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ORIGINAL ARTICLE

Understanding drivers of changing flood dynamics for enhancing coastal community resilience: a participatory approach

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Abstract
In recent decades, coastal communities globally have experienced increased frequency and intensity of flood hazards, especially in developing nations. An increase in flooding has often been attributed to population growth, rising sea levels, extreme weather events, rapid urbanization, and poor land use, often exacerbated by insufficient urban flood risk management policies. However, flood risk management is complex and necessitates an in-depth look at factors that drive changing flood dynamics in coastal cities. This study used a participatory approach to identify, categorize, and analyze drivers of change in the flood-prone city of Limbe, Cameroon, a major tourism hub and contributor to Cameroon's GDP. The study engaged key stakeholders, including community members, government authorities, academic institutions, and non-governmental organizations. The study led to the identification of 46 major drivers classified into six clusters. The study findings emphasized four key priority areas to enhance policy and community resilience: restoring natural buffer zones like wetlands, increasing local involvement in flood risk planning, implementing risk-informed land use regulations, and investing in flood infrastructures. To ensure effective flood risk management in Limbe, a collaborative bottom-up approach involving all stakeholders, especially marginalized community members, is necessary to tailor solutions that meet their needs.

Keywords Flood risk management · Flood drivers · Participatory approach · Community resilience · Stakeholder engagement · Cameroon

Introduction

Understanding the dynamics of coastal flooding is imperative in the face of growing global challenges exacerbated by climate change (Wang et al. 2022; Xu et al. 2021). The 2022 Intergovernmental Panel on Climate Change (IPCC) report warns that a 1.5 °C rise in global temperatures will expose 24% of the world's population to heightened flood hazards (IPCC 2022; Hirabayashi et al. 2021). As Reguero and Griggs (2022) highlighted, coastal cities will be particularly vulnerable to amplified sea level rise, storm tides, and inundations. The staggering economic losses of approximately $4.3 trillion globally since 1970 underscore the inadequacy of existing flood management measures (WMO 2023). The complexity of factors influencing changing flood patterns, including sea level rise, urban growth, and land use planning, necessitates a comprehensive understanding of flood drivers (Igigabel et al. 2022). Drivers influence the frequency and intensity of flood events and can be categorized into natural and human indicators (Echendu 2023; Fang et al. 2021). While climate change is a significant natural driver, poor infrastructure, urban planning, and governance are also human-related factors contributing significantly to flooding (Vallejo and Mullan 2017). Understanding and addressing natural and human drivers are crucial for effective flood risk management and sustainable solutions (Echendu 2023; Santos et al. 2020).

Resilience has emerged as a concept acknowledged by international organizations in the face of escalating hazards (Rasmussen et al. 2021). Resilience is vital for reducing direct and indirect impacts, enhancing well-being, and reducing poverty (Kimber 2019; Barrett and Constas 2014).

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The challenge of building sustainable and resilient cities and communities is central to Sustainable Development Goal (SDG) 11.9 (United Nations 2015). Flood resilience, defined as a community's ability to pursue development goals while managing flood risk, requires understanding underlying drivers (Keating et al. 2017). Shock drivers and stresses within the coastal environment must be identified for proactive flood risk management (Fazey et al. 2018; Frankenberger et al. 2012).

The continent of Africa, like the rest of the world, grapples with increasing vulnerabilities to floods (Rentschler et al. 2022; Lumbroso 2020). Trisos et al. (2022) highlighted that the average temperature across Africa is expected to increase due to increased greenhouse gas emissions. This will also lead to temperature and rainfall extremes across the African continent. Floods are already having devastating consequences across the continent. For example, in 2019, KwaZulu-Natal province in South Africa experienced the worst floods in the country's history (Munyai et al. 2019), while in 2022, Ethiopia, Kenya, and Somalia faced severe flooding that impacted vulnerable communities already affected by droughts and food insecurity. In 2024, Eastern Africa was hit by El Niño-induced heavy rains and flooding, resulting in loss of lives, displacement, and destruction of infrastructure (Eastern Africa: El Niño Floods Impact Snapshot 2024). These events emphasize the need to understand the factors that trigger such incidents and propose effective coping mechanisms tailored to affected African communities. Flood risk, defined as the probability of a flood event happening and the consequences if it eventually occurs, considering the exposure and vulnerability of the affected system, is calculated as follows:

$$\mathbf{FloodRisk = floodprobability \times floodeventconsequences}$$

where flood probability refers to the likelihood or chance of occurrence, while consequences encompass the anticipated extent of flood damage or impacts on a system, considering factors such as exposure and vulnerability (Ranasinghe et al. 2021; Berndtsson et al. 2019). While the formula is a valuable tool for assessing and quantifying flood-related risks, its effective implementation hinges on a profound understanding of the major drivers of flooding within any community (Tariq et al. 2020). For example, conducting an in-depth risk assessment, estimating flood consequences, developing tailored risk reduction strategies, engaging communities, and adaptive planning rely on understanding flood drivers. Therefore, though the formula serves as a framework for understanding flood risk, its practical implementation for comprehensive flood risk management cannot be effective without grasping flood driver's complex and dynamic nature.

In Cameroon, floods accounted for over 77.7% of hazards between 1998 and 2010, particularly impacting urban and coastal areas (Bang et al. 2019b, a). However, the absence of up-to-date statistics necessitates identifying flood drivers for effective risk management in the country and specific communities. Cameroon's recurring flood events, especially in urban areas, raise questions about the effectiveness of existing flood management structures (Bang 2014; Ajonina et al. 2021). Despite significant literature on flooding in Limbe (Ajonina et al. 2021; Fon & Mbella 2015; Munji et al. 2013; Ndille and Belle 2014; Wantim et al. 2022), studies often use complex mathematical approaches, limiting their implementations given that the community's understanding of the research findings is limited. Understanding flood drivers is a major pillar for effective flood risk management in an era of climate change and increasing environmental pressures. This study emphasizes a participatory approach, involving affected communities to understand and propose solutions tailored to their context (Maskrey et al. 2022; Ahmed 2021).

