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Consequences for Maasai Pastoralists of Changing Water Access Regimes in the Greater Amboseli Ecosystem, Kenya

Arthur Bostvironnois

Department of Geography, CNRS 5600 EVS, University Lumière Lyon 2, Bron, France; arthur.bostvironnois@univ-lyon2.fr

François Mialhe

Department of Geography, CNRS 5600 EVS, University Lumière Lyon 2, Bron, France; francois.mialhe@univ-lyon2.fr

Yanni Gunnell

Department of Geography, CNRS 5600 EVS, University Lumière Lyon 2, Bron, France; yanni.gunnell@univ-lyon2.fr

Oldrich Navratil

Department of Geography, CNRS 5600 EVS, University Lumière Lyon 2, Bron, France; oldrich.navratil@univ-lyon2.fr

ABSTRACT: Among the Maasai group ranches surrounding Amboseli National Park in southern Kenya, perennial springwater from the foothills of Mt. Kilimanjaro generates an oasis effect in an otherwise water-scarce landscape; it underpins pastoral livelihoods, agricultural productivity, and wildlife conservation economics. This resource, however, is increasingly under pressure from these competing interests. Based on semi-structured interviews, waterscape mapping workshops with Maasai pastoralists, field observations, and visual interpretations of high-resolution satellite images, we map, describe and analyse how 70 years of uncoordinated proliferation of water extraction, conveyance, and storage features across the semi-arid savanna rangelands has altered the local water cycle and changed power dynamics around water resources. A succession of externally driven rural development, land reform and conservation policies has contributed to the reshaping of patterns and regimes of access to water by modifying land ownership and attracting new activities such as crop irrigation and safari tourism. As a result, the status of water is shifting from a common-property resource with a tradition of sharing, to a commodified resource that is controlled privately and redistributed according to individualistic strategies. Our focus on three hydrosocial territories from a Maasai perspective examines how high densities of private structures such as wells and small runoff- and pipeline-fed storage reservoirs are pushing the livestock-based, semi-nomadic economy towards intensive, sedentary agriculture. Inequalities in access to water have deepened, with water users associations and other water management organisations also experiencing or generating new forms of conflict between resident communities.

KEYWORDS: Political ecology, resource ownership, commons, privatisation, water management, water use, pastoralism, conflict

INTRODUCTION

The accumulation of water extraction, storage and conveyance structures – for irrigation or otherwise – can alter the trajectory and function of water in a local landscape. Collectively, these changes have the potential to alter the water cycle on a regional scale. The introduction of new hydraulic infrastructure in watersheds also generates new power dynamics among resident communities by modifying or resetting conditions of access for water users. In certain circumstances, the multiplication of small hydraulic structures can potentially strengthen the resilience of local communities to hydroclimatic variability (Gunnell and Krishnamurthy, 2003; Mialhe et al., 2008; Bétard et al., 2011; Shanmugasundaram et al., 2017; Gasmi et al., 2024). In other circumstances, it will marginalise certain sections of the population.

In this paper, we address how water-related issues have been playing out in a context of land reform and rapid land-use changes across the Greater Amboseli Ecosystem in southern Kenya, an area consisting of Amboseli National Park (ANP) and its surrounding belt of Maasai group ranches. Whereas natural watersheds display boundaries defined by drainage divides or by aquifer limits, this semi-arid region is internally drained and displays few well-defined, mappable watersheds. The occurrence of water is diffuse, erratic and ephemeral, except for a few more-reliable and highly coveted focal points in the landscape, such as lakes and wetlands. In the modern technological world, however, pumps can lift water across natural topographic boundaries, can help to store and redistribute water against gravity, and man-made channels and pipes can bypass natural water sinks such as lakes and river channels. A hydrological region's natural boundaries, sources and sinks can thus increasingly be replaced by social and economic boundaries, stocks and flows that are defined by money and power (Abbott et al., 2019). Natural watersheds that have undergone technological transformations of this kind can be suitably defined as a hydrosocial territories, *i.e.*; "spatial [configurations] of people, institutions, water flows, hydraulic technology and the biophysical environment that revolve around the control of water" (Boelens et al., 2016).

As a shifting mosaic of hydrosocial territories, the Greater Amboseli Ecosystem (GAE) is well suited to a study that aims to address the dynamics of water harvesting and water transfer systems. A hydrosocial territory is a geographical space which is defined by changing power dynamics that modify natural flow accumulation patterns across the landscape and redefine social relations and hierarchies. The territory undergoes boundary changes over time as a result of shifts in internal and external natural, demographic, economic and political variables. The key components of the water-harnessing system are not necessarily a trunk river or its tributaries and springs; they can equally be a network of pipelines or canals, or a collection of artificial reservoirs, runoff harvesting ponds, open wells or borewells; these can be either traditional or modern, still functional, or derelict.

Water-harnessing structures are not just material features. They are also politically charged entities that reflect the relationships that societies craft with their environment (Harris, 2001; Ribot and Peluso, 2003; Casciarri and Staro, 2019). Various manifestations of power can be observed in such structures, from the scale, siting and design of the infrastructure itself to the activities and social profiles of the agents who most benefit from it (Moss, 2016; Obertreis et al., 2016). Political choices determine how these structures are governed, the priority given to their uses, and the status of the water resources stored or diverted. The structures may be managed by public institutions, private companies, non-governmental organisations (NGOs), or directly by the users themselves. An understanding of who is responsible for managing and controlling access to water in pluralistic hydrosocial territories is important for elucidating the patterns and beneficiaries of water use (Hoogesteger et al., 2016). Any new item of infrastructure is initially designed for a specific purpose such as drinking water, energy, irrigation or wildlife conservation; former users of the resource may thus find themselves marginalised or in competition with new water-related activities. Water can also switch from being an open access resource to a common property resource (Ostrom, 1990) or a privatised resource under exclusive individual rights. Privatisation and commodification are supported in many places in accordance with the principles set out at the 1992 Dublin Conference (Valette, 2024). This results in strengthening the power of those who obtain exclusive rights, but it does not guarantee a more efficient use of the resource (Trawick, 2001; Garrido, 2011). It is not uncommon for these changes to occur concurrently with changes in land use and land tenure regimes.

The study area in southern Kenya is emblematic of nomadic pastoral rangelands worldwide, up to about 60% of which occur in arid and semi-arid areas (Reid et al., 2014) and are experiencing rapid and major environmental change (Sayre et al., 2013). Vegetation and pastoralism in savanna and steppe landscapes are adapted to low and variable precipitation totals, including droughts (Turner and Schlecht, 2019). Herders and their flocks are compelled to move in search of pasture and of ephemeral and dispersed watering places (Reid et al., 2014). These mobility patterns are traditionally governed by customary institutions that establish rules of access, frameworks for collective deliberation, and tools for negotiation with neighbouring populations (Casciarri and Staro, 2019). The institutions define water ownership regimes that play a central role in farmers' abilities to cope with droughts. Their guiding principles such as solidarity, and their processes such as deliberation for conflict resolution, aim to ensure a sustainable use of resources (Blewett, 1995; Thébaud and Batterbury, 2001). Although the systems may appear technologically simple, aspects that determine access to resources can be complex (Casciarri, 2013).

Modern administrations and political authorities do not necessarily recognise the advantages of these traditional means of livelihood and resource management (Postigo, 2021). Itinerant pastoralists are not granted the same level of respect by governments as farmers are (Casciarri and Staro, 2019). Indeed, in some extreme cases such as Palestine's West Bank pastoralism has been entirely suppressed (De Donato, 2019). State policies tend to favour settled lifestyles, land control, and individual resource ownership (Scoones, 2023). This has often entailed a shift away from itinerant pastoral livelihoods towards more sedentary occupations such as farming (Hemingway et al., 2022; Waller, 1999; BurnSilver, 2009). The expansion of irrigated agriculture and protected wildlife areas in semi-arid regions has added further constraints on pastoralists and usually restricted their options in terms of access to water (Mehta and Srivastava, 2019; Ali and Mustafa, 2019). Although in some cases pastoralists have been able to secure access to modern water-harnessing structures while retaining usage of older systems (Casciarri and Staro, 2019), the expansion of irrigation has more often resulted in pushing pastoralists away from previous water access points (Walwa, 2020).

Against the backdrop of this broader global framework, the aim of this paper is to examine the impacts on land use, land management, livelihoods and power relations generated by changes in rules of access to water among pastoralists on the savanna rangelands of the Greater Amboseli Ecosystem, whose total area is 5700 km^2. We adopt a political ecology approach and prioritise a pastoralist perspective to examine the ways in which the expansion of water-harnessing infrastructures since the 1950s has transformed the natural water cycle and reconfigured human relations. We portray these dynamics through an inventory and geographical analysis of water-related infrastructures based on mapping workshops and interviews conducted with Maasai water users. We report past conflictual situations and we document the power dynamics currently occurring in three distinct hydrosocial territories that are embedded in the Maasai group ranch mosaic around Amboseli National Park.

STUDY AREA

Natural features and land tenure regime

The study area is a semi-arid savanna mosaic of herbaceous and woody vegetation patches of Acacia and Commiphora (Githumbi et al., 2018), extending across a plateau that is about 1200 metres above sea level. It is overlooked by the foothills of Mt. Kilimanjaro to the south and the younger volcanic Chyulu Hills to the east (Figure 1). The region is populated by Maasai pastoralists belonging to the Ilkisongo section (which is one of 14 sections in East Africa); it is also home to other ethnic groups that have been immigrating into the area since the 1970s (Rutten, 1995).

The GAE encompasses seven group ranches (GR): Olgulului Olalarashi, Imbirikani, Eselenkei, Rombo, Kuku A, Kuku B, and the former Kimana Tikondo GR. The total human population across the GAE in 2019 was approximately 192,000, with an average population density of about 34 people per square kilometre (Kenya National Bureau of Statistics, 2019). Group ranches were established after Kenyan independence in 1964. They were initially inspired by the North American ranch model of livestock farming (Rutten, 1992) and were funded by the World Bank whose aim was the modernising of Maasai pastoralist practices. A regime shift from collective to individual ownership of land and water occurred first in Kimana GR, which was subdivided into privately owned plots in the 1990s; since 2020, this shift to private ownership has expanded to all GRs in southern Kenya (Galaty, 1992; Mwangi, 2007; Rutten, 1992, 1995).

