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Research paper

How grassroots resistance fosters sustainability: lessons from sand harvesting and water availability in a farming community in Kenya

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Sand harvesting is an economically lucrative business but poses hazards to riverine ecosystems and their inhabitants. In the sand rivers of sub-Saharan Africa, sand harvesting results in depletion of water resources used for agriculture, alongside increased erosion and destruction of agricultural lands and riparian vegetation. Sand harvesting occurs within a complex web of actors and interests, often with injustices and inequities in resource use. This study examines the impact of sand extraction on farming families and their livelihoods. It evaluates how a riparian farming community related to unregulated sand removal from a sand river in Kenya, resulting in a violent conflict. Based on surveys and semi-structured interviews, we evaluate the different impacts of sand harvesting on irrigated agriculture and the coping strategies of farmers. Also, we analyse the interactions between the efforts of the community and the governmental institutions in addressing the violent conflict and in restoring the river ecosystem. We find that excessive sand harvesting led to a depletion of water resources, forcing smallholder irrigators to cease farming operations. Using an environmental justice perspective, we find that grassroots actions evolved into a trigger for local government to curb sand harvesting conflicts and support river restoration. In conclusion, conflict served as a force to induce sustainability, impelled by a critical interplay of actions by community and the newly decentralized government. In this process, grassroots movements were not uniform and resistance was not a straightforward process, but one in which individuals changed position, opinion and alliances over time.

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INTRODUCTION

Sand harvesting, or sand extraction, is regarded as one of the most pressing environmental concerns, both in coastal and riverine ecosystems (UNEP, 2019, 2022). There is limited, yet increasing evidence of the benefits, impacts and challenges of sand harvesting in sub-Saharan Africa, mostly triggered by the construction needs of a growing urban population (Masalu, 2002; Aliu et al., 2022). Although sand harvesting is essential for urban development and can augment incomes for riparian communities, detrimental impacts are observed on, for example, riparian vegetation, land and water availability, and river flow (Bendixen et al., 2019; Akanwa, 2021; Katz-Lavigne et al., 2022; Rentier and Cammeraat, 2022; Nguyen et al., 2024). Riverine sand harvesting thus carries inherent environmental implications, the magnitude of which hinges on variables such as harvesting frequency and methods used on the one side, and sedimentation rates on the other (Rentier and Cammeraat, 2022). Also, sand is a highly contested resource, which can be a cause for conflict, with severe impacts on security and stability of riparian communities (Aduda and Bolf, 2024; Bisht, 2021; Daghar, 2022; Katz-Lavigne et al., 2022). A recent inventory identifies illegal sand mining activities in at least 35 countries in Africa, with violent conflicts observed in 6 countries (Aduda and Bolf, 2024). Despite the imminent need, governance attempts to sustainably manage sand resources are still rare in sub-Saharan Africa, and often face a grim practice (Shitima and Suykens, 2023; Smigaj et al., 2025).

The drylands of sub-Saharan Africa are home to sand rivers, which are water storage systems in areas where other resources are scarce or absent (Walker et al., 2018). Sand rivers evolve as a result of upstream erosion processes, and are recharged during major flow events, transporting both water and sand (Mansell and Hussey, 2005). These ephemeral rivers form vital and reliable water sources for households, farmers and small businesses (Duker et al., 2020; Duker et al., 2022; Karimba et al., 2022; Chauruka et al., 2023). Besides providing water, these rivers are a source of sand that is extracted from the river beds and banks for small-scale and commercial purposes (Daghar, 2022; Smigaj et al., 2025). Within sand rivers, the removal of sand is inherently connected to water resource availability since the sand forms the medium in which water is stored within the river beds. Besides decreasing this water storage potential, sand harvesting can also increase evaporation losses due to the open pits where sand is taken from. Moreover, sand rivers often occur in marginalised regions, where alternative sources of water are very scarce, and livelihoods are vulnerable.

Makueni County in Kenya stands out as an example of the security, social and environmental challenges arising from sand extraction (Aduda and Bolf, 2024). The removal of sand from the ephemeral rivers in this region has been excessive, where cartels dominated the exploitation and trade of sand, leading to violent conflict and severe environmental and social impacts (Muthomi et al., 2015; Daghar, 2022). Inhabitants along rivers such as Ikolya, Kiu, and Enguli faced the socio-environmental consequences

of unregulated sand extraction (Katisya-Njoroge, 2021; Daghar, 2022). This activity adversely affected both the quantity and quality of water resources upon which riparian communities depended. However, since 2015, the sand business in Makueni County has changed through the establishment of harvesting and trade regulations. Makueni County is the first in Kenya to have introduced a Sand Conservation and Utilisation Act (hereafter referred to as the Sand Act) and an authority to oversee its implementation and enforcement – the Makueni Sand Conservation and Utilisation Authority, hereafter referred to as the Sand Authority (Government of the Republic of Kenya, 2015, 2022). This study zooms in to the Enguli sand river, where conflicts over sand were reportedly one of the most intense and violent. The study takes the perspective of a farming community, since sand rivers are an important water storage system for irrigated agriculture, where other water sources are absent or difficult to access. Sand is thus the only viable option to conserve water for the dry seasons, which makes excessive sand removal a threat to the people depending on it for domestic, livestock and irrigation purposes. This study therefore aims to answer the questions of how a farming community is impacted by previously unregulated sand harvesting and how it responds to these impacts. We use the term sand harvesting, and not sand mining, because this is the locally used wording.