Participatory approaches foster collaboration, consider local knowledge, and enhance flood risk identification and mitigation efforts (Bromley et al. 2017; McDonnell et al. 2016). The study holds strategic significance within the global context of sustainable development, addressing challenges faced by coastal communities worldwide. It aims to identify Limbe's underlying drivers of flood through a participatory approach, bridging communication gaps in Cameroon's flood risk management system (Bang 2022a, b). The participatory approach employed to assess vulnerability and resilience within communities is vital, as it fosters collaboration and ensures that local knowledge and perspectives are considered, making the identification of flood drivers more comprehensive and accurate. It prioritizes learning from local communities, seeks diverse opinions, and adapts goals accordingly. It fosters multi-stakeholder cooperation, social innovation, and capacity building, ultimately enhancing community resilience. Input from stakeholders is invaluable in tailoring flood risk management strategies that tackle community needs and enhance the chances of successful outcome implementation, long-term resilience, and overall sustainability of implemented measures. The participatory approach, therefore, strengthens the overall effectiveness of flood risk identification and mitigation efforts (Mahajan et al. 2022; Ahmed 2021; Bromley et al. 2017; McDonnell et al. 2016).

This study contributes to the broader agenda of achieving sustainable and resilient coastal communities globally, emphasizing the urgency outlined in SDG 11. The participatory approach seeks to enhance community resilience and develop context-specific flood risk management strategies for Limbe. Increased vulnerability to floods, rapid urbanization, and inadequate flood management policies mirror challenges faced by many coastal areas globally, allowing this study to act as a microcosm addressing broader challenges coastal communities face, thus fostering a more comprehensive approach to achieving sustainable and resilient coastal communities worldwide. The study seeks to address the questions: what are the underlying drivers of flood dynamics within the coastal community of Limbe and what measures can be implemented to enhance effective resilience? The study is organized into five sections: overview, methodology, discussion and results, and limitations and recommendations.

Study area

Limbe is located in the Southwest Region of Cameroon. It comprises three councils: Limbe I, Limbe II, and Limbe III councils. Limbe covers a total area of 549 km^2 and is dominated by volcanic rocks spanning from Debundscha (the world's second-wettest spot) to Man O'War Bay (Aka et al. 2017). The drainage system of Limbe exhibits a tree-like shape, with small streams merging to form larger ones like the R. Limbe and R. Jenguele. These eventually flow into the Atlantic Ocean (Tiafack et al. 2014). The climate of the Limbe is equatorial, with an annual average temperature of 27 °C and a yearly average rainfall of more than 500 mm. The temperature ranges from 21.45 to 32.75 °C throughout the year. The monthly rainfall ranges from 114.0 to 1053.0 mm. Most rainfall is received from mid-June to October, while November to April has the least rainfall. The city is on a low-lying coastal plain, with the highest elevations rising to 362 m above sea level (Ajonina et al. 2021). The city's climate, geography, population growth, urbanization, economic opportunities, and aging infrastructure make it vulnerable to several hazards, particularly floods, according to Enomah et al. (2023) and Wantim et al. (2022).

The city's economy predominantly relies on agriculture, which serves as the primary source of employment for more than 70% of the population in the region (Epule and Bryant 2017). Figure 1 is the map of Limbe, Southwest region of Cameroon. The city of Limbe has experienced several flood and landslide events due to increased climate variability. The city's coastal location, proximity to the country's only petroleum refinery (SONARA), and fertile volcanic soils that support oil palm, banana, and tea plantations, as well as agribusiness, have been an attracting force for people from other regions of Cameroon and neighboring countries like Nigeria (Ndille and Belle 2014). The majority of inhabitants are engaged in small-scale agriculture and businesses, especially considering that approximately 50% of the Limbe community lies at 1–2 m above sea level (Ajonina et al. 2021). Limbe is a fast-growing city as its strategic and scenic advantages recently attracted massive investment (Ndille and Belle 2014). The growth of the tourism sector has pushed more people into flood-prone areas as suitable land is becoming increasingly expensive.

Materials and methods

Participatory approach

The study used a participatory approach to understand and address flood risk management in the study area through stakeholder engagement and expert knowledge elicitation. The study methodology followed guidelines proposed by Voinov and Bousquet (2010), Inam et al. (2015), and Kotir et al. (2017) in environmental participatory processes. The six-stage methodological process is shown in Fig. 2. The objective was to engage all relevant stakeholders in the disaster management sector in the Limbe sub-division and allocate resources and time to define issues related to flood risk management in the area.

The problem articulation/identification consisted of an extensive literature review of flood occurrences to identify possible drivers of floods. A content analysis of existing literature, specifically books, reports, journal articles, and newspapers published between 2003 and 2023, was conducted to provide valuable insights into understanding past and current flood patterns. The information retrieved from the literature was supplemented by inputs from experts and stakeholders, facilitating extensive discussions on the challenges and prospects of addressing flood risk management in Limbe.

The stakeholder identification and analysis was crucial to ensure equitable representation. The potential stakeholders were identified in the literature and key informant interviews. After identifying and analyzing the different stakeholders involved in flood management within the community, a stakeholder analysis was carried out to evaluate each stakeholder's level of interest and influence. Using the stakeholder matrix, four types of stakeholders were identified. After stakeholder analysis, invitations were extended to confirm their workshop attendance on the scheduled date. The stakeholders comprised individuals from ministries, local councils, organizations, academia, and the community, as shown in Table 1.

The stakeholder engagement workshop was a vital component of this participatory process. Stakeholders convened in Limbe in April 2022 to identify, discuss, and determine the relevance of the drivers of floods in Limbe. The workshop lasted only a day due to limited resources and was attended by 24 stakeholders.