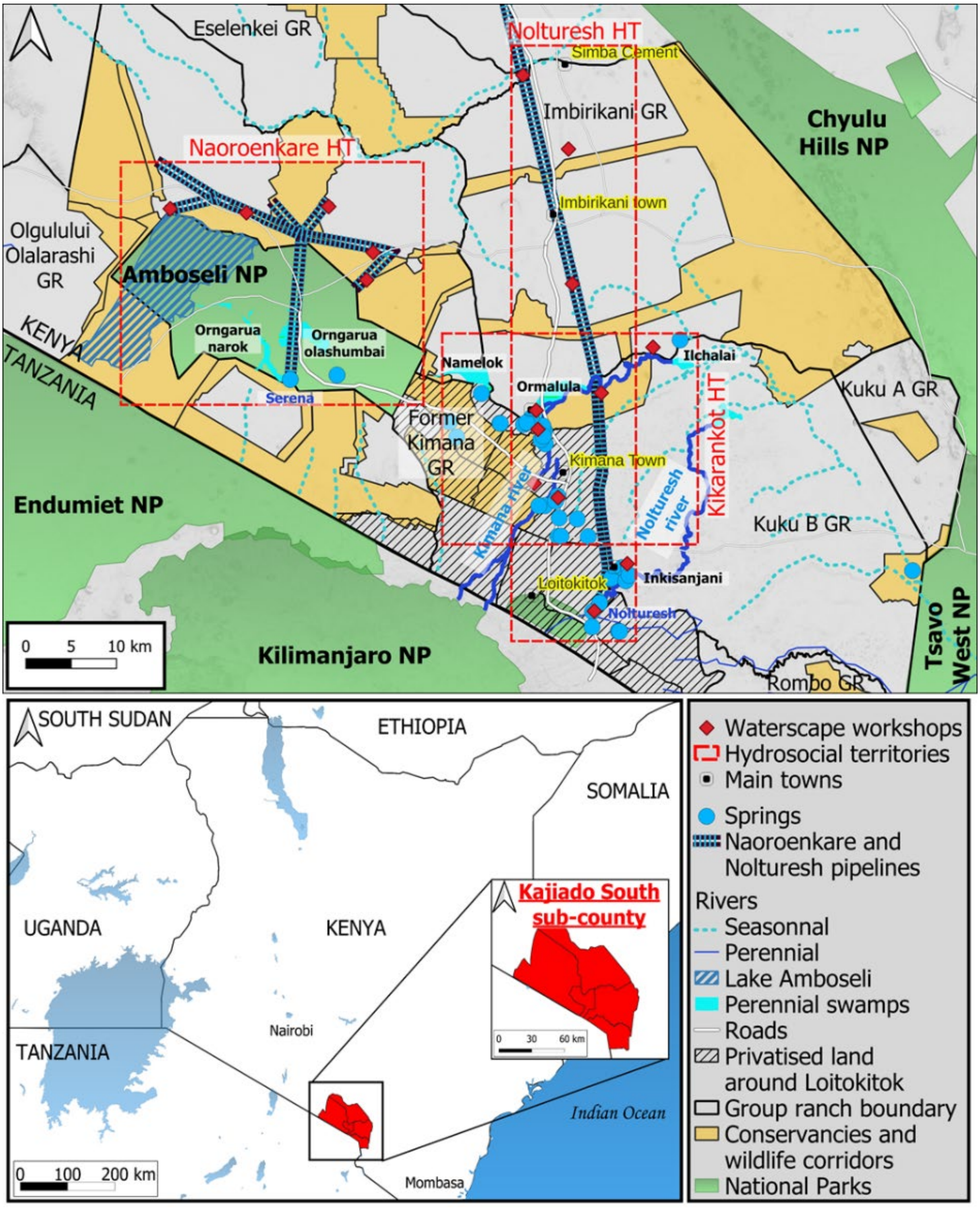
A major feature of the GAE is the presence of protected wildlife habitat areas aimed at conserving emblematic species of the East African savanna. In 1974, an approximately 400 km² portion of land became Amboseli National Park; it included temporary lake Amboseli and two other important swamps. Access to all water points located inside the park was immediately prohibited to livestock (Lewis, 2015). The compensation agreed upon at the time of park creation involved the piping of water from springs inside the park to outlets on the surrounding ranches, which ultimately contributed to the sedentarisation of some pastoralists (Burnsilver et al., 2008; Unks, 2022). Since 1999, the pipeline has been managed by the Kenya Wildlife Service (KWS), which is the state corporation in charge of wildlife conservation within all of Kenya's national parks. Many conflicts have arisen over the park's water resources, which have been used by pastoralists for centuries; during the rainy season, for example, up to 70% of the wildlife moves out of the park (Okello et al., 2011), a situation that causes conflict with the farming minority.

In addition to the group ranch policy, which resulted in transforming common-property resource regimes into private ownership systems, rural development programmes in the last 50 years have also consisted of developing irrigation schemes. Landscapes have been transformed through the development of irrigated agriculture as increasing amounts of water have been captured for the production of subsistence and cash crops. The Swynnerton Plan, implemented in the 1950s, aimed to increase agricultural production (Swynnerton, 1955). Land privatisation and cultivation ensued in the Kilimanjaro foothills (see grey hatching in Figure 1: privatised land around Loitokitok). Immigrants from other parts of Kenya came to the area and established farms (Campbell et al., 2000), and conflicts over resource use arose between Maasai herders and the newly arrived non-Maasai farmers (Rutten, 1992). Southgate and Hulme (2000) have attributed these changes not only to government policies or external influences; they also feel that a key role in these developments was played by 'Maasai pioneers', who were often the wealthiest and most politically influential Maasai individuals in the region.

Hydrology and climate

The study area is semi-arid (Bekure et al., 1991; Pratt and Gwynne, 1977). The KWS weather station in Amboseli National Park has recorded annual rainfall totals of 350 to 500 mm/year, with low and high extremes of 130 mm/year and 550 mm/year; rainfall totals increase with elevation in the foothills of Mt. Kilimanjaro and the Chyulu Hills, reaching 800 to 1100 mm/year. The rainfall regime is bimodal, with short rains in October, November and December (*olturmuren*, in the Maa vernacular), and long rains from March to May (*enkagwai*). Dry seasons occur in January and February (*oladalo*) and from June to September (*olameyu*) (Altmann et al., 2002; Roque de Pinho, 2020). High interannual variability in rainfall is mainly ascribable to failure of the short rains (Kioko and Okello, 2010). This drought-enhancing situation is generally correlated with El Niño – Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) anomalies (Lüdecke et al., 2021). Since 1935, 12 severe droughts have been recorded (Campbell, 1999). Drought severity for livestock varies according to precipitation and biomass productivity. Its impacts are a function of the adaptive capacities of the pastoralists and of the resources and relief measures provided by the authorities (Goldman and Riosmena, 2013).

Figure 1. Outline of three present-day hydrosocial territories in the vicinity of Amboseli National Park, Kenya: Naoroenkare, Nolturesh and Kikarankot.



Note: Red diamonds = location of the 16 waterscape mapping workshops; red rectangles are enlarged in Figures 5, 6 and 7.

The Kilimanjaro aquifer system covers approximately 13,000 km² and extends from Mount Meru to the Chyulu Hills (British Geological Survey, 2019/2021). It is fed by the approximately 2093 million cubic metres (Mm³) of water that is received annually by the flanks of Mt. Kilimanjaro, with 73% originating from precipitation and 27% from fog interception (Agrawala et al., 2003). This aquifer feeds most of the perennial streams (including Rombo, Noolturesh and Kimana-Kikarankot) and the intermittent streams (Figure 1; Githaiga et al., 2003). Temporary lake Amboseli (*embusel* refers to the saline soils) extends across the dry Pleistocene bed of a once much larger lake in the geological past. It functions as a pan, that is, a closed depression that is commonly found in many of the world's drylands. Low-permeability basement rocks beneath the former lake deposits and lavas of the Amboseli basin prevent water from feeding deeper aquifers, although the depth to the bedrock floor remains unknown (Meijerink and Van Wijngaarden, 1997). The smaller Lake Amboseli reaches a maximum size of 140 km² at times of exceptional rainfall; it is currently filled temporarily by (1) local surface runoff, (2) the seasonal Namanga River, and (3) groundwater flooding whenever the pan aquifer has been suitably recharged. High-discharge springs such as *Enkongu'narok* (the 'black spring') and *Enkongu'Olashumbai* (the 'spring of the whites'), supply the southeastern part of the Amboseli drainage basin and sustain two major swamps inside the park (Figure 1; Meijerink and Van Wijngaarden, 1997). These major springs are natural resurgences of water that has descended from the north flank of Mt. Kilimanjaro. Despite natural spring discharges having the reputation of being constant in the study area, an unexplained rise in the water table since the 1960s has led to an increase in the ANP swamp size (Lovatt Smith, 1997).

Water governance

Water governance in Kenya has undergone changes since the passing of two pieces of water legislation in 2002 and 2016. Their purpose was to regulate the management, use and conservation of water and to establish national-scale water governance institutions called Water Resources Authorities (WRAs) that, since 2016, have operated through local branches. The water acts lay down a number of key principles such as the protection of water quality, fair sharing rules, and the regulation of water-related services. The legislation also promotes user participation in decision-making through water user associations (WUAs) (Agade et al., 2022). WUAs have recently displayed shortcomings such as abuse of position and lack of participation; however, there are also recognised benefits in their role as vehicles for conflict resolution and for achieving improved water use efficiency (Richards and Syallow, 2018).