We apply an environmental justice lens to critically examine sand harvesting and its impacts along the Enguli River in Makueni County, Kenya. Environmental justice can be conceptualized via three components; distribution, recognition and representation (Fraser, 2005; Schlosberg, 2007). Taking further inspiration from Swyngedouw and Heynen (2004), Sen (2009), and Joy et al. (2014), we primarily engage with the distributional domain that takes into account how environmental and social change work to reallocate resources such as water, land, income and power. Beyond distributional justice, our approach also incorporates dimensions of cultural justice, or the recognition of diverse cultural identities, rights, and practices, as well as procedural or representational justice, which pertains to meaningful participation in decision-making processes. These interconnected dimensions of environmental justice serve as an analytical framework through which we examine the impacts of sand extraction on farming families and their livelihoods. Literature on natural resource governance suggests that a crisis or conflict often provides the impetus for people to pursue, and find, common solutions, and thus can lead to collective action (Ostrom, 2010). Environmental degradation has been a strong motivator for people to fight against injustice (Agyeman, 2005; Schroeder et al., 2008). In practice, grassroots-level narratives of sustainability are part of fighting environmental and water injustices in many places around the world (Cuadrado-Quesada and Joy, 2021). Resistance to injustices and conflicts can thus act as a force to move towards sustainability of natural resource use, including surface and groundwater (Ostrom, 2010; Cuadrado-Quesada, 2018; Temper et al., 2018a; Temper et al., 2018b). We apply this environmental justice perspective to better comprehend the actions and responses by different actors in the study area, and its implications for future processes in similar settings. We therefore systematically reflect on two intertwined processes: how sand extraction impacted irrigation activities and resulted in diverse coping strategies by individuals, and how community action and decentralised governance conjunctively curbed disruptive sand harvesting.

The following section presents the research area and research approach, after which the results are outlined, starting with an overview of the history of the area with elaboration on three distinct phases of resource exploitation and conflict. Individual motivations and coping strategies of farmers are then explained. Finally, the findings are discussed, followed by the conclusions drawn from the study.

MATERIALS AND METHODS

Area description

This study was carried out in Makueni County, one of the 47 counties of Kenya, and located in the south of the country (Fig. 1). It has two climate zones, classified as arid and semi-arid. The region receives an average of 350–450 mm of rainfall annually, with two rainy seasons, one from March to May (long rains), and one from October to December (short rains) (Government of Makueni County, 2019). Altitude ranges from 600–1 900 m above mean sea level, with natural vegetation consisting mainly of grassland and shrubs (Government of Makueni County, 2023).

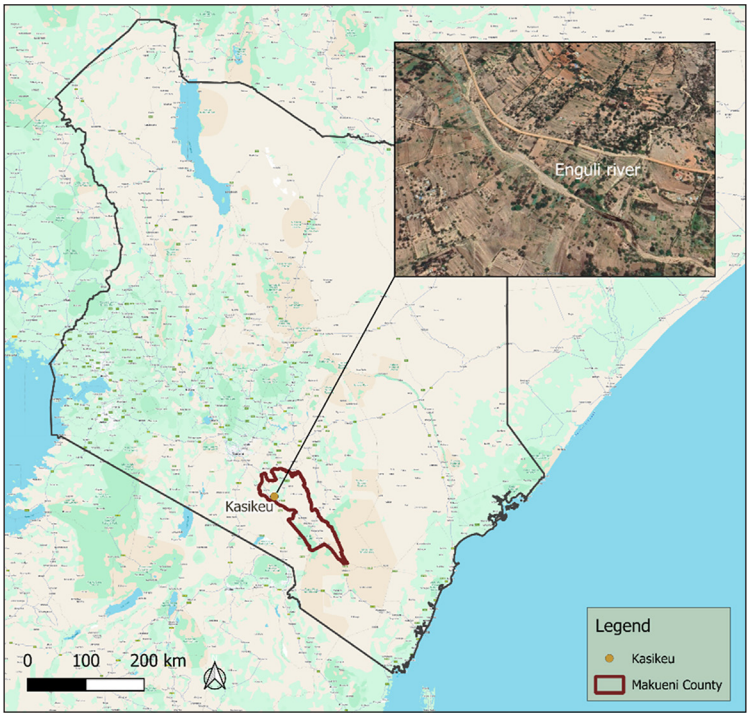

Figure 1. Map of Kenya indicating Makueni County, Kasikeu community and Enguli River

Makueni County has a population of almost 1 million people (Kenya National Bureau of Statistics, 2022). The county is primarily home to Kamba people, who make their living from pastoralism and smallholder farming. Maize, beans, pigeon peas, and drought-tolerant cereals like sorghum and millet are grown using rainfed agriculture. Other crops, such as tomatoes, vegetables and fruits, are produced with irrigation, for home consumption and (local) markets. Water sources used for irrigation are sand rivers and deep groundwater. The majority of rivers in Makueni are seasonal, with water stored in the river beds often accessible throughout the dry season (Government of Makueni County, 2023). The spatial scope of this study is the Enguli River, a sand river located near Kasikeu community (Fig. 1). The Enguli drains into the larger Muooni sand river, as part of the Athi River basin. The river is used for smallholder irrigation, livestock and domestic purposes. Irrigators, who mostly own the land they cultivate, have made incremental investments in irrigation development, adapting to biophysical and socioeconomic uncertainties such as floods, water scarcity and volatile markets (Prasad et al., 2024).

Research approach and methods

This study included three phases: a baseline study, in-depth data collection, and analysis. First, based on preliminary demarcation of farming fields in Google Earth, a total of 158 plots were identified during field work, in a segment of 2.5 km along the Enguli River. Spread along the river, 60 farmers were selected for the baseline study, based on availability during the field visit period. After obtaining informed consent from the participants, the surveys were held with farmers using a digital data collection tool EpiCollect 5. This was used to collect data about crops, technologies, relation to sand harvesting, irrigation methods, duration of farming, and socioeconomic characteristics. Of the 60 farmers selected for the baseline study, 47 were irrigating at the time of field work, while 13 were practicing rain-fed farming (Table 1). The majority of farmers were men, especially those who irrigated, and the proportion of younger farmers is relatively larger for the irrigating farmers.