The principal investigator and facilitator provided an overview of the workshop and explained the purpose of the research generally. After 45 min of interaction, the stakeholders were then split into three (03) sub-groups and placed in separate rooms within the same building to facilitate discussions. These sub-groups constituted government officials and authorities charged with managing disasters (group 1), local inhabitants and indigenes of

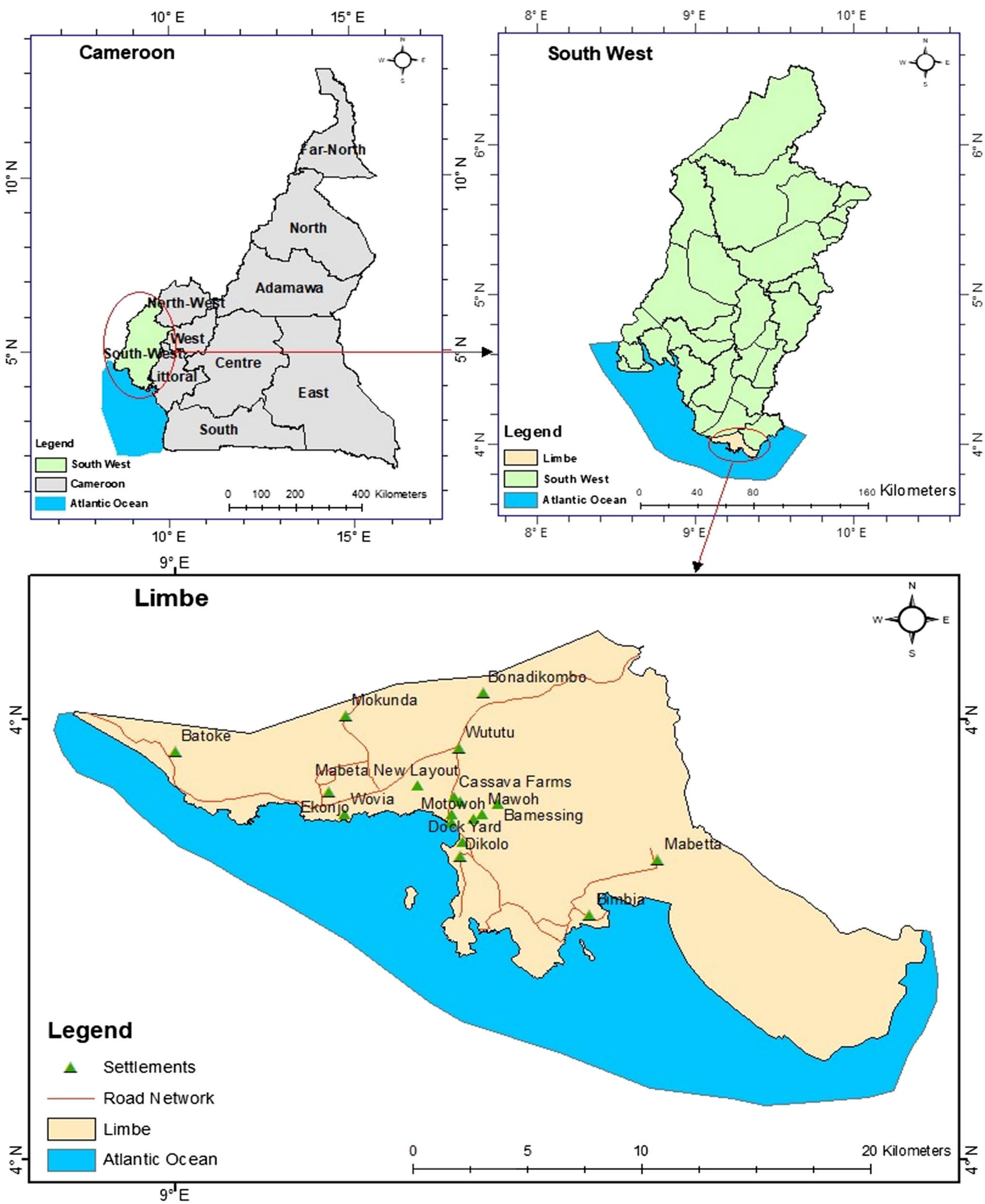

Fig. 1 Study Area Map of Limbe, South West Region, Cameroon

Fig. 2 The participatory process implored in the study

Limbe (group 2), and lastly, NGOs, academia, business owners, and others (group 3). These sub-groups allowed for a more rigorous discussion among stakeholders as they had enough time to discuss their ideas, and this lasted an hour. Some participants could not spend the whole day due to prior engagements and were interviewed separately (Fig. 3b). Figure 3a represents an example of a sub-group engaged in discussions. Ten (10) categories (also referred to as clusters) of drivers were identified and categorized based on the recommendation of scholars like Nyam et al. (2020) and Jordaan (2017). The drivers of change within each cluster were identified and ranking was done based on stakeholder perspectives. Some of the guiding questions included:

- What have been the recent flood trends in Limbe municipality?
- Rate flooding in your community on a scale of 1–5?
- What are the primary drivers or factors contributing to flood vulnerability in your community?
- How effective are existing flood management measures in Limbe, and what are the key challenges faced in their implementation?

The workshop identified and categorized 46 relevant drivers, which were summarized under six categories due to overlaps: natural, technological/infrastructural, socioeconomic, human/cultural, political, and organizational/institutional (Fig. 5).

Weighting flood drivers and clusters

Due to limited data and the potential for misleading conclusions, it was essential to allocate weights to the drivers of change considered in the study. Assigning weights involved subjective judgment based on the researcher's experience and stakeholder collaboration. Previous studies have used various techniques, such as statistical models, expert judgments, and correlation analyses, to allocate weights (Nyam et al. 2020). When assigning weights, the relevance of the driver to flood risk management, its significance and capacity to shape policy outcomes, and the diversity in how it elicits responses were all considered. Thus, weights were allocated from 0 to 1, with 0 representing minimal impact and 1 indicating the highest impact. Following the methodology proposed by Nyam et al. (2020) and Jordaan (2017), the drivers and clusters weights and indices were calculated and assigned to each driver based on their relevance to flood risk management. Detailed calculations are shown in

