Understanding the socio-economic contributions of different wildlife ranching business models in South Africa

By

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Minor dissertation submitted in partial fulfilment of the requirements for the degree of

Master of Science in Conservation Biology by coursework and dissertation

July 2022

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Plagiarism declaration

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Acknowledgements

The Sustainable Wildlife Economies Project (SWEP) was funded by the Presidential Employment Stimulus Programme of the Presidency of South Africa and the initial survey design workshop was funded by the JRS Biodiversity Foundation. My thanks go to Wildlands Conservation Trust for funding the 2022 phase of fieldwork for my thesis.

Thank you to the landowners/managers of wildlife ranches that gave of their time to be interviewed for SWEP. The unique experience I gained from interviewing some of you and realizing the passion you had for conservation helped me to remain motivated.

I am so grateful that this course allowed me to meet amazing people from all walks of life. Thank you to my CB classmates for making the challenging days (especially during coursework) easier and for sharing your different perspectives on conservation, and life, so freely. Some life-long friendships have been made and I wish you all the best for what's next!

I truly feel that I was blessed with the best supervisors. Thank you to Alta De Vos, Hayley Clements, Matthew Child and Timm Hoffman for your excellent guidance from start to finish. Alta, thank you so much for being there for every step and for helping me gain the confidence to think independently for my thesis, whilst still patiently answering all my questions and putting me at ease during the times when I felt I had gone wrong. Hayley, I often think back to our first conservation at the Assegaai picnic table about me doing a project like this. Thank you for sharing your expertise, passion for this field and helping me through the stats, even though you were on leave. Matt, thanks for believing in my ability to contribute to SWEP last year and in Limpopo, and through this thesis. I have learnt so much from knowing you (like getting through flooding in Limpopo like a boss). Timm, thank you for taking on the tedious job of helping me over the admin hurdles and for your feedback on my thesis that reflected your solid expertise that can be applied to any field.

I greatly appreciate the support from my family and friends. My parents have instilled in me independence to trust in my choices and follow my dreams. I am so grateful for their constant support and belief in me. Pa en Ma, woorde kan nie beskryf hoe dankbaar ek vir julle is nie. Alex Odendaal has been my sounding board and witnessed all the ups and downs of completing a Masters. Thank you for walking with me through every milestone since our first Matric exams. I cannot wait to continue learning through life with you!

Nothing would be possible without grounding from God, who has shown me the right path and steered the ship always.

Abstract

Amidst the biodiversity loss crisis, the expansion of wildlife ranching has been associated with a numerous conservation benefits and linked to job creation and substantial economic contributions. However, an understanding of the socio-economic contributions of wildlife ranching that account for the heterogeneity and diverse business strategies within the wildlife economy remains limited. The aim of this research was to determine some of the socio-economic contributions of different wildlife-based business models, as defined by their main revenue-generating activities, within the wildlife ranching industry in South Africa, as well as the financial sustainability of these business models and their contributions. In total, 268 owners and managers of privately-owned wildlife ranches and agricultural farms (for comparative purposes) in the Eastern Cape and Limpopo provinces of South Africa were surveyed. Through these surveys, I collected data on the revenue-generating activities they rely on, differences in their financial metrics, the number of jobs they provided and the salaries and non-salary benefits their employees received. This data was based on a non-pandemic year (2019/2020) and a post-Covid-19 pandemic year (2021/2022) to assess the sustainability of ranches in response to a large-scale threat. Through a hierarchical clustering analysis of revenue-generating activities, six business models within the wildlife ranching sector were delineated according to their primary focus: ecotourism, trophy hunting, mixed hunting (i.e., biltong and trophy), mixed wildlife-agriculture, wildlife breeding and trophy hunting-game meat business models. On average, trophy hunting and ecotourism focused business models were found to make greater economic contributions, through high upfront capital investment and operating expenditure, than the mixed wildlife-agriculture and mixed hunting focused models. Ecotourism focused ranches employed more people than all business models except trophy hunting. They also provided higher quality jobs (defined as jobs that increase job security, workplace equality, and job satisfaction through higher compensation) by employing the highest proportion of women (41% on average) and the highest proportion of skilled employees (45% on average) across business models, including when compared with conventional agriculture. Trophy hunting focused ranches also employed more people per hectare than other models (although on average, over a quarter of these jobs are seasonal). They also offer the greatest variety of non-salary benefit types to employees (particularly in the form of housing and food), along with mixed hunting ranches. Trophy hunting ranches are considerably more profitable than ecotourism and wildlife breeding ranches, though there was high variability within the ecotourism model, likely as a result of some being focused on high-end ecotourism, and others on low-end ecotourism. After Covid-19, all business models experienced lower profitability and some enterprises across all business models retrenched employees. On average, the mixed-

activity models did not retrench employees post-pandemic. Those that fared better during Covid-19 had more diversified profiles of revenue-generating activities (i.e., the mixed activity models), suggesting that enabling this diversity of approaches is important for the sustainability of wildlife ranching. The evidence presented here advances our understanding of the heterogeneous impacts and responses of wildlife ranches and suggests that differences in the socio-economic contributions of these ranches should be considered across business models as several distinctions exist between these models. A more nuanced approach to understanding the socio-economic contributions of wildlife ranching will benefit the policy discourse surrounding the industry by providing information relevant to specific business models', which may lead to more effective policy implementation and improve the industry's sustainability and growth.

Keywords: wildlife ranches, business models, economic contributions, jobs, profitability, diversification

Introduction

As global biodiversity is subjected to unprecedented anthropogenic pressure such as climate change, habitat degradation and overexploitation of resources, protected area expansion strategies remain the mainstay of biodiversity conservation (Venter *et al.*, 2014; Visconti *et al.*, 2015). Although protected areas have been shown to effectively provide ecosystem services and safeguard biodiversity in some areas (Watson *et al.*, 2014; Geldmann *et al.*, 2015), many studies have also pointed to ineffective conservation within these areas (Mora and Sale, 2011; Venter *et al.*, 2014). Protected areas have also been criticised for failing to meet socio-economic objectives tied to biodiversity conservation, such as social justice, transparent decision-making processes and recognition of the diversity of local people living near protected areas (Watson *et al.*, 2014; Zafra-Calvo *et al.*, 2019). Although some protected areas have expanded their management strategies to include local communities in decision-making (Dudley *et al.*, 2014), equity and inclusion of diverse stakeholders remains a key challenge for contemporary protected areas (Zafra-Calvo *et al.*, 2019; Alves-Pinto *et al.*, 2021). The expansion of state protected area networks is also associated with high input costs, an issue of limited suitable space for new protected area establishment and high maintenance costs of protected areas that must be added to the state budget (Venter *et al.*, 2017). Addressing these failures became important for several countries over the last decade as they tried to meet the Aichi Targets, set by the Convention on Biological Diversity (CBD) within the Strategic Plan for Biodiversity 2011-2020 (Visconti *et al.*, 2015).

None of the Aichi Targets, including Target 11, which set out to conserve 17% of terrestrial and inland water areas, were met by the deadline (Díaz *et al.*, 2020). Although the quantitative aspect of Target 11 was almost fulfilled, several qualitative aspects of the goals for protected areas were inadequate. These included the incorporation of key biodiversity areas and areas important for ecosystem services within protected areas, the presence of ecologically well-represented areas, effectively and equitably managed areas, connectivity within protected areas and the integration of protected areas within landscapes (Melzer *et al.,* 2019; Zafra-Calvo *et al.*, 2019). Another issue affecting the success of protected area expansion is area bias, in which protected areas are still being established in areas with low agricultural opportunity costs, instead of areas important for the conservation of threatened vertebrates (Venter *et al.*, 2017). The failure of the protected area expansion approach signals a need for additional strategies to safeguard important biodiversity areas.

The CBD has recognised that different models, which include other governance types, are necessary in addition to protected area management for a more effective global conservation strategy. Other effective area-based conservation measures (OECMs), were

proposed in Aichi Target 11 to complement the role of protected areas in the protection of important conservation areas across landscape matrices (Jonas *et al.*, 2014). Formally recognising different models which can contribute to area-based conservation can help countries to meet Aichi Target 11 and other area-based conservation goals, even though biodiversity conservation may not be the primary objective of these models (Krug, 2001; Donald *et al.*, 2019). In many regions, the majority of land is privately owned, including land of biodiversity importance (Capano *et al.*, 2019). One approach relevant to privately-governed, non-protected area land management is wildlife ranching, which has the potential to address conservation and development outcomes. Wildlife ranches are generally privately-owned or -managed areas that rely on wildlife for commercial purposes. They also often contribute to conservation, although this contribution is an emergent outcome of profit generation-activities, rather than a primary goal of most landholders (Taylor *et al.*, 2021). The growth of wildlife ranching, as well as the conservation benefits provided by some ranches, has put increasing pressure on decision-makers in several countries to consider private and community-based rangelands and wildlife ranches as part of their larger conservation strategies (Krug, 2001; Cousins *et al.,* 2008; Holechek and Valdez, 2018).

Private wildlife ranching as an area-based conservation model

Wildlife ranching is most common in southern African countries, including South Africa, Namibia, Zambia and Zimbabwe, but it also exists as an effective land-use model in East Africa, North America, South America and Australia (Butler *et al.*, 2005; Hoogesteijn and Hoogesteijn, 2010; Clark and Milloy, 2015; Hoogendoorn *et al.*, 2019; Wilson *et al.*, 2020). Since the 1960s, there has been an expansion of wildlife ranching in some regions to capitalize on markets for biodiversity resources and services, both consumptive and non-consumptive (Krug, 2001; Child *et al.*, 2012; Lindsey *et al.*, 2013a; Taylor *et al.*, 2020). Consumptive uses of wildlife include trophy hunting, biltong (meat) hunting and live sales of game, whereas non-consumptive uses include wildlife viewing and donations to wildlife conservation which reflect existence value and bequest value (Krug, 2001; Taylor *et al.*, 2020).

Recent global expansion of wildlife ranching

Several factors have driven differing scales of expansion of wildlife ranching globally. Legislative changes have been a major enabling factor. For example, user rights and ownership rights over wildlife have been granted to private landowners in several southern African countries, including South Africa, Namibia and Zimbabwe, allowing wildlife ranching to be a financially viable land use (Lindsey *et al.*, 2013b; Taylor *et al.*, 2016; Taylor *et al.*,

2020). These legislative changes have resulted in livestock and previously cultivated farms being converted to wildlife ranches. Most parts of Zambia are unsuited to livestock due to the presence of the tsetse fly, regular droughts and leached soils (Lindsey *et al.*, 2013a). In Namibia, extensive wildlife ranching is now considered as a more favourable land use than extensive livestock production due to limited farming subsidies, drought and the lower costs associated with wildlife production over livestock production (van Schalkwyk *et al.*, 2010; Brown, 2019). Zimbabwe was an important hub for private wildlife ranches, particularly after severe drought in the 1980s, and prior to political turmoil associated with land reform in 2000 which affected the trajectory of ranching in the region (Child *et al.*, 2012). Regulations pertaining to foot and mouth disease in northern Namibia, Botswana and Zimbabwe prevent livestock farmers that farm close to protected areas from exporting beef (Scoones *et al.*, 2010). As wildlife ranches have expanded, so has the risk of cattle contracting foot and mouth disease, which may further motivate farmers in southern Africa to adopt wildlife ranching instead (Scoones *et al.*, 2010). Private conservation models outside of southern Africa have not experienced the same expansion, mostly due to differences in legislation (most notably, the restrictions of wildlife user rights), and issues regarding public perception of consumptive wildlife uses. Some countries in east and west Africa, like Rwanda, do allow for ranching in terms of legislation, however there are often barriers in terms of a supporting environment (African Leadership University School of Wildlife Conservation, 2021). Private conservation areas beyond southern Africa still exist for various reasons, including their profitability, potential to act as alternative land conservation strategies to conservationists, and their beauty, but barriers to private conservation (mostly from the state) limit the presence of these areas (Holmes, 2015). In the United States, ownership rights to wildlife differ greatly between states. Some states prohibit private ownership of wildlife, with game hunting being restricted to own consumption (Clark and Milloy, 2015). In Australia, legislation bars private landowners from owning threatened indigenous species (Wilson *et al.*, 2020). In Chile, neoliberal reforms have strengthened property rights, which allows individuals to own land for conservation purposes, although private protected areas are not legally recognised or incentivised by the state (Holmes, 2015).

Conservation impacts and limitations of wildlife ranches

In the South American Pantanal, an alluvial floodplain which is the world's largest wetland, ranches protect greater abundances of wildlife than national parks (Hoogesteijn and Hoogesteijn, 2010). Private and communal protected areas in Peru complement the national protected area network by protecting threatened and endemic species and ecoregions that are not protected by state protected areas (Shanee *et al.*, 2017). Brazilian private protected

areas are also essential to the country's conservation strategy, as they protect watersheds, allow refugia for threatened species and contribute to wildlife corridor creation (Pegas and Castley, 2016). In Namibia, wildlife ranches occupy more than double the land encompassing their protected area network and are a good alternative to livestock farming, with multiple economic, social and ecological benefits (Lindsey *et al.*, 2013b). They provide many jobs and non-salary benefits including game meat to local communities and have a high economic rate of return. Namibian ranches also protect significant populations of wildlife, including several vulnerable species (Lindsey *et al.*, 2013b). Similarly, highly diverse and abundant wildlife populations, including rare species, are present on ranches in Zambia. This is despite legislation that acts as a disincentive to ranching. For example, in Zambia, al wildlife is owned by the state, and individuals or communities are granted withdrawal rights by purchasing hunting or game-capture licences (Chidakel and Child, 2022). This results in both administrative and financial disadvantages even though these ranches offer an opportunity to re-stock the smaller wildlife populations in Zambian state protected areas which are vulnerable to severe poaching (Lindsey *et al.*, 2013a).