From the baseline data, 23 farmers were purposively selected so as to include a diversity in age, duration of farming, location along the river, gender, engagement with sand harvesting, and farming technologies, in order to capture diverse stories on the history of the area. From December 2022 until January 2023, in-depth semi-structured interviews were held with these selected farmers, with the help of a translator (Kiswahili – English). Data were recorded manually in a notebook, followed by transcription. Data collected included their individual farming histories, covering their irrigation activities, relation to sand harvesting, the impacts of sand harvesting, and subsequent coping strategies. In addition, interviews were held with staff of the Makueni Sand Conservation and Utilisation Authority (a revenue officer and an environmental agent), agricultural officers working in the area (2), and sand loaders (2) active in another sand river (Muooni River) near the study area. These interviews generated broader insights into the sand harvesting practices and smallholder agriculture.

The last phase included a qualitative analysis to capture the farming activities, motivations, challenges, and impacts of sand harvesting and coping mechanisms over time. Based on individual histories, a graphic visualisation of the evolving farming activities, sand harvesting and conflict in the areas was made.

Table 1. Basic characteristics of the farmers in the baseline study

Characteristic	Irrigating farmers (*n* = 47)	Rain-fed farmers (*n* = 13)
Gender:		
Male	34 (72%)	8 (62%)
Female	13 (28%)	5 (38%)
Age (years):		
18–30	9 (19%)	1 (8%)
30–50	18 (38%)	5 (38%)
>50	20 (43%	7 (54%)
Education:		
Primary	19 (40%)	5 (38%)
Secondary	26 (55%)	7 (54%)
College	1 (2%)	1 (8%)
None	1 (2%)	0 (0%)
Farm area (ha):		
< 0.4	26 (55%)	7 (54%)
> 0.4	21 (45%)	6 (46%)

RESULTS

A history of exploitation, conflict and restoration of a sand river

Enguli River is among several sand rivers in Makueni where intensive sand harvesting took place between 2012 and 2015. By reconstructing the recent history of sand harvesting from the river according to the narratives of the farmers interviewed, three different phases can be distinguished – before, during and after sand harvesting. Each phase is characterised by a distinctive interplay between agriculture, water availability and access, and sand harvesting activities. Figure 2 presents a graphic qualitative interpretation of the reconstructed history of the river and the effects for the riparian community. It shows how sand harvesting started increasing from 2010 onwards, to reach its peak between 2012 and 2013 (yellow line). During this time, irrigated farming, and the investments in irrigated farming declined (grey-blue and blue lines), whereas rain-fed farming shows a slight upward trend and then also decreases (green line). After conflict resolution, in 2015, farming practices slowly reoccurred. The next sections will elaborate on the three different phases.

Phase 1: Smallholder farming along the Enguli River

During the period prior to the entry of lorries and loaders in the area, rain-fed and irrigated farming was slowly expanding along the river. Farmers produced crops such as maize, mango and vegetables (e.g. spinach, cabbage and kale), mostly for home consumption and some local sales. Farming households, primarily originating from the area, owned farm plots on an individual basis. Most of the farmers dug scoop-holes to fetch water from the river, while some others had shallow wells on their lands to access water for domestic purposes and cultivation. The irrigated area increased gradually as more farmers purchased irrigation equipment, such as motorised pumps, to mitigate the difficulties of irregular rainfall patterns and increase production. Few farmers received assistance from government or NGOs, for example, technical assistance on crop production, the construction of wells or the installation of pumps.

Phase 2: Sand harvesting – an evolving conflict

In 2010, the district commissioner in charge approached the leaders in Kasikeu with the request to allow lorries to enter the area for collecting and purchasing sand from the river. While a part of the community granted permission, viewing it as an opportunity for additional income in the form of commissions and wage labour, others disagreed with the plans for the expected impact on water resources. Hence, from the onset, there were opposing views on

