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Implications of the breakdown in the indigenous knowledge system for rangeland management and policy: a case study from the Eastern Cape in South Africa

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Communal rangelands in South Africa are generally perceived as overgrazed owing to complexities in their histories and collective utilisation which often leads to improper management. A suitable solution has not been found in land management policies because local people's contexts and their indigenous knowledge are ignored. Hence, this paper is aimed at (i) assessing the role indigenous knowledge can play in communal rangeland management, (ii) exploring working solutions to incorporate indigenous knowledge into effective communal rangeland management and land use policies, (iii) assessing mechanisms for generational transfer of indigenous knowledge. Findings from the Participatory Geographic Information System (PGIS) and Focus Group Discussion, conducted with Cata and Guquka villages in the Eastern Cape province were synthesised. This revealed that communal farmers have in-depth knowledge of their communal land, past and present rangeland management strategies and changes in rangeland condition. However, there is breakdown in the indigenous knowledge system whereby this knowledge is not being transferred and translated into good rangeland management practice, owing to the ageing population of communal farmers, limited youth involvement in livestock farming and limited access to extension services. This suggests a need for new policy approaches that would include participation of local people in policy planning and development.

Keywords: Indigenous knowledge, communal rangelands, policy, participatory GIS

Introduction

There is a growing recognition of the importance of the role indigenous knowledge plays in sustainable use and management of natural resources (Tripathi and Battarya 2004, McCullough and Matson 2016, Sithole 2020, d'Hont and Slinger 2022). This recognition stems from the fact that people have an intimate knowledge of many aspects of their surroundings and their daily lives. Over centuries, people have learnt how to grow food, identify medicinal plants, come up with sound management practices for their natural resources, and to survive and find adaptation and mitigation strategies to changes in the environment (Atoma 2011).

Indigenous knowledge is described as the knowledge that people of a given community have developed over time and is based on their experience, which has been tested over centuries of use and adapted to local culture and environment (Moos et al. 2010). In the past, experts often viewed indigenous knowledge as inferior, untrustworthy and largely unstructured and have thus not considered its importance (Golobiĉ and Marušiĉ 2007). However, the complex nature of sustainable natural resource management calls for integration of local knowledge into research as well as policy development.

Tripathi and Battarya (2004), noted that participation and knowledge of local people is a valuable resource in community level natural resource management, decision making and policy planning processes. Additionally, indigenous knowledge provides a foundation for sustainable and environmentally sound approaches to agriculture and natural resource management (Moos et al. 2010). Hessel et al (2009) reported that local people have knowledge about the causes of land degradation, actions needed to deal with its effects and ideas about alternative land-use options. However, despite this knowledge, severe degradation has been cited from many rangelands that are used and managed as common pool resources, such as communal rangelands (Palmer and Ainslie 2005; Snyman and du Preez 2005; Moyo et al. 2008). This degradation is partially attributed to high human populations, overstocking and poor institutional arrangements related to management of natural resources within the rural communities (Palmer and Ainslie 2005; Snyman and du Preez 2005; Moyo et al. 2008; Vetter 2013).

Literature has shown that a lack of appropriate and sustainable management strategies is also a major contributor to the degradation of communal rangelands

and is due to complexities associated with collective management (Ostrom 1990, 2010; Bennett et al. 2013; Hae 2016). Ainslie (1998) explains that management of communal rangelands is complex, as conflicts in the exploitation of the grazing resource often arise. Ostrom (1990) believed individuals are capable of successfully governing common pool resources, and also claimed that there are no universal solutions on how to organise the management of such common pool resources. However, successful governance arrangements have to take into account the unique local situation, and the relationships between people and their resource (Vetter 2013).

Traditionally South African land management policies have not taken local knowledge into consideration, despite the fact that local rural communities are often repositories of key indigenous knowledge (Bennett et al. 2013). As a result, solutions to the complex problems associated with communal rangeland management have not yet been found. For instance, the Conservation of Agricultural Resources Act of 1983 (CARA) focused on prescribed control measures for the utilisation of natural agricultural resources and ensuring that stocking rates are adhered to. Most of these prescribed and imposed measures were ineffective and failed to achieve adoption, especially by communal farmers. The draft policy for the "Sustainable Management of Veld (Range) and Forage Resources in South Africa", focuses on effective veld and forage monitoring and improvement strategies for sustainable use of rangelands. Although it does recognise the need for interdisciplinary collaborations and the establishment of working groups, it still does not include the incorporation of local contexts and indigenous knowledge in its planning (Department of Agriculture Forestry and Fisheries 2014). This makes it difficult for communal farmers to effectively apply their knowledge when having to adhere to policy regulations to improve rangeland management and concomitantly livestock production.

The special issue of the African Journal for Range and Forage Science that was published in 2013, titled "Aligning policy with the socio-ecological dynamics of rangeland commons" set out to show that there is a need to align policy with people's practices. The position paper by Vetter (2013) clearly attributed the limited success of the land management policies to the fact that they ignore engagement with the social and economic dimensions that influence management practices. This suggests that a way to craft methods for sustainable use and management of natural resources that consider people's unique situations and take local indigenous knowledge and spatial awareness should be taken into account (Reed et al. 2015).

This paper was aimed at (i) assessing the role indigenous knowledge can play in communal rangeland management, (ii) exploring working solutions to incorporate indigenous knowledge into effective communal rangeland management and land use policies, and (iii) assessing mechanisms for generational transfer of indigenous knowledge systems.

People's indigenous and spatial knowledge with regards to communal rangeland management and utilisation was established using participatory methods that included Participatory Geographic Information System (PGIS) and Focus Group Discussion. The participatory methods were then synthesised revealing a breakdown in the indigenous knowledge. Hence the need to explore ways to incorporate the existing indigenous knowledge into policy and transfer it to the next generation.

Materials and methods

Methodology approach

A case-study research approach was employed in this study in order to assess the role of indigenous knowledge in communal rangeland management and utilisation of the communal case studies are employed to narrow down a very broad field of research into a researchable topic, to provide an in-depth study of a particular situation. Case studies are used to develop knowledge about an individual, group, organisational, social, political or related phenomena (Yin 2014). The rationale for selection of the sites was that each of the selected case study areas should be located within the same catchment and that they should be held under the communal land tenure system where the rangelands are collectively managed and utilised. Two case study sites, located in the upper Keikamma River catchment in the Eastern Cape, namely: Cata and Guquka were selected. The two study sites offer an interesting story because of their history of land access restrictions, forced relocations and trends in rangelands management associated with the implementation of the Betterment Planning System in the mid 1960's and 1970's. The details of the two case study sites, Cata and Guquka, are provided below.

Case study villages

Guquka

Guquka (32°38′53.8″ S, 26°56′30.0″ E) village is situated about 25 km north-east of the town of Alice and falls under the Nkonkobe local municipality in the Eastern Cape, South Africa. It is one of three villages that form part of the AmaKhuze Tribal Authority, which in turn falls under the AmaRharhabe Paramount Chief. The village is divided into residential, arable and grazing land which are located largely on the foothill of the Amatola mountain range. The boundary between Guquka and the neighbouring village is defined by the Tyume River and this is also where the arable field boundaries end. The arable lands cover a total of 150 ha in extent and are divided into 41 individual fields. The individual residential plots contain one or more dwellings, a livestock pen area ('kraal') and a small garden (Hebinck and Lent 2007). Guquka has a total population of 564 people (48% females and 52% males) and 159 households with 47% headed by females (Statistics South Africa 2016). The population of the village comprises predominantly elderly people or young children, and there is a substantial reliance on welfare payments and grants (Hebinck and Lent 2007). There is a high unemployment rate amongst the youth.

Cata

The Cata (32°35′21.2″ S, 27°07′19.8″ E) village situated 59 km from King Williams Town, South Africa, and falls under the Amahlathi local municipality and is

one of the 13 villages that fall under the Amazizi Tribal Authority, which in turn also falls under the authority of the AmaRharhabe Paramount Chief. The Amatola Mountains surround the village on three sides with the Cata River running through the middle of the village's residential area and into the Cata Dam. In 2004, people were financially compensated for the land they lost under apartheid through the Restitution of Land Rights Act (Act 22 of 1994) and land was transferred to the village's Common Property Association (CPA), established in the same year (Tontsi 2013). Cata has a total population of 891 people (54% females and 46% males) and 285 households with 55% headed by females (Statistics South Africa 2016). Due to development initiatives that are facilitated through the CPA, casual employment is offered to the people of Cata. Hence the village has more young people compared to Guquka. Employment is also offered by the forestry company that owns the commercial pine plantation in the village.