Three water governance regimes coexist in the GAE. The most traditional mode concerns watering pans managed by the pastoralists themselves under customary laws (Ole Seno and Tome, 2013). 'Maasai committees' are not formally considered to be WUAs; under their management regime, however, decisions are taken by an elected chair, a secretary and a treasurer, who together represent the committee members. They determine, for example, the time slot during which pastoralists are authorised to water their livestock, a regimen which aims to avoid overgrazing and the development of water-borne diseases (Agade et al., 2022).

The two other, more recent, forms of governance are organised around infrastructures such as irrigation schemes and pipelines. Each irrigation scheme comes under the responsibility of a WUA (see detail in Table 2). The association's elected chair is also one of the irrigated crop farmers. Each farmer has access to the water flowing into the irrigation furrows during a specific time slot. The WUA also has a mandate to resolve problems such as failure to comply with rota requirements. Pipeline-transported water is managed by the authorities responsible for pipeline maintenance, which may be state corporations, private companies or NGOs. The local WRA branch mainly exercises a policing function, with powers to monitor all cases of illegal water abstraction from streams. In contrast to surface water, the extraction of groundwater and the digging of water reservoirs are not subject to any clearly defined rules (Bakker, 1997).

Water for livelihoods

Maasai pastoralism has been the primary form of land use throughout the Amboseli region for at least two centuries (Kimani and Pichard, 1998; Campbell et al., 2000; Ntiati, 2002). Pastoralists used to move their livestock in response to changing environmental conditions, ensuring access to watering points and a diversity of foraging areas (Ellis and Swift, 1988; Swift et al., 1996; Niamir-Fuller and Turner, 1999; Fratkin and Mearns, 2003). During the rainy season, pastoralists would stay close to their permanent residence (*emparnat*) and use the water available in the immediate surroundings. During the dry season, they moved their livestock to dry-season pastures (*enkaroni*) and would access water found in spring-fed swamps or stored in hand-dug water pans and shallow wells (Figure 2). During severe droughts such as in 2009, they would also travel longer distances with their livestock, for example to Tanzania, and would even enter the cities of Mombasa and Nairobi. There was no acute competition between livestock and wildlife over water resources; conflict only emerged after the gazettement of the region's protected areas, chiefly ANP in 1974 and the Chyulu Hills National Park in 1983 (Okello and D'Amour, 2008).

As far as anyone knows, at least within living memory, water in Maasai territory was never an open access resource and was managed instead as a common-property resource specific to a Maasai section living in a given geographic area, with conflict-management referees (usually elders) and sanctions applied to trespassers and rule transgressors (Southgate and Hulme, 2000; Sokile et al., 2005; Miller and Doyle, 2014). In the early 1970s, however, non-Maasai ethnic groups such as the Kamba and Kikuyu migrated into the area to develop rainfed agricultural in the fertile foothills of Mt. Kilimanjaro (Ntiati, 2002). The drier plateau areas close to perennial water resources have also gradually been brought under cultivation (Campbell et al., 2003; Okello and D'Amour, 2008). Irrigation schemes and WUAs have expanded by channelling water from springs in the lower Kilimanjaro foothills through a trellis-patterned system of furrows, such as in Kimana, Namelok, Ormalula, Ilchalai, and Inkisanjani (Figure 1). The main irrigated crops are tomatoes, maize and watermelons. More recently, a growing number of farmers have been exploiting groundwater from open wells, and since the 2009 drought, water from the Nolturesh pipeline has been used for irrigation. Some Maasai also engage in farming, either directly or under sharecropping arrangements (Hemingway et al., 2022).

MATERIALS AND METHODS

Two exploratory field visits were made in January and June 2019 to meet various water users and managers and to survey different water extraction, transfer and storage infrastructures. After these visits, we identified three hydrosocial territories with contrasting dynamics (Figure 1; Table 1): (1) Kikarankot, which is organised around a trunk river rising from the foothills of Mt. Kilimanjaro; (2) Nolturesh, which relies on a high-discharge spring that feeds a natural river channel as well as a pipeline; and (3) Naoroenkare, which is also structured around a pipeline. Two of those territories cut across different group ranches, with an upstream – downstream issue of water sharing as well as other spatial, social and political issues of water control and distribution.

Further field investigations were conducted between 2019 and 2023 by the first author. These consisted of 14 months of immersion and observation, semi-structured interviews, mapping workshops, and group discussions. Investigations explored qualitative issues relating to water management, use, access and governance, and to water-related conflicts. To ensure a representative sample, interviewees were identified with the help of key informants such as local leaders. In addition to numerous informal discussions, a total of 25, 19 and 23 interviews were conducted in the Naoroenkare, Kimana-Kikarankot and Nolturesh areas, respectively. Of the Maasai interviewees, 24 were full-time pastoralists and 43 were pastoralists involved in part-time crop farming (hereafter referred to as agropastoralists).

Table 1. Main features of the three hydrosocial territories.

Attributes	Hydrosocial territories (rectangles in Figure 1)		
Name	Naoroenkare	Nolturesh	Kikarankot
Area (km²)*	817	430	375
Group ranches concerned	Olgulului	Kuku, Imbirikani, Eselenkei	Former Kimana, Kuku B, Imbirikani
Conservation areas	Amboseli National Park	None	Kimana sanctuary
No. of springs	2	52	20
Swamp names	Orng'arua narok, Olashumbai	Inkisanjani	Ormalula, Ilchalai
Water uses	Pastoralism, wildlife conservation	Pastoralism, agriculture	Pastoralism, agriculture, wildlife conservation
Irrigated land surface in 2020 (km²)	None	33	52
Local stakeholders involved in water governance and management	IFAW, KWS, Maasai committees	NOLWASCO, WRA, Maasai committees	WRA, Big Life Foundation, Maasai committees

Note: * = areas calculated are approximate and are based on mapped clusters of permanent and temporary settlements that, in 2023, were known, or suspected, to be directly dependent on the water infrastructure of each territory; IFAW = International Fund for Animal Welfare. KWS = Kenya Wildlife Service; NOLWASCO = NOlturesh and Loitokitok WAter and Sanitation Company; WRA = Water Resources Authority.

A total of 16 'waterscape mapping' workshops were also conducted. These attracted participants through a snowball sampling procedure at the settlement level; that is, participants were selected with the help of field assistants and key informants in order to ensure workshop diversity in terms of gender and age. The workshops involved a total of 145 participants, among which 40 were women and 9 were non-Maasai farmers (mostly Kikuyu). Among the 136 Maasai participants, 77 were agropastoralists, and 59 were full-time pastoralists. Waterscape mapping was aimed at locating the water extraction, conveyance and storage components of the natural and managed landscape; it was also aimed at discussing associated issues such as difficulties in accessing water and documenting past and ongoing water-related conflicts. Exchanges were conducted in Maa and were immediately translated into English by a Maasai research assistant. Participants were provided with sheets of white paper and asked to position the water infrastructures using different coloured pens. After a map had been validated by all participants, it served as a visual tool for subsequent group discussions among participants.

Based on the information garnered from the workshops, we generated a GIS database of springs and water-harnessing infrastructures. Field observations and visual interpretations of high-resolution satellite images provided by the Google Earth navigator helped further to deliver a comprehensive spatial database of water-related infrastructures. Maasai cattle enclosures (*bomas* in Swahili) that were visible in these high-resolution images were identified and entered into the database in order to determine the spatial distribution of the resident population. Lastly, colonial maps from 1954 depicting the Naoroenkare and Nolturesh areas were consulted and copied from the Kenya National Archives in Nairobi. Their purpose was to obtain independent baseline information that could be matched against data collected during the mapping workshops, and used for tracking historical changes in the rangeland waterscape of the GAE.

