy Arrangement Approach · Literature review

1 Introduction

Urban areas globally, especially in Sub-Saharan Africa, grapple with significant challenges in managing stormwater runoff effectively, amidst the challenges of rapid urbanization, population growth, and inadequate drainage infrastructure. (WMO 2019; IPCC 2022a, b) These

✉ Simon Peter Muwafu
simon.muwafu@hereon.de

[1] Helmholtz-Zentrum Hereon GERICS-Deutsches Institut Für Klimaservices, Hamburg, Germany

[2] Institute of Geography, University of Hamburg, Hamburg, Germany

[3] Faculty of Sustainability, Leuphana University Lüneburg, Lüneburg, Germany

difficulties are compounded by the escalating impacts of climate change, which exacerbate flooding risks and strain existing water management systems (UN-Habitat 2014).

In response, Sustainable Urban Drainage Systems (SUDS) have emerged as promising solutions, leveraging nature-based approaches to mitigate hydrological imbalances (Charlesworth et al. 2017). SUDS, incorporating green infrastructure elements like rain gardens and green roofs, mimic nature's ability to manage stormwater runoff by capturing, treating, and reusing it (Davis and Naumann 2017; Depietri and McPhearson 2017. Notably, SUDS are primarily managed at the local or community levels, necessitating community-level governance for inclusive decision-making and tailored project implementation to meet specific local needs (Evans 2011).

Community governance, emphasizing local management and decision-making, plays a pivotal role in addressing community needs, enhancing capacity, and promoting well-being within the context of SUDS implementation (Totikidis, Armstrong, & Francis, 2005). Through participatory processes, community governance identifies and implements activities, enhancing adaptive capacity and addressing vulnerabilities exacerbated by climate change (Ayers and Forsyth 2009; Reid et al. 2009). However, the influence of social structure determinants significantly shapes the collaborative and participatory nature of community governance, such as in the case of SUDS (Dorst et al. 2022). These determinants, encompassing social factors, guide interactions among community members, governance procedures, and policy processes related to accountability and effectiveness (Máñez et al. 2014; Fazey et al. 2021). Understanding the impact of these social determinants within the community governance framework of SUDS is essential for guiding decision-making processes and enhancing community organization (Mguni et al. 2016a).

Despite the significance of social structures, a notable knowledge gap exists concerning their specific influence on the integration of community governance into urban stormwater policy frameworks, especially regarding SUDS utilization in Sub-Saharan Africa. To address this gap, our study aims to explore the intricate relationship between social structures and effective community governance mechanisms of SUDS for urban stormwater management in the Sub-Saharan context. Through literature review and the Policy Arrangement Approach (Arts and Goverde 2006; Liefferink 2006), we aim to identify key social structure determinants shaping successful community governance patterns within nature-based urban stormwater management systems.

Specifically, our study intends to achieve the following objectives:

i) Review existing literature on social structure determinants influencing successful community governance, particularly in the context of urban stormwater management.
ii) Propose a novel framework for assessing social structure determinants in the integration of community governance of SUDS into policy frameworks.
iii) Discuss the practical implications of assessing social structure determinants for informing policy design and implementation strategies in Sub-Saharan African cities.

This study's significance lies in its ability to guide the development of customized stormwater management policies. Our newly developed framework for evaluating social structure determinants in integrating community governance of SUDS underscores the importance of organized integration in strategy processes. It acknowledges diverse forms of authority and the dynamic nature of change in implementation at the community level, a novel approach not previously applied to SUDS. By empowering

communities to shape their urban environments, our approach fosters resilience and promotes sustainable development practices rooted in local contexts.

2 Methodology

We follow a three-step approach to achieve the aforementioned objectives, including a literature review, analysis, and conceptualization.

2.1 Literature review

In the first step, we conducted a thorough literature search in December 2022, using the SCOPUS database. This search is integral to our research synthesis methodology, which involves selecting, evaluating, and synthesizing relevant existing literature on the topic (Xiao and Watson, 2019). Our goal was to gather diverse studies on governance in implementing nature-based solutions for stormwater management, with a specific focus on Sub-Saharan African cities. We chose the SCOPUS database for its broad coverage, multidisciplinary content, and advanced indexing capabilities, enhancing the likelihood of capturing a relevant body of literature. To expand our investigation, we explored additional sources like Web of Science, Cross-ref, Google Scholar, ResearchGate, and Academia.

Using a combination of OR/AND Boolean search criteria, we utilized selected keywords aligned with the concept domains of our research questions. The keywords, "nature-based solutions," OR "green infrastructure," aimed to explore various aspects of stormwater management through strategically planned natural spaces. We also included "sustainable urban drainage" keywords to focus on sustainable approaches. Recognizing the importance of community involvement, incorporating 'planning' OR 'management' keywords was crucial for gathering literature on the strategic planning and effective management of nature-based solutions, covering policy frameworks, implementation strategies, and project management approaches. Region-specific keywords 'Africa' and 'Sub-Saharan' refined the focus to the African context. This approach aimed to balance exhaustiveness and precision in our search (Xiao and Watson 2019).

To establish inclusion and exclusion criteria, we defined a specific timeframe (2011–2022) to capture noticeable shifts in literature and discourses regarding nature-based solutions. This period also aligns with significant advancements in the field. In the subsequent phase, we limited the search to English literature to ensure linguistic coherence. Articles were selected by reading titles and abstracts, prioritizing those addressing sub-Saharan African contexts. The authors had the freedom to incorporate articles with potential regional significance for sub-Saharan contexts. From the initially identified 87 articles, 47 were deemed relevant after excluding those primarily addressing water systems, stormwater quality, pollution, sanitation, stormwater runoff modeling, and urban forestry.

2.2 Analysis

In the second step, the selected literature was carefully analyzed to identify concepts, arguments, and findings that contribute to defining the critical determinants associated with various dimensions of the policy arrangement approach, which are pertinent to the research objective. This analysis encompasses discussions that potentially affect the community-level governance of SUDS (Fig. 1).