Both study sites were subjected to Betterment Planning in the late 1960's and early 1970's. Their history of land access restrictions forced relocations and trends in rangelands management associated with the implementation and collapse of Betterment Planning system is well documented through studies by de Wet (1989); de Wet and Leibrandt (1994); Fabricius and de Wet (2002); Bennett (2002); Bennett and Barret (2007); Bennett and van Averbeke (2007).

Data sampling

This study was conducted between March 2016 and February 2017 and used Participatory Geographic Information Systems (PGIS) and Focus Group Discussions which are effective ways of capturing indigenous knowledge and thus meeting the study's objectives.

Participants demographics

Non-probability, purposive sampling methods were employed in the selection of both participants for the participatory mapping exercise and key informants for transect and virtual walks. This choice of participants was made based on their knowledge of their environment and changes that have occurred over time. This sampling approach was also used to ensure that both genders and different age groups were represented and to overcome the known and reported challenges of implementing probability-based sampling in a developing country context (Brown and Kyttä 2014). The key informants were recommended directly by community members who agreed that they were best suited for the task.

In Cata, a total of 11 participants comprising three females aged between 35 to over 65 years and eight males aged between 20 to over 65 years took part in the first phase of the participatory mapping process. In Guquka, 10 participants comprising two females in the age categories 20 and over 65 years and eight males aged between 20 to over 65 years participated. In Cata for the second phase, 13 participants were selected, comprising of nine males between the ages of 30 and over 65 and four females between the ages of 35 and over 65. In Guquka a total of six participants were recruited, comprising of three males between the ages of over 50 and three females between the ages of over 20 and over 65 years.

Community participatory mapping

Wang et al. (2008) defines PGIS as a tool designed to reflect local people's spatial knowledge. It is a form of participatory mapping that uses GIS technologies in a manner that accommodates the needs and capabilities of the communities directly involved and affected by planned projects and programmes (Abbot et al. 1998). The participatory mapping exercise employed in this study had two phases, which included the initial hand-drawn maps and the final community map with narratives. The locations and existence of the features identified on the hand-drawn maps were validated through transect and virtual walks.

Phase 1

This phase was conducted in March 2016, with 11 and 10 participants in Cata and Guquka, respectively. Participants were provided with Google Earth aerial maps showing their communal areas for visual reference and to orientate themselves. These aerial maps acted as base maps upon which boundaries, water sources and changes in the rangeland condition were drawn by participants. These were then transferred to A1 paper size where the important landscape features were drawn using different colours and shapes. Features that participants were requested to identify included: village boundaries; grazing areas; roads; rivers and dams; summer and winter camps; areas with good and poor grazing; areas with erosion and those with invasive alien plants. Each study site produced a phase 1 hand-drawn map which acted as the baseline map for phase 2. In addition, the Google Earth aerial map with the changes in rangeland condition was translated into a digital map of rangeland degradation for each village.

Phase 2

The second phase of the participatory mapping exercise was conducted in December 2016 with 13 participants in Cata and six participants in Guquka. In both phases and in both villages there was representation in terms of gender and age. The focus while conducting this phase was to add or remove some features that were drawn on the first phase map, and secondly to delve deeper into people's knowledge of their rangelands and on eliciting narratives linked to specific features. The second part also resulted in addition of new features and areas of importance onto the map. The narratives that were shared were prompted by a set of carefully articulated questions that were prepared beforehand to lead the discussions, which were based on the features and spatial boundaries identified on the phase 1 maps. The questions were framed around these topics: (i) invasive alien plants – when they first appeared, rate of spread and local rehabilitation efforts; (ii) grazing camps – locations of summer and winter camps as well as areas of good and poor grazing, grazing management strategy; (iii) arable plots – title deeds, reasons for cessation of cultivation, effects on food security; (iv) pine plantation – when was it established, on whose land, benefits to the community.

The second phase discussions were conducted in Xhosa and recorded with the full permission of the participants for later transcription and translation into English, followed by a thematic analysis. Once the phase 2 maps were finalised, they were scanned for later validation via transect and virtual walks. The discussions were recorded for later transcription to English by the researchers.

Transect and virtual walks (digital maps)

The transect and virtual walks in Cata were carried out in October to November 2016 with two key informants: a male in his late 40's and a female in her early 40's. In Guquka, a male over the age of 60 years participated. The Cata transect walks were carried out over a period of five days and in Guquka these were held over three days.

The areas walked were extensive and boundaries and features of interest were geo-referenced by the researchers using a GPS. These included parts of the rangelands and arable field boundaries, water points and other areas of importance to the communities. All inaccessible areas were marked on Google Earth Pro using place marks.

Focus group discussions

Prior to conducting the Focus Group Discussions, a total of 60 face-to-face interviews were completed (30 participants from each village). The findings of the interviews will not be discussed in this paper. However themes that were identified as important to people during the interviews were formulated into leading questions for the Focus Group Discussions. Five leading questions relating to rangeland management strategies and how this has changed over time, the perceived causes, and the effects on rangeland condition, livestock health and people's well-being, as well as potential solutions were framed.

The two Focus Group Discussions were conducted in February 2017 with 11 participants in Cata and five participants in Guquka between the ages of 20 to over 65 years, to gain deeper insights on the themes that emerged from the interviews. The focus groups consisted of the people who had participated in the interviews in the preceding weeks, particularly those who had revealed deep local knowledge or expressed concern about the current situation of their rangeland and livestock.

Data analysis

The narratives associated with the features identified on the Phase 2 community maps and the Focus Group Discussions were analysed following Braun and Clarke's (2006) thematic analysis phases. Four steps were followed, namely: (i) generating initial codes, which is a process of organising data into meaningful groups; (ii) searching for (latent) themes, which involves sorting of the different codes into themes; (iii) reviewing, refining and naming the themes by considering the validity of the individual themes in relation to the entire data set and whether or not the thematic map accurately reflects the story told by the entire dataset; and (iv) producing final thematic maps with sufficient evidence of the themes in text extracts or quotations. Analysis of the transect walks was done by mapping all GPS coordinates representing the features and changes in those features over time.

Results

Spatial and indigenous knowledge related to communal rangeland condition and management