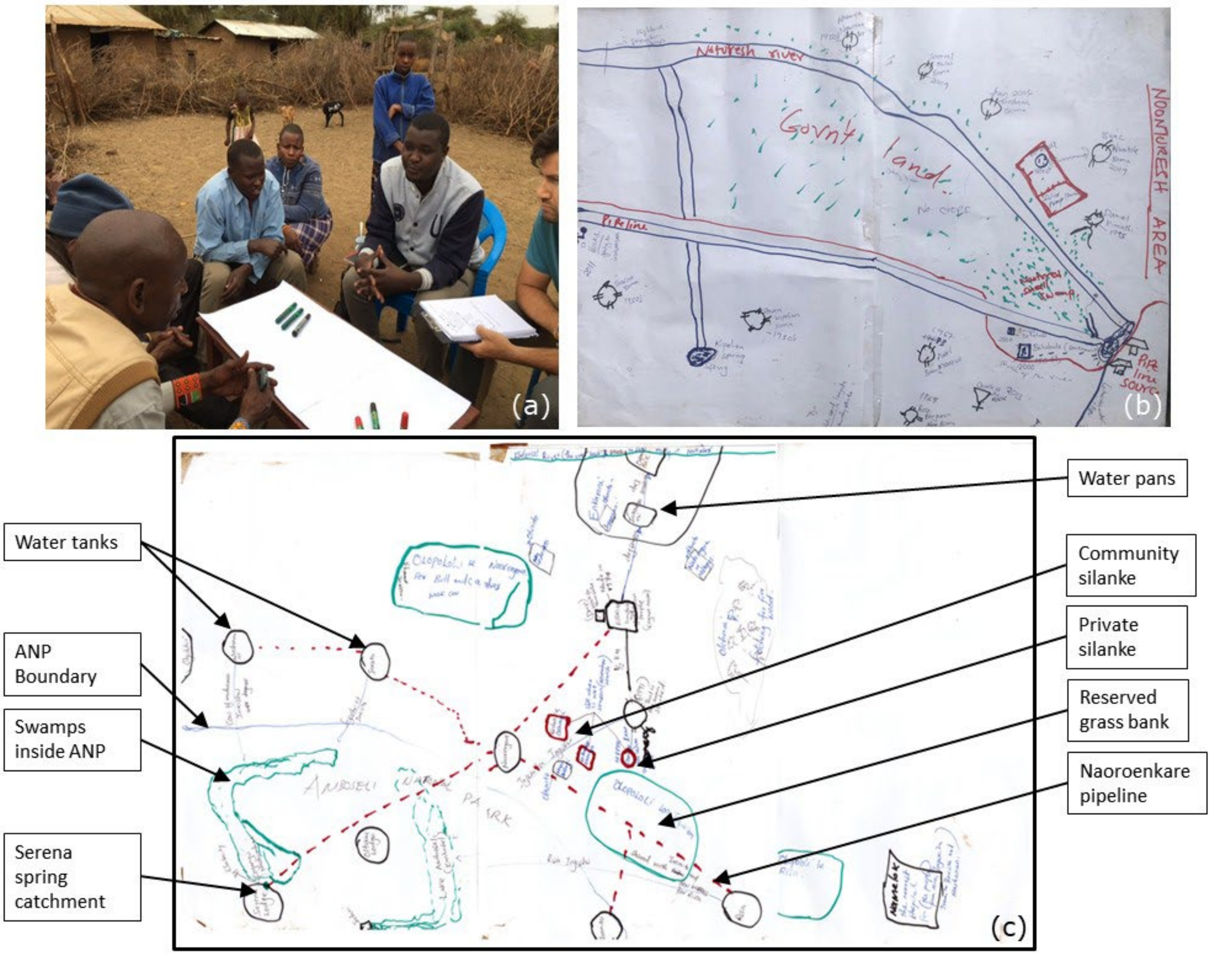
RESULTS

Waterscape changes

Inventory of water-harnessing infrastructures

Waterscape components were identified by workshop participants (Figure 2) through interviews and through direct observation during fieldwork. These were listed, classified (Table 2), illustrated (Figure 3), and mapped (Figure 4). Thirteen categories were identified; these fell into two broader groups (natural or human-made) and then were further subdivided according to their function (water extraction, storage or transfer).

Figure 2. Selected scenes from the mapping workshops along (a) the Kimana River, (b) the Nolturesh pipeline and (c) the Naoroenkare pipeline, with labelled waterscapes elements.



Source: Photo by A. Bostvironnois.

Table 2. Waterscape elements in the Greater Amboseli Ecosystem.

Element (*Maasai name*)	Physical or technical description	Uses, access and management
Natural		
Lake (*empusel*)	Temporary lake Amboseli *(see Section 2.1)*	Almost entirely located within Amboseli National Park; reserved for wildlife
River (*olkedjo*)	Perennial and temporary rivers	Water pumped or derived for irrigated crops and domestic needs; direct consumption by livestock and wildlife; numerous cases of illegal extraction using diesel pumps Each water access point along the river has an elected committee in charge of water access; state institutions (WRA) control illegal extraction through pumping
Spring (*enkogu*)	Often located where volcanic rocks overlie metamorphic bedrock; their perennial discharge is generally quite steady	Used for agriculture, pastoralism, wildlife and domestic needs; when outside of protected areas they are surrounded by stone walls to deter access to motorised vehicles and livestock; access rules are defined by a water committee
Swamp (*orng'arua*)	Fed by perennial springs; flooded all year; the largest (Orng'arua Olashumbai in Amboseli NP) can expand to 12 km²; hosts specific plants and animals such as Acacia xanthophloea and hippopotamus	Habitat for wildlife when located in protected areas; developed for irrigation outside protected areas; supply water and fodder to livestock during the dry season; irrigated systems are managed by a WUA
Infrastructure-related		
Water extraction function		
Deep well (*oltinka*)	Typically 10 – 50 metres (m) deep; the first deep wells were drilled by the colonial government in the 1950s; new ones have appeared more recently on private plots owned by wealthy individuals and by religious institutions and NGOs; water extraction relies on diesel or solar-powered electric pumps recently introduced by NGOs	Public wells are managed by groups of pastoralists who have settled nearby and who elect a committee for its management; they use it mostly for domestic use and to water livestock; private wells are multi-purpose (domestic use and livestock watering); well owners may also sell to middlemen, who then deal with conveying water to buyers
Open wells (*ilchoroi*)	Open public wells constructed by the colonial government in the 1950s are still in use today at Naoroenkare; well digging on private land began in the 1990s – these wells are located on plots that lie furthest from the irrigation canals and are up to 10 m deep	Public ones are used exclusively for domestic purposes and livestock; they are located close to the park and are managed by an elected committee that ensures access and maintenance; wells on privately owned plots are primarily used for crop irrigation; some landowners derive a modest income from leasing their wells to neighbouring landowners; water is extracted using diesel-powered pumps

Pumps (*awoshu)*	Used by farmers to pump water from rivers; used since the 1980s along the Nolturesh and Kimana Rivers	Their use to extract water from rivers is regulated and controlled by the water resource authorities, who can issue fines; also used by pipeline operators to feed water into pipelines
Water transfer function		
Irrigation canals (*eng'ony*)	Typically 50 cm deep and 1 m wide; dug either by inhabitants who have obtained land in the swamp, or by the government and/or NGOs working to expand agriculture; lined canals, often requested by the local population, multiplied in the 1990s	Dedicated to irrigation; farmers access water according to rules set up by the WUAs; users who own or lease the land should participate in canal maintenance and clearance
Pipeline (*orpipe lenkare*)	Cement, PVC or metallic pipes were laid out in 1956 (Nolturesh), 1963 (Naoroenkare), and 2012 (IFAW); they harness water from natural springs or from swamps	Multiple uses: pastoralism, farming, domestic; managed by private organisations (NOLWASCO), state corporations (KWS) or NGOs (IFAW); malfunctions are the source of many conflicts (see Section 4.2)
Small PVC pipe	1/2-inch PVC pipes connected to Nolturesh pipeline manholes to feed the recently dug artificial reservoirs (silanke)	Some pipes are individually owned and managed; in such cases, users have official permission from authorities to access water, but only for livestock and domestic use; other pipes are managed collectively by a committee and used by several users who also pay a monthly access fee; although prohibited, many people use the water to irrigate crops; there are also illegal connections to manholes all along the pipeline
Water storage function		
Water pan (*olturoto*)	Small depressions between 200 and 5000 m² and 1-2 m deep, many of which may have been dug manually; likely to be functional all year after a good rainy season	Located on collective lands in grazing areas designated for the dry season (*enkaroni*); the water is exclusively used by pastoralists, each of whom is permitted access in accordance with the rules established by the water committee; sediment is regularly dredged from the pan
Artificial reservoir (*silanke*) privately, collectively, or public owned	Earth excavation is conducted using a backhoe on private or collective land, with earth being utilised to construct the reservoir embankment; silanke on private land are the most numerous but also the smallest (average size: 2000-3000 m²; average depth: 2-4 m); they first appeared around 2010 and have proliferated since 2020 Government (public) silanke on collective land are the largest, measuring up to 15,000 m² with a depth of 5-10 m; they first appeared in 2015	Private silanke are employed for a variety of purposes, including agriculture, livestock and human consumption; some owners opt to share the water Collective silanke are mainly used for watering cattle and domestic uses Public silanke are reserved for agricultural and livestock purposes; their management is entrusted to a committee appointed from among the local population
Tank (*mbirika*) with cattle drinking trough (*mboat*)	Built in the 1950s and 1960s at Nolturesh and in the 1970s at Naoroenkare; pipeline-fed; storage capacity has increased over time, but they generally contain 50-100 m³. Troughs are filled by gravity	Some are private, but the majority are public; access is regulated by a water committee headed by older and/or wealthier pastoralists; management also includes dealing with pipeline authorities such as KWS or NOLWASCO; when private, they are managed by an individual who controls access and maintenance

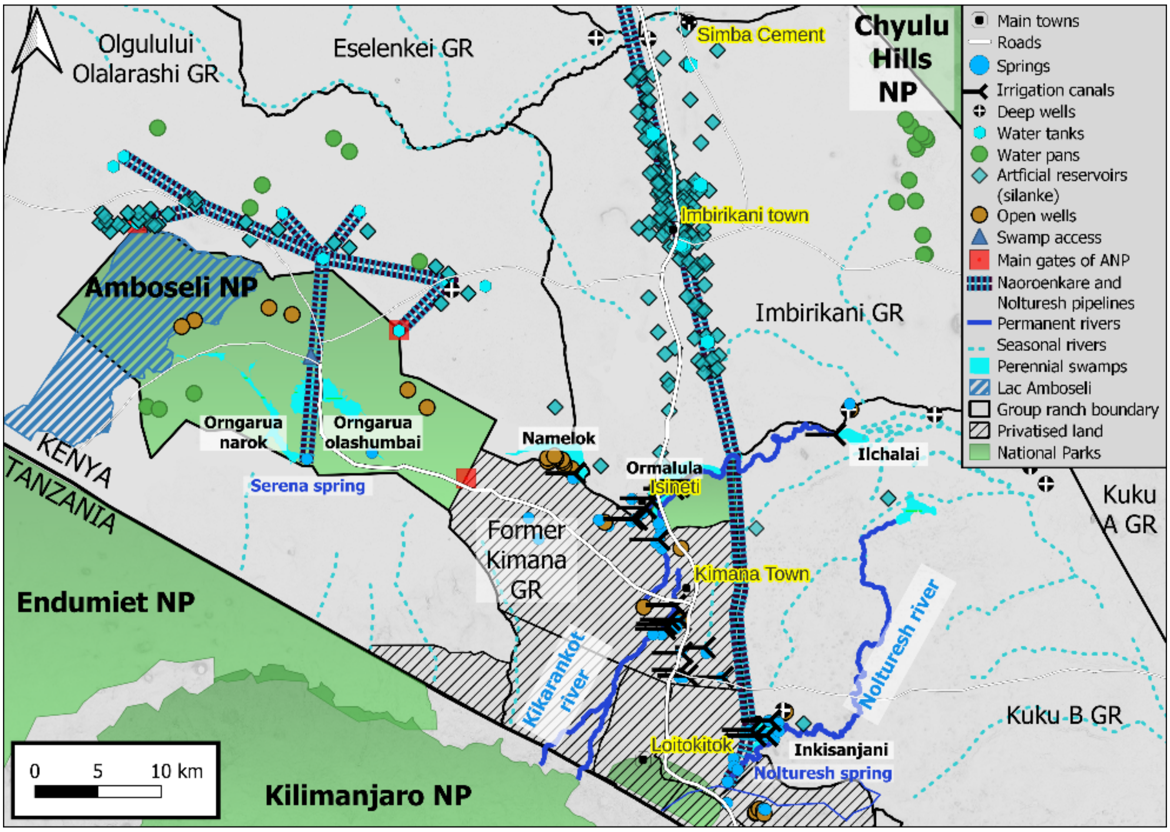
Figure 3. Inventory of waterscape elements described in Table 1, here shown in the field and from the air

Source: Photo by A. Bostvironnois. Note: Satellite imagery provided by Google Earth navigator; red dots on satellite images locate field photographs.

