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Research paper

Social demographic patterns and participation in the Gariep Dam fishery, South Africa, during the Covid-19 pandemic

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The global Covid-19 pandemic resulted in an economic downturn that influenced behavioural and participation patterns of fishing sectors around the world. Monitoring changes in fisheries is essential for understanding their human dimension and informing decision-making for development, conservation and management of fish resources. This study documented and described fishery patterns and participation during the Covid-19 pandemic through roving creel surveys. In addition, due to historic surveys of the recreational and subsistence fishery, it was possible to compare the current patterns to previous results and to show the potential Covid-19 related impacts. Subsistence fishing dominated the fishery, with 94% of 431 regular fishers utilising the resources for home consumption or sale. Compared to historic surveys, a marked decline in estimated recreational fishing was observed, but no significant change was identified in participation patterns of subsistence fishers. This downturn in recreational fishing affected the socio-demographic characteristics of the fishery, where changes in ethnic participation were noted; there was also an increase in the number of unemployed fishers during the pandemic. Utilisation of the fish resources was dominated by subsistence users and 97% of fish caught was for self-consumption or sale. This underlines the importance of fish for subsistence users, who rely on the resource for food or income and could not avoid fishing during the pandemic, as they had no alternative. This study highlights the importance of socio-demographic and participation data on fisheries, to provide scientific advice to policymakers on ideal responses to events such as a pandemic. This evidence of temporal changes in hook-and-line fisheries provides inland fishery authorities the opportunity to develop mitigation measures with greater resilience to cope with future global crises. Lastly, the study emphasises the importance of access to fisheries, especially during times of high regional economic and societal stress.

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INTRODUCTION

Inland fisheries in South Africa are dominated by recreational and subsistence small-scale fishing, that mainly uses hook-and-line fishing techniques, and no large-scale commercial fishing equivalent to the marine fisheries exists (DFFE, 2021). Inland fisheries play an important role as a vehicle for sustaining livelihoods, rural development, poverty reduction, food security and regional economic development in South Africa (Andrew et al., 2000; Weyl et al., 2007; McCafferty et al., 2012). A recent study by Potts et al. (2022) estimated the economic impact of recreational fisheries to be 32.6 billion ZAR per annum, with participation of 1 327 633 individuals (2.4% of the South African population), which constitutes a total of 63.9 million fishing days per annum. Nyboer et al. (2022) found that South Africa has ~750 000 inland recreational fishers, of which at least 25% fall within the low- or middle-income brackets. These inland recreational fishers harvested 4 000 tonnes of freshwater fish annually, of which 72% was consumed. The South African subsistence fishing sector is largely undocumented, but is likely to exceed that recorded by Nyboer et al. (2022) and be more widespread than anticipated (McCafferty et al., 2012; Rouhani, 2021). Evidence also exists that subsistence use of fish from inland resources is increasing (Weyl et al., 2007; Ellender et al., 2010; Hugo and Weyl, 2021).

In 2020, during the global Covid-19 pandemic (hereafter referred to as Covid-19), many nations and jurisdictions implemented lockdown orders to limit the movement of people and in so doing prevent the spread of the virus (Britton et al., 2023). This imposed an immediate decline in economic activity (Arndt et al., 2020), with many workers losing their employment and/or income (Britton et al., 2023). Similarly, in the inland fisheries sector participation patterns changed dramatically (Stokes et al., 2020; Cooke et al., 2021; Britton et al., 2023; Gundelund and Skov, 2021).

South Africa declared a National State of Disaster on 15 March 2020 because of the Covid-19 pandemic, with a national lockdown that imposed travel restrictions, suspended schools and closed ports of entry (Arndt et al., 2020; Swanepoel et al., 2025). This prevented individuals from leaving their homes, except under exceptional circumstances, which had negative implications for the factor distribution of income.

This negative impact of Covid-19 on the South African economy may have changed the characteristics of inland fisheries. Potts et al. (2022) advanced the argument that the pandemic was likely to have reduced the number of people participating in recreational fisheries; however, it may also have resulted in an increase in the number of poor people entering the subsistence fishery to meet their nutritional requirements. Inland fish resources could also prove to be beneficial in times of crisis, such as the downturn of the economy because of Covid-19 (Hara et al., 2021).

Hook-and-line fishing – the use of rod and reel or handline techniques – is an important activity for both recreational and subsistence fishing sectors, providing resources for recreation, food and income for many people worldwide (Gundelund and Skov, 2021). Covid-19 likely changed hook-and-line fisheries worldwide, whilst benefits and impacts derived from hook-and-line fishing were likely to be affected by changes in behaviour and participation patterns. These changes in hook-and-line fishers can be influenced by multiple factors, such as changes in demography, fishing quality and societal-level developments (Gundelund and Skov, 2021; Potts et al., 2022). Changes in hook-and-line fishers' behaviour during Covid-19 have been documented in the developed world (Potts et al., 2022). A reduction in fishing effort was observed as a result of travel restrictions in Australia (Ryan et al., 2021), and an increase in fishing effort from younger people from urban areas was observed in Denmark (Gundelund and Skov, 2021). To date, information on the impact of Covid-19 on the behaviour and participation in hook-and-line fishing of inland waters of South Africa is limited.