The expansion of wildlife ranching in South Africa has led to a major increase in the abundance of wildlife species on private land, with the most recent estimate of the total number of herbivores on private land ranging from 4.66 million to 7.25 million (Taylor *et al.*, 2021). Furthermore, wildlife ranches have the potential to protect areas of ecological importance for megafauna as they allow for the persistence of megaherbivores and predators more than livestock farming does (Clements *et al.*, 2019). Wildlife ranches also contribute to vulnerable species conservation, and conserve significantly more natural land cover and biodiversity intactness than other unprotected areas (Parker *et al.*, 2020; Shumba *et al.*, 2020). This is partly due to private land conservation areas (PLCAs) often occurring in more productive (and thus more threatened) areas of the landscape than state protected areas (Clements *et al.*, 2019). The benefits of wildlife ranching to conservation, particularly in southern Africa, highlight the potential of ranching across diverse landscapes in the presence of certain conditions. These include legislation which enables landowners to have ownership over wildlife, the availability of marginal land that limits other forms of agriculture, and an increased demand for nature-based tourism and safari hunting (Lindsey *et al.*, 2013a; Lindsey *et al.*, 2013b; Taylor *et al.*, 2021).

Socio-economic impacts of private wildlife ranches

Presenting wildlife ranching as an effective conservation model (in southern Africa and more globally) requires fair consideration of its impacts on people and the economy. On cattle ranches with conservation programs in South America, wildlife tourism has increased

financial gains for private landowners, who in turn use a portion of the additional income to further fund conservation (Hoogesteijn and Hoogesteijn, 2010; Hoogendoorn *et al.*, 2019). In Pakistan and Tajikistan, community-based trophy hunting programs have clear economic benefits, with 80% of revenues from hunting being allocated to local communities (Adhikari *et al.*, 2021). The economic advantage of wildlife-based land uses is well-established across southern Africa. In Namibia, for example, farms with wildlife-based land uses appear to earn more than livestock farming despite policies that favour livestock agriculture (Lindsey *et al.*, 2013b). Decades of development in community-based natural resource management on communal land in Namibia have allowed communities to benefit from high income earned from wildlife ranching activities, like trophy hunting (Nuulimba and Taylor, 2015). Also, in Zambia, wildlife ranching produces a higher revenue per unit area than state game management areas (Lindsey *et al.*, 2013a), though social benefits provided by private conservation areas for communities are fewer than those provided by the adjacent national park (Chidakel and Child, 2022). When wildlife ranching rapidly expanded in Zimbabwe between 1980 and 2000, wildlife numbers were considerably higher than before 1980 and wildlife ranching was more profitable than livestock farming and provided more jobs (Child *et al.*, 2012).

In South Africa, it has been found that wildlife ranching provides more jobs, produces higher revenues per unit area, pays employees higher salaries than livestock farms and produces game meat which contributes to food security (Child *et al.*, 2012; Taylor *et al.*, 2020). The wildlife economy's financial gain over livestock production is amplified in drylands in Southern Africa (Child *et al.*, 2012). Private wildlife ranches neighbouring Kruger National Park are important complementary conservation areas which produce greater economic benefits and more jobs than the national park (Chidakel *et al.*, 2020). Additionally to direct ranch income, wildlife ranches contribute to the local economy, from spending across the system supply chain and tourists' local spending, and to the national economy through multiplier effects (Chidakel *et al.*, 2020). A comparison of private land conservation areas in South Africa based on their biophysical characteristics, accessibility, affordability, infrastructure, activities and target market, showed that areas with ecotourism as an income generator were more profitable than areas that generated revenue from hunting or live game sales (Clements *et al*., 2016). However, hunting is also a strong income-generator on wildlife ranches, with trophy hunting generating an estimated R1.96 billion annually in South Africa (van der Merwe *et al.*, 2014; Parker *et al.*, 2020). Recently, Taylor et al. (2020) compared the financial value of wildlife ranching with only wildlife-based land uses, with mixed farms, which had a combination of wildlife, livestock and/or crops. Wildlife only properties had higher revenues and total profit on average than mixed farms and livestock farms, with

revenue and profit having median values of USD 104.3/ha and 45.8/ha versus the values of USD 51/ha and USD 6.5/ha for revenue and profit respectively on mixed farms (Taylor *et al.*, 2020).

Previous studies quantifying the socio-economic contributions of wildlife ranching have tended to either report on the sector in the aggregate, focus on case studies or focus on singular wildlife-based land uses, especially ecotourism. In South America, ranches provide several jobs to communities as skilled tour guides (Hoogesteijn and Hoogesteijn, 2010; Hoogendoorn *et al.*, 2019). In southern Africa, ecotourism has been found to provide skills training and development projects to local communities as well as employ more people and pay them higher salaries than livestock farms do, post-conversion from livestock farms (Sims-Castley *et al.*, 2005; Naidoo *et al.*, 2016; Snyman, 2017). Wildlife properties in general (main revenue-generating activity notwithstanding) have more employees and pay them higher salaries than mixed farming properties (Taylor *et al.*, 2020). Employees on wildlife ranches also receive several other benefits in addition to higher salaries, including improved working conditions and game meat as a protein source (Lindsey *et al.*, 2013b; Taylor *et al.*, 2020). In communal conservancies in Namibia, trophy hunting provides meat for the community and salaries for conservancy management, whereas tourism provides complementary benefits, mainly in the form of salaried jobs (Nuulimba and Taylor, 2015; Naidoo *et al.*, 2016). Wildlife ranches are diverse in the types and combinations of land uses that they undertake, and there is thus a need for more nuanced assessments of the socio-economic contributions of these diverse models.

Despite apparent positive socio-economic contributions, wildlife ranches have faced numerous criticisms related to their social impacts, although several of these studies are speculative or based on case study research. A global review of critiques of private land conservation highlights issues raised on implementation effectiveness (including permanence of land ownership, small size of several private conservation areas, practices that conflict with conservation and a lack of monitoring programs) and value conflict (including inequity, elitism and neo-colonialism) (Gooden and ’t Sas-Rolfes, 2020).The widespread conversion of farms to wildlife ranches is criticised for having led to even greater barriers to access of land by farm dwellers, as well as issues of identity and belonging, in post-Apartheid South Africa (Spierenburg, 2020). Based on case-study research, some authors have criticised the industry for inconsistency in the employment benefits that it provides. For example, in some subsectors such as hunting, venison and wildlife breeding, fewer jobs were provided than those that were available on the farms before they were converted to ranches (Spierenburg and Brooks, 2014). The increase in ranching has

coincided with, and has complicated, agrarian land reform in South Africa. Communities without land argue that they are barred from earning a profit from the land. Also, while the case for ranching as a successful agri-business grows, several politicians further delay land reform in favour of local economic growth (Kamuti, 2018a, 2018b).

The ability of privately conserved areas, such as wildlife ranches, to make both socio-economic and conservation contributions depends on the sustainability of these systems. This includes their ability to be financially viable and resilient to a changing world, in which they can still conserve biodiversity when faced with social-ecological disturbances (Clements *et al.*, 2020). Wildlife ranches are impacted by several different potential or existing threats, which include direct threats to biodiversity (poaching, extreme weather, alien invasive species and inappropriate fire regimes) as well as socio-economic threats (global socio-economic changes such as recessions, regional crime and national politics and legislation perceived to hamper the viability of private land conservation) which interact across multiple scales (Clements *et al.*, 2020). Additionally, wildlife ranches themselves are often thought to threaten aspects of biodiversity through the stocking of extralimital species and the intensive breeding of wildlife (Pitman *et al.*, 2017; Selier *et al.*, 2018), which requires unpacking the trade-offs between biodiversity and socioeconomic gains across business models. The Covid-19 pandemic is a recent disturbance that has had severely negative impacts on state protected areas and wildlife ranches alike due to less conservation funding, depleted conservation management capacity and an increase in other existing threats (Lindsey *et al.*, 2020). Both wildlife ranches and state protected areas experienced severe losses in revenue and had to retrench staff or had to halt community development schemes (Clements *et al.*, in press; Smith *et al.*, 2021). The pandemic has highlighted weaknesses in the resilience of conservation systems, both state- and privately-managed. However, it has also identified possible solutions for building resilience including increased conservation funding and the diversification of income streams (Lindsey *et al.*, 2020; Smith *et al.*, 2021; Spenceley *et al.*, 2021; van der Merwe *et al.*, 2021). Comparing the sustainability of different wildlife ranching business models in response to threats can aid decision-making around increasing resilience in these systems.

There are still many gaps in our understanding of the social and economic contributions of wildlife ranching and their sustainability. Although we have some information on the overall contribution of the industry in specific contexts, these aggregated data hide potentially important differences in how different kinds of wildlife ranches may contribute socio-economically, and how they respond to change. These differences are important for policy, as they often relate to the kinds and combination of activities offered by wildlife ranches,

which are also the focus of many policy regulations (Cousins *et al.,* 2010). Understanding which activity-related business models exist in the wildlife ranching industry, and how these models relate to profitability, employment creation and quality, as well as sustainability in response to market-related disturbances is critical for developing effective, fit-for-purpose conservation and economic policies.

Wildlife ranches in South Africa

South Africa provides a useful case study for understanding these socio-economic contributions. The South African wildlife ranching sector has grown rapidly since the proclamation of the Game Theft Act of 1991, which allowed full devolvement of user rights and ownership rights over wildlife to landowners (Taylor *et al.*, 2016). In South Africa, wildlife ranching now covers 17-20.5 million hectares, which is larger than the state protected area network, comprises 14-17% of total land surface area (Taylor *et al.*, 2020), and contains an estimated 4.6-7.3 million herbivores (Taylor *et al*., 2021). Other drivers of the expansion in ranching are due to conversions from livestock farms, which is due to conventional livestock agriculture being financially unviable in marginal areas, post-apartheid reductions in government support provided to farmers, and a higher rate of stock theft (Cousins *et al.,* 2008; Taylor *et al.*, 2016). The wildlife ranching industry in South Africa is multi-faceted in terms of revenue streams. The most common of these include ecotourism (both high-end establishments with higher prices and less visitors and low-end establishments that are more affordable and attract more local clients), trophy hunting (hunting which results in parts of a whole animal being kept for display, usually by foreign hunters), biltong hunting (hunting for meat products, usually by local hunters), live sales and breeding of high-value species (either in intensive environments where animals are confined to small- or medium-sized camps, or semi-extensively in larger camps but where management interventions are still frequent) and venison (game meat products, which are often a by-product of hunting) (Clements *et al.,* 2016; Taylor *et al.,* 2016). Landowners can rely on a singular activity or a combination of these to earn revenue. This will inevitably result in nuanced sectors, or business models, in the industry that differ in their management and therefore their conservation/environmental impacts, financial metrics (including revenues, operating expenditure and profits) and social contributions (including jobs and other employee benefits).

Research aim and objectives

In this project, I identify important wildlife-based business model typologies, as defined by their main revenue-generating activities, and determine the socio-economic contributions

these models have, within the wildlife ranching industry in South Africa. I also explore the financial sustainability of these business models and their economic contributions. To achieve my broader research aims, the objectives of my thesis are to determine:

1) The main business models that delineate the wildlife ranching industry in South Africa.
2) The contribution of wildlife ranches to the economy through their investment in land and their operating expenditure, and whether certain business models contribute more than others.
3) How the quality and quantity of jobs provided by wildlife ranches differs between business models and in contrast to the conventional agricultural model focused on livestock farming or cultivation.
4) The sustainability of different business models and their socio-economic contributions, in terms of their financial viability and the impact of Covid-19 as a disturbance on the financial and employment metrics of different business models.

Methods

Study sites

Wildlife ranches in the Eastern Cape and Limpopo Provinces were used as study sites (Figure 1). The two study provinces were chosen as the greatest proportion of South African wildlife ranches occur in Limpopo (51%) and the Eastern Cape (14%) (Van Der Merwe *et al.*, 2014). The two provinces also provide very different conditions for wildlife ranching due to the different biomes and the economic activities at play in each province and therefore including ranches from both regions can provide an interesting perspective on socio-economic aspects of wildlife ranching across different conditions in South Africa.

The Eastern Cape is the second-largest province in South Africa and is 168,966 km^2 in extent. It contains eight of the nine biomes in South Africa: Fynbos, Succulent Karoo, Nama-Karoo, Grassland, Savanna, Albany Thicket, Indian Ocean Coastal Belt and Forest (Rutherford *et al.*, 2006). Data were mostly collected in the central and south-western parts of the Eastern Cape, as this region is where wildlife ranching is most common in the province. The Eastern Cape has experienced severe drought since 2015. The drought has had an adverse effect on agriculture due to depleted groundwater and surface water resources (Mahlalela *et al.*, 2020). Since 1996, many conventional farms, which mostly practice extensive livestock farming mixed with arable farming, have been motivated by

drought to convert to game farms (Pasmans and Hebinck, 2017). These game farms have diverse arrangements of wildlife-based land uses (Pasmans and Hebinck, 2017). Farmland and indigenous vegetation in the Eastern Cape is subjected to several other environmental challenges including invasive alien species, soil degradation and overgrazing (Hamann and Tuinder, 2012). The Eastern Cape also faces severe social issues including poverty, poor service delivery and high unemployment rates, especially among groups of previously disadvantaged people (Hamann and Tuinder, 2012; Pasmans and Hebinck, 2017).