In total, 410 waterscape components were described during the 16 mapping workshops, including 91 springs (approximately 22% of all components). These springs are mostly located in the Kimana group ranch (GR) and the western part of the Kuku B GR, each with different discharges. The remaining 319 items are all of anthropogenic origin, with 53, 163 and 103 units for Kikarankot, Nolturesh and Naoroenkare, respectively. Data collected and assembled in Figures 5 to 7 illustrates the historical growth and transformation of the three hydrosocial territories of interest.

Kikarankot stands out by displaying a considerable number of irrigation furrows that facilitate the distribution of water from natural springs to irrigated plots, and numerous open wells are present within the irrigated areas. Many farmers also extract water from the river using diesel pumps. In order to extend the area of land suitable for farming, two public river-fed reservoirs (*silanke*) had recently been dug (Table 2). Nolturesh displays high densities of bomas along the pipeline. This indicates a large concentration of residents who have made themselves dependent on water from the Nolturesh spring and who obtain it, legally or illegally, through PVC pipes feeding out of the pipeline. In the vicinity of Imbirikani, 129 reservoirs were also detected. Based on observations, it can be reasonably assumed that a significant proportion of the reservoirs must be supplied by water from the Nolturesh pipeline. Naoroenkare also appears dependent on pipeline-supplied water, again as determined by the presence of numerous bomas. The distinctive feature here is that the water is sourced from Amboseli National Park, which means that it competes with the demand from wildlife. Another feature is the relatively high number of water pans; this can be attributed to the substantial number of pastoralists in this area, which remains geographically more isolated from urban amenities than the two others. Artificial reservoirs (silanke) have only recently made an appearance in this area, following the process of land privatisation. These three hydrosocial territories are described in greater detail in the following sections.

Figure 4. Overview of waterscape components drawn by workshop participants, complemented by observations in the field and from satellite images.

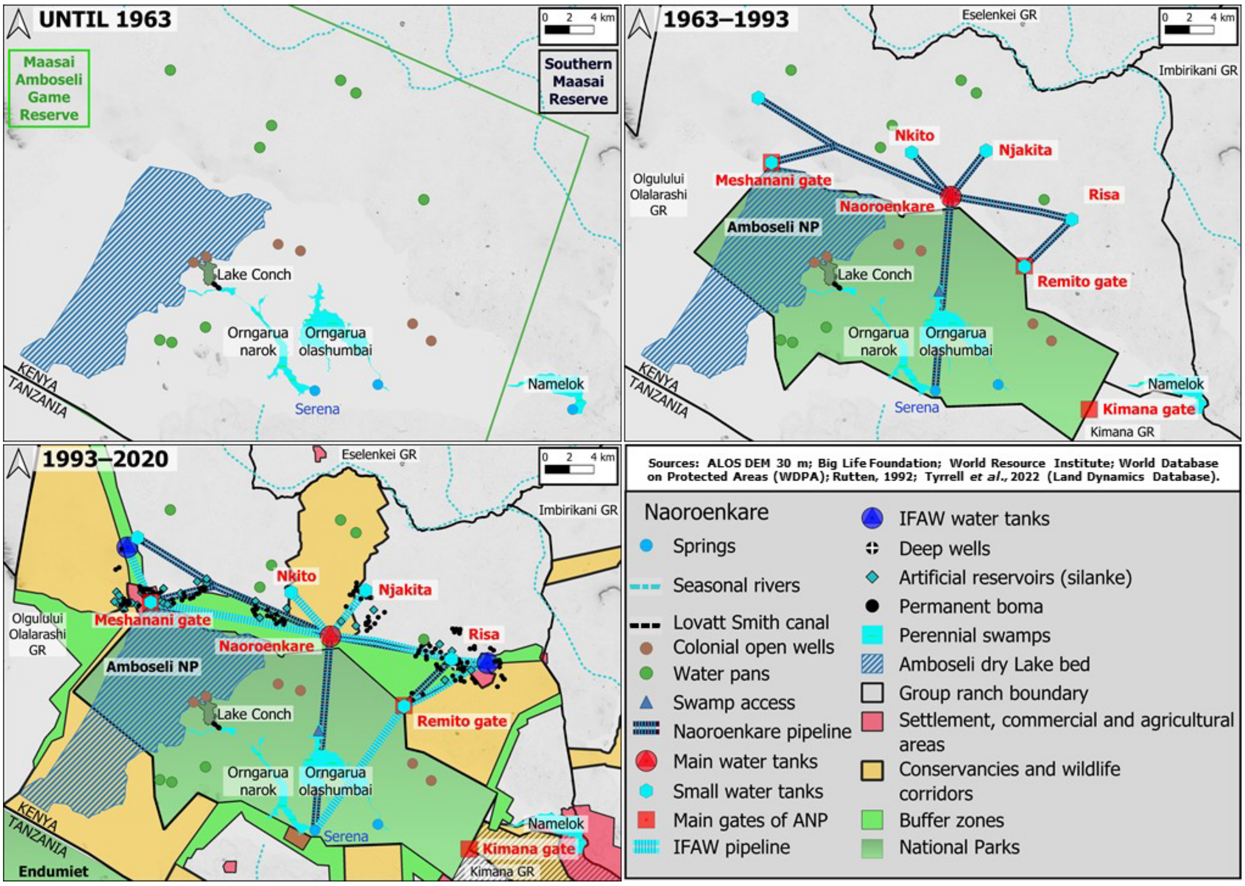


Source: ALOS DEM 30 m; World Resource Institute; World Database on Protected Areas (WDPA).

The pipeline-focused Naoroenkare hydrosocial territory

Figure 5 displays three maps showing the main water supply and access infrastructures at three different periods during the last approximately 70 years. They highlight the transformation of the savanna rangeland from a waterscape comprising only springs and swamps and dispersed water pans (hand dug in the 1920s), to an artificial waterscape. In this post-transformation waterscape, natural springs and swamps are no longer accessible; also, water conveyance pipelines have increased access constraints, encouraged fixed human settlements, and reduced livestock mobility. During the British colonial period, pastoralists regularly moved to the springs and swamps near Lake Amboseli (Orng'arua Narok and Olashumbai) to water their livestock. They would leave the area during the rainy season, mainly because of the proliferation of tsetse flies (a vector of sleeping sickness), but also because of the risk of getting cattle stuck in the sticky, clay-rich soils that are prevalent in this closed basin. The main means of accessing rainy-season water outside of the swamps was capturing residual underflow beneath dried-up streambeds or digging ponds in topographic hollows. As early as the 1940s, open wells were dug to the north of the future park to deter pastoralists from reaching the swamps, thereby reserving the swamps to wildlife and game hunters. The Lovatt-Smith Canal, named after the manager of the 1948 Maasai Amboseli Game Reserve, created a new artificial wetland called Lake Conch a few kilometres from the two natural swamps. It was intended for pastoralists, to prevent their cattle from mixing with the wildlife.

Figure 5. Evolution of the Naoroenkare hydrosocial territory.



Note: Mapped items are based on mapping workshops, Google Earth inventories, and colonial map analyses over three periods: (1) British East Africa (until 1963), (2) Independence and park gazettement (1963-1993), (3) Maasai settlement in group ranches (1993-2020).

In 1974, a 35 km metal pipeline collecting water from Serena spring was laid out and buried through Orn'garua Olashumbai swamp, transferring the spring water all the way to a 100 m^3 reservoir located in a elevated position at Naoroenkare. Water was then pumped daily through secondary pipelines from that main reservoir to five smaller reservoirs near the park entrances. This presumably permanent access to water at strategic places has prompted Maasai communities to settle around the edges of the park and to drive their livestock to wet-season pastures outside the park instead of inside it. Permanent settlement in this area has been accelerated by the provision of water access services and the construction of schools and churches. Water supply through the 35 km pipeline, however, has been severely affected by a continuous rise in the water table in the area, making pipeline repair more difficult. Speculation as to the causes of water table flooding have ranged from recent tectonic subsidence of the Amboseli basin, to changes in land use on Mt. Kilimanjaro that have altered the regional hydrological balance of the system. PVC piping is now used for repairs instead of metal, but it is regularly broken by elephants and other wild animals (elephants can detect water below ground, dig to reach leaky pipes, and damage them further). Since 1993, the KWS, which operates and maintains the pipeline, has also failed to carry out its duties effectively; this has led to numerous complaints from pastoralists against KWS management and has generally encouraged herders to enter the park illegally. Local politicians, in an effort to respond to complaints and contain the conflict, decided to dig wells; however, the groundwater turned out to be either too deep to reach or too salty.