According to Hugo and Weyl (2021), the growing small-scale and subsistence fishing sectors' long-term sustainability will require monitoring to enable the development of management plans. The role of inland fisheries in food security has an important economic value, and understanding this sector is vital to the conservation and management of fish resources (McCafferty et al., 2012). Race, gender, and motivation for fishing may affect the way fish stocks are exploited. Thus, understanding the human dimension of a fishery is essential to inform decision-making for inland fisheries monitoring and development (Ellender et al., 2009; Arlinghaus and Mehner, 2004).

The Gariep Dam, South Africa, has a recognised subsistence and recreational inland fishery sector that has previously been assessed (Ellender et al., 2010, 2009). Since then no monitoring has been undertaken of the subsistence and recreational fishery sectors, and the changes resulting from Covid-19 have highlighted the need to reassess the human dimensions and participation of these fishery sectors for the Gariep Dam. For the present study we aimed to assess how reliant the community was on the fishery during the Covid-19 lockdown through comparison with historic data (Ellender et al., 2010, 2009). With this information available, we were further able to identify temporal changes between 'pre-pandemic' and 'acute-pandemic' fisher social demographics and participation at the Gariep Dam. Finally, we make recommendations to policy makers and implementers based on our findings, on how to develop a more resilient and sustainable hook-and-line inland fisheries sector.

MATERIALS AND METHODS

Study area

The Gariep Dam, also known as Lake Gariep, with a surface area of 360 km^2 at full capacity is the largest impoundment in South Africa (DWS, 2019). The dam wall was completed in 1972, and the resulting impoundment is located across the borders of the Free State and Eastern Cape Provinces (30°37.24.5' S 25°30.35' E). Shoreline length varies from 400–528 km, depending on water levels (Hamman, 1981; Van Vuuren, 2012). Most of the extensive shoreline of the Gariep Dam is closed for fishing (approximately 87%), but designated fishing areas have been set aside by conservation authorities. The designated fishing areas comprise 25 km of shoreline in the Gariep Dam Nature Reserve and 27 km of shoreline in the Oviston Nature Reserve (Fig. 1). Access to some of the fishing areas is in close proximity to the towns surrounding the Gariep Dam and entrance is not controlled, but access to fishing areas within the two nature reserves is managed and recorded (PJ Swanepoel, pers. obs.).

Four rural towns are situated near the shoreline of the Gariep Dam, i.e. Gariepdam (town) and Bethulie in the Free State, and Venterstad and Oviston in the Eastern Cape. From hereon, 'Gariep Dam' will refer to the impoundment, and 'Gariepdam' to the town on the western side of the dam, close to the dam wall. Gariepdam and Oviston towns are the result of housing built for workers during the construction of the dam wall and the Orange–Fish Tunnel for the Orange–Fish River transfer scheme. Gariepdam town (1 568 inhabitants) is situated on the western side of the dam, close to the dam wall, and is largely focused on tourism. The town has various fishing areas that are used by both recreational and subsistence fishers. Oviston (658 inhabitants) is situated on the southern side of the impoundment. According to Ellender et al. (2010), the town's tourism infrastructure is underdeveloped, and it is largely occupied by people in retirement. Oviston and Venterstad (3 596 inhabitants) are less than 10 km apart and fall under the same administration, and the fishing areas around these towns are mainly utilised by subsistence fishermen. Bethulie (2 100 inhabitants) is a small farming town situated on the eastern side of the Gariep Dam in the Free State, near the inflow of the Orange and Caledon Rivers. Ellender et al. (2009) found that the fishing area at Bethulie is a large pan that is separated from the dam for 90% of the year, and this was, therefore, not included in the current assessment. The population size, unemployment rate and racial composition of the rural towns adjacent to the Gariep Dam are summarised in Table 1.

Roving creel surveys

Surveys were conducted every second month for 2 weeks, with a 7-day assessment period in each of the two respective fishing areas, i.e., Gariepdam and Oviston/Venterstad. Exploratory and scoping surveys were conducted between October 2019 and March 2020, to conduct key informant interviews. Randomly stratified roving creel surveys were conducted between November 2020 and October 2021 (1 full calendar year of sampling), replicating the methods that were used by Ellender et al. (2009, 2010)

Table 1. Population statistics of the rural towns adjacent to the Gariep Dam, based on the 2011 census (Stats SA, 2011)

Rural town	Population size	Unemployment rate (%)	Race (%)				
			Black	Coloured	Indian/Asian	White	Other
Gariepdam	1 568	27	31	47.6	0.4	19.6	1.3
Oviston	658	28.5	16.9	45.1	0	39	0
Venterstad	3 596	28.5	87.3	10.6	0.3	1.1	0.6
Bethulie	2 100	27	52.3	20.3	1.4	24.5	1.1