The second study site is Limpopo Province, which is 125,755 km^2 in extent. It is dominated by the Savanna biome, although it also contains some Grasslands and a few Forest patches (Rutherford *et al.*, 2006). As in the Eastern Cape, drought has been a major factor influencing the large-scale conversion of livestock farms into wildlife ranches in Limpopo. Livestock farming in Limpopo is further threatened by crop and livestock diseases and invasive plant species (Hoogendoorn *et al.*, 2019). An important factor influencing the increase in ranches in Limpopo is its proximity to the financial centre of Gauteng (Hoogendoorn *et al.*, 2019). Other factors that have challenged the economic sustainability of livestock farming in Limpopo, thus motivating the shift to wildlife ranching, have been climate-related losses from pests, the weakening of the rand and changes in labour laws as wildlife farming is perceived to be less intensive than livestock farming, which would decrease labour costs (Hoogendoorn *et al.*, 2019). Limpopo's economy is unpredictable, mostly due to its dependence on mining. This primary economic sector experiences highly volatile growth, and is largely absent in the Eastern Cape (Limpopo Provincial Treasury, 2019). Poverty and unemployment in Limpopo are high. The province joins the Eastern Cape as the two lowest-scoring provinces in terms of the Human Development Index (HDI), an important measure of socio-economic development of regions (Limpopo Provincial Treasury, 2019).

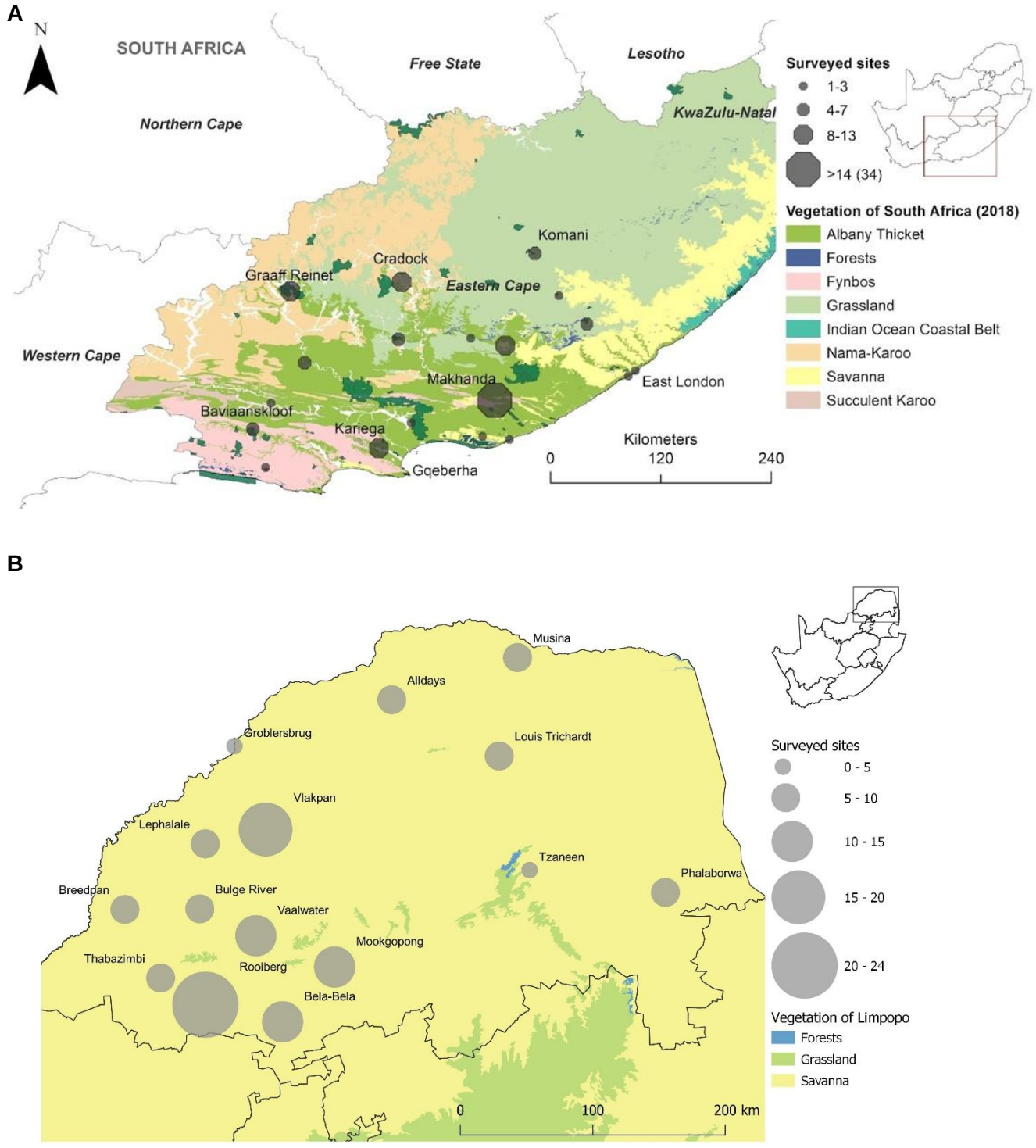


Figure 1: Number of privately-owned and -managed wildlife ranch and conventional agriculture properties surveyed during 2021 and 2022 in each municipality in: (A) Eastern Cape Province, South Africa and (B) Limpopo Province, South Africa (Map creators: Kyra Lunderstedt (Eastern Cape), Cecilia Wagner (Limpopo)). Exact property locations are not given due to a commitment to the anonymity of survey participants.

Data collection

i. Eastern Cape: February-March 2021

In February and March 2021, initial interviews were held with landowners/managers of wildlife ranches in the Eastern Cape for the pilot phase of the Sustainable Wildlife Economies Project. The initial phase of the SWEP survey of wildlife ranches was co-designed and implemented by the South African National Biodiversity Institute (SANBI) and the Department of Forestry, Fisheries and Environment (DFFE). The work was undertaken in collaboration with Wildlife Ranching South Africa (WRSA) and other industry partners, including the United Nations Development Programme (UNDP), Rhodes University, Stellenbosch University and Nelson Mandela University. A group of twenty-three resource auditors were trained to conduct one- to three-hour long interviews at farms in teams of two to four. I was one of the resource auditors trained during this initial phase to conduct interviews with farmers. The aim of SWEP is to provide a knowledge base that will allow for the development of sustainable, innovative and inclusive wildlife economies. The questions that were relevant to this study were included in the Economic Activities section of the SWEP survey and are detailed in Appendix 1.

The initial selection of wildlife ranches for the first phase of surveys relied upon private wildlife industry association sectoral memberships. A video was prepared that conveyed the purpose of the study and it was circulated through landowner networks. Managers and landowners who were interested in participating then contacted the survey coordinators to arrange a meeting. Furthermore, online searches using search terms including ‘ranch’, ‘private’, ‘reserve’ and ‘wildlife’ were used to augment the sample size. When surveys were underway, participants also provided contact details of neighbours or other wildlife ranchers they knew, who were also contacted to inquire about their participation.

The resource auditor teams conducted surveys on 112 wildlife ranches in the Eastern Cape, comprising 758 015 ha. Together with my team members, I personally surveyed 19 of these ranches during this phase. A total of 24 conventional agriculture farms were also surveyed by the broader project. Although some of these agricultural farmers also received a small proportion of revenue from wildlife-based activities, >90% of their revenue came from livestock farming or cultivation.

ii. Limpopo: June 2021 and January-March 2022

During June 2021, and from January to March 2022, landowners/managers of wildlife ranches in Limpopo were interviewed for SWEP Phase 2. To select respondents, private

wildlife industry association prepared communication materials that were shared with their members and other interested parties. Online searches were also used to find respondents, as detailed for the Eastern Cape surveys. The survey format followed that of the Phase 1 survey, with sections combined and additional sections added. All sections are included in Appendix 1.

A total of 156 surveys, comprising 862 034 ha, were conducted on ranches in Limpopo. Four of these surveys were classified as conventional agriculture properties, as >90% of their revenue was earned from livestock, small stock and/or cultivation, and the remainder from wildlife-based activities.

iii. Eastern Cape: February-March 2022

In February and March 2022, I conducted structured follow-up surveys with 24 of the initial participants in the Eastern Cape to collect additional socio-economic data that were not included in the original survey. I used stratified random sampling to select a sub-sample of participants from the initial sample of 136 respondents, as time and funding limited fieldwork capacity in 2022. First, the original sample was stratified per business model, based on a preliminary analysis of business models from the Eastern Cape data only (Clements *et al.*, in press). Six properties per business model were then randomly selected after disregarding some participants in the initial randomly selected sample due to participants being unavailable when contacted or unwilling to answer a follow-up survey.

Data collection for objective 1: Determining wildlife ranching business models

To determine the main business models that delineate the wildlife ranching industry in South Africa, data were collected on the types of revenue-generating activities that were practiced on the ranch and the relative proportion of total revenue contributed by these activities. The percentage of foreign visitors were also included in the analysis, as foreign visitors to ranches usually pay higher prices than local visitors (Clements *et al.*, 2016). The proportion of foreign visitors was also included due to its relevance for assessing the sustainability of properties in response to Covid-19, as travel restrictions limited foreign visitors to the country during the pandemic. Data from ranches in Limpopo and the Eastern Cape were included.

Data collection for objective 2: Economic contributions of wildlife ranches

To assess the economic contributions of wildlife ranches in the Eastern Cape and Limpopo, respondents were asked about the size in hectares (ha) of ranches, for size to act as a coarse proxy for upfront capital investment as land forms part of the capital investment required to start a wildlife ranch. Respondents were asked to provide their total revenues for

the financial years 2019/2020 (pre-pandemic) and 2021/2022 (present; post-pandemic). Data on the total running costs (operating expenditure) for the financial years 2019/2020 and 2021/2022 were collected to assess ranch expenditure in the economy.

Data collection for objective 3: Social contributions of wildlife ranches

To assess socio-economic contributions of wildlife ranches, in the form of employment, data were collected on job quantity (number of jobs provided) as well as job quality (number of women employed, proportion of seasonal versus permanent employees, the different salary brackets into which employee salaries could be classed, and the types of non-salary benefits that employees received, if any). The proportion of seasonal employees (as opposed to permanent employees) was used as a metric for job quality as it is directly related to job security. The proportion of skilled employees (as measured by the proportion of employees in the salary brackets 5,001-R10,000 ZAR monthly or higher) was also related to job quality through higher compensation, and the proportion of women was seen as an important metric of job quality due to ongoing discrimination towards women in the workplace (Block *et al.*, 2018; Gammarano, 2020). The quantity and quality of jobs of different wildlife-based business models was then compared with the quantity and quality of jobs provided by conventional agriculture properties.

Data collection for objective 4: Sustainability of different business models

To determine the financial viability of wildlife ranches, data were collected on the revenues and running costs during the financial years 2019/2020 and 2021/2022. Operating profit margin [(revenue – running costs)/revenue*100] was then used to compare the financial viability of different business models using the data from 2019/2020. The 2021/2022 operating profit margin data were used to assess the sustainability of different business models in response to the Covid-19 pandemic. The number of jobs provided post-Covid-19 was also assessed by using job quantity data from 2021/2021. To assess the perceived viability of different wildlife-based revenue-generating activities, interviewees were asked to rate the long-term (10 years or more) financial viability of their different wildlife-based activities.

Statistical analysis

All statistical analyses included data from ranches in the Eastern Cape and Limpopo.

Analysis for objective 1: Determining wildlife ranching business models

To assess whether wildlife ranch business models influenced financial metrics, the quantity and quality of jobs provided on ranches and the impact of the Covid-19 pandemic on ranch

socio-economic contributions, I first categorized ranches into distinct business models. This was done by performing a principal component analysis of business model characteristics, followed by a hierarchical agglomerative cluster analysis using the approach of Clements *et al.* (2016), Clements *et al.* (in press) and Borcard *et al.* (2011) (R package: vegan; function: rda; Oksanen *et al.*, 2022). I included 164 properties which had complete business model data, 90 of which were in Limpopo and 74 of which were in the Eastern Cape. Business model characteristics included the proportion of total revenue generated by different wildlife-based activities and the proportion of visitors to the ranch that were foreign. The six most common activities which generate revenue on wildlife ranches, and which were used to delineate the different business models, include wildlife breeding and live sales, trophy hunting, biltong hunting, venison sales, ecotourism and agriculture (including livestock and/or cultivation).

The cluster analysis employed Euclidean distance and Ward linkages (R packages: vegan and stats; functions: vegdist and hclust) to identify distinct business models (Ward, 1963; Oksanen *et al.*, 2022). A Mantel-based comparison was used to identify the number of distinct clusters (R package: cluster, functions: daisy and silhouette) (Maechler *et al.*, 2015). I described differences between the business models that were identified by the cluster analysis using the mean (± standard error) values of the seven business model characteristics.