Table 1 List of participating stakeholders

Stakeholders	Number of representatives	Interest/influence
Representative of the Ministry of Territorial Administration and Decentralization	1	High interest/high influence
Representative of the Ministry of Public Transport (MINT)	1	High interest/low influence
Representative of the Limbe City Council	3	High interest/high influence
Community village chiefs and "quarter heads"	7	High interest/low influence
Community-based youth organizations (Limbe Youths and Development Association)	1	High interest/low influence
Non-governmental organizations represented by the Integrated Youth Empowerment Center (IYEC), the Community Action Scheme Africa (CASAF), and LYAT-Cameroon	4	High interest/low influence
Representative of international organizations, i.e., the Cameroon Red Cross Society	1	High interest/low influence
Academia representative from the University of Buea (Head of Department of Environmental Science)	2	High interest/low influence
Community stakeholders, i.e., farmers, small business owners, and workers	4	High interest/low influence

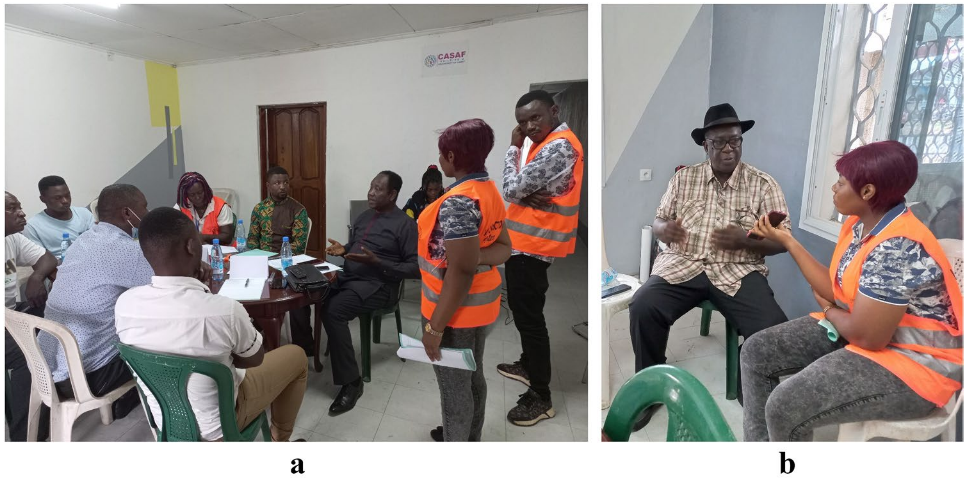

Fig. 3 **a** Discussion session after driver identification and categorization. **b** Interview with a key informant during break session. Source: Authors Fieldwork (2022)

Table 2. The following formulas were utilized to calculate the weighted scores for drivers and clusters, respectively:

$$D_w = W_i I_i \tag{1}$$

$$C_w = \Sigma(W_i I_i)C_i \tag{2}$$

where D_w is the total weighted score per driver, W_i is the allocated weight per driver, I_i is the Index per driver, C_w is the total weighted score per cluster, and C_i is the allocated weight per cluster.

The total weighted score per driver was obtained by multiplying the allocated weight by the corresponding index. For example, prolonged rainfall, considered the most influential natural driver, received a weighted score of 0.3 (*perceived influence*) and an index of 3 (*significanc*e). The total weighted score for prolonged rainfall was calculated as 0.3 multiplied by 3, resulting in 0.9 (*total weighted score/driver*). The total weighted score indicates each driver's influence level, with higher scores indicating more significant influence. There was a reiteration of the process for all identified drivers.

Allocating weighted scores to clusters mirrored assigning weights to drivers. However, to calculate the total weighted score per cluster, the weighted scores of all drivers within the cluster were multiplied by the weighted score of the cluster. Each cluster was assigned a weighted score to determine cluster influence. For instance, the total weighted score for the natural cluster was derived by multiplying (0.4 + 0.8 + 0.8 + 0.9 + 0.2 + 0.1 + 0.4) * (0.23 = 0.83) (see Table 2 for all calculations). Descriptive statistics, specifically weighted means, were utilized to analyze and present the results using simple spider graphs and sunburst diagrams. The study's driver and cluster weight allocation have far-reaching implications for policy and decision-making, resource allocation, research prioritization, and flood risk mitigation strategies. The weighting process provided a basis for understanding and addressing complex drivers of flood risks. Weights must be assigned with transparency, rigor, and sensitivity to ensure the credibility and effectiveness of the study's findings. The process equally relied on subjective judgment and stakeholder collaboration.

Results and discussion

Demographics of participants

The results highlighted that only three (12.5%) of the 24 stakeholders were female, while the remaining 21 (87.5%) were male. During the pilot study, some women from the community expressed discomfort in attending and recommended that men attend instead. An analysis of the respondent age revealed that only four out of 24 stakeholders, representing 16.7%, were youths (classified as those below 40 years). Figure 4a and b show the demographics of participants in the study. The under-representation of women and youths may be attributed to the limited involvement of these groups in disaster management in Limbe.

Drivers of flood

Considering the current increase in flood occurrences in Limbe, it was imperative to ascertain the underlying factors contributing to the frequency of floods in the region; that is particularly important considering the significant damage these floods have on the sustainable development of Limbe and its surrounding communities. The preceding discussion on the identification process facilitates the determination of strategic intervention points for implementing policies and interventions that effectively enhance flood management (Mai et al. 2020; Rosengren