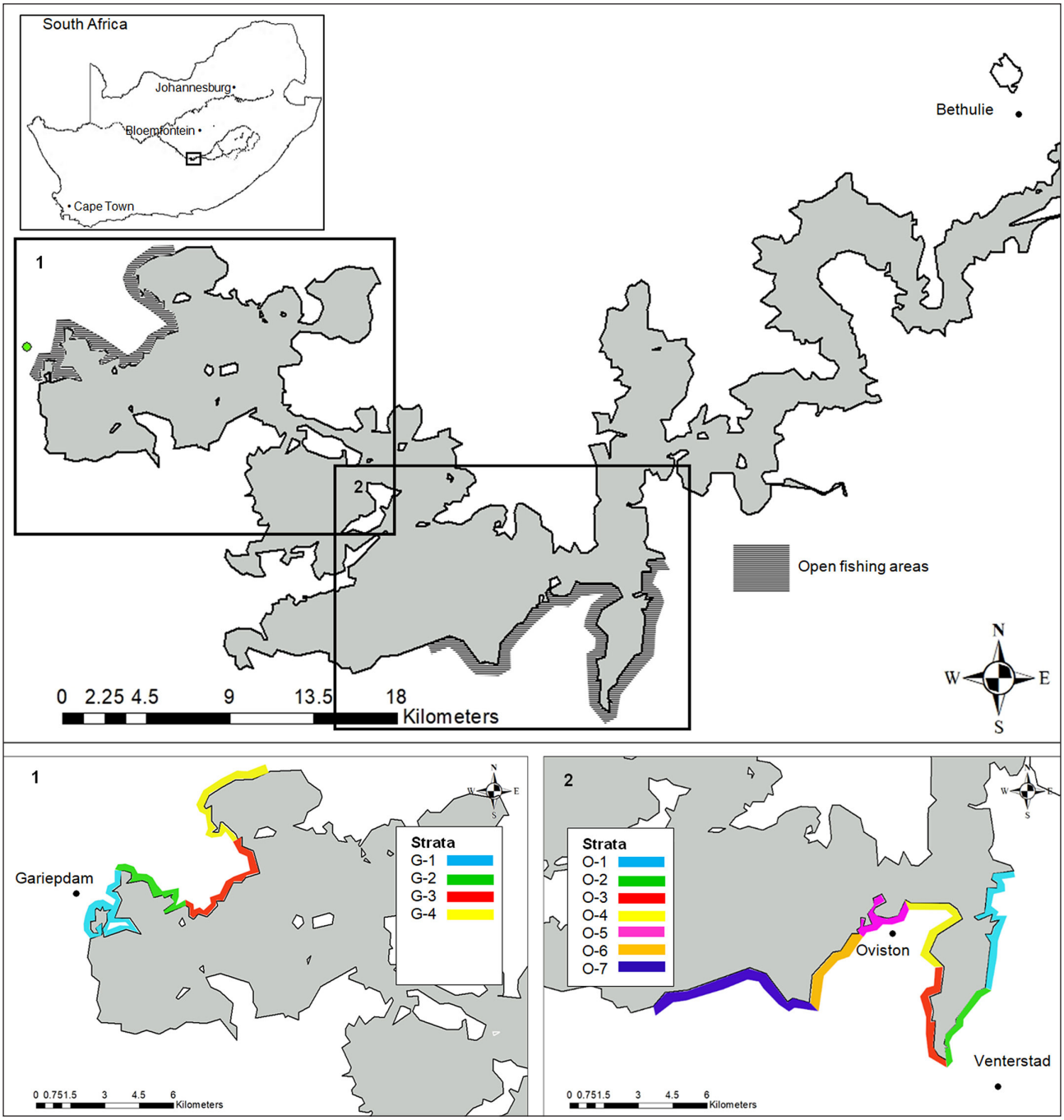

Figure 1. The Gariep Dam, South Africa, showing the two open fishing areas and associated settlements. Each fishing area, Gariepdam (1) and Oviston (2), was divided into strata according to the sampling protocol outlined in Ellender (2008).

for comparative purposes. One surveyor (PJ Swanepoel) conducted the surveys across all regions. The randomly stratified roving creel survey method was used to conduct all surveys. This constructed a 1-week survey period at each fishing area and included surveys on 3 randomly selected weekdays and both weekend days, to account for the influence of the day of the week. Each fishing area was divided into strata as used by Ellender (2008) (Fig. 1). On a sampling day a stratum was selected randomly and fishers interviewed with questionnaires to collect fisher harvest and social demographic data, of which only the latter are reported on here. During the fisher interviews, the surveyor moved through the selected stratum until all fishers were interviewed, or until the surveyor ran out of time.