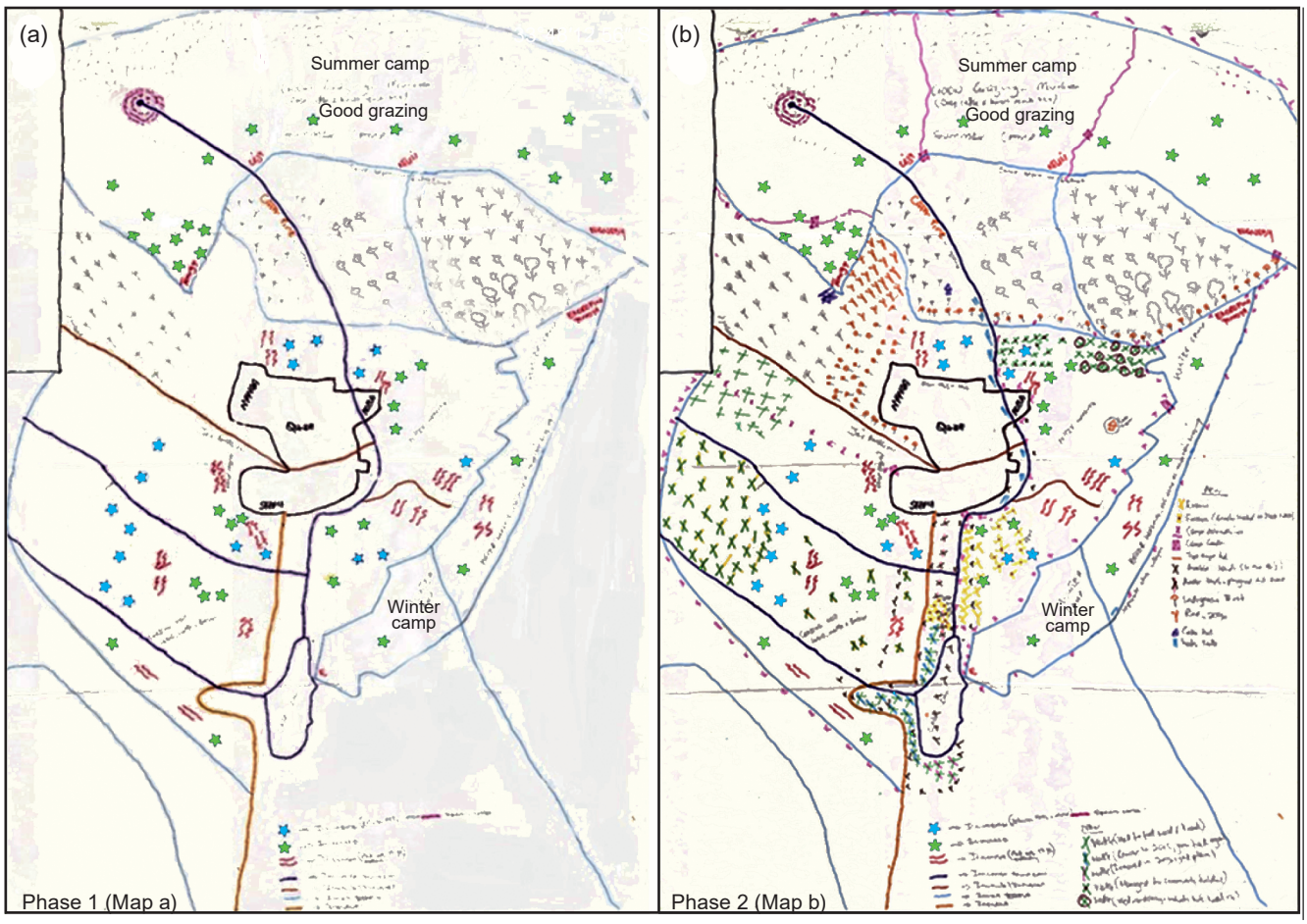
Results indicated that people in both villages have in-depth spatial and indigenous knowledge of their communal land, past and present rangeland management strategies and changes in the condition of their rangeland. Detailed community maps with features and boundaries associated with the communal areas of Cata and Guquka were produced (Figure 1 and 2). Spatial knowledge of the locations where summer and winter camps were previously demarcated during the Betterment planning period, the condition within those areas and the indicators of the good and poor rangeland condition are displayed. As participants were identifying and drawing features on the map, they also shared the names of the different residential areas, arable fields as well as summer and winter camps. These features are listed in Table 1.

Two GIS maps of the entire communal area for Cata and Guquka villages were produced from the coordinate data collected during the transect walks and virtual walk (Figures 3 and 4).

Cata village

Features added by participants to Cata's Phase 1 mapping included areas where grazing camps were located, the residential boundary, a dam, streams, a spring, the road, erosion gullies and black wattle stands (Figure 1a). In Phase 2 (Figure 1b) new features included were the toposcope, Cata huts, camp gates and waterfalls. Existing features that were modified included erosion gullies; camp boundaries; arable fields (plots last ploughed in the 1990's and those ploughed until 2005); forests (indigenous and pine plantation). Features also included black wattle stands which is an alien invasive tree (different black wattle stands were identified and used for fuel wood, kraals or community building projects and kraals, stands that were cleared and those that had resprouted, and black wattle used randomly for other purposes).

Areas of the communal rangeland that were previously demarcated as summer camps namely Nogwebu, Ntusi and Gweju under the Betterment planning system were identified on the mountains which lie behind the indigenous forest and the pine plantations. While areas that were previously demarcated as winter camps namely Tanuka; eKorofini Yomoya, Nyokana and emiQhorhwana were delineated on the foothills and lowlands (Figure 1). Although the boundary fence for these camps no longer exists, people still call the areas that they located by the above-mentioned names. It was shared that the camps were demarcated where people's homesteads were located prior to the forced relocations, and implementation of Betterment planning that led to a change in the rangeland management system and a reduction of livestock numbers. The grazing practice applied during the Betterment period was rotational grazing between fenced paddocks and intensive management by rangers. Prior to the Betterment period, herding and seasonal transhumance were used through a community-based common property regime. The betterment planning system started collapsing in the early



Legend Phase 1 (Map a)

Symbol	Feature
Blue star	*Vachellia mearnsii* (since 1994 recent)
Green star	Rangeland
Two red lines	Soil erosion
Purple line	Water sources − rivers and dam
Pink line	Spring
Red line	Streams
Orange line	Road
Blue line	Camp boundary

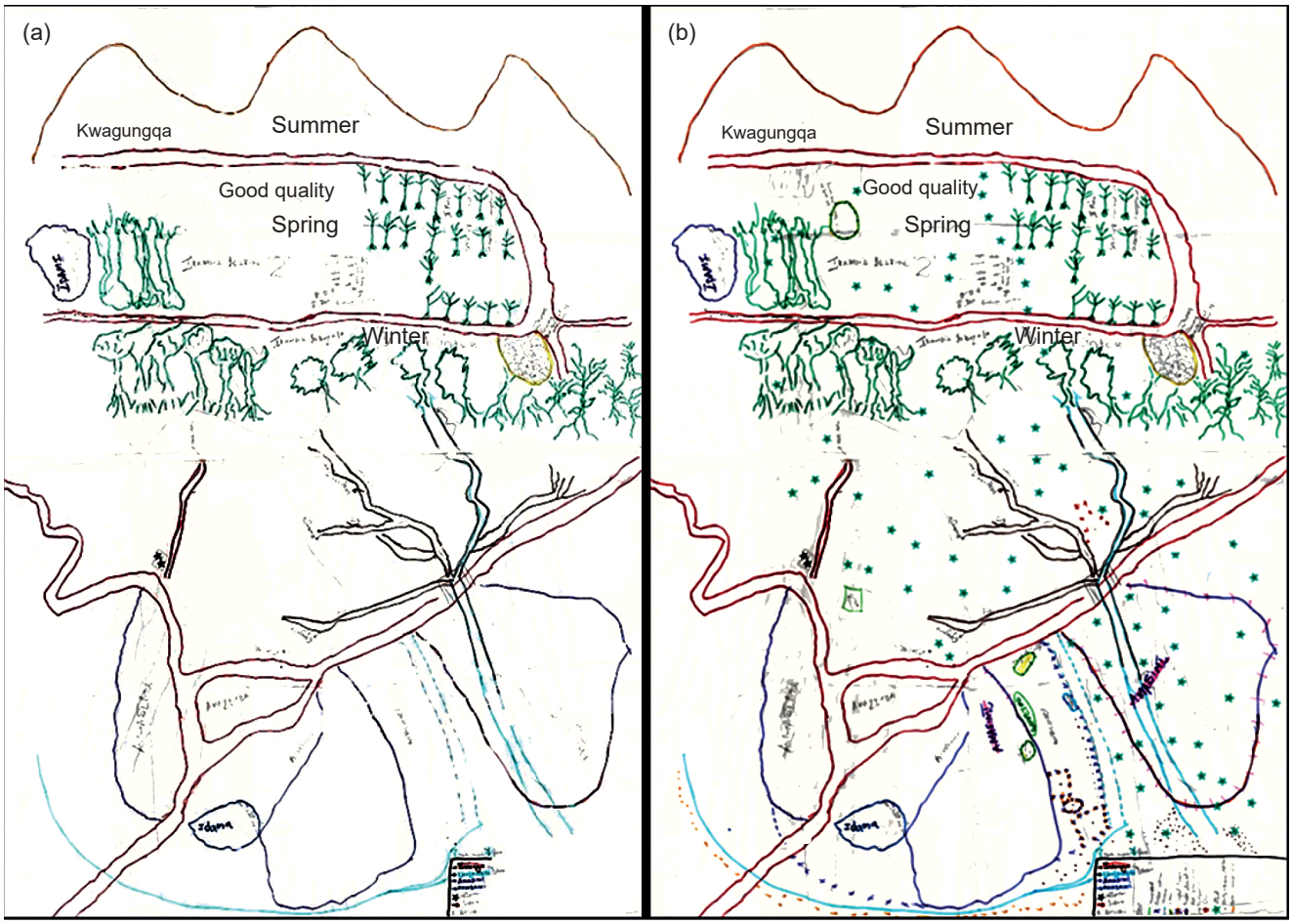
Legend Phase 2 (Map b)