Table 2 Weighted averages for drivers and clusters

	Clusters	Weight	Drivers of change	Weight per driver	Index per driver	Total score per driver	Total score per cluster
1	Natural drivers	0.23	Climate variability	0.14	3	0.4	0.83
			Short and intense rainfall	0.2	4	0.8	
			Lowland	0.2	4	0.8	
			Prolonged rainfall	0.3	3	0.9	
			Wetland degradation	0.04	4	0.2	
			High water table	0.03	4	0.1	
			Impermeable soil	0.09	4	0.4	
2	Technological/infrastructural drivers	0.16	Unmaintained drainage systems	0.15	4	0.6	0.51
			No rain harvesting system	0.08	2	0.2	
			Lack of early warning systems	0.11	4	0.4	
			Poor watercourse maintenance	0.24	4	0.7	
			Defective flood defense	0.15	2	0.3	
			Insufficient drainage size	0.23	4	0.9	
			Lack of flood monitoring	0.04	2	0.1	
3	Socioeconomic drivers	0.13	Lack of access to flood loans	0.08	2	0.2	0.38
			Inadequate flood investment	0.06	4	0.2	
			Lack of government flood support	0.1	3	0.3	
			Limited livelihood options	0.09	2	0.2	
			Income levels	0.07	4	0.3	
			Lack of flood insurance	0.1	2	0.3	
			Population growth	0.17	3	0.4	
			Poverty level	0.14	2	0.3	
			No community-based organizations	0.03	2	0.1	
			urbanization	0.16	4	0.6	
4	Human/cultural drivers	0.15	Deforestation	0.23	4	0.9	0.56
			Poor building patterns	0.17	3	0.5	
			Poor town planning	0.20	4	0.8	
			Educational levels	0.09	2	0.2	
			Poor land use	0.17	4	0.7	
			Limited flood prevention knowledge	0.04	4	0.2	
			Dependence on external expertise	0.02	4	0.1	
			Communication of the gods	0.02	3	0.1	
			Risk perception	0.06	3	0.2	
5	Political drivers	0.22	Flood management policy	0.28	2	0.6	0.53
			Poor policy implementation	0.22	4	0.9	
			Gender inclusion	0.1	1	0.1	
			Internal conflicts/power struggles	0.19	3	0.6	
			Understanding of flood systems	0.21	1	0.2	
6	Organizational/institutional drivers	0.11	Flood management committee	0.12	3	0.4	0.29
			Flood management agencies	0.07	1	0.1	
			NGOs actively involved in FRM	0.08	1	0.1	
			Local government capacity	0.21	3	0.6	
			Lack of collaboration	0.11	1	0.1	
			Community flood management	0.13	4	0.5	
			Community engagement in FRM	0.28	3	0.8	

et al. 2020). The different flood driver categories/clusters, as summarized in Fig. 5, are discussed in the following sections.

Natural/ecological drivers

The concept of natural or ecological drivers of flood risk involves elements in the environment contributing to floods. Understanding these factors is crucial for effective mitigation. Natural factors, linked to climate change, pose challenges for Limbe, impacting communities differently. Key flood drivers include short and intense rainfall, prolonged rainfall, and topography. Floods are exacerbated by precipitation fluctuations, leading to increased surface runoff. Climate extremes have far-reaching consequences, including loss of life, property damage, water pollution, and disruptions to economic activities, supported by Loos and Rogers

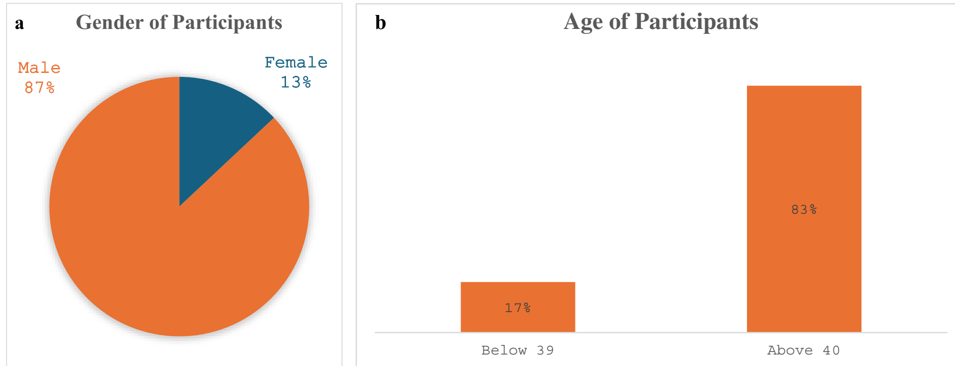

Fig. 4 **a**, Age of respondent **b** Demographics of stakeholders

(2016) and Diaz and Murnane (2008). Effective flood management requires strategies that account for natural factors beyond human control. Proposed measures included regular riverbed dredging, consistent waste collection, and improving vegetation cover as buffer zones. These strategies aim to improve water flow, enhance natural water absorption, and mitigate the adverse effects of flooding on both communities and ecosystems.

Technological/infrastructural drivers

Technological drivers of floods encompass structures and techniques exacerbating or mitigating flood risks. Seven drivers were identified; stakeholders emphasized inadequate drainage, insufficient maintenance of watercourses, and neglected drainage systems as critical factors. This aligns with Tom et al. (2022), who found infrastructure degradation plays a substantial role in floods. It can be inferred that aging, poorly maintained, and intermittently absent flood infrastructures significantly impact flood management. Considering the increasing frequency and severity of flood events, allocating resources toward sustainable flood infrastructure is crucial. Such investments can potentially mitigate flood-related damages and enhance the long-term resilience of the environment and the community.

Findings revealed that stakeholders in the study area had limited awareness of technologies like rain harvesting, early warning systems, and flood monitoring to mitigate floods. This knowledge gap can be attributed to the unavailability of these technologies. However, this situation allows policymakers to enhance flood risk management by utilizing these as strategic intervention points. Research by Josipovic and Viergutz (2023) in Germany demonstrates that early warning systems and flood monitoring serve as intelligent solutions for municipal flood management. Furthermore, studies by Jamali et al. (2020) and Freni and Liuzzo (2019) illustrate that rainwater harvesting (RWH), mainly through the use of RWH tanks in urban areas, can significantly reduce flood risks by mitigating surface runoff. It can be inferred that implementing efficient technologies is a significant driver for enhancing flood management. Implementing innovative technologies and management is crucial to achieving efficiency and effectiveness in flood risk management (Palla and Gnecco 2022; Xu et al. 2022). As Nyam et al. (2020) iterated, infrastructural and technological advancements rely on well-designed technologies with implications for sustainable management.

