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Community perceptions, participation, and satisfaction with existing Water Resource Management Plans: a case study of a polluted water system in South Africa

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ABSTRACT

Globally, there has been increased competition and demand between different water uses to find new and innovative approaches towards managing water resources. This has resulted in a dire need for an integrated approach which needs different sectors to achieve future action on water and sustainable development. Therefore, the aim of the present study was to understand community perspectives of the function and management of the highly eutrophic Roodeplaat Dam (RD) and its tributaries. The required data was collected through interviews and surveys in the surrounding communities. The results of the study showed that in terms of community perceptions, more highly educated people tend to qualify the quality of water as very bad and their perceptions on the potential effects of poor water quality were correlated to gender. People's satisfaction level of the current management plan was negatively correlated to employment status. Surprisingly, the community's involvement in the management and use of water resources in the Roodeplaat Catchment Area were correlated to their ethnicity. Some key recommendations from this study included the development of an ongoing community-based water management plan which adopts a bottom-top approach which incorporated community perspectives and opinions into final decision-making process.

Key words: community-based ecological restoration, IWRM, perceptions, Roodeplaat

HIGHLIGHTS

- Community engagement.
- Roodeplaat Dam.
- Integrated water resource management
- Perceptions.

INTRODUCTION

South Africa is a water-stressed country with an average annual rainfall of 450 mm, which is approximately 60% of the world's average (Oberholster 2013; DWS 2015; Edokpayi *et al.* 2020). Most parts of the interior and the western part of the country are arid or semi-arid and are prone to variable rainfall, droughts, and floods (Oberholster 2013; DWS 2015). The country's freshwater water resources, including dams, rivers, and groundwater, are under increasing pressure due to rising population, land cover changes, and climate change (Oelofse & Strydom 2010; Mwangi 2014; Peterson *et al.* 2017; Donnenfeld *et al.* 2018; Mutamba 2019).

Water is one of the most mismanaged natural resources in South Africa (Reddy 2002; Westen & Goga 2016). It is, therefore, important that this resource is monitored and managed effectively (Oelofse & Strydom 2010; Oberholster 2013). Jonch-Claussen (2001, p. 14) defines water management as '*a process that promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*'. This is linked to not only the quality, but also to the quantity of available water (Berjak 2003; Biswas & Tortajada 2011; Cosgrove & Loucks 2015; Durán-Sánchez *et al.* 2018).

The increased competition and demand between different water uses have motivated for finding new and innovative approaches towards managing water resources (Rodda *et al.* 2016; Muste *et al.* 2017; Ofori & Mdee 2021). An integrated approach is, therefore, required from different sectors to achieve future action on water and sustainable development (Rahaman *et al.* 2004; Koc 2010). Integrated Water Resource Management (IWRM) plays a fundamental role in the achievement of the sustainable development goal (SDG 6). This goal focuses mainly on ensuring availability and sustainable management and sanitation for all by 2030. Target 6.5 of SDG 6 specifically aims to implement IWRM at all levels (Ofori & Mdee 2021). The IWRM process depends on the collaboration of all interested and affected parties (I&APs) in water resource management, however, this can be extremely complex when implemented in practice (Jonch-Clausen & Fugl 2001; Ofori & Mdee *et al.* 2021). Implementing IWRM requires the shift from single-sector, management, to sector-integrated, locally focused management, incorporating stakeholder interests which incorporates the interests of diverse stakeholders (Phiri 2014). The importance of involving communities in conservation projects has been widely accepted and their role in water management is recognised as an important component of delivering water-related outcomes (Cook & Smith 2005; Warner 2006; Fleming & Fleming 2009; Mirumachi & van Wyk 2010; Megdal *et al.* 2017; Jiménez *et al.* 2019). Globally, it has been seen that although implementation is taking place, it differs in levels and implementation scores span the full range from 0 to 100 (UN Water 2018).

The Roodeplaat Dam (RD) is located within a nature reserve (Jones & Lee 1984; Swanepoel 1997; Marchand *et al.* 2012), approximately 24 km north-east of the City of Tshwane (CoT), in the Gauteng Province. The dam was originally constructed to supply water for irrigation purposes (Marchand 2009). However, the original irrigation purpose has been supplemented with a recreational service that the dam is increasingly providing to the local communities and beyond (van Ginkel *et al.* 2007). The Rietvlei, Vaal, and Hartbeespoort Dams are among South African dams that have been supplemented with recreation services (Toerien & Walmsley 1979; Thornton & McMillan 1989; du Plessis 2017). Consequently, the biophysical integrity of the dam has deteriorated over time with an additional high level of eutrophication due to cyanobacteria, algae, and water hyacinths (van Ginkel *et al.* 2000; Marchand *et al.* 2012).