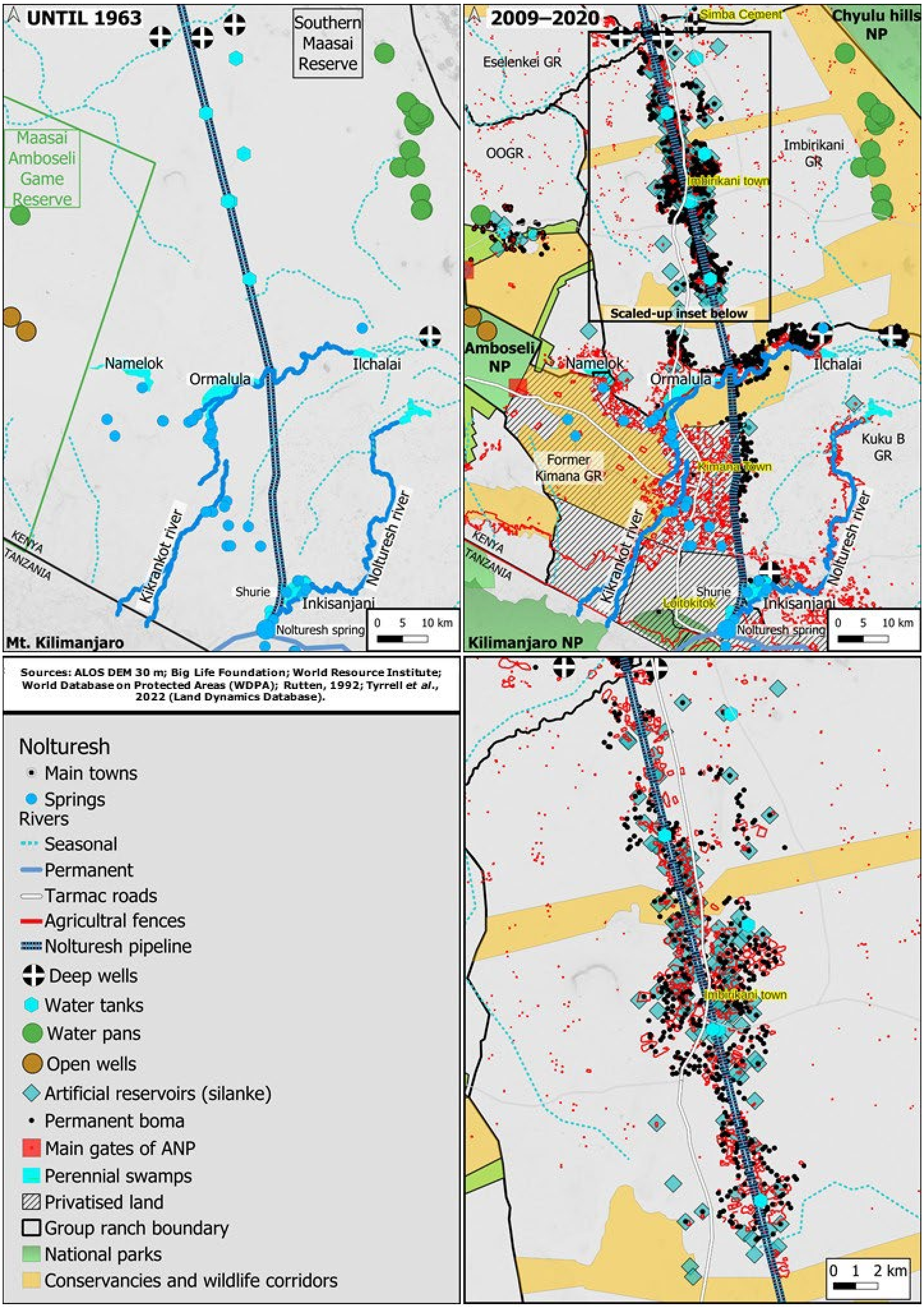
Against the background of these water-related tensions, in 2012, the international NGO International Fund for Animal Welfare (IFAW) received US$ 615,000 to construct a new solar-powered pipeline. The 49 km pipe connects to a reservoir at an even higher elevation than the 1974 reservoir at Naoroenkare, and is supposed to provide gravity-fed water to the same five settlements located at the park entrances. As of 2023, however, the pipeline was still not operational. The impact of these delays on dependable water access has strongly influenced the decision by pastoralists to construct 71 silanke on land that was acquired in the early 2020s through the subdivision process; of these, 66 were privately owned. These rainwater and runoff harvesting reservoirs serve two purposes: watering livestock and shedding a chronic dependency on pipeline water, thereby averting conflict with the KWS.

The pipeline-focused Nolturesh hydrosocial territory

Figure 6 displays the area traversed by the Nolturesh pipeline. As of 2023, the Nolturesh spring was providing a continuous flow at a mean discharge rate of 17 litres per second. The pipeline was commissioned in 1956, during the colonial era, at a time when the British were constructing a railway line between Nairobi and the coast. The pipeline is approximately 100 km long and extends to the station town of Emali in the north, servicing areas outside the GAE. Renovated and extended in 1992, the pipeline now spans 162 km and serves several towns as far north as Athi River, a town that is now part of the Nairobi Metropolitan Area.

From the 1950s onwards, cement-lined reservoirs or tanks, known as *mbirika*, were constructed along the pipeline, giving Imbirikani GR its name. This new access to water altered the migratory routes of pastoralists (Hemingway et al., 2022) and contributed to the sedentarisation of Maasai families. Tanks have been particularly important features in Imbirikani, unlike in Kuku B which hosts the south end of the pipeline but where alternative water sources such as springs also exist (Table 2).

Figure 6. Evolution of the Nolturesh hydrosocial territory.



Note: Mapped items are based on mapping workshops, Google Earth inventories, and colonial map analyses over two periods: British East Africa (until 1963), and agricultural expansion with a proliferation of individual water access points (2009-2020); the scaled-up inset shows permanent settlements, artificial reservoirs (silanke) and fenced-agricultural expansion; small red dots = traditional circular fences around pastoralist bomas, mapped by Tyrrell et al. (2022) using an automated algorithm (they are not protective fencing around crops); blue diamonds with dots = bomas located in the immediate vicinity of a silanke.

Since the beginning of the 2000s, there has been a steady increase in the population that lives along the pipeline and relies on its water; this is indicated by the most recent map showing the high density of bomas and artificial reservoirs (Figure 6). All of these reservoirs are supplied by the pipeline itself, whether legally (for domestic purposes and watering livestock) or illegally (most often for crop irrigation). Obtaining a legal connection requires the drawing up of a contract with the corporation in charge of pipeline management and users must pay a monthly fee. An increasing number of pastoralists have become agropastoralists as a result of access to pipeline water, particularly since the extreme drought of 2009. Income from cash crops such as tomatoes is at times much higher than revenue from livestock (Hemingway et al., 2022).

4.1.4 The river-focused Kikarankot hydrosocial territory

Figure 7 shows the evolution of waterscapes along the Kikarankot River. The area includes approximately 20 springs and 2 swamps: Ormalula and Ilchalai. These natural water bodies were traditionally used by pastoralists to access water during the dry season; however, water usage from these natural outlets has diversified and access to certain water points has been restricted or even forbidden to pastoralists.

The Swynnerton Plan facilitated the development of agriculture, resulting in the expansion of irrigated crops. This coincided with an influx of people from other parts of Kenya. In the early 1990s, members of Kimana GR took the decision to subdivide the land and obtain individual property titles. Each of the 844 members received: (1) 2 acres for irrigated agriculture from the river or springs; (2) 60 acres of dry land without access to water, which they later chose to lease to conservation NGOs; and (3) 7 acres of alluvial forest area along the river that was designated as a wildlife sanctuary, also managed by successive NGOs. This land subdivision resulted in a substantial expansion of cultivated land (Figure 7: note crop-protection fences, generally made from thorny branches), and resulted in increased consumption of surface and groundwater. The water-diversion furrows, funded either by the government or by NGOs, have been cement-lined for most of their length. Each irrigation scheme is managed by a WUA. The construction of a tarmac road in 2011 facilitated the connection of farmers to distant markets and, as a result, Kimana is the main market town and economic hub in the study area. The rise in population has also resulted in a higher demand for potable water, which is increasingly sourced from local foothills aquifers.

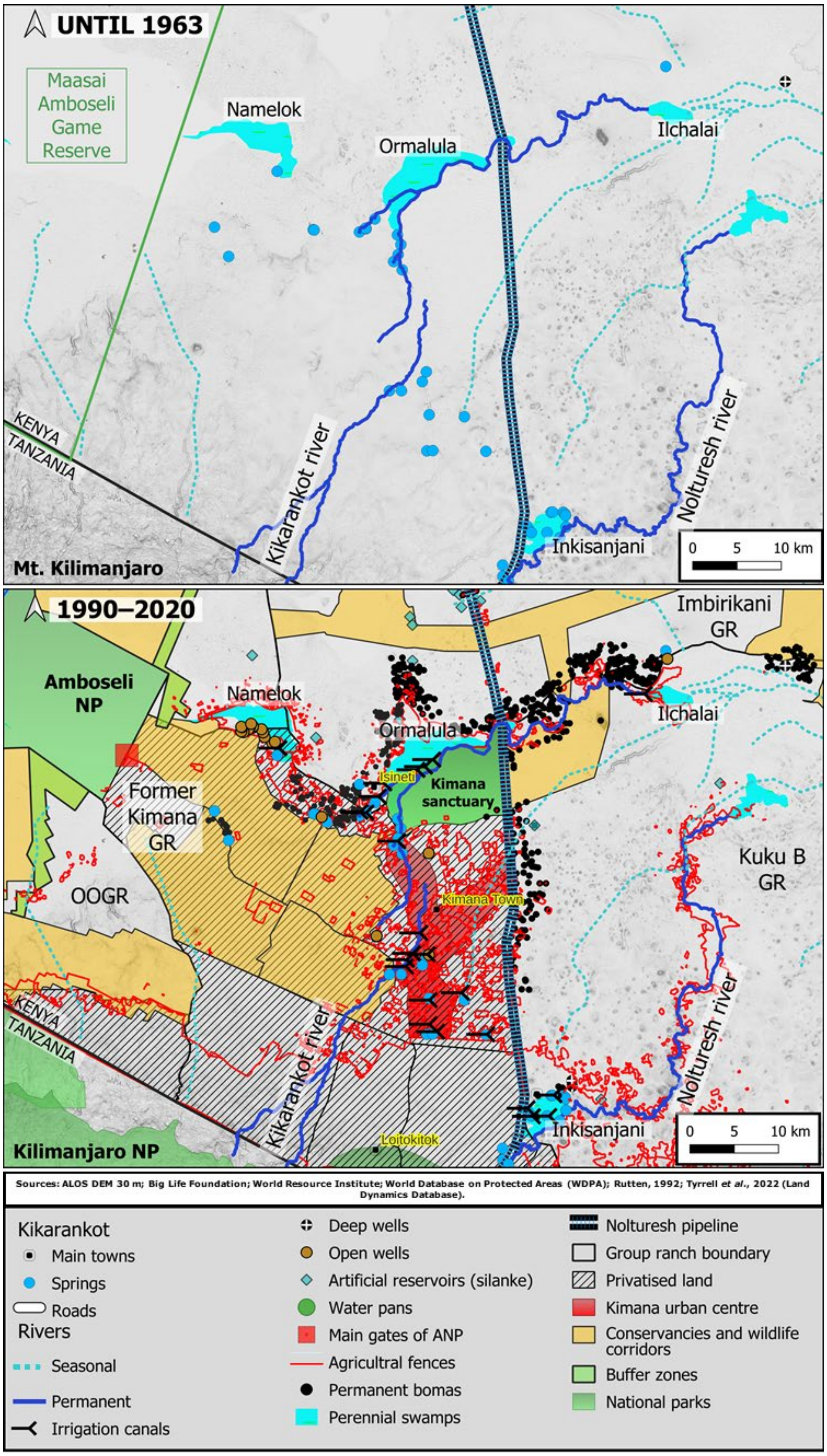
Causes and consequences of waterscape changes from a pastoralist perspective