Socioeconomic drivers

Human perceptions and interactions with their surroundings profoundly influence the relationship between floods and the environment. These drivers, both directly and indirectly, exert pressures on the environment that can contribute to flooding. Additionally, economic drivers play a pivotal role in shaping stakeholder's willingness to invest in poverty alleviation, foster economic growth, and enhance resilience. Environmental changes resulting from economic growth and social transformations often have multiple consequences, affecting a community's flood risk (Rentschler et al. 2022; Manzoor et al. 2022). These drivers encompass population pressures and governmental inaction, among others. The study's findings indicate that population growth and urbanization are the dominant social drivers of change in flood systems within the Limbe region. Previous research conducted by Fon and Mbella (2015) reveals that Limbe has undergone rapid urbanization since the colonial era, marked by the establishment of large oil palm plantations (currently under the Cameroon Development Corporation) to diversify pre-colonial primary activities such as farming, hunting, and small-scale fishing in Limbe (Ndenecho 2011). Notably, Limbe has experienced substantial population growth, estimated to have grown from 129,000 to over 250,000, accompanied by a corresponding increase in population density from approximately 235/km^2 to 369/km^2 between 2016 and 2022 (Fon and Mbella 2015). This growth could be attributed to the ongoing Anglophone crisis, which displaced individuals, particularly from the grassland regions, who sought safety and settled in Limbe. Owing to their low socioeconomic status (SES), they tend to establish residences in areas

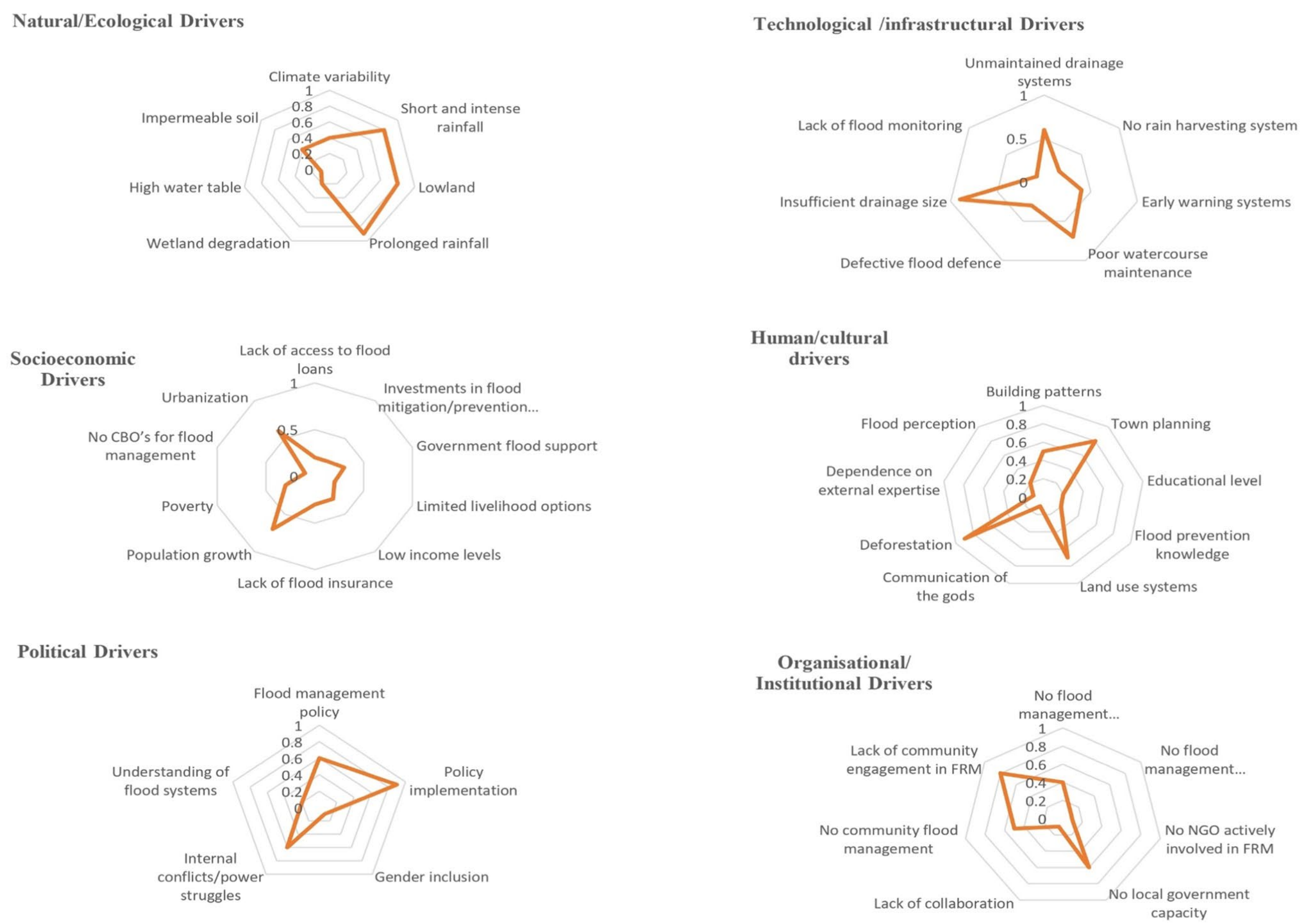

Fig. 5 Categorization of flood drivers in Limbe, Cameroon

where land is inexpensive and affordable. As Johnson (2017) highlighted, individuals with a low SES are more susceptible to disproportionate impacts from natural disasters such as floods. Furthermore, a World Bank and GFDRR report suggests that natural disasters perpetuate poverty by imposing financial burdens on vulnerable populations (Hallegatte et al. 2016).