In the face of these environmental problems, several studies have been investigating the pollution state of the dam as well as its causes (Walmsley & Toerien 1978; Hohls & van Ginkel 2004; Lomberg 2010; Modley *et al.* 2019; Batayi *et al.* 2021), and some of these have even proposed some management plans (DWAF 2008; Mnyango *et al.* 2022). However, very little research has been done to understand the perceptions and roles of the communities surrounding the RD and its inflowing rivers in water resource management. Therefore, an important question remains: What are the perceptions and contributions of local human communities to the management of the dam and its tributaries? This question needs to be investigated so that an integrated management plan that incorporates a community-based perspective can be possible.

Background

The management of water resources in South Africa has evolved over time and the Department of Water and Sanitation (DWS) has been working towards an Integrated Water Quality Management (IWQM) (Polland & du Toit 2008; DWS 2015). Initially, management was based on a pollution control approach (DWS 2015). This approach was primarily reliant on the enforcement of uniform effluent standards. The current approach has progressed to the point where resource planning and management efforts are complemented by appropriate source controls and remedial efforts, within the context of IWRM (DWS 2015). However, Agenda 21 calls for a paradigm shift towards the development of integrated methods and strategies towards the management of water resources (Wilkinson *et al.* 2015). Integrated Water Resources Management is designed to change the traditional methods of water management with a more sustainable and holistic approach (Rolston *et al.* 2017). Given the complex nature of aquatic systems, such an integrated approach is necessary. For example, at the catchment scale, both human and bio-physical factors interact in an integrated fashion. Therefore, making catchments a complex system whose management requires the consideration of the perceptions of all stakeholders involved in the use of the resource (Alam & Quevauviller 2014).

South Africa's highly acclaimed National Water Act (NWA) (Act 36 of 1998) provides the foundation for a new and fundamentally different way of managing water resources in the country. Together with the White Paper for National Water Policy (which sets out 28 principles) (RSA 1997), it challenges the policies and values of the past by framing water resource management within the context of two fundamental principles: equity and sustainability (RSA 1997). The NWA, in particular, called for the creation of a Catchment Management Agency (CMA) (RSA 1998). Catchment management areas are participatory corporate bodies to which management authority is delegated in their respective water management areas. As management is regarded as something of national importance, and rivers often cross provincial boundaries, the CMAs are placed directly under the Minister of the Department of Water and Sanitation (previously known as DWAF). All these policies emphasise the need for public participation in the process of water resources management. All CMAs should have community representatives including racial and gender structures participating in the management of water resources, therefore, ensuring that their water related needs and expectations are considered (RSA 1998). Although a management plan has been proposed for the RD (DWAF 2008), the perspectives of local communities on the dam and its tributaries are not fully integrated into the management of the catchment area.

In the context of water resource management, participation, also known as stakeholder engagement, is an approach which allows stakeholders to participate in monitoring and management of water resources and include them in any decision-making process. This would include their participation from the planning phase to the final evaluation phase of a project or programme (Galvez & Rojas 2013; Waithaka 2013; Rolston *et al.* 2017; Thoradeniya & Maheshwari 2019). It is an approach that empowers people with knowledge, skills, and experience in the functioning and management of the resources at hand (Rolston *et al.* 2017) (in this case RD and its tributaries). Participation in water resources management has gained increasing momentum over the past few years (Chifamba 2013; Behnke *et al.* 2017; Mashazi *et al.* 2019). Some progressive examples include community-based water management being assigned to CMAs promoting public participation and Water User Associations (WUAs) as user cooperatives (Karodia & Weston 2001). There have been calls for a renewed focus on the context in policy, strategic intervention, and resource mobilisation with community participation as a unifying concept in the countries' IWRM paradigm (Merrey 2008; Cassava *et al.* 2015). In addition to this, the second National Water Resource Strategy acknowledges the role of water in social and economic development and commits to infrastructure, services and equity as policy goals (DWA 2013). The SDG Goal 6 feedback report in 2018 also measured the level at that communities participate in water resources planning and management. This indicator proved that of the 61 countries that participated in both questionnaires, 43% report consistent levels of local level participation, and 44% report 'adjacent' levels of participation (UN Water 2018).

In 2008, a Resource Management Plan (RMP) was proposed for the RD. The RMP aimed to meet the objectives of the NWA and to provide operational guidelines and responsibilities (DWAF 2008). The plan was developed based on sustainability development and aspects relating to public participation. The RMP took into consideration the inputs of all interested and affected stakeholders and addressed four Key Performance Areas (KPAs) that align with the NWA (Act No. 36 of 1998).

However, the local community was not engaged effectively nor was it given the opportunity to get involved in this process. The perceptions and roles of the community of communities along the dam–river system have not been adequately investigated. Therefore, the present study assessed the perspectives and contributions of the local communities to the management of the dam and its tributaries. The study also provides achievable recommendations for the improvement of the existing management plan.