Symbol	Feature
Green cross	*Vachellia mearnsii* (for firewood and kraals)
Green and blue cross	*Vachellia mearnsii* (cleared in 2015 but grew back)
Green and pink cross	*Vachellia mearnsii* (cleared in 2016 and still cleared)
Green cross + brown dot	*Vachellia mearnsii* (managed for building houses in the village)
Green cross circled	*Vachellia mearnsii* (random use eg. initiates huts)
Yellow cross	Erosion
Yellow cross + brown dot	Erosion (rehabilitated in 2005 and 2015)
Pink cross	Camp boundary
Pink cross boxed	Camp gates
Orange line	Toposcope hut
Brown cross	Arable (last ploughed in the 90's)
Brown + pink cross	Arable (last ploughed in the 2005)
Orange cirsle	Indegenous forest
Orange Y	Pine plantation (Since 2006)
Purple triangle	Cata huts
Two blue lines	Waterfalls

Figure 1: (a) Cata Phase 1 hand-drawn community maps, showing the grazing camps, arable fields, residential area, indigenous forest, pine plantation and areas with invasive plants and soil erosion, dam and water spring. (b) Cata Phase 2 hand-drawn community maps, showing the modifications done to Phase 1 map

1990's and the camp fence was either stolen or left to rot. According to participants owing to this absence of the camp fence there is no formal management strategy.

The general view with regards to the condition of the communal grazing was that over time, the quality of the entire grazing area has declined. During the participatory mapping exercise the camp that was identified as an area of particular concern was the Tanuga winter camp located below the Jili arable field (Figures 1 and 5) where the prevalence of black wattle and soil erosion were major challenges. However, all the summer camps grazing areas were still viewed to be in a much better condition in comparison to the winter camp grazing areas, with the exception of eKorofeni Yomoya camp which was reported to have portions that were perceived to be in good condition. Although Cata village has no formal communal



Phase 1 (Map a)

Legend

Symbol	Feature
Brown line	Streams
Blue line	River
Purple line	Arable plots
Dark blue line	Dams
Grey star	Reservoir
Red line	Road
Grey hashtag	Old dipping tank

Phase 2 (Map b)

Legend

Symbol	Feature
Green line	Grave yards
Purple cross	Modified arable plots
Blue + grey line	Additional Streams
Green + yellow cross	Old dam
Purple + orange	Planted arable
Purple + pink	Canceled arable location
Grey line	Residential area
Two red lines	Dipping tank
Light green star	Rangeland
Brown dots	*Vachellia mearnsii* + *Vachellia karroo*
Orange line	Cleared area − *Vachellia mearnsii*

Figure 2: (a) Guquka Phase 1 hand-drawn community map, showing the rangeland, grazing camps, arable fields, residential area, indigenous forest, pine plantation and areas with invasive plants and soil erosion, dam and water spring. (b) Guquka Phase 2 hand-drawn community map, showing modifications done to the Phase 1 map

grazing management strategy, individual sub-villages have informally designated specific locations for grazing within the communal grazing area. For example, Ndela sub-village cattle are said to graze on their own, while cattle from Kwa-Nyanga and Kwa-Skafu sub-villages graze together.

Guquka village

On Guquka's community map, features included indigenous forest, pine plantation, arable fields, dams, the river and streams, reservoir, dipping tanks and erosion gullies (Figure 2a). During phase 2, new features added were additional dams and streams; sub-village names and a new dip tank. Modified features included black wattle (areas that were cleared and those that were not cleared); sweet thorn; arable fields (changed location, made additions to existing cultivated arable fields) and rangeland area (Figure 2b).

Areas of the communal grazing that were previously demarcated as summer camps during the Betterment

planning period, namely KwaGungqa and Nyili were identified on the mountain above the pine plantation and the indigenous forest. While areas that were previously demarcated as the winter camps named Mpundunkulu were identified on the foothills (Figure 2). One of the winter camps was dominated by indigenous forest where the village spring was located and the second one was identified below the forest towards the foothills. The betterment planning period in Guquka was associated with a change in the rangeland management system and a reduction in livestock numbers. Similarly to Cata, the grazing practice applied was rotational grazing which came with fenced off grazing camps, a ranger and extension services that included, advice, training, dipping, vaccination, provision of rams and bulls and seeds. Prior to the implementation of betterment planning, the same management strategy as in Cata was applied. Seasonal herding meant that livestock (particularly cattle) were herded into the mountain pastures during the growing season, whilst the lower rangeland areas were largely rested and then were used during the dry season along with crop residues on arable fields. After the collapse of betterment planning, decisions for the management of livestock in Guquka were made at a household level and there was no formal communal rangeland management strategy. However, participants still maintained that the mountain summer camps and the forest winter camp grazing areas were in good condition when compared to the winter camp on the lowland and foothill grazing areas (Figure 2). The mountain camps emerged as the most preferred, owing to the body weight and healthy condition of cattle that graze there.

Table 1: List and names of sub-villages, grazing camps and arable fields in Cata and Guquka

Study Sites	Sub-Villages	Grazing Camps	Arable Fields
Cata	Nyanga	Summer Camps	Jili
	Qunde	Nogwebu	Marhawulela
	Ndela	Ntusi	Ndela
	Skafu	Gweju	Nyanga
		Winter Camps	
		Tanuka	
		eKorofini Yomoya	
		Nyokana	
		Emiqhorhwana	
Guquka	Emachibini	Summer Camps	
	Amagquba	KwaGungqa	
		Nyili	
		Winter Camp	
		Mpundunkulu	

Rangeland degradation categories

Three degradation categories were identified both during the participatory mapping exercise and Focus Group Discussions, namely the invasion of alien plant (encroachment of black wattle), soil erosion and species compositional change. These were mainly attributed to the absence of the camp fence and consequently the cessation