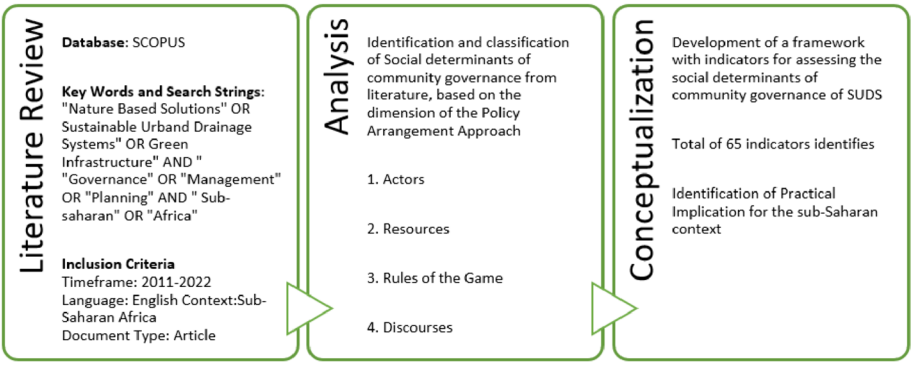

Fig.1 Three-step approach for developing an assessment framework of social structure determinants of community governance of SUDS

The policy arrangement approach used as a foundation for the analysis links structural, social, and political changes to everyday shifts in policy implementation. For instance, community-based governance, as a policy arrangement, stabilizes the structure and content of a specific policy domain at a particular policymaking level or across multiple levels (Leroy and Arts 2006). This approach comprises four interconnected dimensions, with three focusing on organizational or structural aspects: actors and coalitions, formal and informal rules, and resources and associated power. The fourth dimension pertains to substance, encompassing discourses reflecting actors' perspectives. Changes in one dimension correspondingly impact the others (Liefferink 2006). The interplay between the four dimensions is depicted through a tetrahedron, as shown in the Fig. 2 below.

In this study, community governance of SUDS involves coordinating the organizational and policy processes and the interactions between different social and political community

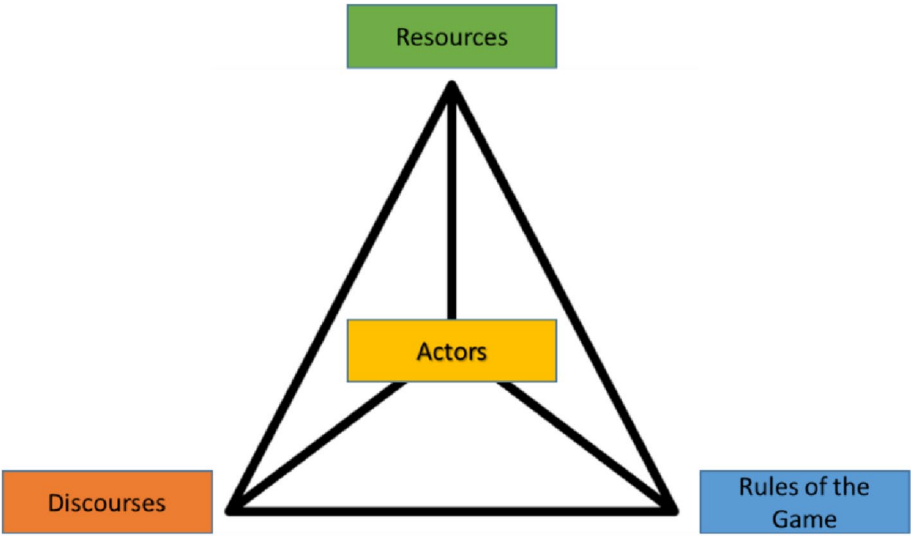

Fig. 2 Model of the Policy Arrangement Approach (adapted from (Arts and Goverde 2006))

actors towards a common public objective of enhancing the sustainability and equity of urban stormwater management using SUDS. The actors involved in the community governance of SUDS potentially include public and private stakeholders such as landowners, community planners, urban planning professionals, and civil society organizations (Qiao et al. 2019). *Resources* include community-level financial resources and facilities, knowledge and skills resources, and land priorities. The *rules of the game* include the formal and informal norms that define the actions of community actors during the implementation of SUDS. At the same time, *discourses* refer to community-level attitudes and perspectives toward SUDS (Qiao et al. 2018). Community change processes can be complex and nonlinear as different actors engage in various ways, potentially leading to solutions and disparities due to varying perspectives on the challenges (Carmen et al. 2021).

2.3 Conceptualization of indicators

In the third step, indicators are formulated based on this analysis to assess the diverse determinants identified in the literature. These indicators aid in identifying the most crucial issues within each of the four dimensions and facilitate the measurement of the performance of these dimensions within the community governance of SUDS for stormwater management.

3 A framework for assessing social structure determinants in local community level governance of SUDS

3.1 Dimensions and social structure determinants

The summary of social structure determinants that affect the community governance of SUDS is categorized according to the four dimensions of the policy arrangement approach: actors, resources, discourses, and rules of the game, as depicted in Table 1.

3.2 Actors

In sub-Saharan cities, the community governance of SUDS involves a range of actors and stakeholders. Public stakeholders may include government officials and local authority representatives responsible for urban planning and infrastructure development (Herslund and Mguni 2019). Private stakeholders, on the other hand, may include landowners, property developers, and consultants involved in urban planning and design. In addition, civil society organizations, community planners, and urban planning professionals may also play a role in the community governance of SUDS (Mguni et al. 2016a, b). The levels and rates of collaboration in developing and implementing strategies for sustainable and effective stormwater runoff management while considering the needs and viewpoints of local communities are primarily influenced by the participation of these actors (Williams et al. 2018).

The range of actors involved in the community governance of SUDS has a significant impact not only on the level and quality of local leadership but also on the allocation of responsibility, which in turn affects the involvement of stakeholders in implementing SUDS (Sutherland et al. 2016). Community perceptions of risk, which are shaped by the local understanding of preparedness, are often influenced by factors such as actors' knowledge

Table 1 Key social structure determinants that influence community governance organized by the four dimensions of the Policy Arrangement Approach

DIMENSION	SOCIAL STRUCTURE DETERMINANTS
ACTORS	• Community leadership and allocation of responsibility
	• Community innovation
	• Technical skills and competencies
	• Private stakeholder involvement
	• Academia involvement
RESOURCES	• Community priorities for funding from both public and private sources
	• Community financial incentives
	• Priorities for land use and development by both public and private entities
	• Human resources
	• Knowledge of SUDS
DISCOURSES	• Management strategies and planning processes
	• Environment regeneration and protection
	• Knowledge of suds ecosystem services
	• Community participation
	• Communication and information dissemination
RULES OF THE GAME	• Regulatory frameworks and legislative support
	• Cultural norms, values, and local languages
	• Quality and reliability of community politics
	• Equitable treatment of all partners
	• Gender Roles and Equality

levels, academic involvement, and the level of innovation in the community (Dodman and Mitlin 2013; Williams et al. 2020; Sañudo-Fontaneda and Robina-Ramírez 2019). These factors can facilitate the implementation of new and creative ideas, productive collaborations, and effective governance, all of which are central to the implementation and management of SUDS (Herslund and Mguni 2019).