MATERIALS AND METHODS

Study area

The RD is located approximately 25 km north-east of the CoT, South Africa. The dam falls within the Crocodile West Marico Water Management Area, with a catchment area of 690 km^2 and a surface area of 3.97 km^2 (Pieterse & Toerien 1978; van Ginkel *et al.* 2007). The dam's reservoir has a net capacity of $41.9 \times 106\ m^3$ and covers an area of 396 ha at full capacity, with a mean depth of 10.6 m and a maximum depth of 43 m (Steyn *et al.* 1976; van Ginkel 2002). The major tributaries flowing into the dam are the Hartbeesspruit (west of the catchment), the Pienaars River (located in the centre of the catchment), and the Edendalespruit (east of the catchment) (Figure 1).

The CoT is one of five district municipalities in the Gauteng Province, South Africa. It is the largest municipality in Gauteng, with an area of 4.173 km^2 (CoT 2017). The municipality has a population of 3.31 million, with an annual growth rate of 2.92% (IDP 2020). Of the total population, 79.11% are Black African, 17.45% are White, and 1.82% are coloured, with other population groups making up the remaining 1.62% (Stats SA 2016). Approximately 60% of Tshwane's population is younger than 35 years of age. The youth accounts for 35.15% and senior residents (above 65 years of age group) only account for approximately 8.42% of Tshwane's total population (Stats SA 2016). Of the total population, 24.2% have no formal schooling, with only 8.11% having Grade 9/Standard 7. The education level of the residents in the CoT is high, with 49.64% of the

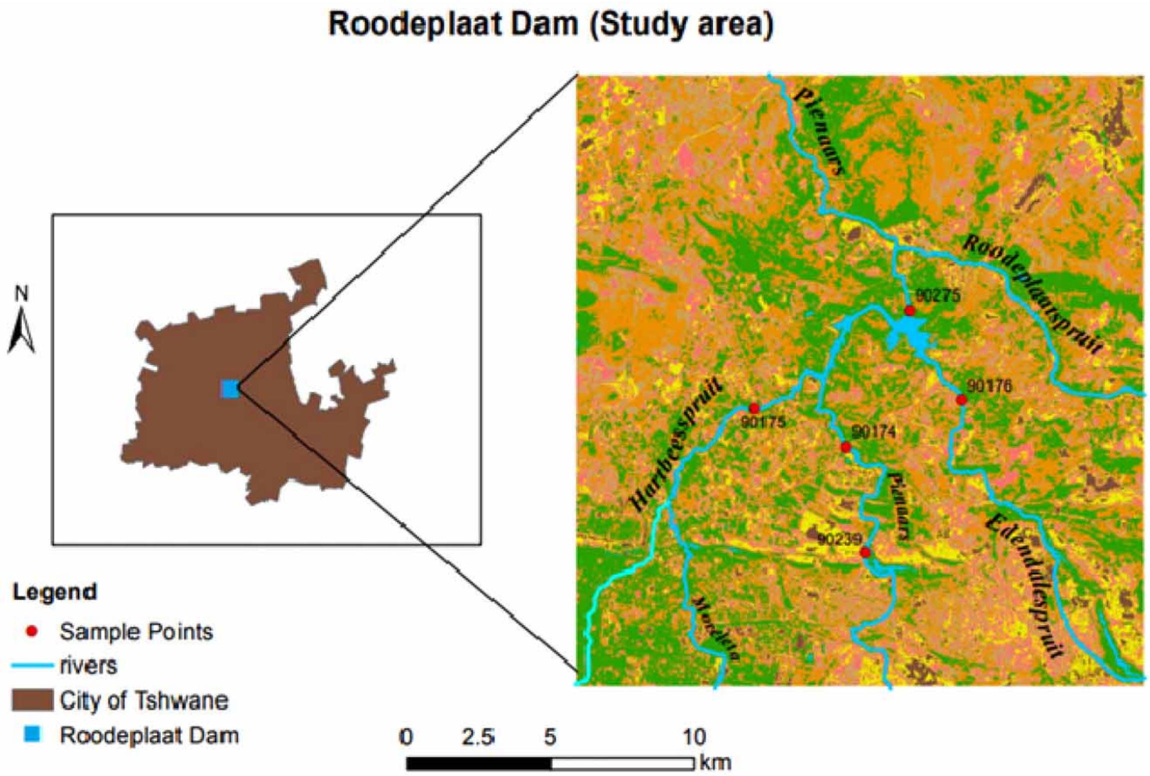

Figure 1 | Location of Roodeplaat Dam within the Tshwane Municipality (left) and a zoom-in image of the dam and its tributaries (right).

population having completed Grade 12/matric (Stats SA 2016). The total number of people with matric has increased by an average annual rate of 4.35% from 2007 to 2017 (CoT 2017). Of the total population, only 8.6% have a tertiary education.