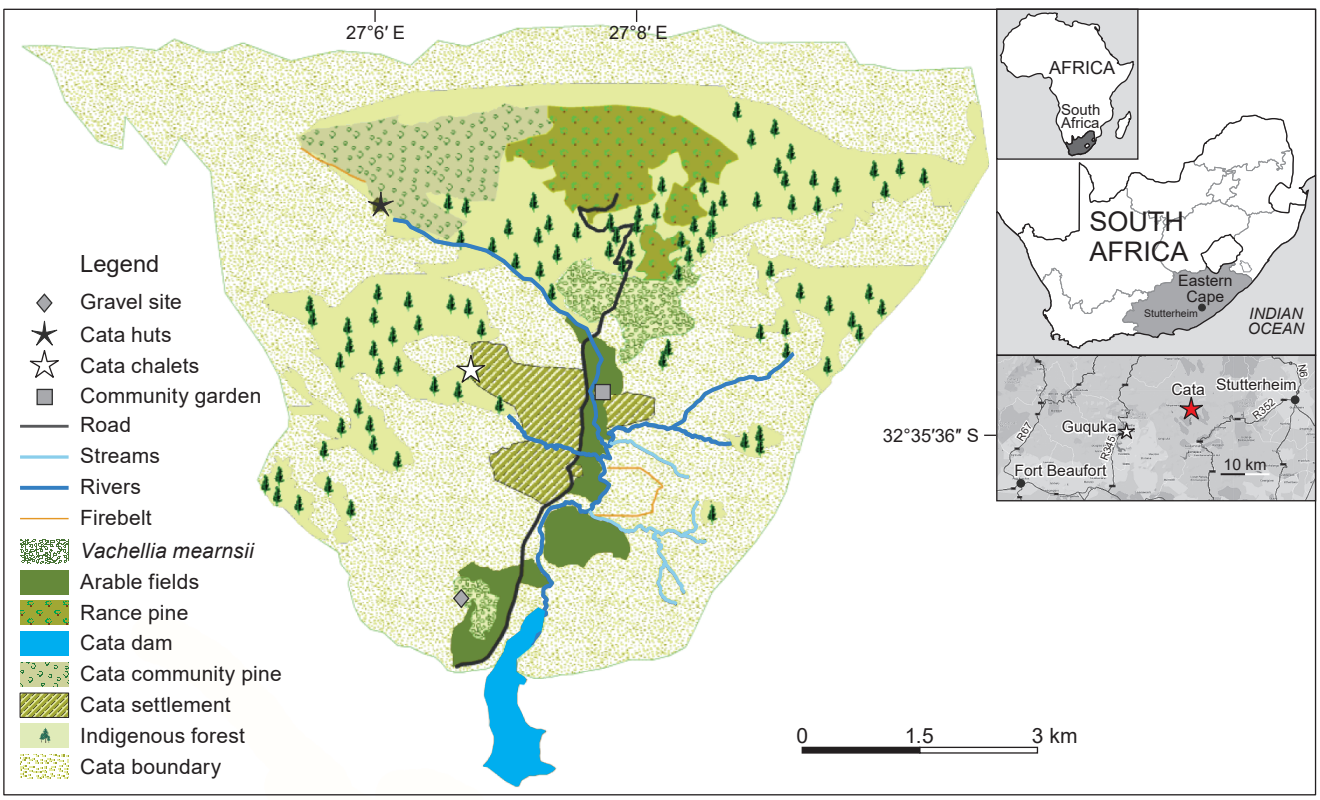


Figure 3: Map of Cata created from points marked during the transect walk and virtual walk exercises

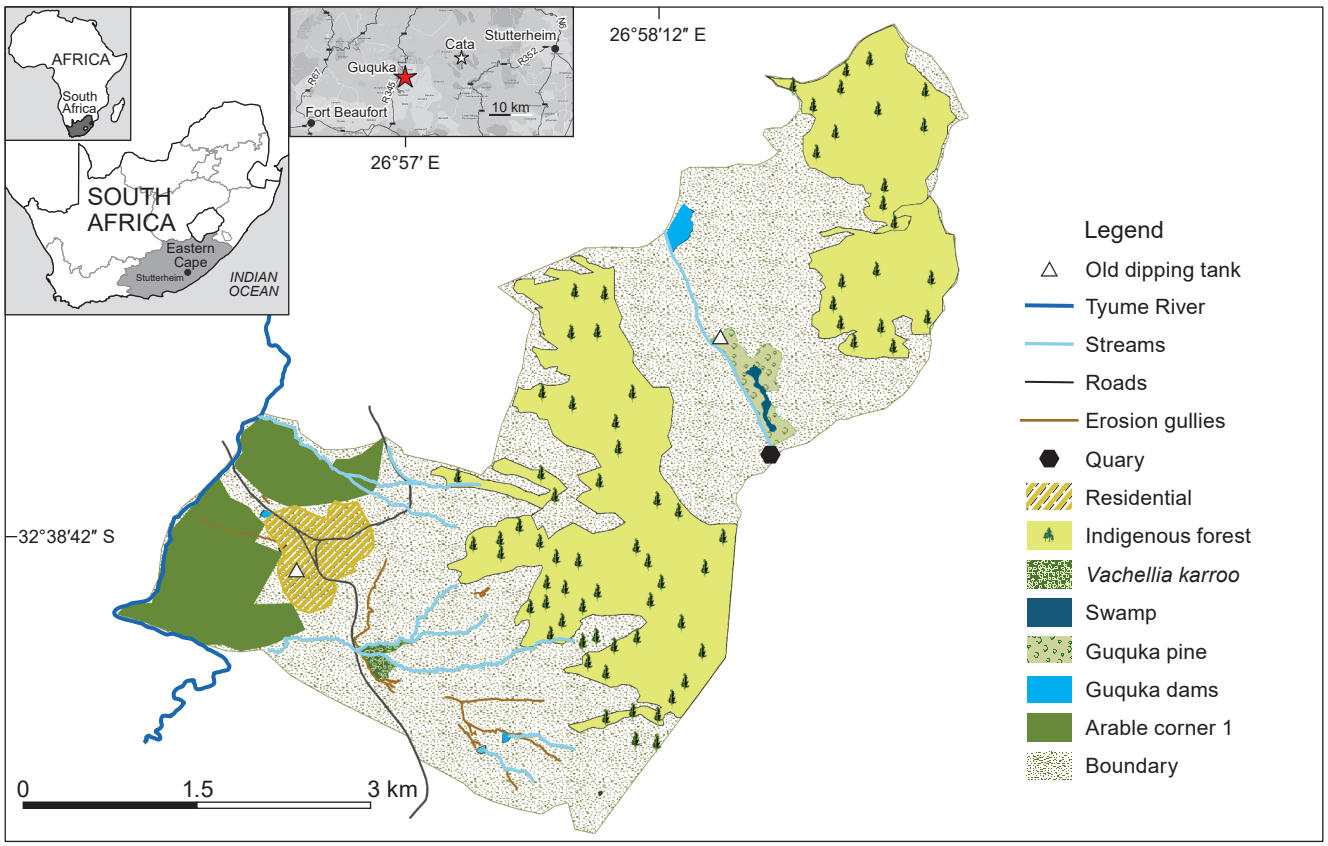


Figure 4: Map of Guguka created from points marked during the transect walk and virtual walk exercises

of rotational grazing. Currently, unregulated continuous grazing practice was applied in both villages, where livestock is led to the same communal grazing areas in the mornings, left there to graze the whole day and collected in the late afternoon. This grazing practice is not preferred by the communal farmers and is perceived to be contributing to the continued degradation of the communal rangeland.

Invasion of alien plants

The main alien invasive plants identified in Cata was black wattle (*Vachellia mearnsii*), while in Guguka they additionally identified sweet thorn (*Vachellia karroo*) (Figures 5 and 6). According to Cata participants, the growth of black wattle was first noticed in the 1990's both on the grazing areas and the arable fields; and later spread to areas close to the Cata dam. Participants reported that clearing interventions took place in 2003, 2015 and 2016 through the Department of Environment Affairs (Figure 1). Re-sprouting of black wattle was observed in some of the cleared areas. The clearing mechanisms were not discussed, which might have given an indication of why clearing in some areas had positive results. There were some areas where black wattle was kept for community use for fuel wood, building of mud houses and long-term community development plans (Figure 1). In Guguka, all black wattle identified by participants were adjacent to the riverbanks, some of which had been cleared but had re-sprouted (Figures 2 and 6). Around the same time that this study was active in the community, participants noted that Working for Water teams were busy clearing black wattle above the river. Sweet thorn invasion was identified on the grazing area that is on the right-hand side of the road within the arable lands and close to the river (Figure 6). Participants were not sure about when the sweet thorn started growing and no rehabilitation efforts (by locals or external agencies) have been made to clear it to date.

Soil erosion

Two types of soil erosion were identified in Cata and Guguka namely, gully and sheet erosion. Both villages reported gully erosion as the most prevalent type of soil erosion within their communal grazing area and arable fields and close to the water sources. In Cata, the most affected areas with erosion gullies are the lower parts of the grazing land and close to the residential area (Figure 3). According to the participants the rehabilitation of the gully erosion on areas close to the river was done by the Department of Environmental Affairs in 2007 and 2017. This area is small compared to the extent of the spread over the entire communal area. Some of the reasons provided for the increase in the spread of gully erosion in Cata included, resettlements, grazing close to the homesteads and large numbers of livestock grazing the same area. In Guguka, gully erosion located on the arable land, close to the river and outside of the