The fisher social demographic data collected during the roving creel surveys were used to determine the fish resource use and qualitative socio-demographic data. The roving creel survey questionnaire recorded the following information: race, gender, age, employment status of fishers, as well as the fisher origin, fishing gear used, transportation method to fishing site and fate of the fish / motivation for fishing. To determine if the fishers were recreational or subsistence users, the primary motivation for fishing was established through social and behaviour characteristics. Here, subsistence fishers were primarily determined by whether they consume or sell their catch, live near the dam, use basic transport methods (walking or bicycles), use basic fishing gear (hand lines) and have no permanent formal employment. Recreational fishers use the resource primarily for leisure, have permanent employment, use commercially made fishing rods and reels and access the fishing sites by vehicle (Ellender et al., 2010; DFFE, 2021; Hara et al., 2021; Tapela et al., 2015).

Fisher qualitative socio-demographic data were only collected from fishers being interviewed for the first time during the sampling

period. If a fisher had a recollection that the surveyor (PJ Swanepoel) had interviewed him/her on a previous sampling day, no fisher qualitative socio-demographic data were collected, to avoid duplication of information. The qualitative socio-economic data between regions and fisher groups (subsistence and recreational) were tested using the chi-squared test of independence. Fisher age frequency distributions were compared using the Kolmogorov–Smirnov test for significance ($p < 0.05$) in Microsoft Excel 365 (following Ellender et al., 2009). The data were also compared to that resulting from the similar study by Ellender et al. (2009), to identify changes in socio-demographic patterns of fishers.

Participation estimate

Participation of fishers was estimated using methods outlined in Ellender et al. (2010). This method uses mark-recapture methods, based on (i) the origin of the fisher and (ii) whether the fisher was interviewed before (mark-recapture), which was collected for all fisher interviews. Ellender et al. (2010) adapted the mark-recapture method proposed by Schnabel (1938), which was initially developed to estimate wildlife populations, to be used to estimate the fisher population identified through the roving creel surveys. The proportion of previously interviewed fishers for each sampling event was used to estimate the fisher population. The closed population marked-recapture model of Schnabel (1938) was used, as individual identifying data were not recorded for the application of an open population model. The closed Schnabel (1938) method was deemed appropriate for subsistence fishers as they reside mainly in the rural towns surrounding the Gariep Dam, representing a closed population. The model was not applied to the recreational fishers as they did not meet the model's closed population requirement. The mark-recapture method of Schnabel (1938) is given as:

$$\widehat{N} = \frac{\sum_{n=1}^{S} n_i M_i}{\sum_{n=1}^{S} m_i}$$

where: $\widehat{N}$ is the population estimate, i is the sampling event and S the total number of sampling events. The variable n_i is the total number of interviews during the i^{th} event and M_i is the total number of fishers that were interviewed prior to the i^{th} event (marked); m_i is the total number of previously interviewed fishers that were previously recorded (recaptured). A 95% confidence interval was used to test variance with the Poisson distribution using *R* (Ogle, 2016).

The mark-recapture method of Schnabel (1938) was applied to the interview data based on the following assumptions: (i) the population was closed (no recruitment or death of fishers), consisting only of fishers residing in the adjacent rural towns; (ii) the fishers had 100% recall of whether they had been interviewed previously; and (iii) all fishers had the same chance to be interviewed through randomised sampling.

The study was undertaken during Covid-19. During the sampling surveys, various governmental restrictions were put in place (including curfew times and travel bans), which prevented fishers from accessing certain fishing areas in order to adhere to social distancing protocols. During most of the study period, fishers were not allowed to enter some of the strata in the Gariep Dam Nature Reserve, because the reserve's accommodation was used by the Department of Health as a Covid-19 quarantine site. Certain fishing areas in the Oviston Nature Reserve were also closed to the public during part of the study because of governmental Covid-19 restrictions.

RESULTS

In total, 438 fishers were interviewed over two periods: October 2019 to March 2020; and November 2020 to October 2021. Of these, 246 fishers were first-time interviewees from both Gariepdam and Oviston fishing areas. By comparison, 621 fisher interviews, including 357 first-time interviews, were conducted in the 2007/08 surveys (Ellender et al., 2009). Two fishery groups were identified and surveyed, namely, subsistence and recreational fishers.

Fisher characteristics

The proportion of recreational versus subsistence fishers differed by area (chi-squared (χ^2) test of independence = 37, df = 1, $p < 0.05$). In both areas, subsistence fishers dominated, making up 75% in Gariepdam and 99% in the Oviston fishing area. The subsistence fishers were predominantly local, 78% and 98% in Gariepdam and Oviston, respectively. During the sampling period, 48% of recreational fishers were not locals, i.e. originated more than 100 km from the fishing area, whereas 48% were identified as locals that reside within 10 km of the fishing area.