Data collection

Residential areas and local communities were targeted to collect data pertaining to their perceptions of water resource management. Site selection was driven by the communities' proximity to the dam–river system. The questionnaire was piloted with 10 different people in order to assess the whole questionnaire under survey conditions and examine the validity of each question. This was also conducted to identify problems before implementing the full survey. A random sampling method was employed to interview the people in the local communities. This included approaching people randomly in the streets and asking for their permission to participate in an interview after having explained the purpose of the study. Data collection took place over a period of 3 months and 149 participants were involved in the study. Ethical approval was sought prior to the commencing of the study from the University of Johannesburg, Faculty of Science ethics committee, this was approved on 8 August 2018 (2018-08-06/Modley).

The demographic information collected from participants included area of residence, age, gender, ethnic group, employment status, and level of education. Community perspectives were measured in three ways: (i) the perceptions of the communities, (ii) their level of participation in the management of the dam–river, and (iii) their level of satisfaction with the existing management plan of the dam. The Likert scale was adapted to produce a 3–5-point Likert scale since the researcher was intent on ensuring that the questionnaire was desirable for younger participants and would also encourage participants with low motivation (Nemoto & Beglar 2014).

In order to determine the community perceptions of the functional values of dam–river systems the following took place where the functional value here is defined as the ecological roles as well as the ecosystem goods and services that the dam–river system provides to the surrounding communities. These functional values were first documented, and then the communities' perceptions and awareness levels of these values were recorded. All these data on functional values, perceptions and awareness levels of communities were obtained through semi-structured interviews, site visits, group discussions, and face-to-face and online surveys. The method of response was based on the accessibility of resources and in terms of poor access, the in-person interviews proved to be more convenient for each participant. The questionnaire has been attached as supplementary material. Data on perceptions were recorded as a binary YES-or-NO response to the following question: do you perceive the dam–river system as a useful resource for the environment and human community?

Data were also collected in order to determine the level of participation of community members in the management of the dam river system. Community members were asked to rank their level of participation in the management of the dam–river system using three levels of ranking: poor < good < excellent (poor = 1, good = 2, excellent = 3). These data were collected through online and face-to-face surveys. Also finally, community members were required to provide their level of satisfaction with their current management plan. During the questionnaire survey, the community was also asked to rank their level of satisfaction towards the existing management plan. This was done using the following rank: Very dissatisfied < dissatisfied < satisfied < neutral < very satisfied.

Data analysis

All quantitative analyses were done in R 3.5 (R Development Core Team 2018). Community perspectives were measured in different ways: community perceptions of water quality, community perception of potential effects of water quality on the community, community satisfaction levels of water management, community involvement in the management as well as community utilisation of the dam–river system.

Community perceptions were defined as a rank variable with three levels: very bad < bad < good. To identify the determinants of community perceptions, the cumulative link model was fitted using the R function CLM implemented in the library Ordinal (Christensen 2013) using the rank variable as response and community demographic data as predictors. Because the respondents to the questionnaire are not independent data points (since some belong to the same community), the cumulative link mixed effect model (CLMM) was also fitted to the data to correct for this non-independence, using the residential area as a random effect. This was done using the R function CLMM also implemented in the library Ordinal. The CLMM is preferred to the machine-learning methods based on a number of advantages that the CLMM provides (Luiz *et al.* 2016). In summary, CLMM is a better approach as it does not require that the ranked categorical variable (used as response variables; here quality of water) be converted into numerical values. The CLMM also prevents an unnecessary elevated type I error generally observed when ranked variables are converted into numerical values in which differences between consecutive rank levels are assumed to be equal. While fitting the CLMM, cultural groups will be used as a random effect to account for the potential effects of shared cultural groups between residents.

On a community satisfaction level, this was also measured as a rank variable: very dissatisfied < dissatisfied < satisfied. Consequently, the same cumulative link model was also fitted to test for the determinants of community satisfaction levels by fitting the R functions CLM and CLMM; the first (CLM) without correcting for community non-independence in relation to the residential areas they belong to, and the second (CLMM) to correct for this non-independence.

In contrast to the perception and satisfaction levels, community involvement in the dam–river management was measured as a binary variable, that is, poor vs. good involvement. To test for the determinants of the community involvement levels, a GLM model was fitted to the data with a binomial error structure. Similarly, to the analyses above, the non-independence of the community was corrected by fitting this time the generalised mixed effect model using the R function glmer in the library lme4 with the residential area used as a random effect. The same GLM and glmer were also fitted to test the determinants of the perceptions of potential effects of water quality on the community, given that these perceptions were here measured as a binary variable, that is, Yes/No to the question does the water quality of the RD and its inflowing rivers affect the surrounding community? If so, how? Finally, similar analyses were too done to test for the determinant of the community utilisation of the dam–river system, which is also a binary variable, i.e., Yes/No to the question do you use the dam–river system for anything? The significant level was tested at $\alpha = 0.05$.