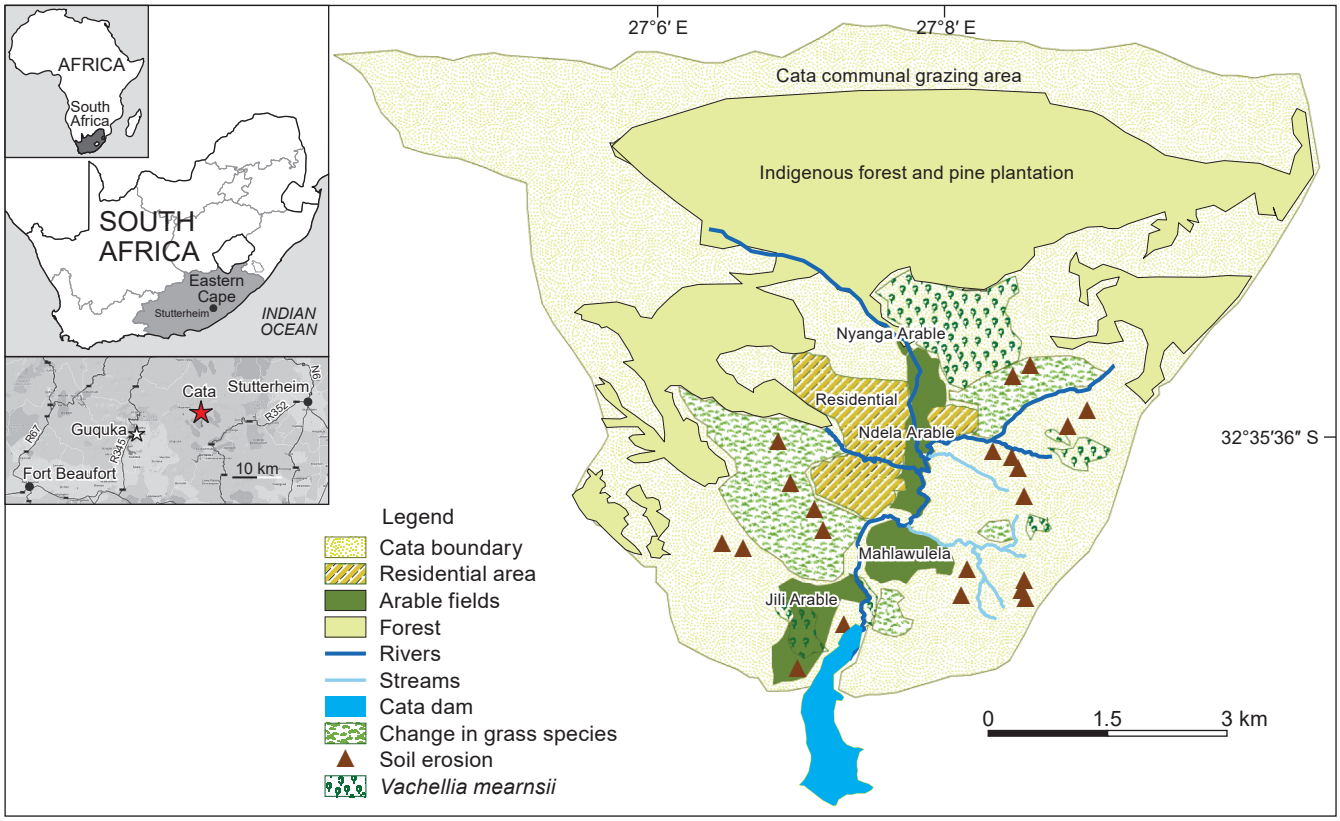


Figure 5: Cata rangeland degradation map derived from Google Earth Aerial Maps showing areas where change in grass species, soil erosion and black wattle invasion are located within the communal grazing and the arable fields

defined rangeland boundary were identified in Phase 1 mapping (Figures 2 and 4), however on the Phase 2 map participants were undecided about whether some of these were really gullies or streams, especially those close to the river and as a result these were changed (Figure 2). During the Focus Group Discussions, the same areas identified as having gully erosion that are dangerous or harmful to animals were also reported because of how deep they are. In these eroded areas, changes in grass species composition were also reported. The soil erosion reported in both Cata and Guquka is not only unique to these villages, Mhangara et al. (2012), also reported 47% of the Keiskamma catchment has soil losses higher than 12 t ha^{-1} year^{-1}, which are above sustainable tolerance limits. Moreover, the Eastern Cape is cited as the province with the highest annual soil loss rates of about 25 t ha^{-1} year^{-1}.

Change in grass species composition

Changes in grass species composition that included an increase in annuals and/or less palatable grasses over time also emerged as one of the challenges. Both villages noted that good palatable grasses such as *Themeda triandra* (grass) and *Cynodon dactylon* (couch grass) were replaced by *Cymbopogon marginatus* (turpentine grass) and *Hyperrhenia hirta* (thatching grass) which are both tough and unpalatable. Most of this change in grass species composition was identified on the low-lying areas, closer to the homesteads and arable fields. It was also maintained that good grazing is found on the upper slopes and on top of the mountains (Figures 5 and 6). The knowledge shared by Cata and Guquka participants is consistent with the veld condition assessment findings, which showed that the grass species with high palatability such as *T. triandra, C. dactylon and Sporobolus fimbriatus* dominated the upper slopes and mountains. Less palatable and unpalatable grasses such as *Cymbopogon excavates, Cymbopogon marginatus*, *Sporobolus africanus*, and *Hyperrhenia hirta* dominated the low-lying grazing areas (Finca 2020). Participants in Cata and Guquka attributed this change in species composition to unplanned veld fires and drought, as these grasses are drought resistant. In Cata specifically, they added that thatching grass was no longer used for roofing and was thus not harvested as it was used previously and this could be contributing to its spread. While these observations are sound, it is also possible that change in grazing management and the grazing pressure on the low-lying areas could have affected the change in grass species composition. The grasses that were identified as being replaced are ‘decreaser’ species which decline with over and underutilisation while the grasses that replaced them are ‘increaser’ species which are favoured by overutilisation (Kioko et al. 2012). Guquka participants also added that *H. hirta* hosts the bont-legged ticks that can cause the animals to limp. The teeth of cattle are also damaged because of the tough grass species.