Employment status of fishers was dependent on the user group ($\chi^2 = 78$, df = 5, $p < 0.05$) and fishing area ($\chi^2 = 47$, df = 5, $p < 0.05$). In Oviston, 70.9% of the subsistence fishers were unemployed and in Gariepdam, only 34.5% of subsistence fishers were unemployed. Of the recreational fishers in the Gariepdam area, 61% were employed on a full-time basis and only 16.7% were unemployed. The remainder comprised of youth and retired people.

The mode of transport to the fishing sites was dependent on the fishing area ($\chi^2 = 37$, df = 3, $p < 0.05$). Gariepdam's recreational fishers predominantly accessed the dam by vehicle (53%). In contrast, only 10.8% of fishers in Oviston used a vehicle to access the fishing area. The predominant mode of transport to access the fishing areas in Oviston was walking (73.5%), followed by vehicle and using a bicycle (each 10.8%), with 4.9% of fishers traveling with someone else in a vehicle.

The final fate of the fish was significantly dependent on the user group ($\chi^2 = 153$, df = 4, $p < 0.05$). Subsistence fishers predominantly fish for self-consumption and/or to sell their catch (97%). Recreational fishers release 87.5% of their catch, give away 6.25% and sell 6.25% of the catch. No subsistence fishers released or gave away their catch, and no recreational fishers used their catch for food.

Fisher demographics

The race of fishers was dependent on the user group in both the Gariepdam and Oviston fishing areas (Gariepdam $\chi^2 = 57$, df = 3, $p < 0.05$; Oviston $\chi^2 = 65$, df = 2, $p < 0.05$). The Coloured race group in both fishing areas dominated the subsistence fisher user group: 93.1% in Gariepdam and 91% in Oviston, with little representation of other race groups. The opposite was recorded for recreational fishers, where the White race group was dominant. Black fishers represented only 6% of the Gariep Dam fishing population.

Adult males, who represent 82.6% of all fishers, dominated the Gariep Dam fishing sector, with only 12.4% being children under the age of 18 years and 5% adult females. Subsistence male fishers made up 79% and 83%, whilst females only made up 2% and 6%, in Gariepdam and Oviston, respectively. The same fisher gender distribution pattern was evident throughout both fisher groups and fishing areas.

The age frequency distribution of fishers did not differ between the fisher groups and the fishing areas (Kolmogorov–Smirnov test: $p > 0.05$). For both fishing areas and fisher groups, fishers of 20–40 years of age were the most dominant (35.4%), followed by 0–20 years (28%), 40–60 years (24.5%) and > 60 years (11.2%).

Fisher participation

The Schnabel (1938) mark-recapture model estimated the population of subsistence fishers for the Gariepdam at 98 (95% CI: 72–137) and for Oviston at 333 (95% CI: 263–453).

Covid-19

To describe the effect of the Covid-19 pandemic on the Gariep Dam fishery, fisher socio-demographic data derived from the current study were compared to that of Ellender et al. (2009) from surveys conducted between 2007 and 2008. The same methodology was used for the current study and the 2007/08 study and the results were thus statistically comparable. The first major difference between the two studies was a change in employment of fishers. A marked decline in employed fishers was noted. There was also a marked decline in fishers representing the White race group with a significant increase noted in fishers representing the Coloured race group during the Covid-19 pandemic. It was also evident that 97% of fishers during the pandemic resorted to eating or selling their catch, compared to the historic data where only 71% of fisher catches were for subsistence use. A difference in the mode of transport was noted where the majority of the fishers walked to the fishing sites (62%), which was much higher than what was previously reported by Ellender et al. (2009) (Fig. 2).

A comparison between the descriptive data for the current study (2019–2021) and the 2007/08 surveys indicates that a marked decline in recreational fishers was evident during the pandemic in both the Gariepdam and Oviston fishing areas (Fig. 2). However, the mark-recapture method recorded little difference in the subsistence fishing population for both fishing areas when the two studies are compared (Fig. 3).