Changes in the waterscape were shaped by the decisions and actions of individuals and groups. Here we report issues and impacts related to water sharing, which frequently generates conflict.

Conflicts between water users

Conflicts between users mainly concern surface water from rivers and reservoirs, whether cemented or unlined. During interviews and workshops along the Nolturesh and Kikarankot Rivers, several conflict situations were reported to us. They arose between users who were dependent on their position along the river, and the conflicts were most acute during the dry season. Conflicts in the Kikarankot watershed occur between upstream farmers who are often non-Maasai, and downstream herders who are often Maasai agropastoralists who graze their animals in the Ilchalai swamp and depend acutely on its water. Diminished quantities of water reaching the swamp are detrimental to the growth of the wetland vegetation that constitutes an important source of natural fodder for livestock. Domestic water needs are met by extracting water from subsurface underflow in the many dry river channels, but quantities are insufficient given the livestock numbers. Similar upstream – downstream conflicts also occur in the natural watershed area of the Nolturesh River. In both instances, periodic confrontations involve the destruction by Maasai pastoralists of diesel pumps used illegally by non-Maasai farmers during critical dry periods. Over the years, the situation has been worsened by the expansion of irrigation farming and

Figure 7. Evolution of the Kikarankot hydrosocial territory.



Note: Mapped items are from mapping workshop data, enhanced by an analysis of Google Earth imagery and colonial maps; two main periods are shown: British East Africa (until 1963), and agricultural and urban expansion spurred by group ranch subdivision (1990-2020).

the accompanying increase in water abstraction upstream. The WRA conducts yearly inspections, searching for illegal pumps, but low budgets cannot ensure effective and continuous control.

Within the irrigated areas themselves, ineffectual rules established by the WUAs also generate inequalities in access to water between irrigation farmers operating upstream and downstream. In these cases, tension between water users is more muted and does not result in outbreaks of violence. The WUAs establish a water-sharing schedule and are also responsible for controlling spills of pollutants such as pump fuel. Some users, however, have pointed out the futility of these regulations and have denounced numerous cases of abuse of authority by committee members who may not always ensure equitable water sharing. Crop cultivation along watercourses also restricts physical access to riverbanks by livestock because driving cattle across cultivated areas can cause tension. Such issues, however, are less severe after harvest; at that point, grazing of crop residue is allowed and offers mutual benefits through manuring.

Recurring conflict also concerns the use of water stored in tanks for livestock. Maasai water committees manage these reservoirs and are responsible for setting access rules and making decisions based on case law. The committees routinely establish the time at which troughs can be accessed, and have the authority to punish rule-breakers. Priority water use is reserved for village and GR members. When visiting or passing members from another group ranch request access to the troughs, several criteria are considered, including clan (each Maasai individual belongs to a specific clan or extended family), family, and age-set membership. When the committee is unable to decide, a public meeting (*emurua enkiguena*) is convened and the local community makes a collective decision.

Conflicts between water users and water management authorities

In the previous examples, water managers were often also water users. For certain water-harnessing structures, however, managers remain separate from users. This is prevalent when the infrastructure requires large funding and engineering expertise for construction and maintenance, and it leads to a different category of conflict between management authorities and users.

The situation at Naoroenkare involves pastoralists who water their cattle at the five tanks connected to the Naoroenkare reservoir. The KWS operates the diesel pumps that deliver the water from the national park to the main reservoir. Users reported that this service was often unavailable for reasons such as pump fuel unavailability, pump malfunction, or PVC pipeline damage caused by wildlife. According to the KWS technician in charge of maintaining the Naoroenkare reservoir, the KWS management often displays contempt towards threats of livestock dehydration. Whether out of defiance or desperation, some pastoralists resort to entering the national park illegally; they risk being beaten by patrolling rangers or losing their animals when rangers chase them away. Solutions are found on a case-by-case basis through unofficial negotiations between farmers and rangers, who generally know one another. Settlers at Remito gate, for example, reported that they had reached an unofficial agreement with rangers to access watering points located in the park more than 10 km from the gate, but only between 11 a.m. and noon. The reason for this timing is that during the lunchtime hours, tourists enjoying a safari 'wilderness' experience are less likely to see these domestic herds, which are considered to spoil the experience. As a result of this rule, however, farmers are compelled to walk 20 km each day to access water for one hour. After 11 years of waiting, hope for completion of the new pipeline has diminished and the pastoralists are disheartened.

The Nolturesh pipeline is managed by NOLWASCO, a private company contracted by the Kenyan government. One or two days a week, a small part of the Nolturesh flow, which is otherwise directly captured by the pipeline at the source, is left to the natural Nolturesh River channel. The volumes released are considered insufficient by both the non-Maasai farmers living upstream on privatised land since the 1950s, and by the downstream Maasai herders from Kuku B GR (Figure 6). The situation is critical, with the river sometimes running dry as a consequence of water diversion by the pipeline. Three

Maasai water committees monitor water volumes granted to the Nolturesh channel, but they have no negotiating power with the NOLWASCO authorities. The users' method of demanding more water is to form picket lines outside the water intake gates. These demonstrations may prompt an intervention from the provincial governor, who may decide to release more water into the river. According to interviewees, political conflicts between the county governor and members of parliament – powerful individuals who own land along the Nolturesh River – also contribute to water release controversies. The process, however, is based on cronyism. No long-term policy is under discussion that may, for example, succeed in establishing reserved flow targets by addressing the requirements of downstream users. To compensate for water access denial, some users resort to poaching water from the pipeline by harvesting burst pipeline outflow at some of the manholes built along it.

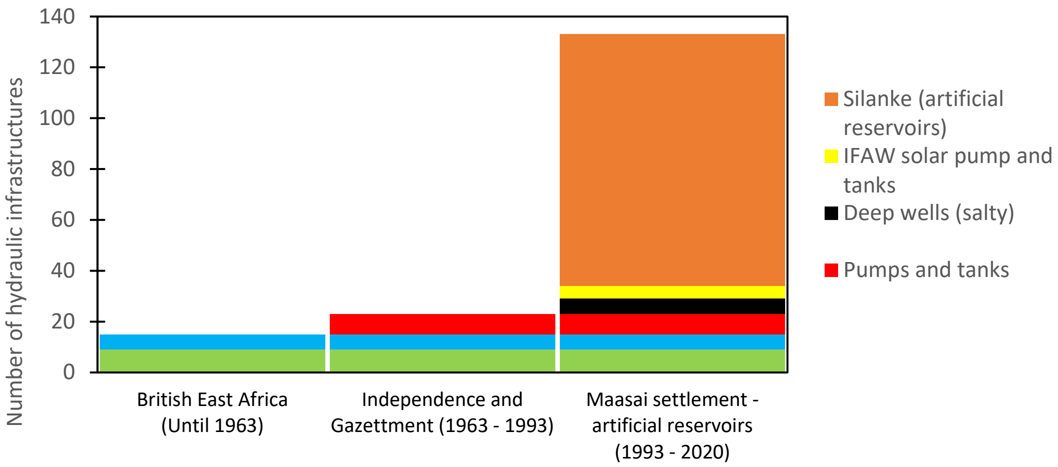
The rise of water markets

The status of water is gradually changing from a common-property resource to a privatised resource stored in individual-use infrastructures. Water is also increasingly being accessed privately by individuals and sold as a commodity. Several cases illustrate this phenomenon.

KWS has started selling water from the Serena spring – the same spring that feeds the Naoroenkare pipeline – and buyers rank among the wealthiest Maasai pastoralists. The selling price for 10 m^3 is 4000 Kenyan shillings (KES, or KSh), an amount that leaves small pastoralists out of the race. The same wealthier farmers also have the option of buying water from urban re-sellers who pump it from aquifers through deep wells. The water is then hauled by truck to dry-season pastures in areas such as the Chyulu Hills, where there is no access to surface water. The water can also be resold to other pastoralists. Legal access to water from the Nolturesh pipeline requires consent from the local customary and government chiefs. A fixed monthly fee of about 5000 KES must also be paid to NOLWASCO to obtain a ½ inch pipe connection to the main pipeline; this does not include bribes and the cost of travelling to NOLWASCO headquarters in order to be registered as a legal water user. The amounts required mean that only the wealthier minority has access.

The proliferation of silanke-type reservoirs is particularly intense, except within the Kikarankot territory where accessing water is not as difficult given the steady discharge from a large number of foothills springs (Figure 4). Figure 8 shows the historical increase in the numbers of silanke at Naoroenkare. The overwhelming majority of these reservoirs are privately owned, with water storage

Figure 8. Evolution of hydraulic infrastructures at Naoroenkare.