Education campaigns can help to increase the adoption of SUDS among private stakeholders by promoting awareness of the benefits of SUDS, such as improved stormwater management, reduced flooding, and improved water quality (Bredhauer 2016; Armitage et al. 2013). However, the time needed for implementing or managing SUDS can be a significant factor in determining private stakeholders' level of engagement, as it may require substantial investments in time and resources (Olumuyiwa 2014). Therefore, it is essential to consider the perspectives and priorities of private stakeholders and the potential barriers they may face when developing and implementing SUDS strategies. Addressing these barriers can help to ensure that private stakeholders are fully engaged in promoting sustainable stormwater management practices.

3.3 Resources

Access to sufficient community resources is essential for successfully implementing SUDS in sub-Saharan cities. These resources encompass a range of financial, infrastructural, technical, and knowledge-based assets at the local level (Winter 2016). Financial resources can be used to invest in the necessary infrastructure, such as permeable pavements, rain

gardens, and green roofs, which can help to reduce runoff and improve stormwater management (Cettner and Ashley 2014).

Technical knowledge and experience levels within the community can also be critical in successfully implementing SUDS (Armitage 2011). Community training programs and educational materials can help to increase awareness of SUDS, influence the availability of labor to oversee implementation, and promote the adoption of sustainable practices. The technical expertise of community members can also be leveraged to support the design, installation, and maintenance of SUDS infrastructure (Bredhauer 2016; du Toit et al. 2018). In addition to financial and technical resources, space availability for SUDS implementation is also essential. Community land priorities, such as designating spaces and areas for green infrastructure, can play a critical role in promoting effective stormwater management (du Toit et al. 2018). The availability of land for SUDS implementation is crucial in areas where land is scarce or competition for land use is high (Mguni et al. 2016a, b).

Finally, market incentives can also play a role in motivating the uptake of SUDS. For example, tax incentives or rebates may encourage homeowners or businesses to invest in SUDS infrastructure, while financial incentives may motivate developers to incorporate SUDS into their projects (Ndeketeya and Dundu 2019).

3.4 Discourses

The discourses surrounding the community governance of SUDS are crucial in determining the structure of local governance arrangements, decision-making processes, and power distribution within the community (Herslund and Mguni 2019). These discourses, which may include local neighborhood meetings, community forums, social groups, and other communication channels, refer to the various forms of communication and exchange of ideas, information, and opinions among community members regarding the governance of their community (Williams et al. 2020). The discourses may also reflect the values and beliefs of community members, as well as their social and political attitudes and perspectives toward environmental sustainability programs (Sañudo-Fontaneda and Robina-Ramírez 2019).

In addition to shaping community norms and rules for behavior, practical community governance discourses necessitate active engagement, respect for diverse perspectives, and a willingness to engage in constructive dialogue. Engaging in such dialogues can nurture a sense of community ownership and collective responsibility for the community's welfare. This involves empowering residents and stakeholders to actively and meaningfully participate in making decisions, managing, and implementing projects or initiatives that directly influence their lives and well-being. Consequently, these inclusive practices contribute to more effective and sustainable governance (Mulligan et al. 2020). Community-level discourses can also influence management strategies and planning processes for the implementation of SUDS, community awareness of and reliance on the ecosystem services provided by SUDS, as well as the community's inclinations towards post-flood environmental regeneration and protection (Shackleton et al. 2015).

3.5 Rules of the game

Rules of the game, whether formal or informal, play a crucial role in shaping the behavior of community actors during the implementation of SUDS. Formal rules may be established through regulatory frameworks or legislative support, guiding issues such as zoning, land

use, environmental protection, risk mapping, emergency planning, and water management (Ndeketeya and Dundu 2019). These formal rules ensure compliance and accountability among community actors (Qiao et al. 2019). However, informal rules, such as cultural norms and local languages, are critical in shaping behavior and determining social rules. For example, community members may have cultural practices that influence how they interact with the environment or other community members.

Similarly, local languages may determine how information is communicated and disseminated among community members, influencing the effectiveness of communication strategies (du Toit et al. 2018). Gender roles and equality are also important considerations when it comes to the implementation of SUDS. Women, for example, may have different roles and responsibilities within the community that may affect their participation in SUDS projects (Dodman and Mitlin 2013). Ensuring equitable treatment of all community partners is also essential for building trust and transparency in local political actions and promoting cooperation among stakeholders involved in the implementation or management of SUDS (Dodman and Mitlin 2013).

3.6 Indicators for assessing social structure determinants

As depicted in Table 2, a set of indicators has been developed to render the social structure determinants more concrete and practical for assessing the potential integration of community governance of SUDS into local urban stormwater management frameworks. These indicators have been specifically designed to facilitate a comprehensive evaluation of community governance in the context of SUDS governance. They serve as a tool for measuring the performance of the social structure determinants and the various dimensions of the policy arrangement within community governance.

Through carefully assessing these elements, it becomes feasible to identify specific dimensions within community governance that may exhibit deficiencies or vulnerabilities. This identification, in turn, creates valuable opportunities for implementing targeted interventions and strategic actions to address these specific dimensions. The objective is to enhance the overall effectiveness of community governance and enable a seamless integration of SUDS into local urban stormwater management frameworks.

The assessment of these indicators can be conducted through interviews with relevant stakeholders or stakeholder groups who have a stake or are affected by the SUDS governance processes, both at the individual and system levels. Each indicator's performance can be evaluated using a predefined scale, such as low, medium, or high, which can be calibrated, based on the community stakeholders' capacities to engage with involvement and participation in SUDS governance processes, such as design and management.

The overall performance of indicators at the system level can be evaluated using a weighted average rating. This involves assigning specific weights to each indicator based on its relative importance within the community governance framework. The performance ratings of all indicators are then multiplied by their respective weights and added to calculate the weighted average rating, providing a comprehensive measure of the system's effectiveness. This approach allows for a holistic assessment that considers the collective impact of various indicators and their significance in managing the community governance aspects being evaluated.