Analysis for objective 2: Economic contributions of wildlife ranches

A Kruskal-Wallis test was performed to test for significant variation among the sizes of wildlife ranches across different business models. I performed Kruskal-Wallis tests to determine if there were significant differences between the financial metrics of wildlife ranches across different business models. Total revenues were compared across business models (n = 67). Total operating expenditures were compared across business models (n = 68). The response variables ‘revenue’ and ‘running costs’ were non-parametric. These responses were for the 2019/2020 financial year (pre-pandemic). This was done to assess the revenues and operating expenditures of ranches in a typical year (i.e. in the absence of a large disturbance such as Covid-19). For significant results, Wilcoxon post-hoc tests were performed to test pairwise comparisons.

Analysis for objective 3: Social contributions of wildlife ranches

To compare the quantity of jobs provided by different business models, agriculture ranches from Limpopo and the Eastern Cape were included as a separate business model and compared with the wildlife-based business models. The quantity of jobs provided by 136

ranches across distinct business models in a non-pandemic year (2019/2020) was modelled using a generalised linear model with Poisson error distribution (R package: car; Fox and Weisberg, 2019). The quantity of jobs was modelled as the response variable and the business model as the explanatory variable. A generalised linear model was used here as job quantity data was count data. However, the form of the data collected for finance metrics and aspects of job quality were not appropriate for generalised linear models and were therefore assessed using a non-parametric Kruskal-Wallis test instead. To calculate labour intensity, the number of jobs per Rand (ZAR) of operating expenditure in the financial year 2019/2020 was compared across ranches adopting different business models for which data were available. To calculate labour intensity per capital investment, the number of jobs per hectare of land in 2019/2020 was compared across ranches which used different business models and for which data were available.

The quality of jobs provided by ranches which used different business models was compared based on the proportion of women employed by different business models, the proportion of seasonal employees and the proportion of skilled employees, as defined by the proportion of total employees that earned a salary of 5,001 ZAR or above. Differences between the proportion of women, the proportion of seasonal workers and the proportion of skilled workers employed by 136 ranches across different business models (including agriculture) in 2019/2020 were statistically compared by performing Kruskal-Wallis tests as data were non-parametric.

To determine the most common types of non-salary benefits which employees on wildlife ranches received, I performed inductive thematic coding of non-salary benefit responses from 191 ranches by reading through the responses and inductively coding the different non-salary benefits mentioned. I re-visited these codes, grouped similar ones into themes and placed uncommon themes into the “other” category as there were not congruent with the focus of the analysis. A Chi-square test of independence was performed to see if there was a statistical relationship between the quantity of types of non-salary benefits provided by ranches and their business models. A contingency table was used to compare the count of ranches reporting each type of non-salary benefit.

Analysis for objective 4: Sustainability of different business models

To assess the financial viability of different business models, the operating profit margin for each business model in a non-pandemic year (2019/2020) was compared. The change in operating expenditure and operating profit margin due to Covid-19 was determined by calculating the percentage change between both response variables from the 2019/2020

financial year to the 2021/2022 financial year. As these data were non-parametric, Kruskal-Wallis tests were then performed to determine if there were differences in the changes to financial indicators of different business models.

To assess the impact of Covid-19 on employee numbers, the proportion of change in the number of employees between 2019/2020 and 2021/2022 was calculated. A Kruskal-Wallis test was performed to test for significant differences between the change in the number of jobs provided post-pandemic.

For all wildlife ranches, differences in the number of respondents that rated different revenue-generating activities as financially viable in the long-term (in 10 years plus) (Likert scale rating > 3) vs. not viable (Likert scale ≤ 3) were assessed using a Chi-square test of independence. Two-by-two contingency tables were used for pairwise comparisons.

Additional data analyses considerations

Some business models are excluded from some of the above analyses due to insufficient sample sizes, as some respondents did not answer all the survey questions. Certain outliers were excluded in figures, but still included in analyses. All excluded outliers are described in figure captions. All summary metrics are reported as the median and interquartile range (IQR) (Q3 – Q1), unless specified otherwise. All statistical analyses were conducted using R (version 4.1.3) (Team, 2022) at a significance level of $\propto = 0.05$. To correct for multiple comparisons, sequential Bonferroni corrections were performed (Rice, 1989).

Ethics statement

Ethical approval to conduct face-to-face interviews in 2022 for this study was granted by the University of Cape Town (approval code: FSREC 009 – 2022). The data collected for SWEP that was analysed here, was granted ethical approval by Rhodes University (clearance number: 2021-2810-5892). I have also been granted permission to use the SWEP data owned by the South African National Biodiversity Institute. No identifying information of wildlife ranches has been used to comply with the Protection of Personal Information Act.

Results

1. *Determination of different business models*

The most common revenue-generating activities on wildlife ranches in the Eastern Cape and Limpopo were trophy hunting (72% of properties), wildlife breeding (67%) and ecotourism (63%). Livestock farming was also practiced on 29% of properties, whilst cultivation was

practiced on 12% of properties. The proportion of foreign visitors to ranches varied from 0 to 100% and was 50% (± 3% SE) on average.

Two principal components (PCs) explained almost half of the variation across wildlife ranches in the proportions of revenue generated by the six most common activities and the proportion of foreign visitors to ranches (Figure 2; Appendix 2). Six distinct business models were evident, based on their main revenue-generating activities (Figure 2; Mantel r = 0.58, n = 164).

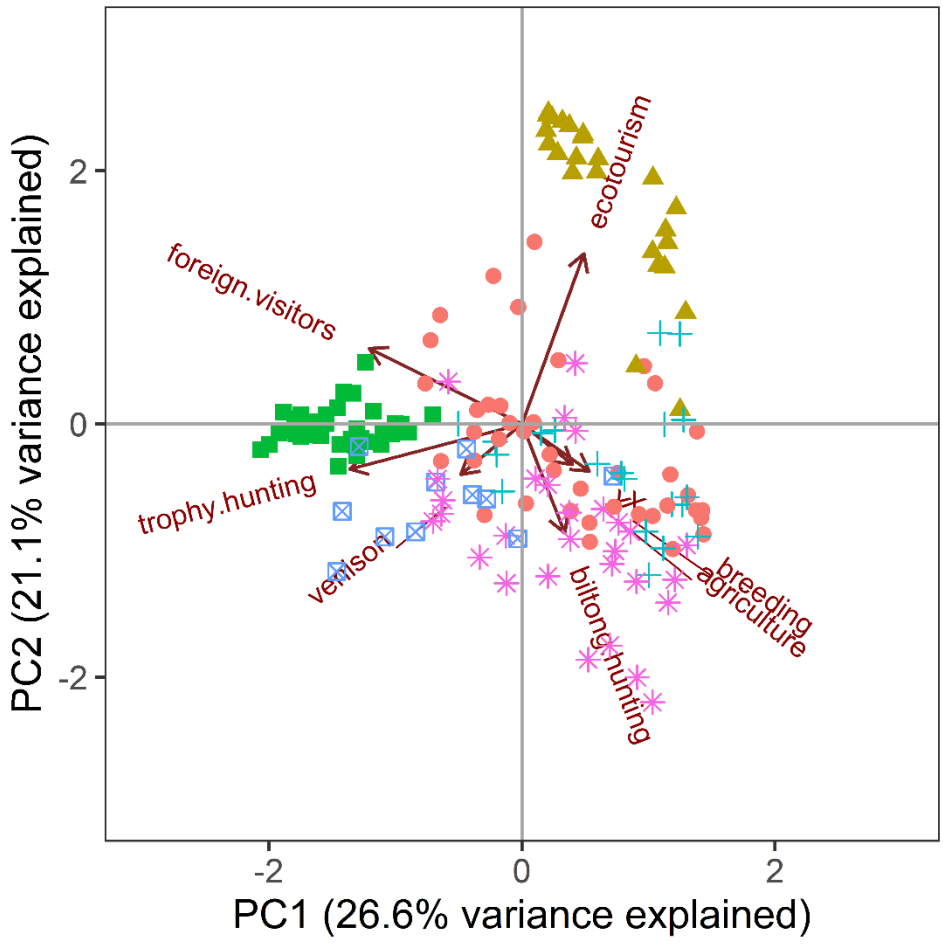


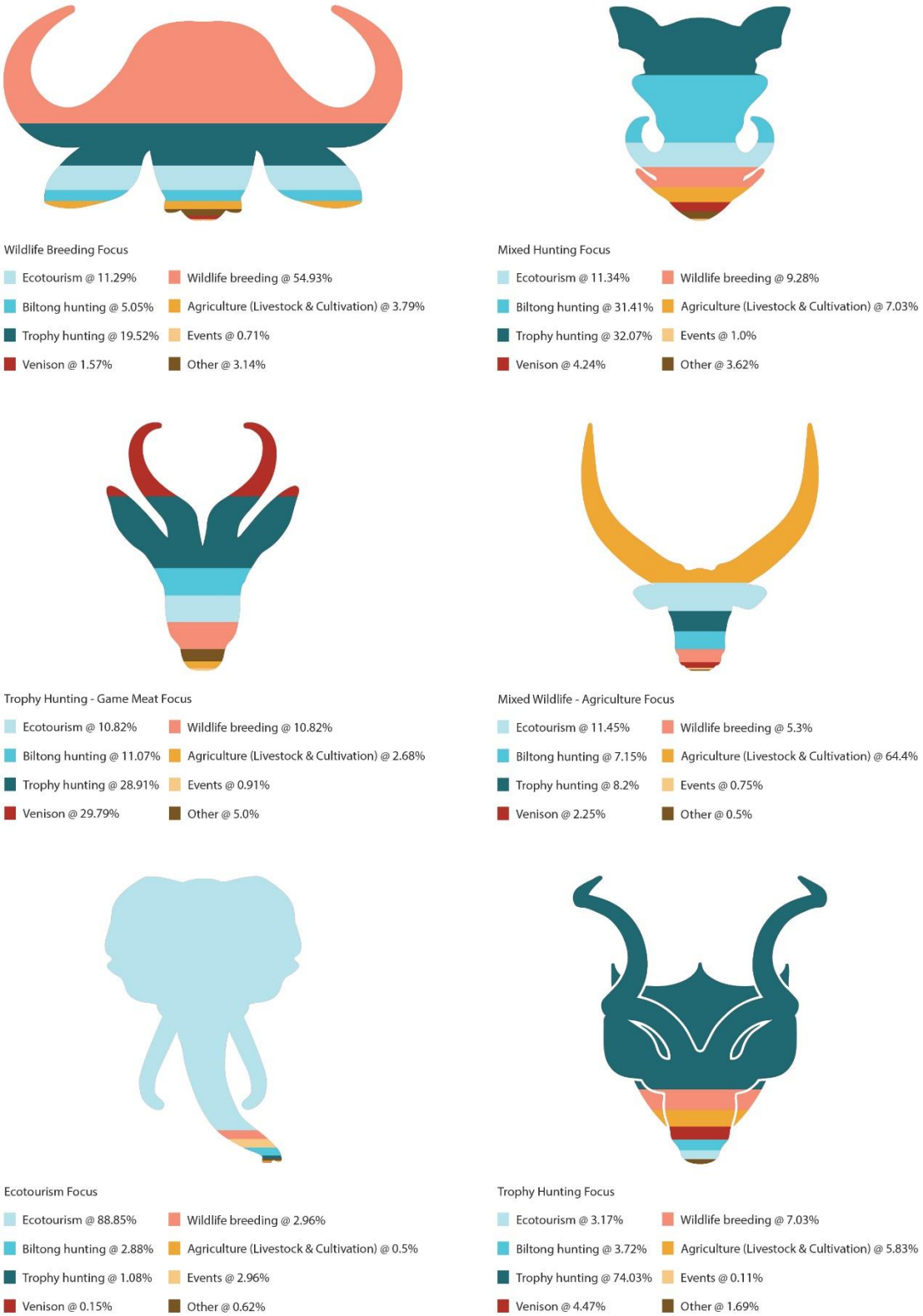
Figure 2: Biplot depicting the relative scores of seven response variables on the first two principal components (PCs), depicting the relative contributions of different revenue-generating activities to wildlife ranch overall revenues. Datapoints show the scores of 164 properties from the Eastern Cape and Limpopo provinces. Shapes and colours correspond to six identified clusters (ecotourism ▲ , trophy hunting □ , venison ⊠, mixed hunting * , wildlife breeding • , and mixed wildlife-agriculture +).

Trophy hunting focused ranches (22% of properties) earned three-quarters of their revenue from trophy hunters, 92% of whom were foreign (Figure 3; Appendix 3). The total revenue of mixed hunting focused ranches (18% of properties) was earned from several activities, with

the majority of revenue earned in almost equal parts by biltong hunting and trophy hunting from a mostly local client base. Mixed wildlife-agriculture focused ranches (12% of properties) earned most of their revenue from agriculture, with the remainder of their revenue being earned from local clients engaging in other wildlife-based activities. Ecotourism focused ranches (16% of properties) earned an average of 89% of their revenue from ecotourism, with just over half of their clients on average being foreign. Cultivation did not contribute to the revenue of any ecotourism ranches, and livestock and game meat (venison) production was practiced on only a few properties. Wildlife breeding focused ranches comprised 25% of all properties, with breeding and live sales contributing to 55% of their revenue, followed by trophy hunting and ecotourism. Trophy hunting-game meat focused ranches (7% of properties) on average received 29% of their revenue from venison and received their remaining revenue across all other wildlife-based activities (although agriculture was rare) from an almost equal local to foreign client base.