Flood occurrences in Limbe are also driven by economic factors, such as limited access to flood loans, inadequate investments in mitigation measures, insufficient government support, limited livelihood options, and low incomes. Rapid population growth has led to high unemployment rates, pushing people to rely on self-employment in the informal sector, especially among internally displaced persons. Economic constraints force many to occupy inexpensive but flood-prone marginal zones (Fombe and Balgah 2010). This aligns with the assertion of Mtapuri et al. (2018) on the interconnectedness of poverty and floods in Zimbabwe. A study by Fon and Mbella (2015) in Limbe revealed that rising building material costs has led to the prolifieration of substandard housing in flood-prone areas, exacerbating flood-related damages. Stakeholders note the absence of evacuation and mitigation measures, subpar structures, and insufficient flood infrastructure, echoing the findings of Nojang and Jensen (2020) on household disaster preparedness in Limbe. The low economic status and inadequate risk perception amplify vulnerabilities (Ajonina et al. 2021). Some recommendations from stakeholders included flood subsidies, government support, and streamlined processes for obtaining land certificates, aligning with the findings of Fon and Mbella (2015). Other suggestions included investments in sustainable flood infrastructure, human capital, research, and technology to manage floods, reduce poverty, and boost economic growth. Government involvement is crucial for promoting insurability through effective land-use planning and flood risk management investments (Bang 2021; OECD 2016). Thus, incorporating socioeconomic drivers in flood management is vital for long-term sustainability, considering current and future flood trends and infrastructure development.

Human/cultural drivers

Human and cultural drivers notably influence flood occurrence and impact, encompassing behaviors, practices, and beliefs shaping the community-environment relationship. Deforestation, driven by poor land-use practices, facilitates urbanization and negatively impacts the environment, heightening flood likelihood in Limbe. The conversion of natural areas into built environments reduces water-absorbing capacities, increasing surface runoff. Settlement expansion into flood-prone areas increases vulnerability. Inadequate land management practices, such as unregulated building, obstruct water flow, exacerbating flood risks. Human interventions modify watercourses, altering flood dynamics (Serra-Llobet et al. 2022). Stakeholders highlight poor waste management's role in blocked drainage systems, increasing flood risks (Jha et al. 2012; Sakijege 2019). Research by Serra-Llobet et al. (2022) demonstrated that channelization and embankment construction have heightened flood vulnerability in downstream areas, as observed in California and Germany. Human interference with natural systems has exacerbated flood risks in Limbe. Stakeholders emphasized that poor waste management/disposal practices are a primary cause of blocked drainage systems, limiting the water flow in inadequate and poorly maintained drainage infrastructures and increasing flood risks, which is similar to the findings of Jha et al. (2012) in the UK. A study in Tanzania by Sakijege (2019) highlighted that improvement in municipal solid waste management in Dar es Salaam significantly reduced flood risks with a reduction in solid waste in drainage channels. Cultural beliefs significantly influence people's attitudes toward floods. Some stakeholders perceive floods as divine communication, attributing unusual sea level increases to marine creatures locally called "mami-wata." In Limbe, a cultural preference for traditional wooden houses contributes to substandard structures. Similar findings in Ghana emphasize community perceptions affecting adaptability to flood risks (Tasantab et al. 2020).

Political drivers

Political drivers of floods encompass the governance, policies, and decision-making processes that can contribute to the occurrence, intensity, or impacts of flooding events. While floods are often attributed to natural and human factors, political drivers can exacerbate or mitigate their effects. Political drivers significantly influence flood risk management through policy formulation and implementation related to flood preparedness, emergency response, land-use planning, urban development, and cooperation at community, national, and international levels. However, stakeholders stated that there is minimal government involvement in flood risk management despite their crucial role in flood mitigation. Weak policy enforcement and implementation related to building regulations, waste disposal, housing structures, and land reform are not fully implemented and emerge as notable drivers of flood policies. This iterates the findings of the European Environment Agency report (Vanneuville et al. 2016) that stated an intricate link exists between policy implementation and flood vulnerability.

The political drivers of floods extend beyond weak policy enforcement and implementation. There is primarily non-compliance with building regulations along riverbanks, building standards, land reforms, and land acquisition policies in hazard-prone areas. A study by Ndille and Belle (2014) in Limbe revealed that the existing flood management strategy employs bureaucratic, highly centralized approaches that fail to achieve essential disaster risk reduction (DRR) goals. Policy implementation at the municipal council level is challenging as approval must be obtained from the national level. This leads to policy defaulters evading consequences through corruption. Local councils fail to ensure that regulations are adhered to by the inhabitants. Another study by Bang (2022a, b) found that Cameroon's legislative and institutional frameworks for disaster risk management (DRM) predominantly revolve around the concept of Civil Protection rather than being a distinct entity dedicated to ensuring optimal results. Stakeholders also emphasized that there is limited incentive to enforce laws or make appropriate decisions, as they are unlikely to be held accountable in the event of a hazard. For instance, discussions on disasters in Limbe primarily revolve around the regular dredging of the city's two main rivers and the enforcement of building codes by the technical staff of the Limbe City Council, as noted by Maes et al. (2019).

Conflict and political instability were identified as potential drivers of floods. According to stakeholders, the ongoing Anglophone crises have led to an influx of internally displaced persons into flood-prone areas. These individuals have settled in these areas due to cheap and affordable land availability. However, their presence has resulted in increased deforestation and negative alterations to land cover, exacerbating the risk of flooding (Ghimire and Ferreira 2016).

Organizational/institutional drivers

The organizational drivers for inadequate flood management were identified as the limited capacity of local governments, which stemmed from their exclusion in flood policy design and implementation (Glaus et al. 2020). Local governments play a pivotal role, directly influencing flood risk management through policy development and mitigation measures. To bolster disaster risk reduction (DRR), involving local governments and stakeholders is essential, fostering awareness and contributions to non-structural measures like spatial planning (Sakijege 2019). As highlighted by Sakijege (2019), raising community awareness is crucial, linking individual actions such as improper waste disposal to flooding. In Limbe, community members face barriers like insufficient knowledge and financial resources hindering flood mitigation adoption. Furthermore, inefficient resource allocation, information-sharing gaps, and conflicting approaches to flood prevention among responsible agencies and departments contribute to coordination challenges (Spires et al. 2014; Merz et al. 2014). In Limbe, this lack of effective coordination hampers the implementation of comprehensive flood risk management strategies. Access to flood risk zonation maps is limited for community members, emphasizing the necessity for improved organizational coordination and communication in flood risk management (Maes et al. 2019).