It is essential to acknowledge that there may not be a need to evaluate all indicators within the framework in a given assessment. The evaluation process can be context-specific and selective, with indicators chosen from different framework dimensions based on the

Table 2 Framework for assessing social structure determinants of community governance for Sustainable Urban Drainage Systems

DIMENSION	DETERMINANT	EXPLANATION	INDICATOR	REFERENCE
ACTORS	Community leadership and allocation of responsibility	Particular assignment and definition of duties related to the implementation and management of SUDS	• Precise definitions of objectives and goals related to sustainable management of stormwater in urban areas and the implementation of SUDS • Degree of community individuals' dedication to participate in the implementation of SUDS	(Sutherland et al. 2016)
	Community innovation	Development of creative ideas, solutions, and practices by community members that contribute to the effective management and maintenance of SUDS	• Level of participation of community members in the planning, design, implementation, and monitoring of SUDS • The extent to which local knowledge and resources are applied to develop efficient SUD solutions that meet the community's needs	(Mguni et al. 2016a)
	Technical skills and competencies	Degree of technical knowledge and proficiency in SUDS within the community	• Level of knowledge about SUDS's design, construction, operation, and maintenance • Level of community understanding regarding the technical dimensions of stormwater management	(Herslund and Mguni 2019; Morison and Brown 2010)
	Private stakeholders' involvement	Participation of non-public community actors, including firms, companies, and private individual investors, in SUDS preparation, development, performance, and management	• Private sector financial contribution to SUDS initiatives • Private sector involvement in SUDS planning and implementation • Transparency of private sector interests and decision-making in SUDS	(Dhakal and Chevalier 2017; Bos and Brown 2015)
	Academia involvement	Participation of academic institutions, researchers, and scholars in the planning, design, implementation, and evaluation of community SUDS initiatives	• Level of involvement and collaboration between academic experts, institutions, and local community organizations on SUDs projects • Quantity and quality of SUDs research publications • Availability of SUDs community training programs and events led by academic institutions	(Bredhauer 2016; Mulligan, et al. 2020)
RESOURCES	Community priorities for SUDS funding from both public and private sources	Identification and allocation of financial resources towards specific SUDS projects and programs based on their level of urgency, feasibility, and potential impact on the community	• The proportion of the budget for community SUDS projects by local governments, NGOs, and private entities • Criteria used for evaluating and prioritizing community SUDS projects, such as impact, feasibility, and cost-effectiveness	(Armitage 2011; Mguni, Herslund and Jensen 2016a, b)
	Community financial incentives	Monetary incentives such as rebates, tax credits, grants, or other forms used by the community or local government to encourage the adoption of SUDS)	• The number of financial incentive programs implemented by the local government to promote the adoption of SUDS • Amount of funding allocated to SUDS programs • The number of individuals or businesses receiving financial incentives to implement SUDS	(Ndeketeya and Dundu 2019)

Table 2 (continued)

DIMENSION	DETERMINANT	EXPLANATION	INDICATOR	REFERENCE
	Priorities for land use and development by both public and private entities	Strategic allocation of land for the implementation of sustainable urban stormwater management practices such as SUDS, taking into consideration the needs and interests of both public and private stakeholders	• Degree of consideration of SUDS implementation in community land use decision-making processes • Percentage of public land allocated for SUDS • Level of collaboration between public and private entities in land use planning and SUDS implementation • The number of policies and regulations promoting SUDS integration in land use planning	(Dhakal and Chevalier 2017; Sutherland et al. 2016)
	Human resources	The presence, proficiency, and competencies of individuals and collectives engaged in the preparation, creation, execution, and supervision of SUDS, e.g., public officials, private industry stakeholders, and specialists with technical expertise in establishing stormwater management infrastructures	• Adequacy of staffing levels and resources allocated to support SUDS implementation and management • Availability and accessibility of relevant training programs and resources for SUDS management • The capacity of local government officials and private sector actors to support SUDS implementation and management	(Dhakal and Chevalier 2017; Morison and Brown 2010)
	Knowledge of SUDS	The community's level of understanding and awareness regarding the technical and operational aspects of sustainable urban drainage systems (SUDS) for stormwater management	• Number of community members with knowledge of SUDS design and implementation • Number of community members with technical expertise in stormwater management and SUDS • Level of community awareness and understanding of the benefits of SUDS • Availability of SUDS-related training and education programs for community members	(Barbosa et al. 2012; Cettner et al. 2014)
DISCOURSES	Management strategies and planning processes	The techniques and steps utilized by community stakeholders involve the creation of policies, regulations, and plans that define the duties, accountabilities, and measures necessary to accomplish the objectives of SUDS	• The number of community stormwater management plans in place • Use of adaptive management to respond to changing conditions • The scale of allocation of resources to support SUDS implementation and management • Regular monitoring and evaluation of SUDS performance for future planning	(du Toit, et al. 2018)
	Environment regeneration and protection	Measures taken to restore, preserve, and enhance natural ecosystems and biodiversity within communities through the implementation of SUDS, e.g., designing or implementing SUDS to promote the sustainable use of natural resources	• Stakeholder collaboration level in sustainable SUDS practices • Community participation in SUDS maintenance and management for habitat and ecosystem protection and restoration • Community knowledge of SUDS' environmental benefits for regeneration and protection	(Shackleton 2015)

Table 2 (continued)

DIMENSION	DETERMINANT	EXPLANATION	INDICATOR	REFERENCE
	Knowledge of SUDS Ecosystem services	Understanding of the pros and cons of SUDS for ecosystem services, including benefits like improved water quality and biodiversity, as well as potential risks like changes to land use and impacts on local communities	• Community knowledge of SUDS ecosystem services • Community familiarity and usage of monitoring methods for SUDS ecosystem services • Incorporation of ecosystem service considerations in SUDS decision-making	(Shackleton 2015)
	Community participation	Active engagement of community members and stakeholders in collaborative SUDS solution development that meets community needs and broader environmental/social goals	• Community ownership, engagement, and management of SUDS infrastructure and projects • Community awareness and understanding of SUDS • Community satisfaction and perceived effectiveness of SUDS • Community-led initiatives and activities for SUDS education and advocacy	(Mguni, Herslund, and Jensen 2016a, b)
	Communication and information dissemination	The various ways in which information about stormwater management using SUDS and related activities are shared among community members, stakeholders, and relevant authorities	• Existence and quality of community communication plan for SUDS projects • Diversity, frequency, and quality of communication activities to stakeholders • Effectiveness of communication activities in raising awareness and increasing knowledge • Effectiveness of feedback mechanisms in assessing stakeholder perception of SUDS	(Mguni et al. 2015)
RULES OF THE GAME	Regulatory frameworks and legislative support	The laws, policies, and guidelines that provide a legal and institutional basis by defining the roles and responsibilities of different stakeholders, outlining the procedures for decision-making and implementation, and establishing standards and criteria for SUDS design, construction, operation, and compliance with environmental and health regulations	• Existence and comprehensiveness of SUDS-related laws and policies at the national and local levels • Level of compliance with environmental and health regulations in the design, construction, and operation of SUDS • Effectiveness of SUDS integration into broader urban planning and development strategies • Frequency and quality of monitoring and evaluation of SUDS regulatory frameworks to assess their effectiveness and identify areas for improvement	(Ndeketeya and Dundu 2019; Jiusto and Kenny 2016)
	Cultural norms, values, and local languages	The cultural practices, beliefs, and language systems influence the attitudes and behaviors of community members towards SUDS	• The scale of diverse cultural group representation in SUDS decision-making and governance • The scale of use of local languages/culturally appropriate communication in SUDS planning • Level of incorporation of traditional knowledge for water management into SUDS design • Respect cultural values related to water/land use in SUDS decisions	(du Toit et al. 2018)