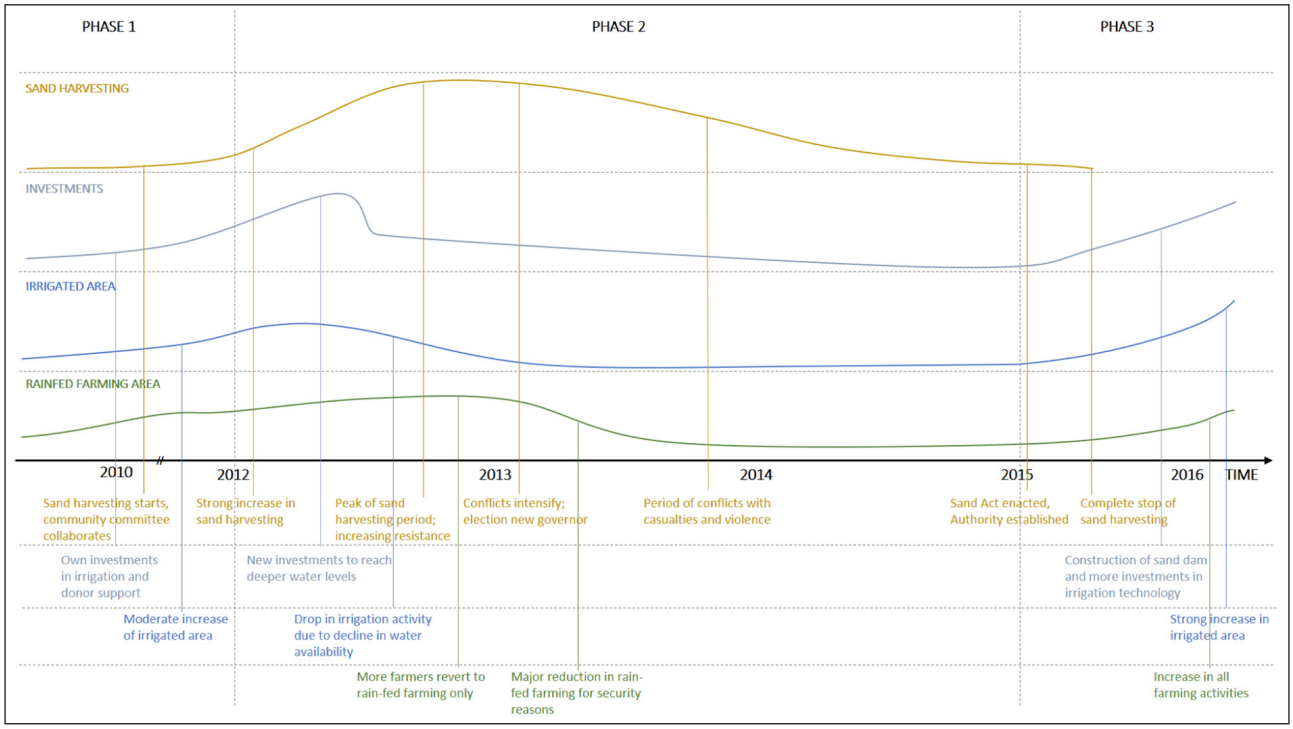

Figure 2. Representation of the sand harvesting and farming history of Enguli River

sand harvesting within the community, with farmers represented in both perspectives. In response, community members, including a local leader, established a community committee to facilitate the commercialization of sand extraction. This organization, called Kamu, is named after two rivers; the Kaluku River and Mwua River. The Enguli River is a tributary flowing into the somewhat larger Kaluku sand river, also adjacent to Kasikeu community. Kamu aimed to establish the necessary connections between sand cartels, transporters, loaders, and landowners, and became responsible for managing the resources and distributing the respective revenues to each actor involved. There was an agreement about benefit-sharing and the extent to which sand harvesting was allowed. Different community members were paid for each lorry load, with approximations up to a maximum of 3 400 KES, depending on the tonnage of the lorry (3 400 KES corresponded with approx. 39 USD as of 1 January 2014 (Oanda, 2024)). This amount included 1 300 KES to distribute among members of the sand harvesting committee (Kamu), 100 KES for savings by Kamu, 200 KES to officers/government members, 800 KES to sand loaders (as a group) and 1 000 KES to land owners. The price for sand carried by a 7-tonne lorry was reportedly approx. 28 000 KES in Nairobi (Yusuf, 2024). These listed benefits are approximations and may have altered slightly over the years.

Initially, the operations appeared favourable to involved community members. However, sand removal soon occurred beyond the agreed limits, and it was around 2013 when sand harvesting became an uncontrolled activity. The harvesting of sand intensified with increasing numbers of lorries, removal beyond the river boundaries into the plots of the farmers, and more aggression. This caused anguish and fear among farmers and families residing in the riverside area. Farmers have described the sand harvesters and their interactions with terms like "Those people were aggressive", "You could not talk with them", and "They were very hostile". Impacts on water availability, crops and farmlands, and on security were experienced. These are explained in the following sections.

Water available for irrigation: The removal of sand reduced the water storage capacity in the river substantially, making it more difficult to extract water. The depletion of sand in the river reached a point where water extraction became impossible for the farmers with the available technologies. Even when water was present, the placement of pumps had to be lower or with extended suction, negatively impacting their hydraulic efficiency and/or fuel consumption. For farmers using buckets, the task became more arduous, since the water levels to which it was necessary to descend had dropped.

Damage to lands and crops: Several farmers discovered that a portion of their land was scooped by sand harvesters and removed overnight. For example, one of the farmers (male, 28 years) stated: "When they (sand loaders) came, they uprooted the crops and took part of the cropped land to take the sand". Others accused people from outside who were in the sand business of taking part of their harvested crops. Finally, because the river banks were damaged, some farmers perceived increased impacts of floods during the rainy season, further damaging their plots.

Security within the community: The extraction of sand triggered conflicts between the opposing farmers and community members on the one hand, and sand dealers, loaders and drivers (both external and from within the community) on the other hand, resulting in violence and threats that forced farmers to alter their way of life during that period. Some farmers claim to bear physical scars from the confrontations in the area. Others have memories of individuals suffering injuries or even losing their lives. Some people who resisted sand harvesting faced threats and coercion, and were compelled to relocate. One farmer (male, 61 years), explained: "(…) During sand harvesting time, the water started to deplete, and the confrontations in the area were hard. I was even beaten on my head and I had to go to the hospital and to the court (…)".

Phase 3: Grassroots and government efforts leading to change

While the community sand committee initially had a facilitating role, they soon lost control over the actions of the loaders and could not ensure that the loaders adhered to the agreed limits.