RESULTS

The demographic representation of the participants is presented in Figure 2. The results here show that the majority of participants resided in the Sable hills estate, followed by Eersterus. The minority of participants stayed in Derdepoort, this could be due to the reluctancy of residents in this area to participate. The majority of participants were female (58%) and the Black group was represented by 46% of the participants followed by White participants (36%). The majority of participants were

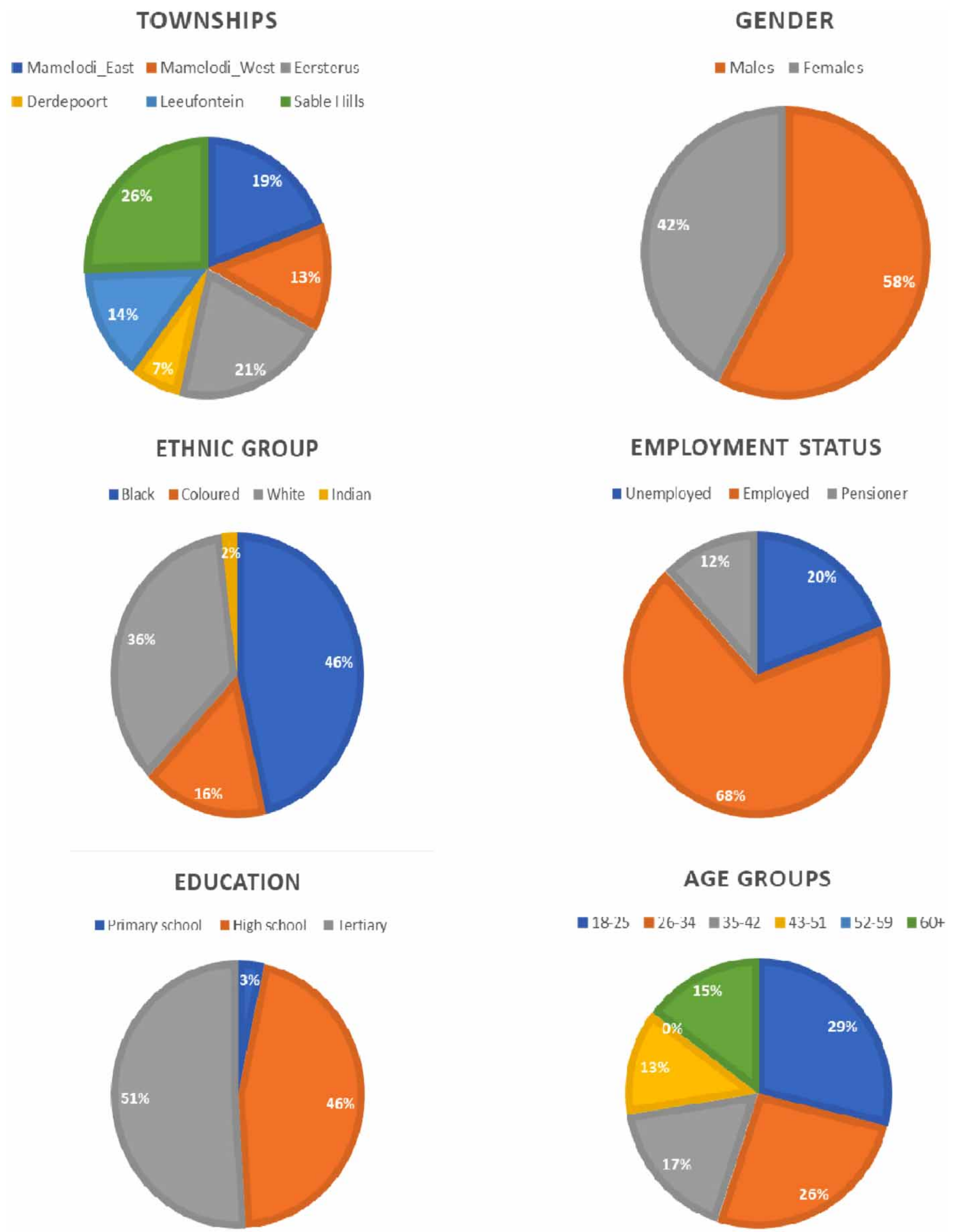

Figure 2 | Demographics detailing the area of residence, gender, ethnic group, employment status, education level, and age of participants in the study.

employed (68%) and 51% of participants had a tertiary qualification. The majority of participants were from the 52- to 59-year-old age group while the 41- to 53-year olds were not represented at all during this study.

Since the water resource is located in close proximity to a number of residential areas, the researcher attempted to understand the relationship that participants had with the water resource and if they considered themselves as 'users'. These results are captured in Figure 3 and show that the majority of participants (52%) do not consider themselves as users while almost a quarter of participants (30%) use the dam for recreational purposes. A small percentage of participants (3%) also use the dam for religious activities.