Table 2 (continued)

DIMENSION	DETERMINANT	EXPLANATION	INDICATOR	REFERENCE
	Quality and reliability of community politics and power dynamics	The effectiveness, transparency, and accountability of community-level decision-making processes and mechanisms that guide the planning, implementation, and management of SUDS	• Level of transparency and accountability in community decision-making processes • Level of trust and cooperation among stakeholders of community-led initiatives • Presence of conflict resolution mechanisms • Presence of a mechanism to report the abuse of power	(Dhakal and Chevalier 2017; Armitage et al. 2013)
	Equitable treatment of all partners	The fair and just treatment of all stakeholders involved in the planning, implementing, and managing sustainable urban drainage systems (SUDS), regardless of their socio-economic status, ethnicity, or other characteristics	• Level of inclusivity/diversity of SUDS decision-making and marginalized group representation • Level of equitable distribution of SUDS benefits/costs for all stakeholders • Level of access to SUDS governance information/resources for everyone • The scale of implementation of policies/mechanisms for equal participation and power balance	(Dodman and Mitlin 2013; Cettner et al. 2014)
	Gender Roles and Equality	The extent to which gender considerations are integrated into decision-making processes and implementation of SUDS, such as recognizing the different needs, roles, and responsibilities of women and men concerning water management	• Level of women's participation/representation and gender-specific needs in SUDS • Level of stakeholders' awareness of gender issues in SUDS governance • The scale of implementation of policies/mechanisms for gender equality in SUDS governance	(Dodman and Mitlin 2013; Patt and Suarez 2009)

specific requirements and objectives. This allows for a more focused and relevant assessment, tailored to the unique circumstances, without the burden of assessing every indicator in the framework. Figure 3 illustrates a method for evaluating community governance of Sustainable Urban Drainage Systems (SUDS) within a specific study area.

4 Practical implications of applying assessments of social structure determinants of community governance of SUDS

Assessing the determinants of social structure within the community-level governance of SUDS is crucial for understanding the factors influencing their effectiveness as community-led initiatives (Nóblega Carriquiry et al. 2020). This discussion builds upon the developed framework, delving into practical implications tailored to the sub-Saharan context.

4.1 Local actor empowerment

In sub-Saharan contexts, renowned for successful community-led initiatives, evaluating local actors and leadership in governing SUDS is a foundational step (Mguni et al. 2016a, b). This assessment can contribute to the understanding of vital roles played by local leaders in fostering community engagement. By comprehending the roles of local actors and leaders thoroughly, the assessment can facilitate the identification of entry points for their involvement, empowering them to be catalysts for transformative change, drive community engagement, and ensure that SUDS projects resonate with the unique fabric of each local community (Nemutamvuni et al. 2020). This not only enhances the efficiency of SUDS as stormwater management projects but also reinforces the community's commitment to the initiatives in place, fostering a sense of ownership within the community and contributing to the sustainability and success of SUDS projects.

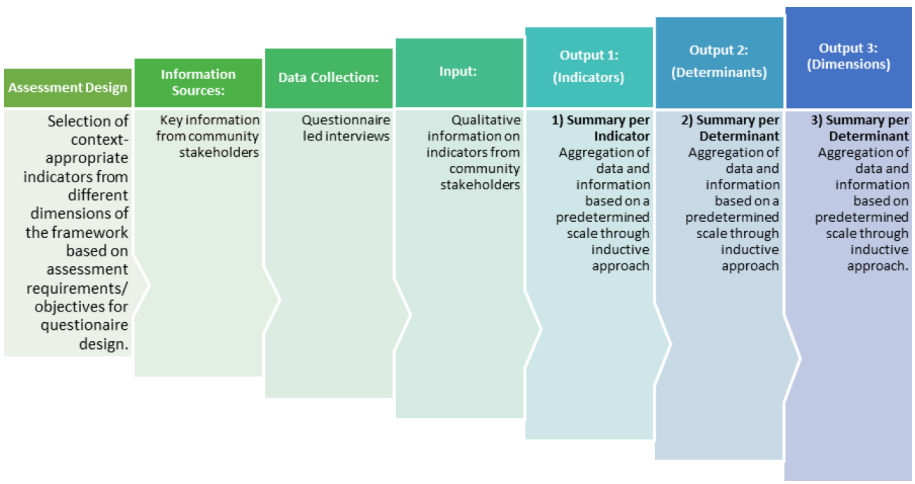

Fig. 3 Methodology for Applying Framework for Assessing Community Governance of SUDS

4.2 Addressing socio-economic considerations and financial constraints

Our assessment framework acknowledges the inherent link between the success of community-led initiatives in Sub-Saharan contexts and socio-economic factors, encompassing elements like income disparities, poverty, and their interconnected association with vulnerability (Cilliers 2019). It recommends a strategic evaluation of governance determinants dependent on resources, including community human resources, available land for implementing SUDS projects, and funding, which significantly influence community engagement. This assessment seeks to identify opportunities to optimize cost-effectiveness, and task allocation based on community skills and capacities, identify incentives for active community participation, and guide fund allocation decisions by weighing synergies and trade-offs among SUD options or other stormwater management approaches. These considerations are essential for bolstering the sustainability of community-governed SUDS projects.

4.3 Assessing regulatory frameworks for transparency and accountability

The evaluation of local regulatory frameworks is essential for transparency and accountability in community-led initiatives, particularly within the sub-Saharan context, which has a historical legacy of corruption and mismanagement of public funds (Williams et al. 2018). It serves to foster good governance practices and ensure responsible utilization of resources. Within the community governance of SUDS, analyzing these frameworks provides possibilities to identify gaps, inefficiencies, or potential areas of improvement that can contribute to a more robust and accountable governance structure (Wijesinghe and Thorn 2021). Moreover, this evaluation can provide a mechanism for instilling public trust and confidence in community-led SUDS initiatives. When regulatory frameworks are transparent and well-monitored, community members are more likely to actively engage and participate in these initiatives, knowing that their contributions and resources are managed in a responsible and accountable manner. This, in turn, contributes to the overall success and sustainability of community-led projects.

4.4 Examining discourse dynamics

In diverse sub-Saharan urban communities, exploring discourse-related determinants within the framework establishes a basis for SUDS community governance rooted in transparent and inclusive planning (Shackleton et al. 2015). This goes beyond technical aspects, delving into community dynamics, where effective discourse acts as a catalyst for meaningful change. Factors like community participation, information dissemination, management strategies, and planning processes empower stakeholders to express perspectives and voice concerns. (Mulligan et al. 2020). This process not only facilitates open communication but also supports the building of trust between community members and decision-makers. Trust becomes pivotal in fostering an environment where collaboration and cooperation are the norm, not the exception (Diep et al. 2022). This, in turn, nurtures a sense of ownership and responsibility among community members, encouraging active participation in decision-making processes that directly impact the implementation of SUDS in their living spaces.