Consequently, several community members began expressing complaints to the leader of the community sand committee regarding threats and abuses that they faced. After acting as a leader for about half a year, he switched sides under community pressure and started supporting the farmers in their fight against sand harvesting. From 2013 onwards, several farmers and other community members increasingly undertook attempts to halt the sand extraction. As one farmer (male, 60 years old) expressed his resistance against sand loaders and lorry drivers "Do not touch it, please leave this land". Initially, complaints were made with the Kasikeu community chief officer and his staff, who have their offices close by. However, the chief officer and his assistant were unwilling to support them and to expel the sand cartels from the area. Then, the opponents raised their complaints with the police, the District Commissioner, and members of parliament, but several farmers claim that these authorities benefited from the sand harvesting and therefore refused their support to curb the violence and control the sand harvesting. National level regulations, including the Mining Act (revised in 2012) and regulations by the National Environmental Management Agency (NEMA), were not enforced.

As a response, several community members decided to unite and collaborate in counter groups, sometimes referred to as '*kiwingu*', undermining the activities of the sand cartels. For example, they set lorries on fire and expelled loaders and traders. At this stage, they were on their own in fighting the cartels, without the support of formal authorities. Also, some people from outside the Kasikeu community joined the resistance, out of fear for the spread of the sand harvesting and related violence to their river communities.

In 2013, when sand extraction in the Enguli and neighbouring sand rivers was highly contested, Kenya introduced a decentralised governance structure that devolved substantial powers to counties. With the new governor in place in the newly established Makueni County, a more open and public opposition against the sand harvesting practices in the region emerged. In 2015, the Makueni Sand Conservation and Utilisation Act was established, which resulted in the establishment of the Makueni Sand Conservation and Utilisation Authority, with the primary task to conserve sand rivers and regulate sand harvesting (Government of the Republic of Kenya, 2015). The Sand Act stipulates that it is prohibited to sell sand outside the county, and the Sand Authority regulates commercial sand harvesting for local use through the issuance of licences at designated sites (Makueni County Sand Conservation and Utilisation Act, 2015, sections 6 and 19-26). The Sand Authority aims to maintain a balance between the benefits from both sand and water. It employed staff from diverse communities to enhance its acceptance as a regulatory entity. Although most of these jobs were temporary, the active role of community agents is seen to be one of the key factors in the establishment of the Sand Authority, and moreover, in the enforcement of the new regulations.

Besides establishing regulations, the Sand Authority also blocked roads for lorries to enter the area, in which they initially also faced violence from the cartels. In the end, the violence along the Enguli River ended, as a result of combined resistance of the community members, and efforts by the Sand Authority. Some of the community members who were active in sand harvesting left the area, while others reconciled after a compensation to the community.

Moreover, several initiatives were taken to restore the sand levels in the Enguli River bed, for example, the construction of sand dams. Residents of Kasikeu community were involved in the construction and maintenance of a sand dam and in planting of riparian vegetation to prevent further erosion and reinforce the river banks (Fig. 3). Sand extraction from Enguli River stopped altogether. When sand levels increased in the course of several flood events, irrigated farming returned and expanded over subsequent years. At the time of field visits, no sand harvesting was observed along the river. Moreover, the community that is still scarred by history now fiercely protects the sand river. Stories on how the environmental movement and collective action were enabling forces, and how and why to care for the river are actively shared with younger generations in the Kasikeu community.

The evolution of farmer motivations and actions within an evolving resource conflict

Farmers took diverse approaches both towards the sand harvesting activities, and in dealing with the resulting challenges on their farms. Analysis of individual timelines of farmers show that there is no single or uniform approach and, moreover, that their strategies may change over time. The majority of farmers (44 out of 60; 73%) were not engaged in sand harvesting at all. This diverse group of farmers were engaged in irrigation, either with buckets or motorised pumps and were affected by sand harvesting in their irrigation activities. Of the 23 interviewed farmers, almost all stopped irrigating at some point, with about half of them (12) continuing with rain-fed farming, and others abandoning the farm altogether. Of those who left the irrigated plot, few continued rain-fed farming on another field (4), found employment within the community (7), or left for cities to find other employment (4), and sometimes a combination of these options. They engaged in activities such as motorcycle taxis, brick manufacturing, or businesses or shops in nearby towns. Some continued rain-fed farming on the plot near the river for some time, but eventually left it and searched for alternative livelihood sources. Despite the challenges of water scarcity and security, a few farmers managed to continue their irrigation activities by adapting the water abstraction methods (bucket or pump) or deepening their wells.

Figure 3. Planting of Napier grass along the Enguli River for bank protection (left), and a sand dam constructed near Kasikeu with restored sand levels (right) (photos taken September 2023, credit: Duker)

Farmers who benefitted from the sand harvesting practices relate differently to the impacts on water and land. A minority of farmers (16 out of 60; 27%) were at some point active as loaders or sellers, and one as leader of the community sand committee. This was mostly done alongside their agricultural practices, providing them with an additional income while also gaining protection for their land and crops. Because sand loading was flexible and often carried out at night, farmers could remain engaged in agricultural activities. Also, some farmers were either persuaded or coerced into selling the sand in front of their fields. These different ways of active or passive engagement with sand harvesting offered farmers an additional source of income. For example, one of the farmers (D47 – male, 47 years of age), already had a leading role in the community when he was approached by the district commissioner to facilitate sand harvesting. He was engaged in the Kamu group for at least 6 months and gained financial benefits for facilitating the sand harvesting business. He acted as a bridge between the cartels and the community and was responsible for receiving and distributing payments for each truckload. At the start he tried to persuade community members to allow sand harvesting: "Come and join us in the development". However, he changed his perception about sand harvesting after increasing numbers of complaints by neighbours, about the extent of sand harvesting, security issues, and damage to fields, crops and water resources. He then joined the resistance movement, and at a later stage took part in the violent conflict against the sand cartels. He is one of the few farmers who could continue irrigating as his field was behind a rocky part in the river that continued to have some water.