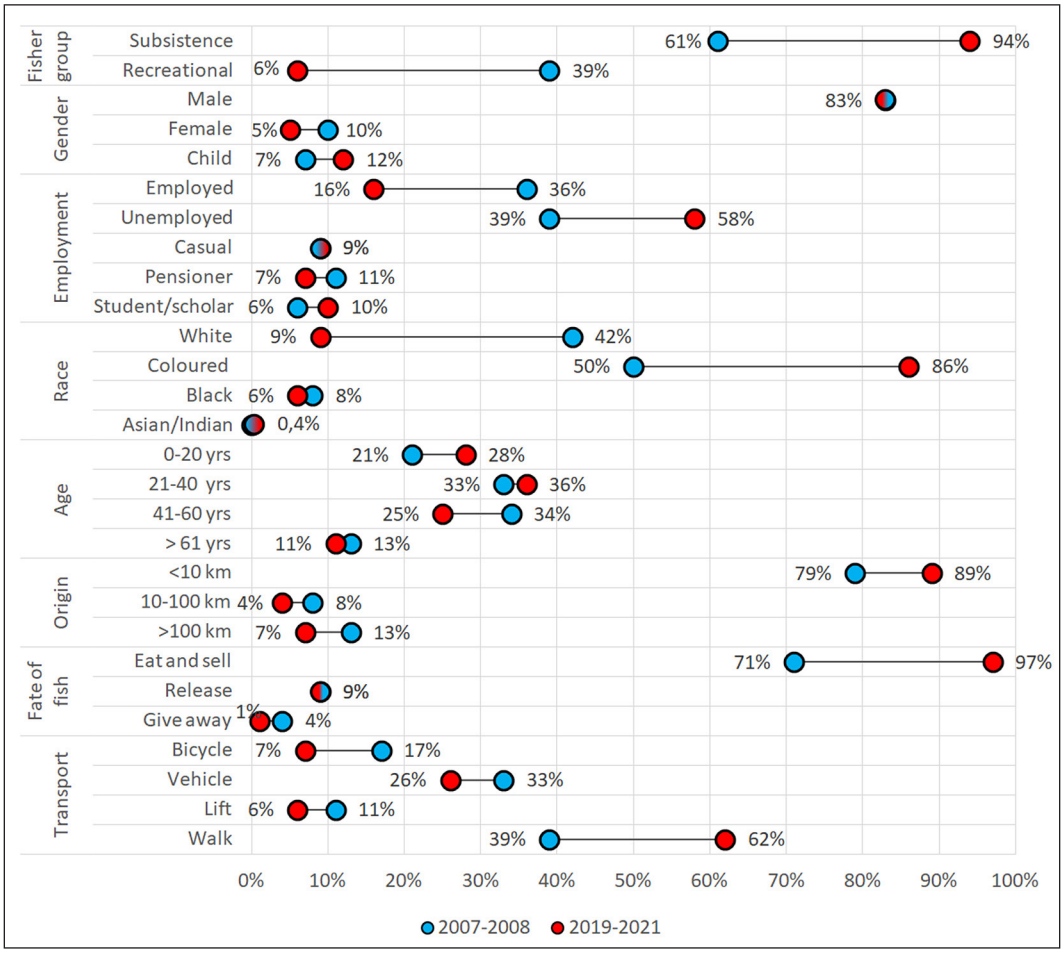

Figure 2. The fishing population associated with the Gariep Dam, characteristics and demographics based on first-time interviews (n = 267) collected from October 2019 to October 2021 (red) compared to similar data collected in 2007/08 (blue) from the same sampling area by Ellender et al. (2009)

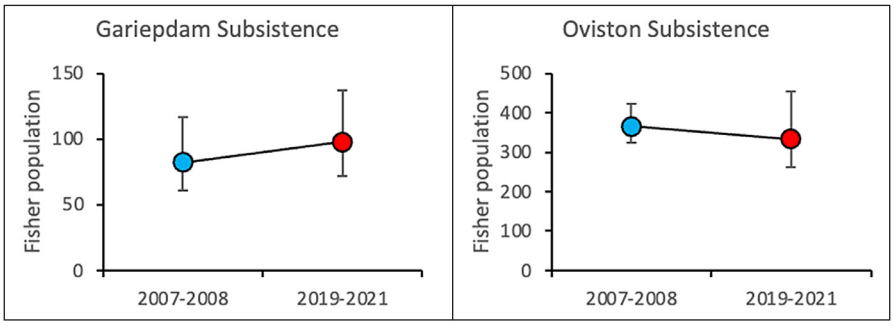

Figure 3. A comparison of the estimates of subsistence fisher population numbers for the Gariep Dam between the current study (acute-Covid) and data from Ellender et al. (2010) collected in 2007/08 (pre-Covid), derived using the Schnabel (1938) mark-recapture method. Error bars represent 95% confidence intervals.

DISCUSSION

The results of the study have demonstrated that changes in patterns of recreational and subsistence fisher activities for the Gariep Dam fishery were evident during the Covid-19 pandemic. The comparison of roving creel survey data for 'pre-pandemic' and 'acute-pandemic' states of inland fisheries allowed for a better understanding of the impacts on fishers imposed by lockdowns and movement restrictions.

The Covid-19 pandemic created the opportunity to investigate the effect of economic conditions and movement restrictions on socio-demographics and participation of fishers. Potts et al. (2022) hypothesised that the demography of fishers would have changed during the Covid-19 lockdown, with an increase in subsistence fishing to meet nutritional requirements, but a decline in recreational fishing due to economic pressure and movement restrictions. Strong pandemic-related changes in behaviour, demographics and recreational fisher engagement were evident. The mark-recapture method illustrated that there was no significant difference between pre-pandemic and acute-pandemic periods in the subsistence population of the Gariep Dam for both Gariepdam and Oviston fishing areas. This was contrary to the hypothesis of Potts et al. (2022) that the subsistence fishery would increase because of a decline in the economy during the pandemic. A household survey conducted in 2007/08 indicated that 56% of households of Oviston and Venterstad are regular subsistence fishers, which is a significant proportion of the population (Ellender et al., 2010). The results of the current study therefore indicate that the subsistence fishing population of the Gariep Dam did not show a noticeable increase during Covid-19, because most households in the rural towns surrounding Gariep Dam already participated in subsistence fishing before the pandemic. However, there were also fishing areas that were closed during the pandemic and anecdotal reports indicated that local law enforcement prevented fishers from accessing fishing areas, which might also have prevented an increase in subsistence fishing. This result should, however, be treated with caution as the two studies were conducted more than a decade apart.