To understand the perspectives of communities, a number of questions were investigated. First, how can people's perceptions of water quality in the dam–river system be explained? Among all the demographic variables tested (gender, age, education level, ethnic group, and employment status), there was a negative but significant correlation between people's perception and only education level (Table 1), irrespective of whether we corrected for the residential area ($\beta = -4.64$, $P = 0.08$) or not ($\beta = -2.40$, $P = 0.003$) (Table 1). This means that highly educated people tend to qualify the quality of water as very bad.

Second, how can people's satisfaction level of the dam–river management be explained? The analyses revealed that only employment status matters, as it is the only variable that correlates significantly but in a negative way with people's satisfaction level (Table 2), meaning that employed people tend to be very dissatisfied with the current management of the dam–river system. Again, this finding holds irrespective of whether the residential origin of the respondent is corrected for ($\beta = -0.92$, $P = 0.05$) or not ($\beta = -0.76$, $P = 0.06$) (Table 2).

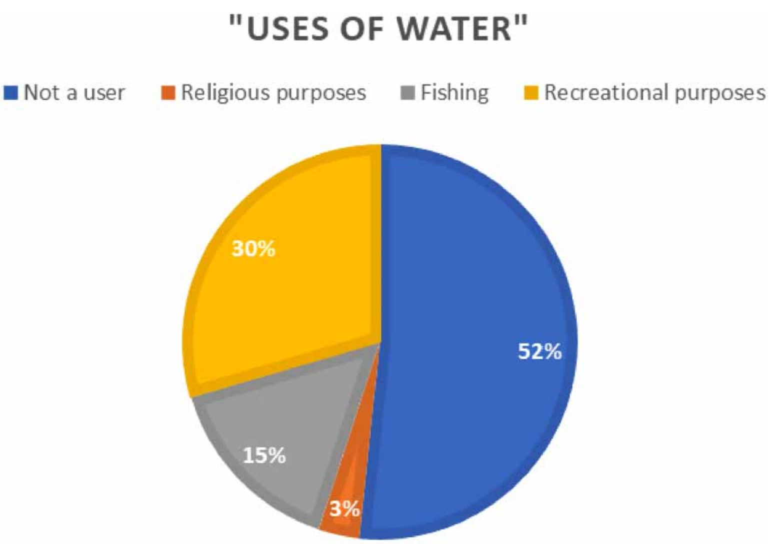

Figure 3 | Uses of water in and around the Roodeplaat Dam.

Table 1 | Path coefficients of people's perceptions on water quality as tested in the study

	Not corrected for residential area			Corrected for residential area		
Predictor	**Estimate (β)**	**Std. error**	***P*-value**	**Estimate (β)**	**Std. error**	***P*-value**
Gender	−1.04542	0.84165	0.2142	−0.32399	1.03201	0.7536
Age	−0.01150	0.02865	0.6880	−0.00259	0.03441	0.9399
Education level	−2.40972	0.83496	0.0039**	−4.64045	2.65316	0.0803·
Ethnic group	−0.00056	0.40526	0.9989	−1.16770	2.34272	0.6182
Employment	−0.00058	0.44289	0.9989	−0.16992	0.54580	0.7556

· Significant *p*-value

Table 2 | Path coefficients of people's perception on their level of satisfaction as tested in the study

	Not corrected for residential area			Corrected for residential area		
Predictor	**Estimate (β)**	**Std. error**	***P*-value**	**Estimate (β)**	**Std. error**	***P*-value**
Gender	−0.76290	0.67940	0.2615	−0.42404	0.72119	0.5566
Age	−0.01057	0.02245	0.6379	−0.01942	0.02428	0.4239
Education level	−0.64198	0.63773	0.3141	−0.81996	0.68170	0.2290
Ethnic group	0.42927	0.28772	0.1357	0.52524	0.40235	0.1917
Employment	−0.7618	0.41075		−0.92585	0.47873	0.0531•

· Significant *p*-value

The next question was: do you think that the water quality may affect communities? The analyses revealed that gender and education levels explain people's perceptions of the potential effects of water quality on the community: males tend to believe that water quality may affect the community ($\beta = 2.04$, $P = 0.07$) but this too depends on education level ($\beta = -1.49$, $P = 0.09$). These relationships, however, disappear when residential origin is corrected for (Table 3).

Community members were also asked if they are involved in the management of the system. The results indicate that their involvement depends on the ethnic group: the White community tends to be more involved in the management of dam–river system than other communities, irrespective of whether residential origin was corrected for or not ($\beta = 0.52$, $P = 0.06$) (Table 4).

Finally, what explains the differences in communities' interactions (utilisation) with dam–river system? The analysis showed that only ethnic group matters in this case with White communities tending to show more engagement ($\beta = 0.56$, $P = 0.0003$). However, again, this relationship disappears when the residential origin is corrected as depicted in Table 5.