Some farmers, and other community members, opposed the sand harvesting from the start, but were not effective in preventing the influx of lorries. Other farmers opposed the practice only after realising the detrimental impacts on the ecosystem and security. Four out of 23 farmers actively joined the resistance movement, including violent actions to undermine the sand harvesting activities.

DISCUSSION

The history of Enguli River shows how sand harvesting can severely impact water availability in sand rivers, which are unique water resources in regions where other sources of water are often absent. As a result, excessive removal of the sand storage system forced farmers to stop irrigating. Through studying this contestation over water and sand resources two related issues emerge: how grassroots resistance and state-actors relate in addressing resource conflicts, and how such an environmental movement evolves as a result of changing perceptions on resource exploitation. The Enguli case study shows how grassroots resistance and a shift in politics provided a window for halting excessive resource use, and for restoring a river and livelihoods depending on it. The riparian community in Kasikeu brought resistance, and a governmental intervention translated this resistance into a framework for further action. A shift in the political arena, both the entity and the persons, resulted in a new mandate to enforce the change desired by the opponents of the sand cartels. In addition, the creation of the counties is likely to have created a more capable and accountable geographical and administrative level for managing this resource use, as opposed to the previous (ineffective) national-level legislation. Finally, a decision to become politically active in opposing environmental injustices can also be a way for individuals to 'repoliticize' themselves (Joy et al., 2014; Grant and Le Billon, 2019).

Farmers and other community members employed different strategies to adapt to, fight or benefit from a new yet controversial resource opportunity. Initially, despite awareness of the threats created by sand harvesting, several community members participated in or facilitated the practice to their own (short-term) benefit, while those who opposed the practice lacked the power to change it. Yet, resistance against sand harvesting increased over time, both among community members and politicians, as a result of experiencing more adverse impacts and pressure from community members. The creation of the Sand Authority and the Sand Act instrumentalized the legitimization and claims of resistance. This resonates with cases in other water conflict settings where grassroots movements employ diverse strategies and accumulate social capital over time (Cuadrado-Quesada and Joy, 2021; Godinez Madrigal et al., 2024). Change thus emerged from resistance and not from a managed process alone, or from technological advancements (Temper et al., 2018b).

A shift to more sustainable use of sand rivers evolved as an interplay between state and non-state actors, implying that a clear distinction between state-led and citizen-led transformation cannot always be made (see for example, Scoones et al., 2015). A dichotomy between state and non-state actors simplifies complex relations and power distributions. Likewise, this case cannot be positioned as resistance from the community versus the state, as is repeatedly seen in literature, for example over forest tenure (Roberts, 2016). Instead, we found that allies and opponents exist both within communities and state actors, and that they may change viewpoints over time for a variety of reasons.

Moreover, resistance to environmental injustices often emerges from the poor, as they are the ones directly depending on the resources, and thus affected by environmental degradation, in the absence of livelihood alternatives (Martinez-Alier, 2002). This environmentalism of the poor is to a large extent visible in the Kasikeu community. The riparian community, who initiated the resistance, was the primary dependent of the sand river, and therefore more vulnerable than the sand traders and politicians facilitating the sand business. Yet, within the community we can distinguish different roles and resulting distributions. Some, either farmers or other community members, and the youth involved in sand loading with limited livelihood options in particular, also benefitted from the environmental disaster that unfolded. Thereby the position of several community members towards sand extraction changed throughout the phases of the river's history.

The case demonstrates that disaster evolved, before a more sustainable management of sand rivers could develop. In this process, bottom-up resistance and (violent) confrontations were imperative in creating political will and triggering decentralized governance efforts. This multi-scalar process is regarded as one of the key features of radical transformations as analysed within environmental justice movements (Ostrom, 2010; Joy et al., 2014; Temper et al., 2018b). Hence, although the adoption of multiple strategies, such as physical obstruction and building alliances, is found to often be successful in bottom-up resistance movements, as in our case, these forces may not be considered sufficient in addressing injustices on their own (Gobby et al., 2022).

CONCLUSIONS

We conclude that sand harvesting from ephemeral sand rivers can have devastating impacts on the water availability in riparian communities depending on these storage systems. While the relation between sand volume and water storage in these particular rivers is understood theoretically (Joy et al., 2020), there is scarce literature on the manifestation of how sand extraction impacts the livelihoods of riparian smallholder farmers (see also Duker et al., 2025). Also, there is a knowledge gap on the physical processes of sand dynamics, the impacts of removal of sand, and possible effective and sustainable approaches towards sand management. How to attain sustainable and just governance of these sand rivers is ambiguous and contested. We have seen

that a process of grassroots resistance, collective action and government policy formulation can end a persistent conflict over natural resources, and advance the potential for conservation and sustainable management. A deep conflict developed into a force for transformation of the sand extraction activities in the area, where a strong sense of care for the sand river has emerged. Yet, we conclude that environmental movements are not uniform and resistance is not a straightforward process, but one in which individuals change position, opinion and alliances over time.

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AUTHOR CONTRIBUTIONS

Annelieke Duker; writing initial draft, manuscript review, analysis, visualization, conceptualization, methodology, coordination. Diego Zuluaga Velásquez; data collection, methodology, analysis, visualization, writing initial draft. Pooja Prasad: methodology, conceptualization, manuscript review, coordination. Charlotte de Fraiture: manuscript review, coordination. Gabriela Cuadrado Quesada: manuscript review, conceptualization, coordination, resource mobilization.

REFERENCES

ADUDA L, BOLF L (2024) The conflict potential of sand: Illegal sand mining on the African continent. *Environ. Secur.* **2** (4) 548–567. https://doi.org/10.1177/27538796241230583

AGYEMAN J (2005) *Sustainable Communities and the Challenge of Environmental Justice*. NYU Press, New York, USA.