Conventional agriculture properties were included as a separate business model and compared with wildlife-based business models determined using the cluster analysis. Properties were classified as conventional agriculture focused if >90% of their revenue was generated by non-wildlife-based activities. Farming activities on these properties included livestock, cultivation of crops and fodder, citrus farming, honey production, pig processing and poultry farming. Of the 24 agriculture properties surveyed in the Eastern Cape, an average of 85% (± 27% S.D) of their revenue was generated through livestock farming, whereas 7% (± 19% S.D) of their revenue was generated through cultivation of crops or fodder. In Limpopo, three of the four agricultural properties that were surveyed earned their revenue from conventional agriculture through cattle farming only. The fourth farm in Limpopo earned 100% of its revenue from cultivation of maize.

Figure 3: The six wildlife ranching business models, as filled by the proportions of revenue generated by eight different activities for each model on average (Design Credit: Daniëlle Botha)



2. *Economic contributions of wildlife ranches*

2.1. Property size

The business model with the largest size on average was trophy hunting, with a median size of 4300 ha (IQR = 7375 – 1181 ha), closely followed by ecotourism focused ranches (median = 3800; IQR = 8511 – 2800 ha; Figure 4). Mixed wildlife-agriculture focused ranches had the smallest median size of 1500 ha (IQR = 2400 – 676 ha).

The size of ranches did not differ significantly across business models (x^2 = 9.49, df = 6, p = 0.15), due largely to high variability of ranch sizes within the wildlife breeding, ecotourism and trophy hunting models.

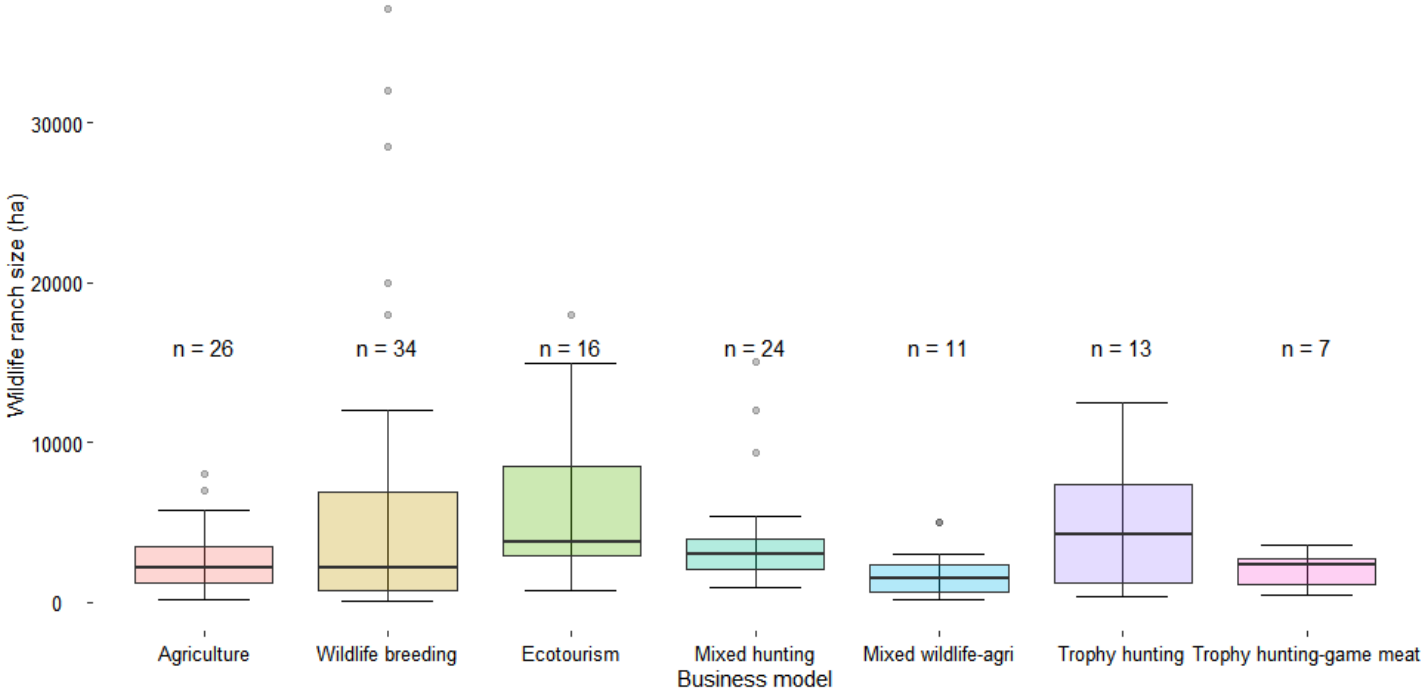


Figure 4: The range in sizes in hectares (ha) of wildlife ranches across different business models, with sample sizes provided above each business model

2.2. Revenue

The annual revenue earned by different wildlife business models was highest for trophy hunting focused ranches, with a median of 4,500,000 ZAR per annum (IQR = 7,225,000 – 2,250,000 ZAR). Ecotourism earned the second-highest revenue, with a median of 3,50,000 ZAR (IQR = 25,500,000 – 1,625,000 ZAR). Mixed hunting focused ranches had the lowest median revenue of 750,000 ZAR (IQR = 2,000,000 – 217,500 ZAR). Trophy hunting-game meat and mixed wildlife-agriculture focused models were not included here due to small sample sizes.

For revenue earned in 2019/2020 as a response variable, significant variation was explained by business model (x^2 = 11.2, df = 3, p = 0.01). Pairwise comparison tests revealed that the median revenue earned by the trophy hunting business model was significantly higher than that earned by the mixed hunting model (p = 0.01).

2.3. Running costs (operating expenditure)

The annual operating expenses incurred by wildlife ranches was highest for trophy hunting focused ranches, with a median of 3,800,000 ZAR (IQR = 5,72, 000 – 3,150,000 ZAR; Figure 5) and lowest for mixed hunting focused ranches (median = 1,250,000 ZAR; IQR = 2,050,000 – 500,000 ZAR).

For the response variable operating expenditure in 2019/2020, business model explained significant variation in total operating expenditure (x^2 = 13.8, df = 3, p = 0.003). Pairwise comparison tests revealed that the median operating expenditure for the ecotourism business model were significantly higher (more than double) than those of the mixed hunting business model (p = 0.03). The median operating expenditure for the trophy hunting business model were more than triple the median operating expenditure of the mixed hunting model (p = 0.008). There was considerable variation in the operating expenditure of ranches in the ecotourism business model.

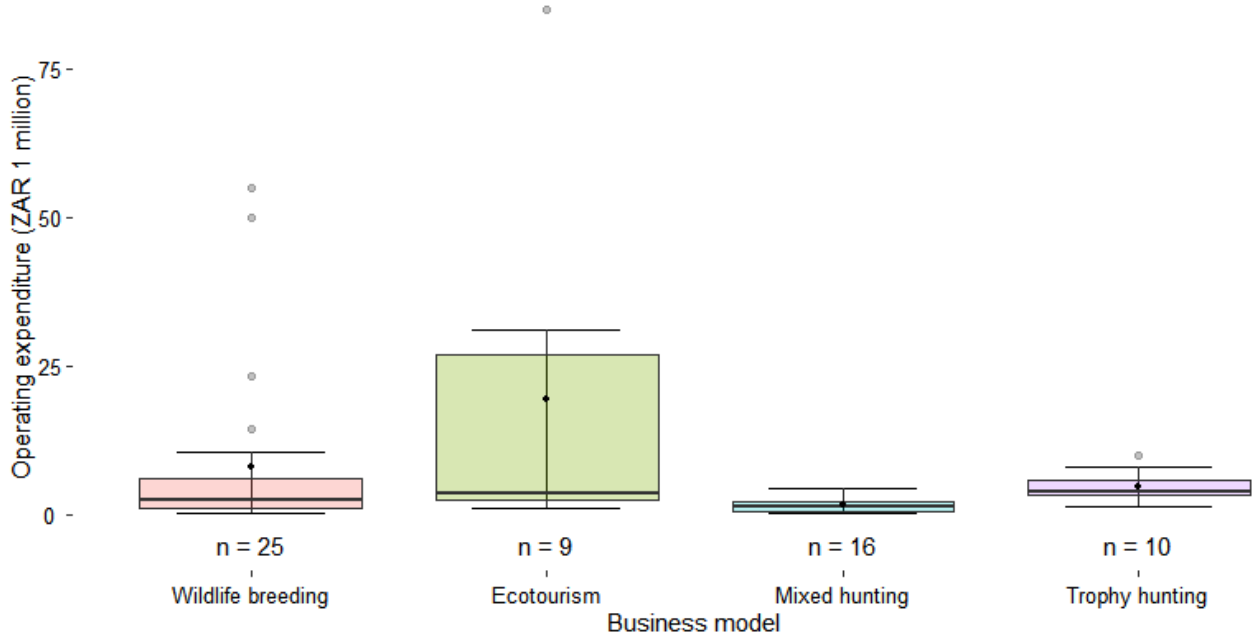


Figure 5: The operating expenses incurred by wildlife ranches across different business models in 2019/2020, the year preceding the Covid-19 pandemic, with sample sizes below each boxplot

3. Employment across different business models

3.1. Quantity of jobs

Total jobs per business model

Prior to the pandemic, in 2019/2020, ecotourism focused ranches provided more jobs than all other business models, with a median number of jobs of 23 (IQR = 81 -11; Figure 6), closely followed by trophy hunting, with a median of 21 jobs (IQR = 27.5 – 15). Mixed hunting focused ranches provided a median of 8 (IQR = 11 – 7) jobs, the lowest of all business models.

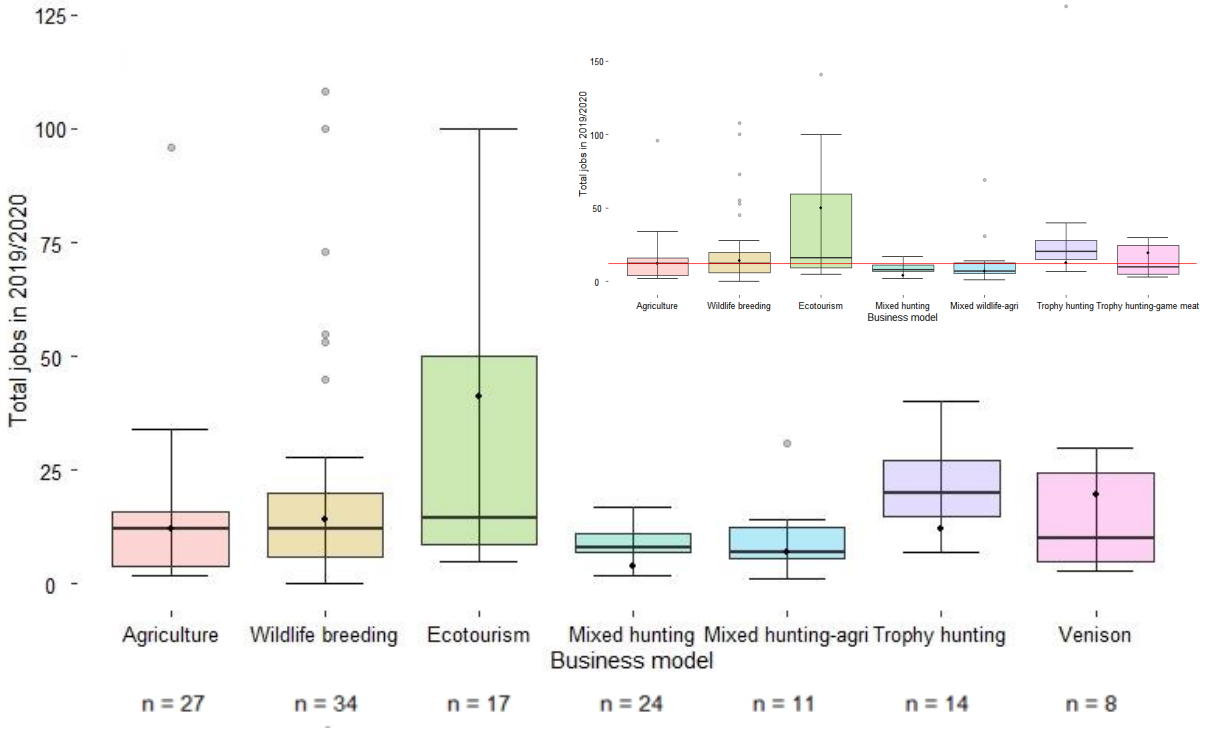


Figure 6: Total jobs provided in 2019/2020 by 7 business models, including conventional agriculture farms. Two outliers were excluded from this plot: ecotourism properties with a total of 461 and 492 jobs, both of which are high-end luxury ranches with many staff members required for reserve and lodge management. The red horizontal line intercepts the agriculture business model median. Sample sizes for all business models are provided below the figure. The inset figure (top right) shows the figure without any outliers excluded.

For the response variable 'Total jobs pre-Covid (2019/2020)', significant variation was explained by business model (x^2= 2336.9, df = 6, p < 2.2e-16). Pairwise comparison tests of the business model variable revealed that ecotourism employed more people than

agriculture, wildlife breeding, mixed hunting, mixed wildlife-agriculture and trophy hunting-game meat focused business models (Table 1).

Table 1: Pairwise comparison results of generalized linear model (GLM) with total jobs in 2019/2020 as a response variable and business model as the explanatory variable. P values are shown in the top row of each business model whilst Z ratio values are at the bottom of each row. Bold P values signify a significant amount of variation in the model.