DISCUSSION

For the purpose of this study, the communities' perceptions were assessed by understanding their perspectives on water quality, uses of water, their involvement in the management and their satisfaction with the current management of the RD. Comparative analysis of the findings indicated that demographic characteristics (income levels, age, and gender) played a

Table 3 | Path coefficients of people's perceptions on the effect of water quality on communities as tested in the study

	Not corrected for residential area			Corrected for residential area		
Predictor	**Estimate (β)**	**Std. error**	***P*-value**	**Estimate (β)**	**Std. error**	***P*-value**
Gender	2.048155	1.14594	0.0739•	2.267682	1.44431	0.116
Age	−0.007392	0.03015	0.8064	−0.008775	0.03334	0.792
Education level	1.490466	0.89656	0.0964•	0.449034	1.43938	0.755
Ethnic group	0.047997	0.42307	0.9097	1.795349	1.5858	0.258
Employment	0.168342	0.49532	0.7340	−0.313168	1.58586	0.632

· Significant *p*-value

Table 4 | Path coefficients of community members involvement in the management of the system as tested in the study

	Not corrected for residential area			Corrected for residential area		
Predictor	**Estimate (β)**	**Std. error**	***P*-value**	**Estimate (β)**	**Std. error**	***P*-value**
Gender	−0.691925	0.62237	0.2662	−0.691925	0.62242	0.2663
Age	0.001499	0.02057	0.9419	0.001499	0.02057	0.9419
Education level	−0.905152	0.64414	0.1600	−0.905152	0.64419	0.1600
Ethnic group	0.527569	0.28670	0.0657•	0.527569	0.28672	0.0658•
Employment	−0.223386	0.36435	0.5398	−0.223386	0.36437	0.5398

• Significant *p*-value

Table 5 | Path coefficients of differences in communities' interactions (utilisation) with dam–river system as tested in the study

	Not corrected for residential area			Corrected for residential area		
Predictor	**Estimate (β)**	**Std. error**	***P*-value**	**Estimate (β)**	**Std.error**	***P*-value**
Gender	−0.240983	0.37192	0.5170	−0.112823	0.46185	0.807
Age	0.007098	0.01277	0.5783	0.000351	0.01559	0.982
Education level	0.280812	0.37020	0.4481	−0.465391	0.49244	0.345
Ethnic group	0.560514	0.15513	0.0003•	−0.168734	0.26477	0.524
Employment	−0.054391	0.22778	0.8112	−0.224445	0.27200	0.409

• Significant *p*-value

negligible role in people's perceptions and behaviours of water management. The 2022 review of the National water resources strategy highlighted a number of water sector priority focus areas from 2020–2030 in South Africa. One of the biggest challenges highlighted in ensuring the effectiveness of water conservation and water demand management programmes is the paradigm shift required amongst all South Africans to understand the importance of conserving the nation's water resources. Evidence has shown that most technical interventions without adequate social engagement and education of communities often lead to failures of good technical interventions. The social pillar is thus driven mainly to ensure community buy-in and support of technical programmes aimed at reducing water losses and wastage within communities.

The results revealed a negative correlation between people's perception of the quality of water and their level of education. This indicates that highly educated people tend to qualify the quality of the water in the dam–river system as bad, regardless of their surroundings. This may be due to educated people being more aware of environmental issues such as water pollution and water shortages (Noga & Wolbring 2013). The expectation is that educated people tend to quantify the quality of water in the dam–river system as bad. The expectation was grounded on the assumption that educated people are more aware of water pollution and have a better knowledge of the chemical parameters causing pollution. Educated people tend to have more knowledge of environmentally responsible behaviour, are conscious about environmental protection and are likely to be active members of the community (Syme *et al.* 2000; Frick *et al.* 2004; Phiri 2014). Lotz-Sisitka & Burt (2006) highlighted the fact that many South Africans still need to be educated on the environment. Therefore, awareness of environmental issues such as water pollution, water quality and quantity are important for understanding the implications of different users. Greater awareness and education are required to promote the monitoring, management and conservation of water resources at the community level (Nare *et al.* 2011; Noga & Wolbring 2013). By doing so, local communities are encouraged and trained to take care of their own health and wellbeing through learning.

People's satisfaction level with the current management of the dam–river system was negatively correlated to their employment status, irrespective of whether the residential area was corrected for or not. This meant that employed people tend to be very dissatisfied with the current management of the dam–river system. During the questionnaire survey, the majority of those employed were highly dissatisfied with the implementation of the current management plan by DWS. The unemployed population clearly indicated that they were reluctant to participate in the management of the dam–river system, due to not receiving incentives towards this participation. The community also mentioned that the CoT municipality needs to involve them in the planning, monitoring and management of dam–river system. Heyd & Neef (2004) investigated the participation of local people in water management from the Mae Sa watershed in Northern Thailand. The communities' perception of water management was analysed through semi-structured interviews, focus group discussions, and a literature review. Heyd & Neef (2004) found that community members were dissatisfied with how their government managed their water resources. As a result, the community was very sceptical and expressed their distrust towards the officials. In a study to analyse the perceptions and levels of satisfaction from water users, Thompson *et al.* (2013) highlighted that local communities would be more satisfied with the management of water resources provided they are involved in participation and included in the decision-making processes, which is in agreement with the results of the present study.