4.5 Innovation and collaboration assessment for effective governance

Broadening the assessment to evaluate community innovation, technical skills, private stakeholder engagement, and academia involvement is a recognition of the nuanced and location-specific traits within local adaptation arenas in sub-Saharan communities (Dodman and Mitlin 2013). This evaluation becomes a crucial tool in shaping SUDS solutions that are tailored to the unique challenges of each community. By acknowledging the distinct context and characteristics, the assessment ensures that SUDS initiatives are not one-size-fits-all but rather responsive to the intricacies of each local environment. Furthermore, the assessment of private stakeholders and academia involvement unveils opportunities to synergize local insights with external expertise. This strategic integration not only opens avenues for private sector investments in stormwater management but also enriches the decision-making processes with diverse perspectives. The collaboration between local and external actors further enhances the robustness of SUDS initiatives, fostering innovation and efficiency.

4.6 Cultural and environmental adjustment

The governance assessment framework places a significant focus on evaluating the influence of integrating cultural values into the design and governance of SUDS. Tailoring assessments to diverse cultural and environmental contexts in sub-Saharan Africa underscores the need to cultivate local knowledge. This approach ensures that vulnerability assessments not only identify key factors but also facilitate the seamless integration of evaluation outcomes into actionable steps within planning processes. The framework, therefore, underscores the dynamic relationship between cultural values, local knowledge generation, and the effective implementation of SUDS initiatives.

5 Conclusion

This study presents a novel assessment framework rooted in the policy arrangement approach to evaluate social determinants influencing community governance in SUDS implementation. By exploring dimensions such as community actors, resources, discourses, and rules of the game, this holistic approach provides insights into the intricate dynamics of community governance systems. The development of 65 indicators offers a comprehensive tool for researchers and practitioners to delve into the complexities of SUDS management.

The contextual nuances within the sub-Saharan context underscore the importance of tailored assessments that account for local adaptation arenas. Moreover, the emphasis on community knowledge and participation highlights the significance of inclusivity in SUDS projects. However, challenges persist in assessing ecological and economic factors, as well as broader issues beyond community control, such as state support and resource distribution.

While this study primarily focuses on social structure determinants, addressing these challenges will be crucial for advancing community governance of SUDS. Future research should strive to develop strategies that effectively navigate these complexities, ensuring equitable and sustainable management of nature-based urban stormwater systems.

Author contributions Simon Muwafu conceived the idea, conducted the literature search and formal analysis, and drafted the initial manuscript. Simon Muwafu and Lena Rölfer devised the research design. María Máñez Costa and Jürgen Scheffran provided guidance and supervision. All authors critically revised and approved the final version, resulting in a comprehensive contribution to the sustainable urban drainage systems field.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability We do not analyze or generate any datasets. One can obtain relevant materials from the references below.

Declarations

Conflict of interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Anderson P, Okereke C, Rudd A, Parnell S (2013) Regional assessment of Africa. In Elmqvist T, Fragkias M, Goodness J, Güneralp B, Marcotullio J, McDonald RI, . . . Wilkinson C. Urbanization, Biodiversity and Ecosystem Services: Challenges and pportunities (pp. 453–459). Dordrecht: Springer. https://doi.org/10.1007/978-94-007-7088-1_23

Armitage N, Vice M, Fisher-Jeffes L, Winter K, Spiegel A, Dunstan J (2013) Alternative Technology for Stormwater Management: The South African Guidelines for Sustainable Drainage Systems. Water Res Comm

Armitage N (2011) The challenges of sustainable urban drainage in developing countries. SWITCH closing conference (24–26 January 2011). Paris, France

Arts B, Goverde H (2006) The Governance capacity of (new) policy arrangements: a reflexive approach. In: Arts B, Leroy P. Institutional Dynamics in Environmental Governance. Springer, Dordrecht. https://doi.org/10.1007/1-4020-5079-8_4

Asadzadeh A, Fekete A, Khazai B, Moghadas M, Zebardast E, Bisirat M, Kotter T (2023) Capacitating urban governance and planning systems to drive transformative resilience. Sustain Cities Soc 9:104637. https://doi.org/10.1016/j.scs.2023.104637

Ayers J, Forsyth T (2009) Community based adaptation to climate change. Environ Sci Policy Sustain Dev 22–31

Barbosa AE, Fernandes JN, David LM (2012) Key issues for sustainable urban stormwater management. Water Res 46(20):6787–6798

Biesbroek R (2021) Policy Integration and Climate Adaptation. Current Opin Environ Sustain 52:75–81. https://doi.org/10.1016/j.cosust.2021.07.003

Bos G, Brown H (2015) Overcoming barrier to community participation in catchment scale experiment: building trust and changing behavior. Freshwater Sci. https://doi.org/10.1086/682421

Bredhauer M (2016) Transformative adaptation in informal settlements: the case of kounkuey design initiative in Kibera. Department for international development

Brouwer H, Woodhill M, Hemmati M, Verhoosel K, van Vugt S (2016) The MSP guide: how to design and facilitate multi-stakeholder partnerships. Practical Action Publishing, Wageningen

Carmen E, Fazey I, Caniglia G, Anthony J, Penny L (2021) The social dynamics in establishing complex community climate change initiatives: the case of a community fridge in Scotland. Sustain Sci 17:259–273. https://doi.org/10.1007/s11625-021-01075-x

Cettner A, Ashley RH (2014) Sustainable development and urban stormwater practice. Urban Water J 11(3):185–197

Cettner A, Hedstrom A, Asley R, Viklander M (2014) Assessing receptivity for change in urban stormwater management and contexts of action. J Environ Manag 29–41. https://doi.org/10.1016/j.jenvman.2014.07.024

Chambers J, Wyborn C, Klenk N, Ryan M, Serban A, Bennett N, . . . Spierenburg M (2022) Co-productive agility and four collaborative pathways to sustainability transformations. Glob Environ Change 72:102422. https://doi.org/10.1016/j.gloenvcha.2021.102422

Charlesworth S, Winter K, Adam-Bradford A, Mezue M, McTough M, Warwick F, Blackett M (2017) Sustainable drainage in challenging environments. New Water Policy Pract:2380–6540

Cilliers EJ (2019) Reflecting on Green Infrastructure and Spatial Planning in Africa: The Complexities Perceptions and Way Forward. Sustain 11(2):455. https://doi.org/10.3390/su11020455