	Agriculture	**Breeding**	**Ecotourism**	**Mixed wildlife**	**Mixed-wildlife agriculture**	**Trophy hunting**	**Trophy hunting-game meat**
Agriculture	-	-	-	-	-	-	-
Breeding	**<.0001** -5.58	-	-	-	-	-	-
Ecotourism	**<.0001** -31.46	**<.0001** -26.30	-	-	-	-	-
Mixed wildlife	0.96 -0.98	**<.001** 4.44	**<.0001** 24.65	-	-	-	-
Mixed-wildlife agriculture	**0.02** -3.2	0.74 1.52	**<.0001** 18.81	0.4 -2.03	-	-	-
Trophy hunting	**<.0001** -15.96	**<.0001** -10.21	**<.0001** 13.85	**<.0001** -13.03	**<.0001** -9.13	-	-
Trophy hunting-game meat	0.14 -2.57	0.78 1.44	**<.0001** 15.57	0.66 -1.64	0.13 1.00	**<.0001** 7.84	-

Quantity of jobs per hectare (labour intensity per capital investment)

Ecotourism provides the highest number of jobs per hectare of land with a median of 0.008 (IQR = 0.016 – 0.004), followed by trophy hunting (median = 0.006; IQR = 0.01 – 0.003), trophy hunting-game meat (median – 0.006; IQR = 0.008 – 0.004), wildlife breeding (median = 0.005; IQR = 0.008 – 0.003), agriculture (median = 0.004; IQR = 0.007 – 0.002), mixed wildlife-agriculture (median = 0.003, IQR = 0.02 – 0.002) and mixed hunting, which provided the lowest number of jobs per hectare (median = 0.002, IQR = 0.004 – 0.002; Figure 7).

The number of jobs provided per hectare of land differed significantly across business models (x^2 = 16.67, df = 6, p = 0.01). Pairwise comparison tests revealed that ecotourism provides four times more jobs per hectare than mixed hunting (p = 0.02). Trophy hunting provides three times more jobs per hectare than mixed hunting, with a marginally non-significant result of p = 0.05.

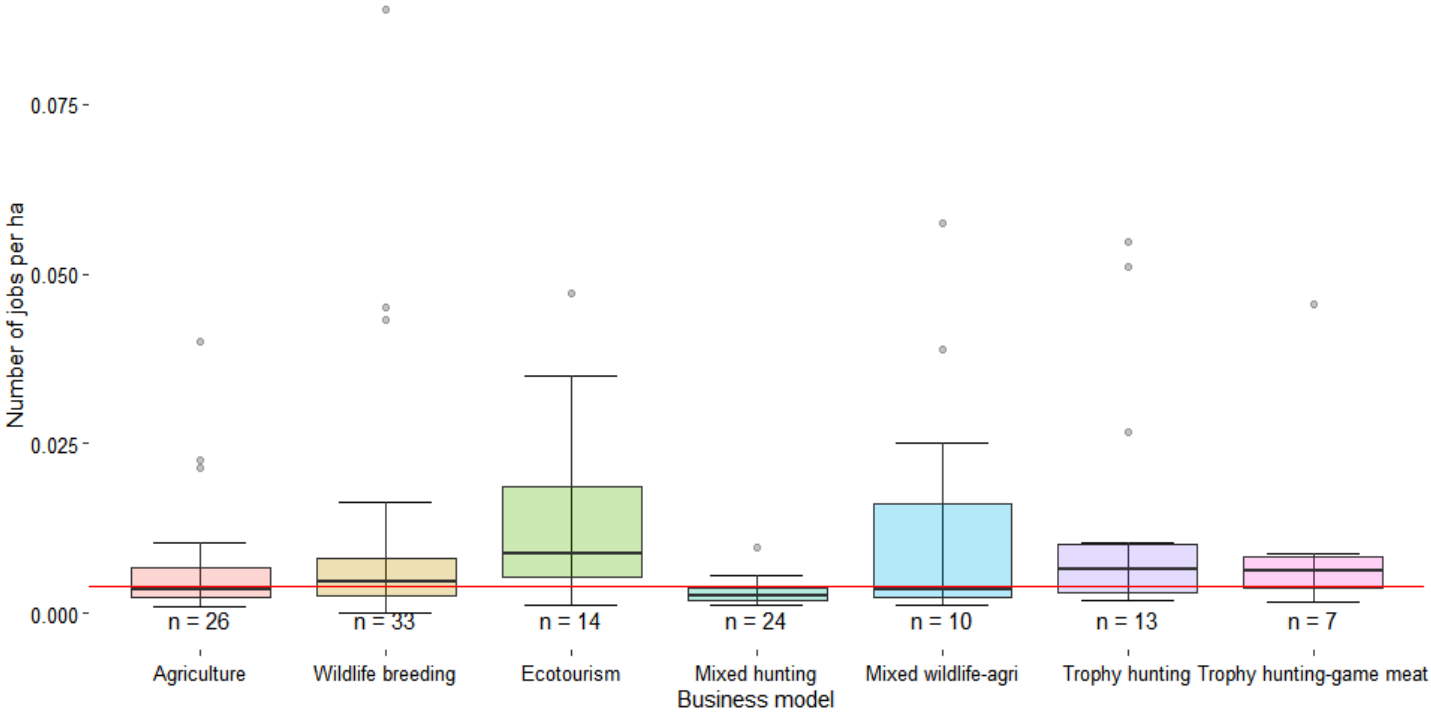


Figure 7: The number of jobs per hectare (ha) of land on wildlife ranches across different business models and the conventional agriculture business model. Two outliers were removed from the plot: a wildlife breeding property that provided 0.19 jobs per ha and an ecotourism properties that provided 0.2 jobs per ha. Sample sizes for business models are given below each boxplot. The red horizontal line intercepts the agriculture business model median.

Quantity of jobs per ZAR of operating expenditure (labour intensity)

The mixed hunting focused model had the greatest labour intensity, with a median of 7.2 jobs per million ZAR of operating expenditure (IQR = 10.88 – 3.88). This was followed by

trophy hunting, with a median of 5.48 jobs per million ZAR of operating expenditure (IQR = 10.9 - 3.67) and ecotourism, with a median of 5 jobs per million ZAR of operating expenditure (IQR = 5.79 - 3.22). The wildlife breeding focused model was the least labour intensive (median = 4 jobs per million ZAR; IQR = 9.44 - 2.34).

The number of jobs provided per 1 million ZAR of operating expenditure did not vary significantly across business models (x^2 = 1.94, df = 3, p = 0.58; Figure 8).

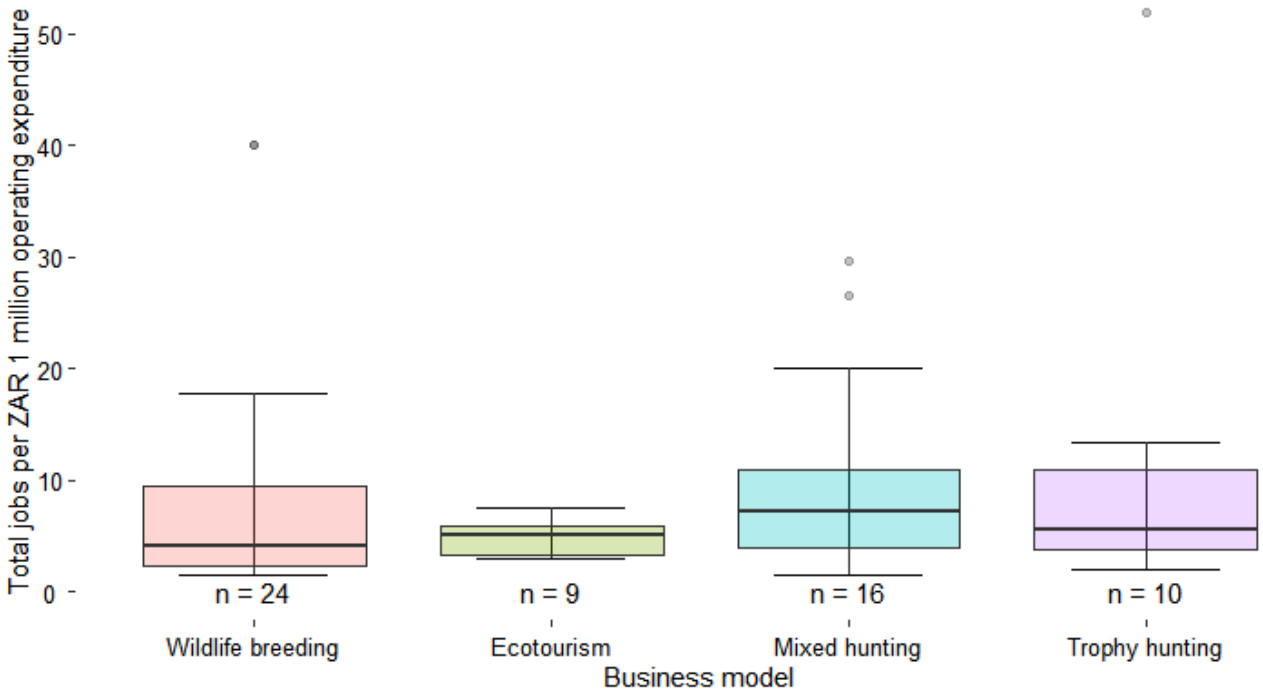


Figure 8: The number of jobs provided per million Rand (ZAR) of total operating expenditure by wildlife ranches across the wildlife breeding, ecotourism, mixed hunting and trophy hunting business models. One outlier was removed from the plot: a wildlife breeding property that provided 100 jobs per million ZAR of operating expenditure. Sample sizes for each business model are given below each boxplot.

3.2. Quality of jobs

a. Proportion of female employees

Ecotourism employed the highest number of female employees as a proportion of total jobs provided, with a median of 41% (IQR = 52 – 33%) of all employees being female (Figure 9). The conventional agriculture model had the lowest proportion of female employees with a median of 17% (IQR = 33 – 6%).

Female employees as a proportion of total jobs provided on wildlife ranches in 2019/2020 had significant variation, as explained by business model (x^2 = 18.03, df = 6, p = 0.006). Pairwise comparison tests revealed that ecotourism ranches employ a significantly higher proportion of women than wildlife breeding ranches (p = 0.04) and conventional agriculture farms (p = 0.03).

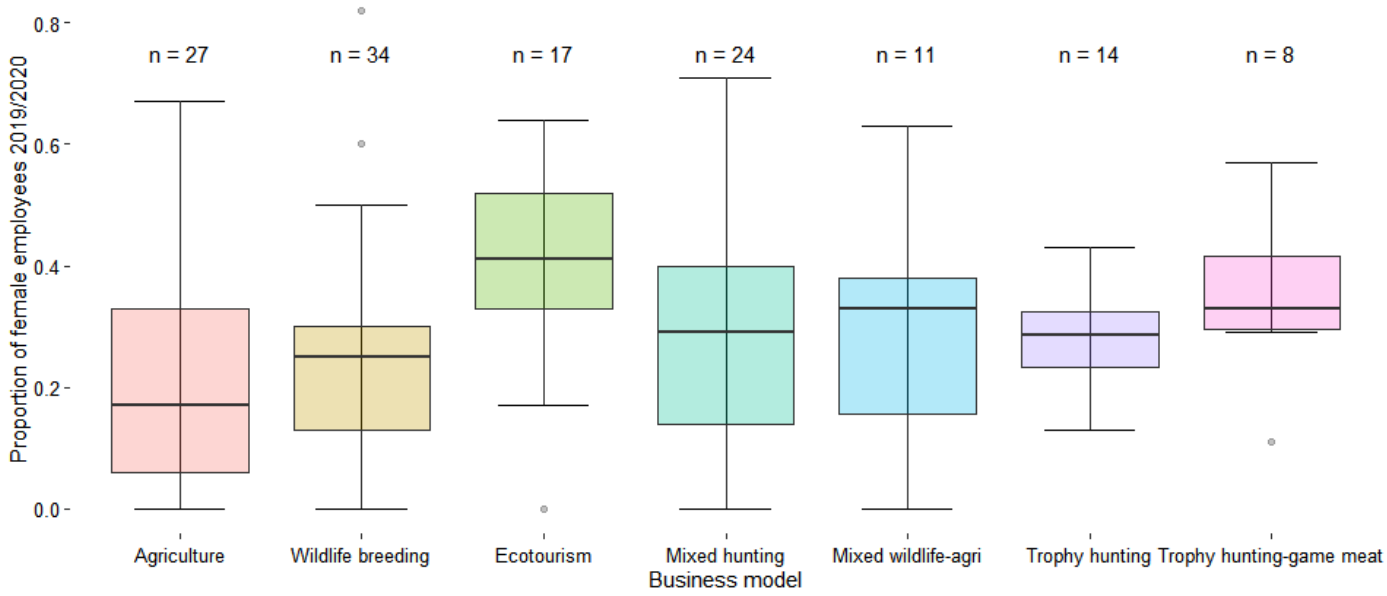


Figure 9: Female employees as a proportion of total employees in 2019/2020 for the different business models. Sample sizes are given above boxplots.

b. Proportion of seasonal employees

The trophy hunting focused model was the only model with a median proportion of seasonal jobs higher than zero, with a median of 32% (IQR = 44 – 15%; Figure 10). The proportion of seasonal employees was marginally non-significant across business models (x^2 = 12.62, df = 6, p = 0.05). The proportion of seasonal employees was highly variable across properties for the agriculture business model, whereas the ecotourism business model had low variability.