Source: Data compiled from the five workshops carried out across this territory.

Note: The period 1993-2020 illustrates the declining reliability of pipeline supply; this led, in about the year 2000, to the appearance of the first artificial reservoirs (silanke) and, after the 2009 drought, to their proliferation.

opening up prospects for agricultural development in the ongoing context of changing land tenure. One reason for the growing popularity of reservoirs is their limited construction costs; another is that they can extend water availability into the dry season, providing an additional chance to compensate for erratic rainfall. Other strategies for individual access include digging wells, illegally using pipeline water, and illegally pumping from springs and rivers. Behaviour focused on sharing water has nonetheless not disappeared. This is shown by the example of an elderly pastoralist from Olgulului GR who, since 1993, has granted free access to his private borehole to anyone from the village because of chronic Naoroenkare pipeline failure in Risa. Sharing thus remains a value among some stakeholders, in addition to more generic claims among pastoralists that access to water is a fundamental human right.

DISCUSSION

In the last 70 years, water in the Greater Amboseli Ecosystem has experienced a succession of access regimes; these include being constituted as: (1) a common-property resource managed by Maasai sections; (2) a collective private resource managed by group ranch members and WUAs; and now (3) an individual private resource that coexists with the latter two regimes. The Amboseli waterscape has thus evolved from an adaptative system based on short- and long-range livestock mobility dispersing across natural watersheds unimpeded by human infrastructure, to a system organised in piecemeal fashion around fixed water storage and conveyance structures.

Rivers, springs and swamps were the initial natural components of the waterscape, determining land use and settlement patterns. Externally driven pressures, particularly from the wildlife conservation sector, have transformed the identity-shaping natural water bodies previously familiar to Maasai pastoralists, and have intensified competition for the resource. The objectives of the Amboseli National Park and other wildlife conservancies are to maintain high concentrations of animal populations at watering holes and to develop lucrative safari tourism; political support for water grabbing by such entities can be explained by the higher opportunity costs for these activities compared to livestock-keeping which, in Maasai culture, is a capital asset rather than a profit-making commodity that feeds into national GDP statistics.

The Nolturesh and Naoroenkare pipelines, built respectively in 1952 and 1974, have modified the natural pathways of water storage and circulation; in the process, they have reconfigured the spatial distribution of livelihood-related activities and residential clusters. The recent construction of additional pipeline-fed water storage facilities – particularly a large number of silanke on the Imbirikani GR – has served to reinforce those patterns, while simultaneously generating new islands of settlement and patches of land use. Whereas pipeline management authorities until now exerted power over water resources from outside the communities, the control of water sources is increasingly falling into the hands of some wealthier individuals from within the group ranch communities. Indeed, inequalities in access to water resources did exist previously: (1) between pastoralists (for their livestock) and nature conservationists (for wildlife), (2) among pastoralists from different group ranches, and (3) among crop farmers within a given irrigated area. New inequalities, however, are now deepening within each of the three hydrosocial territories, including between pastoralists who get direct (for livestock watering and irrigation) and indirect (by selling water) benefits from their privatised water, and pastoralists who remain dependent on water as a common-property resource still shared on the basis of collectively negotiated rules. The longer-term socio-economic consequences of water flowing increasingly and disproportionately towards wealthier land users are not yet clear, but the evolving power dynamics are unprecedented.

Privatisation of land and changes in water ownership have combined to accentuate another substantial change, that is, the steady expansion of agriculture into what was previously an almost exclusively pastoral area. The Ilkisongo Maasai themselves have gradually begun to practice agriculture alongside pastoralism. This is a major cultural change for this Maasai section, which, unlike other sections that grow staple crops (Spear and Waller, 1993), has always been predominantly pastoralist. For now, crop production among the Ilkisongo community has been limited to tomatoes and watermelons (Hemingway et al., 2022). This transformation first took place on Kimana GR, where springs along the foothills of Mt. Kilimanjaro are closely spaced. It has expanded more recently to wherever agropastoralists are able to store water using technological opportunities that have been made available to them. Repeated droughts, such as in 2009 and 2022-2023, have also had a severe impact on pastoralists. Interviewees indicated, however, that the primary causes of vulnerability and conflict were not so much rainfall scarcity or drought occurrences as such, but rather the constraints around access that have emerged over the last approximately 30 years, which have generated a new form of scarcity. When water no longer satisfies the needs of livestock as it used to, it is not strictly because rain no longer falls or water no longer flows, but rather because access to it has become more complicated under new and often improvised rules. Other rangelands across Kenya are also experiencing similar issues (Agade et al., 2022).

Water harvesting and redistribution infrastructures are a complex combination of technology, cultural norms, governance and hydraulic function (Obertreis et al., 2016). Conflicts that arise from malfunctioning pipelines, in particular, reflect a geographical, social and cultural divide between users and water managers or suppliers, meaning, in this case, between Maasai pastoralists, employees of KWS (a state-run agency), and NOLWASCO (a private company). These tensions are perpetuating the consequences of the engineering and management failures of earlier modernisation agendas such as the Swynnerton Plan, as well as endeavours under French colonial rule in the West African Sahel. The efforts of these agendas to manage water resources around pastoralist communities often overlooked the merits of existing local practices and ecological realities (see, for example, Allan, 2003; Baroin, 2003; Molle et al., 2009). Engineering initiatives would typically result in a reorganisation of water flow and storage across the landscape, thereby reshaping settlement patterns and land use and provoking widespread social transformations. The hydrosocial dynamics in Amboseli are also reminiscent of reports from the highlands of Ecuador, where multiple stakeholders with competing interests (state organisations, private companies, local communities) shape water governance on multiple levels (Hoogesteger et al., 2016). This plurality of interests often leads to tension and overlapping claims on resources; it also challenges efforts to establish equitable and sustainable management systems in the absence of well-staffed and well-funded regulatory bodies. Ongoing processes in Amboseli also confirm previous evidence from Asian settings that human conflict is exacerbated by poor governance, illegal pumping, and endemic water scarcity. Technology in and of itself, such as canal irrigation, does not fix inequality or social discord (see, for example, Wade, 1987; Mosse, 2014). Here in the GAE, where the earliest water access system was organised around natural water bodies such as springs and swamps, the new system is driven by unregulated expansion of agriculture and is underpinned by small silanke-type reservoirs, high-discharge but leaky or dysfunctional pipelines, and randomly distributed and often unreliable groundwater extraction wells.

The uncoordinated proliferation of water users and managers is identified here as a critical issue in at least two respects. First, the principle of water sharing that continues to occur at local levels around collective reservoirs is not being upscaled within or between the identified hydrosocial territories under a new vision of water management. If anything, the water-sharing ethos is in decline regardless of the institutional powers held by WUAs and WRAs. Second, poor coordination is also reflected at the GAE level by a conspicuous absence of monitoring of volumes extracted and recharge rates, whether for surface or underground water. This results in a risk of resource overexploitation, with subsequent threats to ecosystems and livelihoods. The customary institutions that are intended to regulate water sharing and resolve problems of access have gradually seen their power eroded as new users and players have emerged. Along the many fault lines currently reshaping the political ecology of the Amboseli waterscape, ethnicity appears to be an important new factor underpinning rivalry between stakeholders. Conflict between Maasai pastoralists and non-Maasai farmers occurs with varying degrees of violence, and in other parts of Kenya it is well documented to peak at times of extreme drought (see, for example, Linke et al., 2015).

CONCLUSIONS

The Greater Amboseli Ecosystem is a semi-arid rangeland endowed with perennial springs along the northern foothills of Mt. Kilimanjaro. The spring-fed wetlands of the GAE have now become a magnet for the development of staple- and cash-crop farming on the Maasai group ranches surrounding Amboseli National Park. The ongoing waterscape dynamics are measurable and mappable, revealing an evolution in the last 70 years from a nature-based pastoral system with regulated but flexible access to pasture and water resources, to a system that is increasingly organised around low- and high-cost engineered water extraction, storage and conveyance infrastructure. Mapping the historical transformation of three hydrosocial territories straddling Amboseli National Park and its surrounding group ranches has provided a first step towards understanding the metabolism of these territories, that is, where the water comes from, flows, accumulates and leaks, as well as whom it benefits; this can help, lay the ground for a future study of this region – perhaps one that is more quantitative and systemic and goes beyond the reconnaissance groundwork presented here.

Land reform, water grabs and cronyism are generating new challenges for Ilkisongo Maasai pastoralists living in the area. In addition to restricting access to rangeland pasture, the expansion of agriculture and protected areas has resulted in reduced access to water for livestock. Maasai herders have sometimes offset this constraint by diversifying their activities into farming and leasing dry rangeland to conservation organisations. Changes in land ownership from collective to individual have occurred alongside significant socio-economic and cultural shifts within the Maasai community. Some individuals are reaping economic benefits from these transformations; they are mostly landowners who have either retained or recently acquired plots of land close to already existing water extraction, conveyance, or storage elements of the waterscape. Others have meanwhile lost their land and livestock as a result of unfair land sales and due to losing access to water because of other forms of mismanagement or malpractice. The difficulties of ensuring that pastoralism, tourism and farming coexist advantageously for all stakeholders within the same area have led to competition and conflict among all three. Accessing water becomes a competitive necessity among land users; it is propelled by rural development and conservationist policies that back agriculture and tourism rather than livestock herding. Tension intensifies seasonally and peaks during extreme droughts. In a country where most of the land is semi-arid, it would make strategic sense for policymakers to deal with land and water resources at the same time and in a more coordinated way.

Under the current impetus of expanding agriculture, accelerated land reform, and perhaps definitive group ranch subdivision into private plots, increasing pressure on water resources could lead to an unsustainable impasse unless scientific monitoring of water reserves and transfers helps to regulate future water allocation and distribution. New investigations should focus on quantifying the continuing inflation of artificial reservoirs (silanke) and any associated runoff harvesting potential, measuring underground water extraction and recharge dynamics, and gauging spring and river discharge patterns while also expanding the rain gauge network.

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