Dahlenburg J, Morison P (2009) Tapping into our biggest resource: engaging with the community in water quality objective setting and WSUD planning. Conference: 6th International Water Sensitive Urban Design Conference, May 2009, Perth

Davis M, Naumann S (2017) Making the case for sustainable urban drainage systems as a nature-based solution to urban flooding. In: Kabisch NK. Nature-based solutions to climate change adaptation in urban areas.theory and practice of urban sustainability transitions. Springer. https://doi.org/10.1007/978-3-319-56091-5_8

Depietri Y, McPhearson T (2017) Integrating the grey, green, and blue in cities: Naturebased solutions for climate change adaptation and risk reduction. In: Kabisch N, Korn H, Stadler J, Bonn A. Nature-based solutions to climate change adaptation in urban areas. Theory and practice of urban sustainability transitions (pp. 91–109). Springer, Cham

Dhakal K, Chevalier RL (2017) Managing urban stormwater for urban sustainability: barriers and policy solutions for green infrastructure application. J Environ Manag 171–181. https://doi.org/10.1016/j.jenvman.2017.07.065

Diep L, Mulligan J, Oloo M, Guthman L, Raido M, Ndenzi T (2022) Co-building trust in urban nature: Learning from participatory design and construction of Nature-Based Solutions in informal settlements in East Africa. Front Sustain Cities 4. https://doi.org/10.3389/frsc.2022.927723

Dodman D, Mitlin D (2013) Challenges for community based adaptation: discovering the potential for transformation. J Int Dev 640–659

Dorst H, van der Jagt A, Toxopeus H, Tozer L, Raven R, Runhaar H (2022) What's behind the barriers? Uncovering structural conditions working against urban nature-based solutions. Landsc Urban Plan 220:104335. https://doi.org/10.1016/j.landurbplan.2021.104335

Douglas I (2018) The challenge of urban poverty for the use of green infrastructure on floodplains and wetlands to reduce flood impacts in intertropical Africa. Landsc Urban Plan 180:262–272. https://doi.org/10.1016/j.landurbplan.2016.09.0

du Toit M, Sarel C, Martin D, Goddard M, Solène G, Susanna F (2018) Urban green infrastructure and ecosystem services in sub-Saharan Africa. Landsc Urban Plan 180:249–261. https://doi.org/10.1016/j.landurbplan.2018.06.001

Evans JP (2011) Environmental Governance (1 ed.). London: Routledge. https://doi.org/10.4324/9780203155677

Eversole R (2011) Community agency and community engagement: re-theorising participation in governance. J Publ Policy 31(01):51–71

Fazey I, Carmen E, Ross H, Rao-Williams J, Hodgson A, Searle B, . . . Kenter J (2021) Social dynamics of community resilience building in the face of climate change. Sustain Sci 16(5):1731–1747

Flynn CD, Davidson C (2016) Adapting the social-ecological system framework for urban stormwater management: the case of green infrastructure adoption. Ecol Soc 21(4):26270003

Gajjar SP, Wendo H, Polgar A, Hofemeier A (2021) Ecosystem-based flood management: a comparative study report of the cities of Cape Town and Durban (South Africa), Nairobi, and Mombasa (Kenya). Berlin: PlanAdapt Collaborative. Climate and Development Knowledge Network (CDKN).

Herslund L, Mguni P (2019) Examining urban water management practices – Challenges and possibilities for transitions to sustainable urban water management in Sub-Saharan cities. Sustainable Cities Soc 48:101537. https://doi.org/10.1016/j.scs.2019.101573

IPCC (2014) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, New York

IPCC (2022a) Climate change: impacts, adaptation, and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change. Cambridge, UK and New York, NY, USA: Cambridge University Press. https://doi.org/10.1017/9781009325844.

IPCC (2022b) Climate change 2022: impacts, adaptation and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change(Africa). New York: Cambridge University Press.

IUCN (2020) IUCN global standard for nature-based solutions. IUCN, Gland

IUCN (2017) From guiding principles to action: integrating a gender-responsive and socially inclusive approach into SRJS strategies and results; IUCN

Jiusto S, Kenny M (2016) Hard rain gonna fall: strategies for sustainable urban drainage in informal settlements. 13(3):253-269.https://doi.org/10.1080/1573062X.2014.991329
Leroy P, Arts B (2006) Institutional dynamics in environmental governance. Springer, Dordrecht
Liefferink D (2006) The dynamics of policy arrangements: turning round the tetrahedron. In: Arts B, Leroy P (eds) vol 47. Springer, Dordrecht. In:Leroy P, Arts B, Institutional dynamics in environmental governance. Springer, Dordrecht
Máñez M, Carmona M, Gerkensmeier B (2014) Assessing governance performance, Report 20. Hamburg: Climate Service Center, German
Mesham TG, Preston BL, Smith TF, Brooke C, Goddard R, Withycombe G, Morrison C (2011) Adapting to climate change through local municipal planning: Barriers and challenges. Mitig Adapt Strat Glob Change
Mguni P, Herslund L, Bergen M (2016a) Sustainable urban drainage systems: examining the potential for green infrastructure-based stormwater management for Sub-Saharan Cities. Nat Hazards 82(2)
Mguni P, Herslund L, Jensen MB (2016b) Sustainable urban drainage systems: examining the potential for green infrastructure-based stormwater management for Sub-Saharan cities. Nat Hazards 82(Suppl 2):241–257. https://doi.org/10.1007/s11069-016-23
Mguni P, Jensen MB, Herslund L (2015) Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: exploring the potential for transitions towards sustainable urban water management. Water Policy 17:126–142. https://doi.org/10.2166/wp.2014.047
Morison PJ, Brown RR (2010) Avoiding the presumptive policy errors of intergovernmental environmental planning programmes: A case analysis of urban stormwater management planning. J Environ Planning Manage 53:197–217
Moyson S, Scholten P, Weible CM (2017) Policy learning and policy change: Theorizing their relations from different perspectives. Policy Soc 36(2):161–177
Mulligan J, Bukachi V, Clause J, Jewell R, Kirimi F, Chelina O (2020) Hybrid infrastructures, hybrid governance: New evidence from Nairobi (Kenya) on green-bluegrey infrastructure in informal settlements. Anthropocene 29:100227
Ndeketeya A, Dundu M (2019) Maximising the benefits of rainwater harvesting technology towards sustainability in urban areas of South Africa: a case study. Urban Water J 16(2):163–169. https://doi.org/10.1080/1573062X.2019.1637907
Nemutamvuni K, McKay TJM, Tantoh HB (2020) Active citizenry community - Based organisations and the protection of urban wetlands: The case of Colbyn Tshwane South Africa. Glob Ecol Conserv 24:e01244. https://doi.org/10.1016/j.gecco.2020.e01244
Nóblega Carriquiry A, Saurí D, March H (2020) Community involvement in the implementation of Sustainable Urban Drainage Systems (SUDSs): The case of Bon Pastor, Barcelona. Sustainability, 12, 510. https://doi.org/10.3390/su12020510
Olumuyiwa BA (2014) Coping with stormwater in a Johannesburg, South Africa informal settlement. Proceedings of the Institution of Civil Engineers. Johannesburg
Parkinson J, Taylor K, Mark O (2007) Planning and design of urban drainage systems in informal settlements in developing countries. Urban Water J 4(3)
Patt A, Suarez P (2009) Gender and climate change vulnerability: what's the problem, what's the solution? In: Ruth M, Ibarraran M, & Edward E, Distributional impacts of climate change and disasters: concept and cases (pp. 82–102). Cheltenham
Pedersen Zari M, MacKinnon M, Varshney K (2022) Regenerative living cities and the urban climate–biodiversity–wellbeing nexus. Nat Clim Chang 12:601–604
Pozarny P (2016) Gender roles and opportunities for women in urban environments (GSDRC Helpdesk Research Report 1337). GSDRC, University of Birmingham, Birmingham
Qiao KA, Liu L, Randrup T (2019) Governance factors of sustainable stormwater management: A study of case cities in China and Sweden. J Environ Manag 248:109249. https://doi.org/10.1016/j.jenvman.2019.07.020
Qiao X-J, Kristoffersson A, Randrup T (2018) Challenges to implementing urban sustainable stormwater management from a governance perspective: A Literature Review. J Cleaner Prod 943–952. https://doi.org/10.1016/j.jclepro.2018.06.049
Reed B (2004) Sustainable urban drainage in low-income countries—a scoping study; project report. WEDC Loughborough University
Reid H, Reid H, Mozaharul A, Berger R, Cannon T, Huq S, Milligan A (2009) Community-based adaptation to climate change: an overview. Participatory Learning and Action 11–60
Sañudo-Fontaneda LA, Robina-Ramírez R (2019) Bringing community perceptions into sustainable urban drainage systems: the experience of Extremadura Spain. Land Use Policy 89:104–251. https://doi.org/10.1016/j.landusepol.2019.104251