The proportion of female employees that were employed seasonally followed a similar trend to the total proportion of employees employed seasonally per business model in 2019/2020. The proportion of female seasonal employees did not differ significantly across business models (Chi-square = 6, df = 5, p = 0.307).

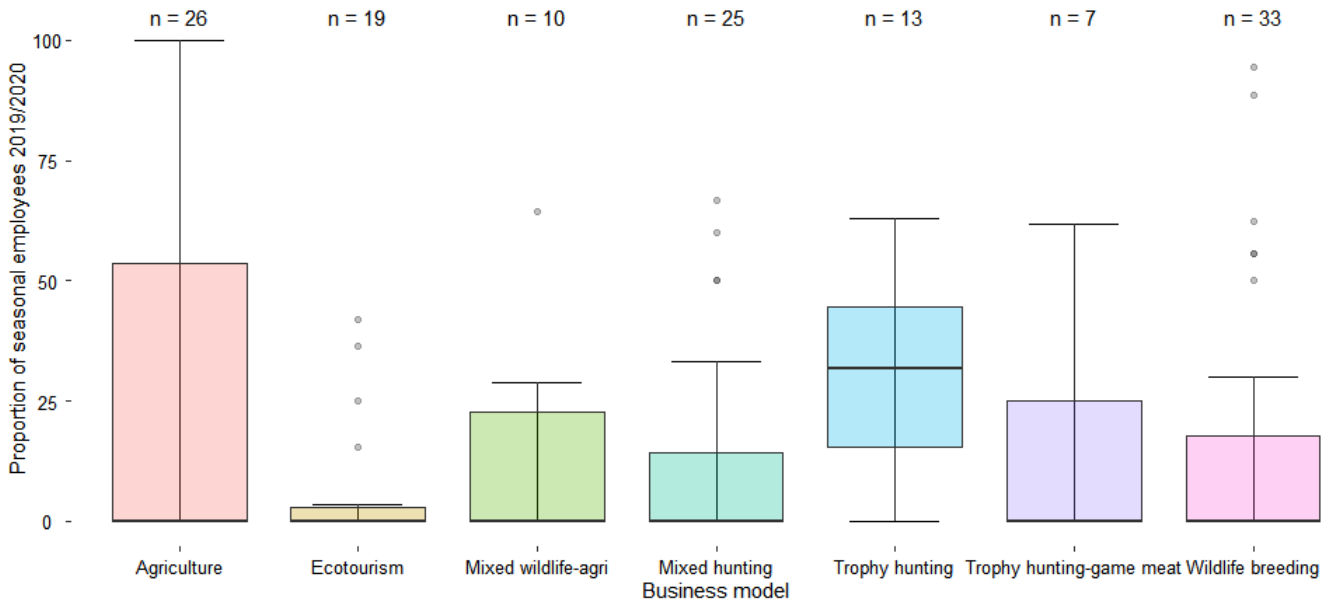


Figure 10: The percentage of employees that were employed seasonally across different business models, including agriculture. Sample sizes are given above each boxplot.

c. Proportion of skilled employees

Across all business models, ecotourism employed the highest proportion of skilled employees, with a median of 45% (IQR = 73% - 25%) of skilled employees as a proportion of total employees (Figure 11). Three business models had a median of 0 skilled workers employed on ranches: agriculture (IQR = 10% - 0), mixed wildlife-agriculture (IQR = 5% - 0) and trophy hunting-game meat focused models (IQR = 19% - 0).

Significant variation in the proportion of skilled employees working on wildlife ranches was explained by business model (x^2 = 36.86, df = 6, p = 1.87e-06). Pairwise comparison tests revealed that ecotourism employed significantly more skilled employees than agriculture (p < 0.001) and mixed wildlife-agriculture (p = 0.01). Wildlife breeding ranches also employed significantly more skilled employees than agriculture (p < 0.001) and mixed hunting agriculture (p = 0.01).

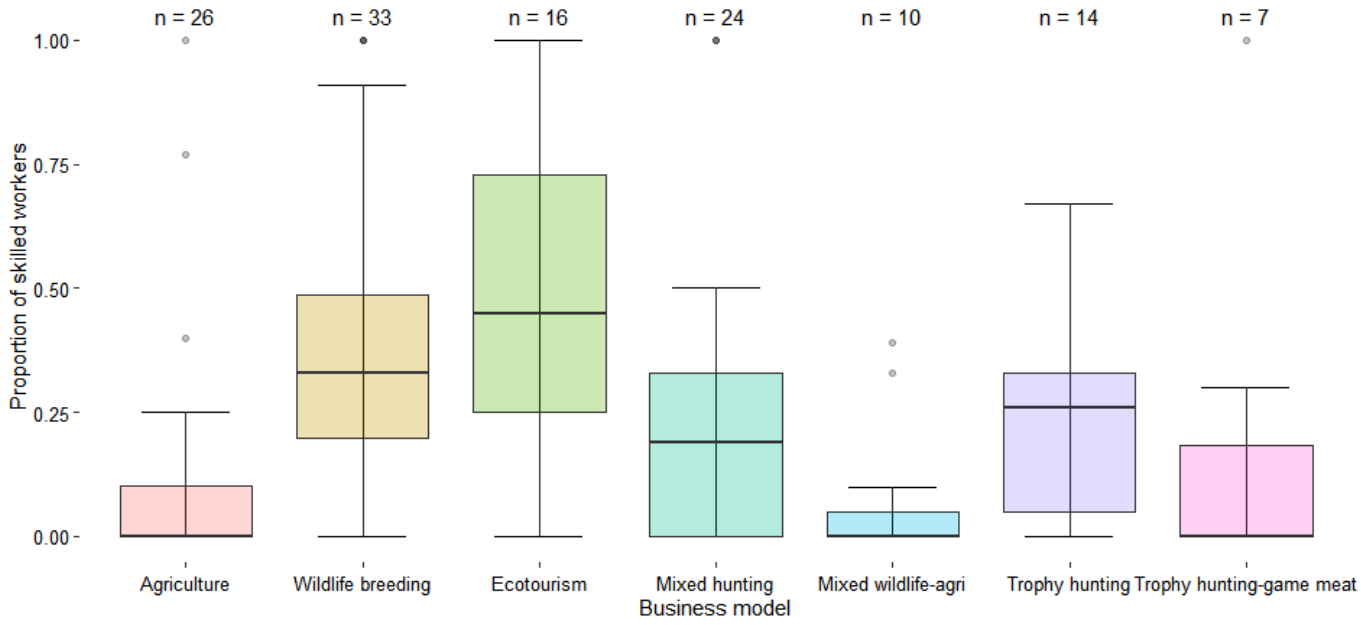


Figure 11: Skilled workers as a proportion (%) of all employees across all business models, including conventional agriculture. Sample sizes for business models are indicated above each boxplot.

d. Non-salary benefits

In terms of non-salary benefits provided to employees on wildlife ranches, eight main themes emerged: housing, food, rates, transport, uniforms, financial insurance, gratuities and upskilling (Table 2). Other benefits not included in these themes were grouped in the ninth theme, "other", as they were stated as non-salary benefits less than five times.

The most commonly provided non-salary benefits were housing, which was provided by 83% of all respondents and food, which was provided by 75% of respondents. Trophy hunting and mixed hunting focused business model respondents provided the greatest variety of non-salary benefit types as they were the only business models that had respondents providing all nine themes of benefits (Table 2, Figure 12).

No association was found between business model and the types of non-salary benefits provided by individual properties across business models (x^2= 45.65, df = 48, p = 0.57).

Table 2: Non-salary benefits provided by respondents to their employees grouped according to the main themes. A description of each theme and the proportion of all ranches (including all business models) providing this benefit is also indicated. Business models that had the highest and second highest proportion of respondents providing the non-salary benefit are also listed with the proportion of respondents that provided each benefit per model. Sample sizes were as follows: wildlife breeding = 42, ecotourism = 25, trophy hunting = 36, mixed wildlife-agriculture = 20, trophy hunting-game meat = 11, mixed hunting = 29 and agriculture = 28.

Non-salary benefit	Description	**Proportion of all ranches providing this benefit (%)**	**Business models with most and second-most respondents providing benefit**
Housing	Free on-site or off-site accommodation	83	Trophy hunting (94%) Mixed hunting (92%)
Food	Game meat rations, groceries, meals, farm produce	75	Trophy hunting (92%) Mixed-hunting agriculture (80%)
Rates	Water and electricity	41	Mixed wildlife-agriculture (65%) Agriculture (54%)
Transport	Transport between farm and town, fuel for personal vehicles	35	Mixed hunting (52%) Trophy hunting-game meat (45%)
Uniforms	Uniforms, other clothing	23	Trophy hunting (28%) Trophy hunting (24%)
Other	Wood, Wi-Fi, cellphones/airtime, TV, appliances, laundry service	15	Mixed hunting (28%) Wildlife breeding (14%)
Financial insurance	Pension, provident fund, funeral benefits, medical benefits, Unemployment Insurance Fund (UIF) contributions	13	Ecotourism (27%) Wildlife breeding (14%)
Gratuities	Gratuities/tips	9	Trophy hunting (25%) Mixed hunting (14%)

Upskilling	Training, education of employees or their children	9	Trophy hunting-game meat (18%) Ecotourism (16%)

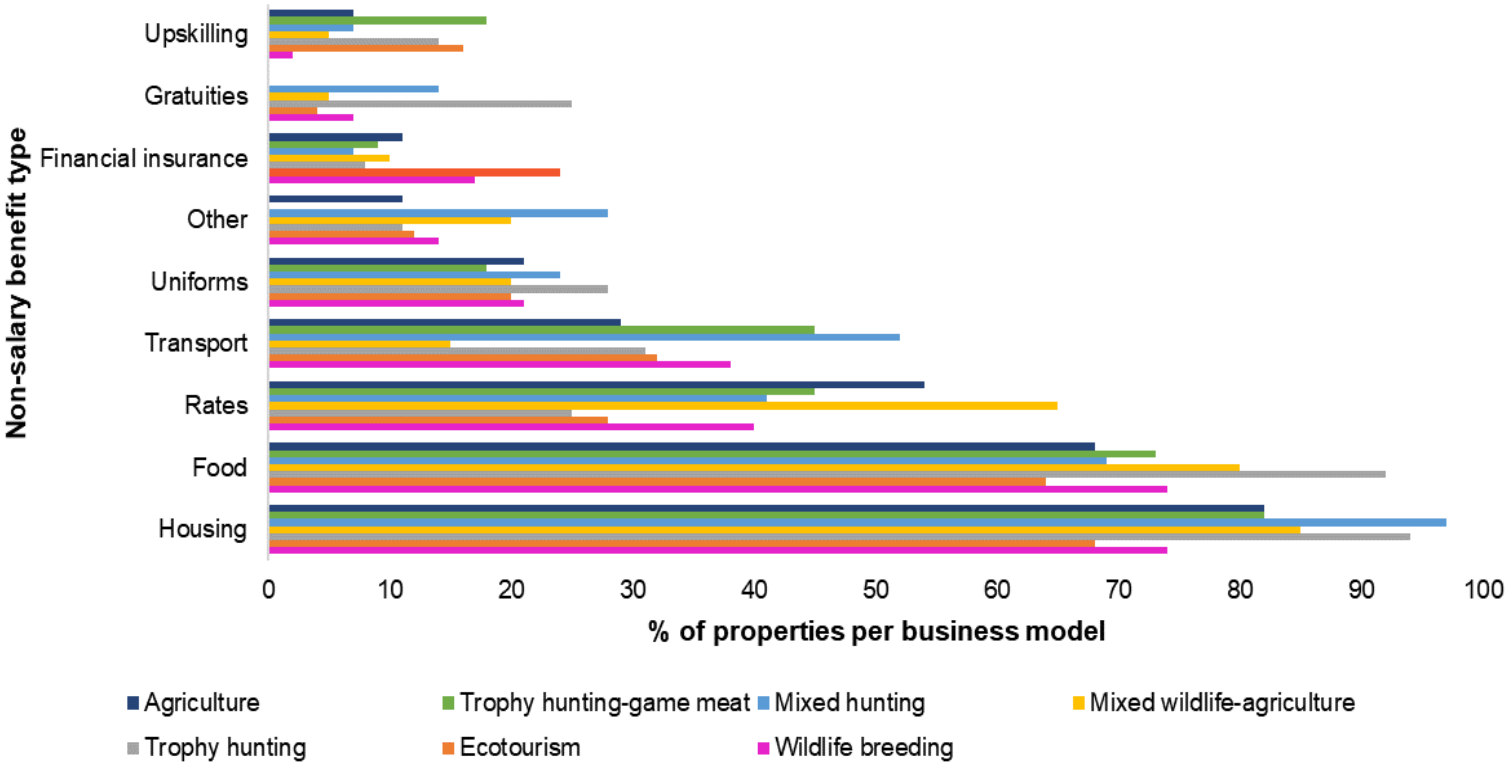


Figure 12: The proportion of properties within each business model that provided non-salary benefits included in nine themes

4. Sustainability of different business models

4.1. Profitability of wildlife ranches

For the financial year 2019/2020, wildlife breeding focused ranches had an operating profit margin of zero (IQR = 13.15 – (1145.75 %; Figure 13). Trophy hunting ranches had a median operating profit margin of 33.24% (IQR = 47.8 – 29.5%) while mixed hunting ranches had a median operating profit margin of 12.22% (IQR = 41.52 – (-13.84)%). Ecotourism ranches had a median negative operating profit margin of -9.87% (IQR = 14.02 – (-32.22)%).