The descriptive roving creel survey data provided strong evidence that indicates a decline in the recreational fishing population during the pandemic when compared to 2007/08 survey estimates. This decrease in the recreational fishing population can be attributed to the economic downturn because of the Covid-19 pandemic, that reduced the number of people with sufficient means to participate in recreational fishing (Potts et al., 2022). Recreational fishers also use the resource primarily for leisure purposes, and thus could avoid fishing to prevent the risk of infection during the pandemic. However, the subsistence fishers, who rely on the resource for food or income, could not avoid the risk as they had no alternative (Swanepoel et al., 2025). It should, however, also be noted that a general long-term decline in the whole recreational fishery sector of South Africa has become evident, which could also have influenced the results. This decline in recreational fishing was noted through historic comparisons and is also supported by a general decline in tournament angling effort in the Free State Province (Potts et al., 2022; Barkhuizen et al., 2017).

Racial group participation in fishing activities in the Gariep Dam differed by user group. The results show that more than 80% of recreational fishers were from the White race group and more than 90% of subsistence fishers were from the Coloured race group. The reduction of the recreational fishing population during the Covid-19 pandemic is also evident when racial participation data from the current study and 2007/08 is compared (Fig. 2). The percentage of White fishers reduced from 42% to only 9%, whereas the participation of Coloured fishers increased from 50% to 86% during the pandemic. This result supports the assumption that subsistence fishers still had to fish during the pandemic for livelihood purposes, whereas the recreational fishers avoided fishing to reduce the risk of contracting the Covid-19 virus.

Andrew et al. (2000) and Ellender et al. (2009) noted that fishing was not a traditional activity for all ethnic groups of South Africa. This was also seen at the Gariep Dam during the current study, where only 5.7% of all subsistence fishers were of the Black race group. This trend was observed despite the Black race group being the dominant race group, representing 65% of the regional population (Table 1) (Stats SA, 2011). Though all race groups had equal access to the available fishing areas of the Gariep Dam, the Coloured race group dominated the fishery, representing 84.5% of all fishers. According to Sowman (2006), Coloured people played a dominant role in the fishing sector under the apartheid regime despite discriminating legislation. Coloured and Black subsistence fishers did not have direct access to fisheries resources, but despite this Coloured subsistence fishers continued to operate illegally or under regulations governing recreational fishers. This can be a reason why the Coloured subsistence fishers still dominate the Gariep Dam fishery today. This demographic trend was also reported by Gilliland (2016), who found the Coloured race group represents 72% of all anglers at Zeekoeivlei in the Western Cape, South Africa. However, elsewhere in South Africa, there has been a noticeable increase in the use of freshwater fish for nutritional needs by communities for which this is not traditional, such as isiXhosa speaking communities in the Eastern Cape Province and (Tshi)Venda speaking communities in Limpopo Province (Britz et al., 2015).

Access to fishing areas by subsistence fishers was mostly by walking, indicating low income, whereas recreational fishers accessed the fishing area only by driving. A similar trend was observed by Ellender et al. (2009), indicating that subsistence fishing is mostly practised by poor people, as a last resort for a source of food or income. Smith et al. (2005) mentions that participation in inland fisheries requires relatively few resources, making them accessible and important in the livelihoods of poor people. This is supported by the occupation data of the Gariep Dam fishery, which indicated that most subsistence fishers were unemployed. This is consistent with a previous study at Zeekoevlei in Cape Town where Gilliland (2016) found that 35% of fishers were unemployed and fished for subsistence. Most subsistence fishers in South Africa are from the low-income group; however, in some cases poor fishers has evolved into recreational fishers, which makes it difficult to classify an individual as a recreational or subsistence fisher (Britz et al., 2015; Nyboer et al., 2022). This was, however, not the case in the Gariep Dam fishery where the motivation for fishing was clear, as defined in Swanepoel et al., 2025). Unemployment and walking as a mode of transport, which are both associated with subsistence fishers, also saw a noticeable increase during the Covid-19 pandemic. This increase can also be explained because of the collapse of recreational fishing during the national lockdown.