Sattler CB, Schröter B, Meyer A, Giersch C (2016) Multilevel governance in communitybased environmental management: a case study comparison from Latin America. Ecol Soc 21(4). Retrieved from http://www.jstor.org/stable/262

Shackleton S e (2015) Why is socially just climate change adaptation in sub-Saharan Africa so challenging? a review of barriers identified from empirical cases. Wiley Interdisciplin Rev: Climate Change 6(3):321–344

Shackleton S, Chinyimba A, Hebinck P, Shackleton C, Kaoma H (2015) Multiple benefits and values of trees in urban landscapes in two towns in northern South Africa. Landsc Urban Plan 136:76–86. https://doi.org/10.1016/j.landurbplan.2014.12.004

Sutherland C, Sim V, Buthelezi S, Khumalo D (2016) Social constructions of environmental services in a rapidly densifying peri-urban area under dual governance in Durban, South Africa. Bothalia - African Biodiversity Conserv 46:18

Thorn J, Biancardi Aleu R, Wijesinghe A, Mdongwe M, Marchant R, Shackleton S (2021) Mainstreaming nature-based solutions for climate resilient infrastructure in periurban sub-Saharan Africa. Landscape Urban Plann 216

Totikidis V, Armstrong A, Francis R (2005) The concept of community governance: a preliminary review

UNEP (2022) Kunming-Montreal Global Biodiversity Framework. Conference of the Parties to the Convention of Biological Diversity, Montreal Canada

UN-Habitat and OECD (2017) Global State of National Urban Policy. Nairobi: United Nations Human Settlements Programme

UN-Habitat (2014) State of African Cities Report: Reimagining Sustainable Urban Transition. United Nations. Retrieved from https://unhabitat.org/state-of-african-cities-2014-reimagining-sustainable-urban-transitions

United Nations (2015) Transforming our world: The 2030 Agenda for Sustainable Development

van den Berg H, Rickert B, Ibrahim S, Bekure K, Gichile H, Girma S, . . . AM dR (2019).Linking water quality monitoring and climate-resilient water safety. J Water Health 17(6):989–1001. https://doi.org/10.2166/wh.2019.059

Williams DS, Máñez Costa M, Celliers L, Sutherland C (2018) Informal settlements and flooding: identifying strengths and weaknesses in local governance for water management. Water 10:871. https://doi.org/10.3390/w10070871

Williams S, Máñez CM, Sutherland CC, Celliers L, Scheffran J (2019) Vulnerability of informal settlements in the context of rapid urbanization and climate change. Environ Urban 31:157–176. https://doi.org/10.1177/0956247818819694

Williams DS, Celliers L, Unverzagt K, Videira N, Manez Costa M, Giordano R (2020) A method for enhancing capacity of local governance for climate change adaptation. Earth's Future 8(7). https://doi.org/10.1029/2020EF0015

Winter K (2016) Interim measures towards sustainable drainage in the informal settlements of South Africa. In: Susanne M, Charlesworth C, Booth A. Sustainable Surface Water Management: A Handbook for SuDS. Wiley. https://doi.org/10.1002/9781118897690.ch24

Wijesinghe A, Thorn J (2021) Governance of Urban Green Infrastructure in Informal Settlements of Windhoek Namibia. Sustain 13(16):8937. https://doi.org/10.3390/su13168937

WMO (2019) A State of the Climate in Africa. World Meteorological Organization, Geneva

Woods Ballard B, Wilson S, Udale-Clarke H, Illman S, Scott T, Ashley R, Kellagher R (2015) The SuDs UK Manual. CIRIA

Wyborn C, Louder E, Harrison J, Montambault J, Ryan M, Bednarek A, . . . Pullin A (2018) Understanding the Impacts of Research Synthesis. Environ Sci Policy 86:72–84. https://doi.org/10.1016/j.envsci.2018.04.013

Xiao Y, Watson M (2019) Guidance on Conducting a Systematic Literature Review. J Plan Educ Res 39(1):93–112. https://doi.org/10.1177/0739456X17723971

Xu H, Randall M, Fryd O (2023) Urban stormwater management at the meso-level: A review of trends, challenges, and approaches. J Environ Manag 331. https://doi.org/10.1016/j.jenvman.2023.117255

Ziervogel G, Enqvist J, Metelerkamp L, van Breda J (2022) Supporting transformative climate adaptation: community-level capacity building and knowledge co-creation in South Africa. Climate Policy 22:607–622. https://doi.org/10.1080/14693062.2020.1863180

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.