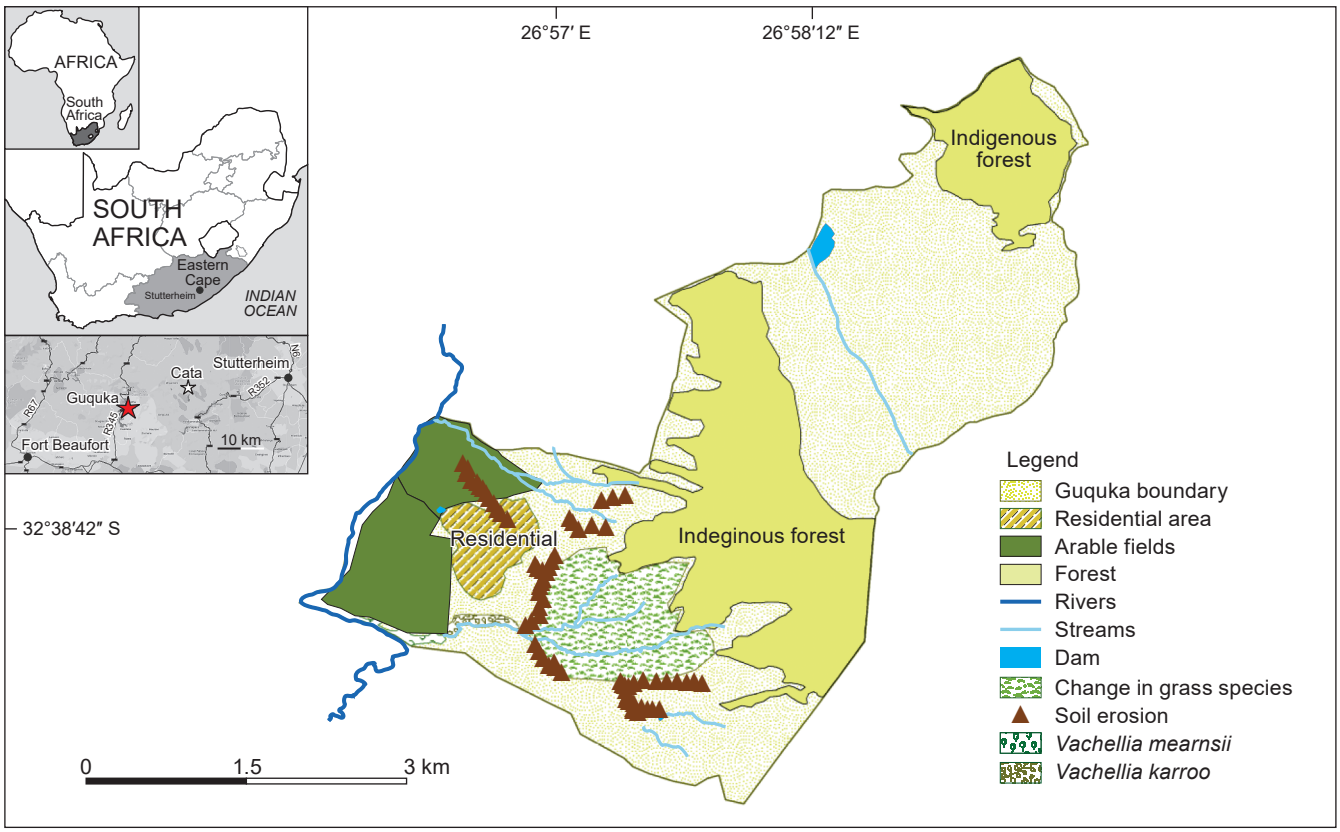


Figure 6: Guguka rangeland degradation map derived from Google Earth Aerial Maps showing areas where change in grass species, soil erosion and black wattle and sweet thorn invasion are located within the communal grazing and the arable fields

Social structure and perception of community well-being

Four arable fields were identified in Cata and two in Guguka. In Cata, each arable field belonged to people from a specific residential area, while in Guguka this distinction was not made. The arable plots in Cata cover a total of approximately 170 ha in extent while in Guguka they cover 150 ha. Each field in both villages was divided into individual plots that belong to the different households. In Guguka these individual plots have title deeds while in Cata people only have rights of use. In both villages, none these arable fields are cultivated with the exception of the community garden which was active on the Ndela arable field in Cata. Cata and Guguka participants attributed the abandonment of cultivation to a number of factors including the 1982/83 drought, cessation of the provision of tractors, seeds, fertiliser and working tools; health issues associated with ageing; lack of youth involvement, and absence of the boundary fence separating the arable fields from the residential areas, resulting in livestock entering the arable and destroying the crops. The abandonment of cultivation in both villages also meant that the supplementary feed for livestock that they derived from left over maize stovers was no longer available.

The issue of ageing livestock farmers which comes with health issues, coupled with limited youth involvement and limited extension services, emerged strongly as a barrier to effective livestock and rangeland management. As pointed out both during the participatory mapping exercise and focus group discussions, good grazing is mostly found on the hills and mountains. However due to their age, most communal farmers are not physically strong enough to reach these areas. Instead they end up grazing livestock close to their homesteads, on the foothills and in arable fields. Older communal farmers believe that their children are not interested in livestock farming, and lack the passion for it. Young people rather have a desire to leave their village homes in pursuit of a better life in the urban areas, where they can earn a salary. It was also reported that even those that were at home do not offer their help to look after livestock or plough the fields. As a result, some communal farmers have resorted to reducing numbers of animals because they cannot manage large herds/flocks on their own. This is especially difficult for older women who currently owned fewer livestock compared to their male counterparts. According to the few young people who were part of these discussions, in a communal setting livestock farming does not offer sufficient returns to support a person without any need for supplementary income.

Cata and Guguka village maps derived from the transect walks

A GIS map for each village was produced during transect and virtual walks (Figures 3 and 4). During the transect

walks the coordinates of the following features and boundaries were marked and recorded with the guidance of the key informants: parts of the boundary for the rangeland and arable fields; pine plantations; part of the river, streams and dams; some erosion gullies in Cata and Guquka. Additional features such as the community garden, toposcope (a monument dedicated to people who were affected by the forced relocation), Cata huts and Cata chalets were marked in Cata only (Figure 3), while dipping tanks were marked in Guquka only (Figure 4). During the virtual walk, the following inaccessible features and boundaries were digitised on Google Earth Pro, i.e. the remainder of the boundaries for the rangelands, arable fields and the pine plantations, the forest comprising of the indigenous tree and black wattle stands, additional erosion gullies, rivers, dams, and streams.

Discussion

The breakdown in indigenous knowledge cycle

Synthesis of the findings from the community mapping process and focus group discussions reveal a breakdown of indigenous knowledge system in Cata and Guquka, which are obstacles to the improvement of their rangelands condition and management. Firstly, it was revealed that livestock ownership in both Cata and Guquka is dominated by the older generation and the majority of young people from both villages are neither interested in nor involved in livestock ownership nor rangeland management. This denotes that the extensive indigenous and spatial knowledge that exists in Cata and Guquka in relation to communal rangeland management is 'trapped' in the older generation who find it difficult to transfer it to the younger generations. This is a concern, as this knowledge may be lost if not passed on and utilised. This also suggests that the understanding of livestock farming and rangeland management in rural Eastern Cape is dwindling amongst the younger generation. Magagula and Tsvakirai (2020) reported that the continuous reliance of farming on the ageing population, could have adverse impacts on agricultural production including livestock production as physical strength is key in this sector. Hence there is growing need to increase youth participation in all aspects of agricultural production especially in the rural areas.

Moreover, recent statistics show that youth between the ages 18–34 years form over one-third of the South African population and 52.5% are currently unemployed although actively seeking employment (Statistics South Africa 2020). However, getting employment in the current climate requires experience which subsequently excludes those who have never been employed, giving rise to increase poverty levels amongst rural youth. According to a feature published in Water Wheel in December 2021, youth could play a vital role in food security and agriculture which has been identified as one of the biggest sectors that could create jobs for the youth (Moitui 2019). However, a number of studies in the sub-Saharan region including South Africa, Tanzania, Uganda, Malawi and Nigeria demonstrated that getting youths to productively engage in agriculture and its related value chains has not yielded the envisaged results (Proctor and Lucchesi 2012; Irungu et al. 2015; Magagula and Tsvakirai 2020). Magagula and Tsvakirai (2020) further described the youth's participation in farming as limited, sporadic and does not reflect the money and effort spent in the sector thus far. According to August (2020), the youth from two regions in the Free State province in South Africa perceive agriculture to be less economically motivating owing to the poor remuneration, low productivity, poor infrastructure and limited resource availability. Mthi et al. (2021) concurs and reports that the youth identified land ownership, capital costs, access to credit, visibility of extension personnel, access to market, and low returns as constraints. This denotes that an improvement to the support and service provision could encourage youth participation in agriculture. It is therefore important to explore new policy approaches that would restore and instil the value of livestock farming for rural well-being amongst young people.

Secondly, it emerged that community members currently do not have sufficient knowledge on how to access the extension and veterinary services, which are necessary for sustainable use and management of their communal rangelands. Extension and veterinary services such as dipping, livestock medicine, livestock vaccination, and the provision of bulls and rams for livestock improvement were provided during the betterment planning. Presently, there is a decline to the provision of these services and the communal farmers did not know how or what they needed to access them again. Some speculations as to why they were experiencing this decline included a lack of skilled extension advisers, limited resources, transport and reduced numbers of employed extension officers. In addition, some livestock owners did not know who their designated extension officer was. According to Davis (2008) agricultural extension services are important to communal farmers and play a role in linking them to resources, information and training, thus building their capacity to improve their productivity. The issues with access to extension services are not unique only to Cata and Guquka villages, nor are they unique to the Eastern Cape. In Mpumalanga for instance, the farmers that are part of the New Forest Irrigation scheme shared that the agricultural extension and irrigation cooperative did not meet their expectations and they felt neglected (Ncube 2017). This could be linked to a shortage of extension and support services to assist smallholder farmers in South Africa. According to Williams et al. (2008), South Africa only has one-third of the required number of extension officers and about 80% of them do not have adequate training. The difficulty in accessing the extension advisory services often forces people to fend for themselves and indeed in both Cata and Guquka people revealed that they have had to buy medicine for their animals and in some cases even dipping chemicals. Many livestock owners depend on old-age social grants meaning that in addition to the decline in extension service provision, there are financial constraints that make improvement of rangeland management difficult in these communal areas.