Results from the current study showed that most fishers live less than 10 km from the fishing areas (88.6%) and reside in the rural towns and villages of Gariepdam, Oviston and Venterstad, all of which are near the Gariep Dam. This was true for both recreational and subsistence fishers from both fishing areas, indicating that fishers avoided travelling more than 10 km during Covid-19, contrary to pre-Covid-19, when 67.4% of all recreational fishers in the Gariepdam fishing area travelled more than 10 km, as reported by Ellender et al. (2009). According to Gwazani et al. (2023), lockdown measures affected small-scale fisheries in Africa as the pandemic displaced most fishing communities because of travel restrictions. This was also evident in the Gariep Dam fishery as most fishers were local with little participation from fishers elsewhere.

The Gariep Dam fishing sector was found to be male-dominated throughout both fishing areas and fisher groups. This result is consistent with that of the recreational fishing sectors in Bloemhof and the Vaal Dam, which were reported to be 94% male-dominant (Van Zyl, 2010). The same trend was seen at the Vhembe inland fisheries sector in Limpopo, South Africa, where 92% of the fishers surveyed were male (Mokhaukhau et al., 2022). This is in line with the average gender participation reported for fishing countries around the world: 1 female for every 7.3 males that participate in inland fisheries (FAO, 2018). However, in Africa the majority of women (91.5%) in inland fisheries are involved post-harvest (FAO, 2018). This is also the trend in Sub-Saharan countries where women are involved in the fish value chain, which includes processing and trade (Nkhoswe et al., 2024). Mokhaukhau et al. (2022) stated that the role of women in inland fisheries is at times undervalued, uncredited and underappreciated by society, policymakers and the fishery sector.

Due to the decline in recreational fishers during the pandemic, the roving creel surveys of the current study showed that 97% of fishers either sell or consume their catch, which is a clear increase from pre-Covid conditions (2007–2008), when this was estimated at 71% of fishers. This result emphasises the importance of the fish resource from the Gariep Dam for subsistence users residing in rural towns surrounding the dam. According to Ellender et al. (2010), subsistence use of inland fisheries in South Africa needs to be recognised and rights to access fishing sites need to be secured to protect their livelihood. The National Freshwater (Inland) Wild Capture Fisheries Policy for South Africa states that all citizens have the right to fish in inland waters (DFFE, 2021); however, how subsistence fishers fit into this policy is still unclear.

The study has demonstrated that Covid-19 has altered fisher demographics and participation in inland fisheries of the Gariep Dam, and the results provide an opportunity to inform the protection and management of the fishery. According to Potts et al. (2022), understanding the consequences of Covid-19 for hook-and-line fishing participation and fisher behaviour is especially necessary for developing countries, where the sector may provide opportunities for local economic development. The present study addresses these, especially for Gariep Dam.

During the lockdown period, other food-providing sectors had lighter restrictions that prevented total shutdown, but the small-scale fisheries sector did not have such provisions (Bassett et al., 2021). In South Africa the agricultural sector was classified as 'essential services' and was allowed to operate, whereas small-scale fishers were restricted from going out fishing (Isaacs et al., 2022). According to Gwazani et al. (2023), small-scale fishers are generally regarded as a non-essential food sector, which explains why they were not classified as essential during Covid-19. Small-scale fisheries are, however, a marginalised and vulnerable group that was heavily susceptible to the pandemic stressors (Gwazani et al., 2023; Isaacs et al., 2022). This paper highlights the lack of resilience amongst subsistence and recreational fishers during times of crisis and the authors urge the South African Government to see inland fisheries in the same light as other sectors earmarked as 'essential'. It is recommended that Government should support inland fisheries during crisis events to be allowed to operate, be provided with market channels, and be recognised as an essential sector for food security.

CONCLUSION

Hook-and-line inland fisheries are difficult to track due to their rural, highly dispersed, and informal nature, and this must be articulated in discussions regarding the sustainable development of inland fisheries (Funge-Smith and Bennett, 2019). Policy approaches to support sustainable inland fisheries development will also depend on continuous research that identifies assessment methods and knowledge gaps. Studies of this kind underline the high value of information on fisheries human dimensions and participation, for monitoring and evaluation to provide scientific advice to policymakers to respond to events such as a pandemic (Ryan et al., 2021). This evidence of temporal changes in hook-and-line fisheries provides inland fisheries authorities the opportunity to develop mitigation measures with greater resilience to cope with future global crises, including facilitating the ability of people to access fishing opportunities during periods of high economic and societal stress (Britton et al., 2023). As South Africa's national inland wild capture fisheries policy is nearing implementation, the current study will be instrumental in providing policy implementation efforts with information required to manage impacts on recreational and subsistence fishing. This study also motivates for the development of regulatory measures that promote inland fisheries opportunities during crisis events.

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AUTHOR CONTRIBUTIONS

Pieter Swanepoel: conceptualisation, investigation, data curation, formal analysis, writing – original draft, review and editing. Leon Barkhuizen: visualization, investigation, supervision, writing - review and editing. Bruce Ellender: methodology, supervision, writing – review and editing. Liesl van As: supervision, writing – review and editing. Olaf Weyl: conceptualisation, methodology, supervision, funding.

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