Mitigating and effectively managing flood risk in Limbe and similar communities in Cameroon and Africa requires addressing key drivers. Government entities play a crucial role in influencing decision-making and supporting policy implementation at all levels. Governance factors such as government effectiveness, flood regulation implementation, political stability, accountability, and stakeholder engagement significantly impact flood risk management. The study finds that increased flood occurrences result from non-existent or ineffective policies, aligning with a study by Bang (2022a, b) on Cameroon's limited disaster management capacities. Entities, like city councils and local chiefs/authorities, influence flood management locally but are subject to centralized decision-making by the national government. This top-down approach excludes affected individuals from the decision-making process, leading to gaps and ineffective flood mitigation. Green Peace Cameroon (2021) emphasizes participatory governance's importance for analyzing solutions, managing consequences, considering group interests, and improving communication. Misappropriation of funds, stakeholder exclusion, policy centralization, and lack of accountability contribute to poor flood policy implementation in Limbe and Cameroon (African Development Bank 2019; Morrison et al. 2018).

Lessons learned from the stakeholder engagement process

Lessons were learned in conducting this exercise that have implications for designing and implementing similar participatory exercises. Previous studies have conducted similar exercises and employed this approach (Nyam et al. 2021; Ekmekcioğlu et al. 2021; Perrone et al. 2020) and have also reported lessons and experiences based on their respective studies. It is worth noting that the approach requires a significant amount of time and effort, particularly in identifying and assembling stakeholders with the required technical and intellectual know-how (Nyam et al. 2021; Kotir et al. 2017).

Firstly, it is important to note that the representation of women in the "Demographics of participants" section of the study was disproportionate to men, suggesting that future studies should focus on including more women participants to ensure fair gender representation. It was observed that stakeholders from specific sectors and organizations tend to focus on and give higher rankings to drivers related to their sector of interest, thus regarding other drivers as less critical during the identification and ranking process. Other stakeholders primarily identified micro-level drivers at the community level. However, the activity aimed to formulate catalysts for transformation within the municipality. Since the exercise involved diverse stakeholders, some participants introduced issues not directly relevant to the objectives. Additionally, most stakeholders participated in this type of exercise for the first time, making it challenging to fully comprehend the whole process, thereby increasing the time required to complete the exercise. Lastly, not all invited stakeholders were present despite being reassured they would be present. Initially, the researcher invited 40 stakeholders; however, only 24 attended the workshop.

At the end of the workshop, a statement sheet with nine (09) questions was required from all participating stakeholders. Stakeholders were to respond by indicating their agreement, disagreement, or neutrality level to each statement. This simple evaluation exercise aimed at assessing stakeholder perception of the entire process. A 3-point scale was used to code all statements, with scores of (1) indicating agreement, (2) indicating disagreement, and (3) indicating neutrality and the 24 stakeholders responded to the statements. The analysis revealed that 96% of stakeholders agreed that the process was inclusive. Additionally, 83% of stakeholders considered the participatory process useful. Furthermore, 92% of stakeholders affirmed that cluster categorization was easy to understand, and 79% agreed that the process helped them to better understand flooding in Limbe. Moreover, 88% of stakeholders agreed that identifying drivers of change helped them gain insights into flood risk management issues in Limbe. Finally, 75% of stakeholders affirmed that the identified drivers would help develop robust flood management policies in Limbe. Stakeholders were also willing to participate in future research endeavors (92%). Stakeholders also indicated contentment with the process, knowledge acquisition, and overall experience.

Study limitations and recommendations

The participatory approach in flood management has yielded valuable outcomes when well-designed and executed effectively. However, the study's limitations include the sample size not fully representing the entire study area and the reliance on the perspectives of a specific group of stakeholders due to time and financial constraints. Future studies should include all critical stakeholders within the Southwest region, not just Limbe, to avoid bias in the findings. Additionally, future studies should conduct a more comprehensive understanding of each driver, such as employing time series analysis, to examine the dynamics of factors, identify trends, and facilitate improved planning for future flood occurrences. This approach has demonstrated its effectiveness, especially for communities with limited data and marginalized groups excluded from flood management decision-making processes. While the study identified significant drivers of change that influence floods in Limbe, it is important to note that these drivers may not be exhaustive, as they reflect the perceptions of participating stakeholders, which may be limited by their knowledge and experience. The study, therefore, provides a valuable methodological framework for further research in disaster management in Cameroon and other developing countries where applicable.

Conclusion

Floods have become more frequent and severe globally, causing significant damage to both human settlements and natural habitats. Underdeveloped and rural areas are particularly vulnerable due to a lack of resources to cope with these disasters. Limbe, for example, experiences roughly five to 10 floods every year, impacting the livelihoods of its residents. To address this issue, a participatory methodology was employed to identify the root causes of flooding. A comprehensive data analysis revealed 46 drivers, which were grouped into six clusters, highlighting the most pressing issues driving floods in Limbe. This process was crucial for optimizing resource allocation and prioritizing interventions to tackle the key drivers of flooding in the municipality. The findings were validated through stakeholder input and existing literature, underscoring the urgency of the identified challenges. The study's significance lies in its potential to inform targeted flood management strategies to enhance community resilience and foster preparedness, response, and mitigation initiatives in Limbe. Policymakers must prioritize enhancing policy implementation and long-term capacity to manage flood risks sustainably. Identifying intervention points enables the development and implementation of policies addressing underlying drivers of changing flood dynamics in the study area and Cameroon (Bang 2022a, b; Nojang and Jensen 2020; Fon and Mbella 2015; Ndille and Belle 2014). The study organized a follow-up workshop 3 months later, allowing stakeholders to review the results and provide feedback. This participatory approach helped build trust and fostered stakeholder cooperation, ensuring that the drivers identified were relevant and accurate and that the study's recommendations were well-received and likely to be implemented.

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Data availability Data will be provided upon request.

Declarations

Competing interests The authors declare no competing interests.

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