Mechanisms required to translate existing knowledge into effective rangeland management

Mechanisms that will assist famers to apply their knowledge in the management of their communal rangelands include the transfer of knowledge banks between generations. Innovative

ways of farming could open up new opportunities for young people to explore the sector. For instance, stakeholder engagement workshops that are aimed at capturing people's priorities related to sustainable management of their rangelands, knowledge transfers between generations and between farmers could be organised. Here, those regarded as good veld farmers, including young farmers could share their journeys and success stories to motivate youths that are unemployed. Through these engagements, effective and non-opposing ways of upscaling practices that are working for farmers that are farming under the same conditions (social, environmental and climatic) can be developed. Although this on its own is not a solution, it may be a step in the right direction (Mashala 2013).

In addition, a change in the structure of the education curriculum with agricultural subjects becoming more practical and include visits not only to commercial farms but also to communal areas where livestock production is thriving. This could provide a platform for the younger generation to witness the benefits of livestock farming first hand. Furthermore, training young unemployed youth on the basics and value of herding in the management of communal rangelands could be explored, which will also elevate the status of herders as qualified skilled professionals. Knowledge exchange workshops would allow not only indigenous knowledge to be shared but also facilitate ways to incorporate new technologies with indigenous knowledge for effective utilisation and management of the rangeland. These processes are time-bound while knowledge holders are still alive or it may be lost which will have implications on rural well-being into the future.

Technology can also play a vital role and can help change of how young people perceive farming and improve productivity (Aduroja 2021). Ways to introduce youth to artificial intelligence (AI) technologies including agriculture-related digital applications and other technical gadgets such as the use of drones, could also be explored to make agriculture more interesting for youth, as sometimes they view livestock farming as an archaic way of existence. Other options that could be considered are ways of involving youth in the value chain where they can develop the markets or be the link to abattoirs, or establish feedlots before animals go to markets. This option will be especially beneficial in cases where the communal area is already overstocked and there is no space for them, if they were to acquire livestock for themselves to farm. Furthermore, with the shortage of supplementary fodder in the dry season, some can be motivated to develop new fodder flow programmes in their villages, making use of new technologies like hydroponics. The benefits of a hydroponic fodder flow system, as opposed to a planted fodder system, is that the water-requirements/ usage is minimal, with approximately 2 to 3% of the water that is used under field conditions to produce the same amount of fodder (Al-Karaki and Al-Hashimi 2012).

Regarding the agricultural extension services, their effectiveness in supporting communal farmers depends on their ability to mobilise the social capital of communities (Ferris et al. 2014). Agricultural extension services are a form of institutional support provided by the government to boost smallholder agricultural production, provide training, information and connect farmers to markets (Ncube 2017). Therefore, their role in the agrarian communities is of great importance. A study by Davis (2008) to measure the impact of access to extension services on productivity in Zimbabwe showed that access to one or two visits per year from extension advisors increased crop yields by approximately 15%. The community also needs to mobilise themselves so that when requesting extension services, it is done at communal level rather than individually. Channels such as those involving ward councillors and committee, chiefs and headmen can be used to bring community members together. Improved support from the extension office can also encourage increased participation of young people in farming.

The importance of incorporating spatial knowledge in planning and policy

Indigenous knowledge has been viewed by experts as inferior, untrustworthy and largely unstructured for decades (Golobiĉ and Marušiĉ 2007). It is only in more recent years that the role of insights provided by local people in informing complex land use planning activities is gaining attention (KasemIr et al. 2003; Hessel et al. 2009; Moos at al. 2010; McCall and Dunn 2012). This is largely due to the growing awareness of localised environmental issues which has prompted the need for participation of local people in spatial planning. When experts' knowledge and indigenous knowledge are incorporated into one process, successful and collaborative planning outcomes can be generated (Brown et al. 2014) and can co-evolve to mutual satisfaction (Rolston et al. 2017). However, research has shown that policy interventions in communal rangelands have ignored people's traditional ways of managing, with adverse effects on rangeland productivity, contributing to increased poverty (Rohde et al. 2006; Bassett 2009; Palmer and Bennet 2013; Vetter 2013).

Basupi et al. (2017) used local spatial knowledge to critically examine the impacts of subdivisions and privatisation policies in Nganiland, Botswana and revealed that government policy interventions were blamed by the local communities for the loss of traditional grazing territories, erosion of traditional management institutions, and overall rangeland degradation in the communal areas. Golobiĉ and Marušiĉ (2007) noted that ideally planning decisions and policy interventions are not supposed to be taken or implemented without the consent of the communities affected. According to Friedmann (1993), disconnect between planners and stakeholders often results in poor adoption of policies by the targeted groups. Indeed, that the exclusion of indigenous knowledge in the development and implementation of plans and policies makes it difficult to solve people's real problems in a sustainable manner. For instance, this study revealed that the adoption of the Betterment planning was difficult because it was an imposed grazing management system. Although the grazing condition during the Betterment period was perceived to be good, the forced relocations, and concomitant erosion of social structures and restrictions on livestock numbers were associated with increased poverty and urban migrations, hardening people's hearts towards this system. Their traditional ways of seasonal herding were undermined, replaced by fencing, and now uncontrolled grazing has become the normal situation.

Nakashima (2010) pointed out that common vehicles that exclude local people when mobilising international action against poverty in developing countries such as the United Nations Sustainable Development Goals can impact the very people they set out to assist in a negative way. Friedmann (1993) promoted a non-engineering and human relations approach where planners appreciate and accept that the knowledge provided by local communities about their lands and resources is valid. Recent research on inclusion of indigenous knowledge in spatial planning concurs with this, revealing that successful governance arrangements have to take into account the unique local situations and the relationships between people and their resource (Adams 2013; Bennett et al. 2013; Vetter 2013; Reed et al. 2015; Basupi et al. 2017). For instance, Basupi et al. (2017) suggested that the community maps, such as those produced during their participatory mapping exercises, could be incorporated into the government cadastral classification to improve awareness of customary tenures, and ensure protection of indigenous grazing land patterns.

In this study PGIS, interviews and Focus Group Discussions approaches have provided insights into the social history of access to, and management of, the communal rangelands for Cata and Guquka communities and their current social and environmental situation. These participatory methods allowed people to share their experiences and describe how the past and present government interventions and how the lack thereof have affected their range management. Although the current situation in Cata and Guquka villages reveals a narrative of decline because of the socio-cultural shifts and declines in agricultural extension services, PGIS in particular allowed this local knowledge from communities to be used in a meaningful way through translation into accurate digital maps with accompanying shared narratives. Inclusion of people's indigenous knowledge can improve planning, decision-making and adoption of policy-based interventions on common resources by affirming their views and opinions, making people feel valued thereby encouraging their future involvement (Wolff et al. 2020).

Conclusion

This study highlighted that communal farmers from Cata and Guquka have in-depth indigenous and spatial knowledge about their rangelands, their management and changes in condition. However, because of ageing communal farmers, limited youth participation and declines in agricultural extension services, the knowledge is not optimised into effective communal rangeland management. There was also an apparent breakdown in the transfer of knowledge, which has implications on sustainable management and use of the communal rangelands now and into the future. It is this breakdown in the knowledge system that also dissuades young people from participating in farming.

The mechanisms proposed in this study can also only be affected when there is a flow of knowledge between the villages and from external sources. Agricultural extension is better positioned to assist with the knowledge flow amongst communal farmers from different areas, generational transfer of indigenous knowledge, new technologies that farmers can incorporate into their indigenous knowledge and training. This is in line with their mandate which is to support farmers, whether commercial, communal or land reform beneficiaries with knowledge and skills that will improve their productivity for sustainable economic returns. Thus, extension services have a key role to play in ensuring the functionality of the knowledge cycle in the rural areas.

Moreover, PGIS offers a solution for capturing and documenting indigenous and spatial knowledge from communities so that it can be used in a meaningful way through maps showing past, current and future projections of rangeland condition and associated interventions. Additional creative ways can also be explored such as using art to document community history and changes and their effects of people's well-being.

Furthermore, local to international land management policies should incorporate indigenous knowledge, in order to develop workable and adoptable solutions to the complex problems associated with communal rangeland management. The existing knowledge if harnessed effectively could form a key component in adaptive management of communal rangelands.

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