AKANWA AO (2021) River sand mining and its ecological footprint at Odor River, Nigeria. In: Banerjee A, Meena RS, Jhariya MK and Yadav DK (eds.) *Agroecological Footprints Management for Sustainable Food System*. Springer, Singapore. 473–514. https://doi.org/10.1007/978-981-15-9496-0_16

ALIU IR, AKOTEYON IS and SOLADOYE O (2022) Sustaining urbanization while undermining sustainability: the socio-environmental characterization of coastal sand mining in Lagos Nigeria. *GeoJournal* **87** 5265–5285. https://doi.org/10.1007/s10708-021-10563-7

BENDIXEN M, BEST J, HACKNEY C and IVERSEN LL (2019) Time is running out for sand. *Nature* **571** 29–31. https://doi.org/10.1016/j.exis.2023.101364

BISHT A (2021) Conceptualizing sand extractivism: Deconstructing an emerging resource frontier. *Extractive Industr. Soc.* **8**. https://doi.org/10.1016/j.exis.2021.100904

CHAURUKA M, DUKER AEC, PRASAD P and VAN DER ZAAG P (2023) Endogenous irrigation in arid Zimbabwe: farmer perceptions of livelihood benefits and barriers to scaling. *Water SA* **49** 355–362. https://doi.org/10.17159/wsa/2023.v49.i4.4031

CUADRADO-QUESADA G (2018) Challenges and opportunities at implementing groundwater governance in Australia: Case studies from South Australia and Western Australia. *Environ. Polic. Law J.* **35** 588–605.

CUADRADO-QUESADA G and JOY KJ (2021) The need for co-evolution of groundwater law and community practices for groundwater justice and sustainability: insights from Maharashtra, India. *Water Alternat.* **14** 717–733.

DAGHAR M (2022) Kenya's sand cartels – Ecosystems, lives and livelihoods lost. ENACT research paper. URL: https://enact-africa.s3.amazonaws.com/site/uploads/2022-035-03-sand-research-paper-26.pdf (Accessed 6 November 2024)

DUKER AEC, EMBAYE TG, HAGOS EY, SMIGAJ M, WALKER D and YUSUF H (2025) Balancing water and sand demands: a research agenda to support more sustainable sand harvesting from sand rivers in sub-Saharan Africa. *Environ. Sci. Polic.* **171**. https://doi.org/10.1016/j.envsci.2025.104162

DUKER AEC, KARIMBA BM, WANI GE, PRASAD P, VAN DER ZAAG P and DE FRAITURE C (2022) Security in flexibility: accessing land and water for irrigation in Kenya's changing rural environment. *Cahiers Agric.* **31**. https://doi.org/10.1051/cagri/2022003

DUKER AEC, MAWOYO TA, BOLDING A, DE FRAITURE C, VAN DER ZAAG P (2020) Shifting or drifting? The crisis-driven advancement and failure of private smallholder irrigation from sand river aquifers in southern arid Zimbabwe. *Agric. Water Manage.* **241**. https://doi.org/10.1016/j.agwat.2020.106342

FRASER N (2005) Reframing justice in a globalizing world. *New Left Rev.* **36** 69–88. https://doi.org/10.64590/ys5

GOBBY J, TEMPER L, BURKE M, VON ELLENRIEDER N (2022) Resistance as governance: Transformative strategies forged on the frontlines of extravism in Canada. *Extractive Indust. Soc.* **9**. https://doi.org/10.1016/j.exis.2021.100919

GODINEZ MADRIGAL J, VAN CAUWENBERGH N, OCHOA-GARCIA H, VAN DER ZAAG P (2024) Can grassroots movements in water conflicts drive socio-technical transitions in water management systems? *Environ. Innov. Societal Transitions* **51**. https://doi.org/10.1016/j.eist.2024.100837

GOVERNMENT OF MAKUENI COUNTY (2019) Makueni County Spatial Plan 2019–2029.

GOVERNMENT OF MAKUENI COUNTY (2023) Makueni County Integrated Development Plan 2023–2027.

GOVERNMENT OF THE REPUBLIC OF KENYA (2015) The Makueni County Sand Conservation and Utilization Act 2015. Makueni County Government.

GOVERNMENT OF THE REPUBLIC OF KENYA (2022) The Makueni County Sand Conservation and Utilization Amendment Act 2022. Makueni County Government.

GRANT H and LE BILLON P (2019) Growing political: violence, community forestry, and environmental defender subjectivity. *Soc. Nat. Resour.* **32** 768–789. https://doi.org/10.1080/08941920.2019.1590669

JOY KJ, KULKARNI S, ROTH D and ZWARTEVEEN M (2014) Re-politicising water governance: exploring water re-allocations in terms of justice. *Local Environ.* **19** 954–973. https://doi.org/10.1080/13549839.2013.870542

JOY KJ, BHADBHADE N, BAGHAT S, LOHAKARE K, RAO N, SAMUEL A (2020) Is sand mining killing our rivers? mining riparian health. West Zon Regional Report. India River Week 2020. URL: https://indiariversforum.org/wp-content/uploads/2020/11/irw2020_westindiasandminingoverview_soppecom_v3.pdf (Accessed 10 September, 2025).

KARIMBA BM, DUKER A, PRASAD P, KARIMI P, DE FRAITURE C and VAN DER ZAAG P (2022) Irrigation on the move: How transient farming partnerships facilitate the expansion of smallholder irrigation along ephemeral rivers in dryland areas of Kenya. *Agric. Water Manage.* **265**. https://doi.org/10.1016/j.agwat.2022.107526

KATISYA-NJOROGE C (2021) Kenya's sand harvesting laws and the sustainable development licence to operate: in quicksand? *J. Conflict Manage. Sustainable Dev.* **6** 167–186.