Statistical analyses revealed that both gender and education levels explain people's perceptions of the potential effects of declining water quality on communities. When compared to their female counterparts, the male population perceived water quality to have a greater negative effect on the community. Wendland *et al.* (2017) reported that the differences and inequalities between women and men influence how individuals respond to changes in the environment and these power relations in communities make it difficult for women to voice opinions that contradict the views of those in power. These power differentials may even affect who participates in specific meetings (GWA 2006). Highly educated people tend to not only quantify the quality of water as bad but also perceive the declining quality of water to have a negative effect on the communities. As mentioned above, educated people tend to be more concerned about water quality issues and have more knowledge on issues related to water quality and the availability thereof (Noga & Wolbring 2013).

The results also indicate the 'use' of water from the dam–river system and the level of participation in water management depends on the ethnic group. The Black population indicated their use of water in the dam–river system for domestic activities (cooking, bathing, and washing of clothes), entrepreneurship (brick making) and cultural and religious practices (baptism). The majority of the White population indicated their use of water for irrigational purposes and recreational activities such as fishing, boating, and canoeing. In a study conducted in North-West Province in South Africa, Coetzee *et al.* (2016) assessed people's perceptions of people on the sources and uses of water among Africans. A study conducted by Coetzee *et al.* (2016) in South Africa, assessed people's perceptions of people on the sources and uses of water among the African population. The results of the study revealed that water uses relating to spiritual and cultural beliefs were identified by Black South Africans. A few participants indicated their strong spiritual connection with water which included using the water as a means to establish contact with ancestors, spiritual cleansing to drive out evil spirits and initiate traditional healers (Coetzee *et al.* 2016).

Finally, when asked about their involvement in the management of the dam–river system, the White communities showed more interest in the involvement of the management of the dam- river system. The majority of the White community members (Leeuwfontein Estate and Sable Hills Waterfront Estate) showed interest towards participation in the management of the dam–river system. A few of these people mentioned that have been involved in river clean-up programmes. Those closer to the dam have also been largely involved in the manual removal of water hyacinth, which has been conducted through hand pulling from the water surface using a pitchfork. However, the Black and Coloured communities of Mamelodi East and West, Derdepoort and Eesterust expressed their disinterest in the participation towards the management of the dam–river system. Vavricka (2013) emphasised that while Africans considered both individuals and the government responsible for environmental issues, ethnic groups such as Indians, Chinese, Filipinos, Japanese, and Koreans living in America held the government primarily responsible for environmental protection. A more recent study conducted by Yan (2016) to investigate the ethnic and cultural correlations in water consumption highlighted how different ethnic groups perceive the management of water resources due to the uses of each group. The study concluded that it is important to understand water use patterns from different ethnic and cultural backgrounds, and how these differences may influence water usage and conservation (Yan 2016).

CONCLUSIONS

The community perspectives on water quality and water management were successfully investigated and interesting results were observed. A negative correlation was revealed between people's perceptions of the quality of water and their level of education. Surprisingly, people's satisfaction levels with the current management plan were negatively correlated to their employment status. Statistical analyses revealed that gender explains people's perceptions of the potential effects of declining water quality on communities. For this specific study, the male population perceived water quality to have a greater negative effect on the community. The use of water and participation in water management was highly dependent on the communities' ethnic group. The results showed that the Black population tends to use water for domestic activities, entrepreneurship, and cultural and religious practices. While the White population tends to use water for irrigational purposes and recreational activities (fishing, boating, and canoeing). It was also indicated that the Black and Coloured populations were less interested in participation towards the management of the dam–river system. However, the majority of the White population showed interest towards participation in the management of the dam–river system.

It is evident that a more effective and sustainable approach is needed to manage the water quality in the Roodeplaat Catchment Area. A community-based management approach is possible, provided that the local communities are included in the planning, monitoring and decision-making processes towards the management of the RD and its tributaries. The information from this study can be presented to the DWS and CoT Municipality to bring about awareness of the communities' perspectives on the water quality and water management in their areas. Subsequently, these perceptions can be incorporated into the existing water resources management plan to ensure a community-based management approach.

RECOMMENDATIONS

Community perspectives on water resource management depend on demographic characteristics such as educational level, employment status, gender and ethnic group.

- Develop programmes focusing on education and creating awareness in the surrounding communities on water quality and the impacts of their day-to-day practices on the quality of water.
- The DWS needs to ensure the collaboration and participation of all I&Aps within the catchment. The process should also aim to promote capacity building to all stakeholders involved, which includes the local community as well as government officials.
- Develop an ongoing community-based water management plan which adopts a bottom-top approach which incorporated community perspectives and opinions into the final decision-making process.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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