KATZ-LAVIGNE S, PANDEY S, SUYKENS B (2022) Mapping global sand – extraction, research and policy options. Ghent University.

KENYA NATIONAL BUREAU OF STATISTICS (2022) Makueni County Statistical Abstract 2022.

MANSELL MG, HUSSEY SW (2005) An investigation of flows and losses within the alluvial sands of ephemeral rivers in Zimbabwe. *J. Hydrol.* **314** 192–203. https://doi.org/10.1016/j.jhydrol.2005.03.015

MARTINEZ-ALIER J (2002) *The Environmentalism of the Poor: a Study of Ecological Conflicts and Valuation*. Edward Elgar Publishing Ltd., Cheltenham, UK. https://doi.org/10.4337/9781843765486

MASALU DCP (2002) Coastal erosion and its social environmental aspects in Tanzania: a case study in illegal sand mining. *Coast. Manage.* **30** 347–359. https://doi.org/10.1080/089207502900255

MUTHOMI S, OKOTH P, WERE E and VUNDI S (2015) An examination of the nature of sand harvesting conflicts and their influence on poverty alleviation initiatives in Makueni County, Kenya. *J. Educ. Pract.* **6** 28–36.

NGUYEN BQ, KANTOUSH SA and SUMI T (2024) Quantifying the consequences of unsustainable sand mining and cascade dams on aspects in a tropical river basin. *Sci. Rep.* **14**. https://doi.org/10.1038/s41598-024-51405-z

OANDA (2024) Oanda historical currency converter.

OSTROM E (2010) Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Change* **20** 550–557. https://doi.org/10.1016/j.gloenvcha.2010.07.004

PRASAD P, DUKER A, VELASQUEZ DZ, CHAURUKA M, KARIMBA BM, DE FRAITURE C, MANZUNGU E and VAN DER ZAAG P (2024) From few large to many small investments: lessons for adaptive irrigation development in an uncertain world. *Front. Water* **6**. https://doi.org/10.3389/frwa.2024.1296262

RENTIER ES, CAMMERAAT LH (2022) The environmental impacts of river sand mining. *Sci. Total Environ.* **838**. https://doi.org/10.1016/j.scitotenv.2022.155877

ROBERTS K (2016) It takes a rooted village: networked resistance, connected communities, and adpative responses to forest tenure reform in Northern Thailand. *Austrian J. South-East Asian Stud.* **9** 53–68. https://doi.org/10.14764/10.ASEAS-2016.1-4

SCHLOSBERG D (2007) Reconceiving environmental justice: global movements and political theories. *Environ. Polit.* **13** 517–540. https://doi.org/10.1080/09644010420000229025

SCHROEDER R, MARTIN KS, WILSON B and SEN D (2008) Third World environmental justice. *Soc. Nat. Resour.* **21** 547–555. https://doi.org/10.1080/08941920802100721

SCOONES I, NEWELL P and LEACH M (2015) The politics of green transformations. In: Scoones I, Newell P and Leach M (eds): *The Politics of Green Transformations*. Routledge, Oxon. 1–24. https://doi.org/10.4324/9781315747378-1

SEN A (2009) *The Idea of Justice*. Allen Lane, London, UK. https://doi.org/10.4159/9780674054578

SHITIMA C and SUYKENS B (2023) Formalization of sand mining in Dar es Salaam, Tanzania. *Resour. Polic.* **82**. https://doi.org/10.1016/j.resourpol.2023.103589

SMIGAJ M, WALKER DW, TIRIVAROMBO S, MORERI K, PRINGLE C, MCCOSH J, MUSTAFA SMT and JOVANOVIC N (2025) Local perspectives, regional consequences: The socio-environmental impacts of sand harvesting in southern Africa. *Extractive Indust. Soc.* **23**. https://doi.org/10.1016/j.exis.2025.101631

SWYNGEDOUW E and HEYNEN NC (2004) Urban political ecology, justice and the politics of scale. *Antipode* **35** 898–891. https://doi.org/10.1111/j.1467-8330.2003.00364.x

TEMPER L, DEMARIA F, SCHEIDEL A, DEL BENE D, MARTINEZ-ALIER J (2018a) The Global Environmental Justice Atlas (EJAtlas): ecological distribution conflicts as forces for sustainability. *Sustainability Sci.* **13** 573–584. https://doi.org/10.1007/s11625-018-0563-4

TEMPER L, WALTER M, RODRIGUEZ I, KOTHARI A and TURHAN E (2018b) A perspective on radical transformations to sustainability: resistances, movements and alternatives. *Sustainability Sci.* **13** 747–764. https://doi.org/10.1007/s11625-018-0543-8

UNEP (United Nations Environment Programme) (2019) Sand and sustainability: Finding new solutions for environmental governance of global sand resources. United Nations Environment Programme, Geneva.

UNEP (United Nations Environment Programme) (2022) Sand and sustainability: 10 strategic recommendations to avert a crisis. United Nations Environment Programme, Geneva.

WALKER D, JOVANOVIC N, BUGAN R, ABIYE T, DU PREEZ D, PARKIN G and GOWING J (2018) Alluvial aquifer characterisation and resource assessment of the Molototsi sand river, Limpopo, South Africa. *J. Hydrol. Reg. Stud.* **19** 177–192. https://doi.org/10.1016/j.ejrh.2018.09.002.

YUSUF H (2024) Personal communication, 16 July 2024. H. Yusuf, former CEO Makueni Sand Conservation and Utilisation Authority, Wote, Kenya.