Business model explained significant variation in the response variable operating profit margin in 2019/2020 (x^2 = 10.34, df = 3, p = 0.02). Pairwise comparison tests revealed that

trophy hunting ranches had significantly higher operating profit margins than ecotourism ($p < 0.01$) and wildlife breeding ranches ($p = 0.04$).

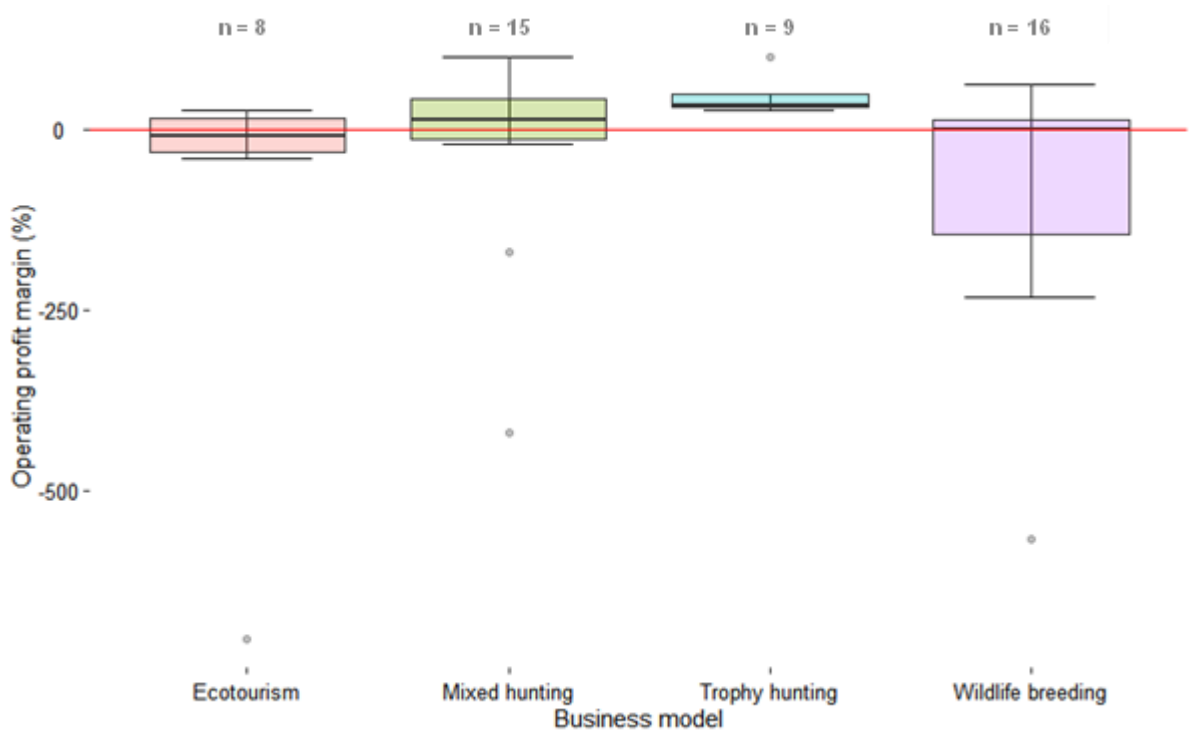


Figure 13: The operating profit margin (%) of ecotourism, mixed hunting, trophy hunting and wildlife breeding focused business models after the 2019/2020 financial year. One outlier was excluded from the plot: a mixed hunting focused property with a -1900% profit margin. Sample sizes of business models are indicated above each boxplot. The red horizontal line intercepts 0 on the operating profit margin (%) axis.

4.2. Impact of Covid-19 on financial metrics

The greatest decrease in revenue was experienced by the ecotourism focused business model, which experienced a median of 59.21% less revenue (IQR = 9.02 – (-74.29)%). Mixed hunting focused ranches had a median increase in revenue of 55.56% (IQR = 156.25 – (-20.26)%). Wildlife breeding and trophy hunting focused models both experienced a decrease in revenue as well, with a median 8.34% (IQR = 40.24 – (-38.33)%) and 53.95% (-21.25 – (-66.92)%) decrease respectively. The percentage change in total revenue post-pandemic differed significantly across business models (x^2 = 9.07, df = 3, p = 0.03). Pairwise comparison tests did not show where significance was found, but the most variation existed between the trophy hunting and mixed hunting focused models (p = 0.11).

The greatest change in operating expenditure post-pandemic was for trophy hunting focused ranches, which had a 15% decrease in costs (IQR = 4.17 – (-46.25); Figure 14). Ecotourism focused ranches had a decrease of 14.2% (IQR = 0 – (-33.18)%). Both wildlife breeding and mixed hunting focused models had no change in operating expenditure. Percentage change in operating expenditure post-pandemic did not differ significantly across business models ($x^2 = 8.12$, df = 5, p = 0.15).

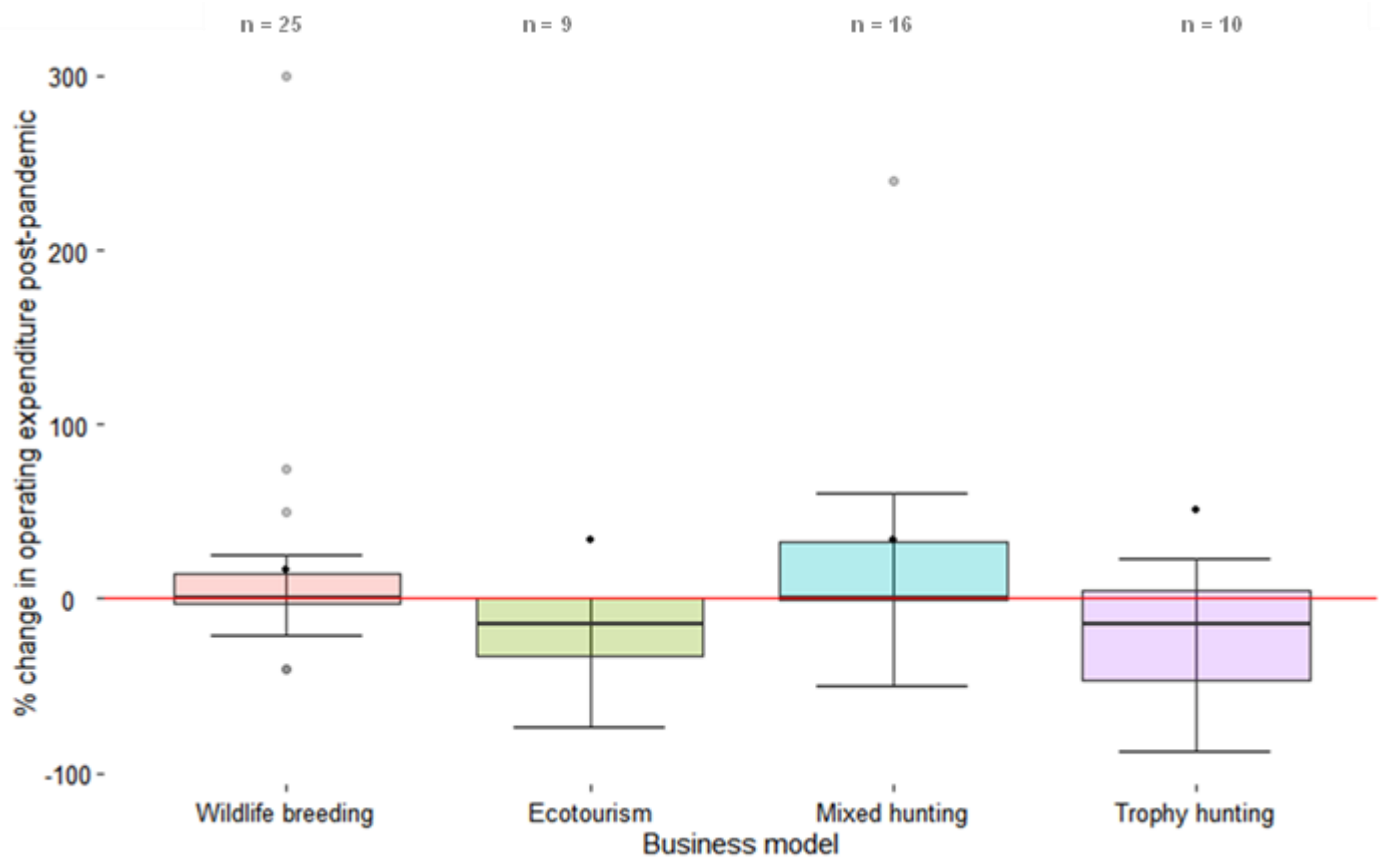


Figure 14: The percentage change in total operating expenditure of different business models prior to the pandemic (financial year 2019/2020) to the post-pandemic financial year (2021/2022). Sample sizes are indicated above each boxplot. The red horizontal line intercepts 0 on the % change in operating expenditure post-pandemic axis

All business models had a lower operating profit margin in 2021/2022 than in 2019/2020 (Figure 15). Ecotourism focused ranches experienced the greatest decrease in profit (median = -112%, IQR = 24.93 – (-510.31)), whilst trophy hunting and wildlife breeding focused models both had a 100% decrease in profit and mixed hunting had a 72% decrease in profit.

The change in operating profit margin of ranches from 2019/2020 to 2021/2022 did not differ significantly across business models ($x^2 = 3.48$, df = 3, p = 0.32).

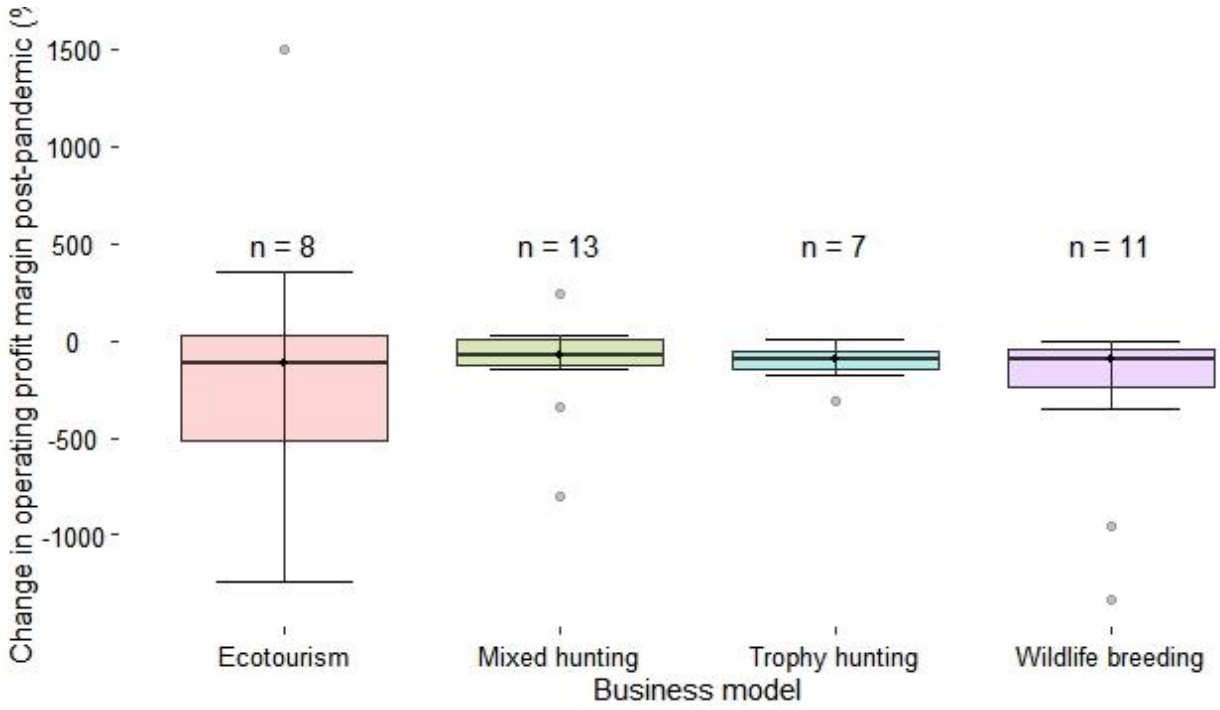


Figure 15: The proportion (%) of change in operating profit margins across business models from the 2019/2020 financial year to the post-pandemic 2021/2022 financial year. Sample sizes for each business model are indicated above each boxplot. One outlier was removed: a trophy hunting property with a 5021% decrease in profit margin.

4.3. Impact of Covid-19 on employment

The change in the number of jobs provided prior to Covid-19 compared to the number of jobs provided in 2021/2022 was greatest for the trophy hunting focused business model, with a median 29.4% decrease in jobs (IQR = -43.33 – 0%; Figure 16). Ecotourism and wildlife breeding focused models also decreased the number of jobs provided with a median decrease of 12.5% (IQR = -44.64 – 0%) and 5.48 % (IQR = -35 – 0%) respectively. Mixed hunting, mixed wildlife-agriculture and trophy hunting-game meat focused models did not experience a change in the number of jobs provided pre- to post-pandemic.

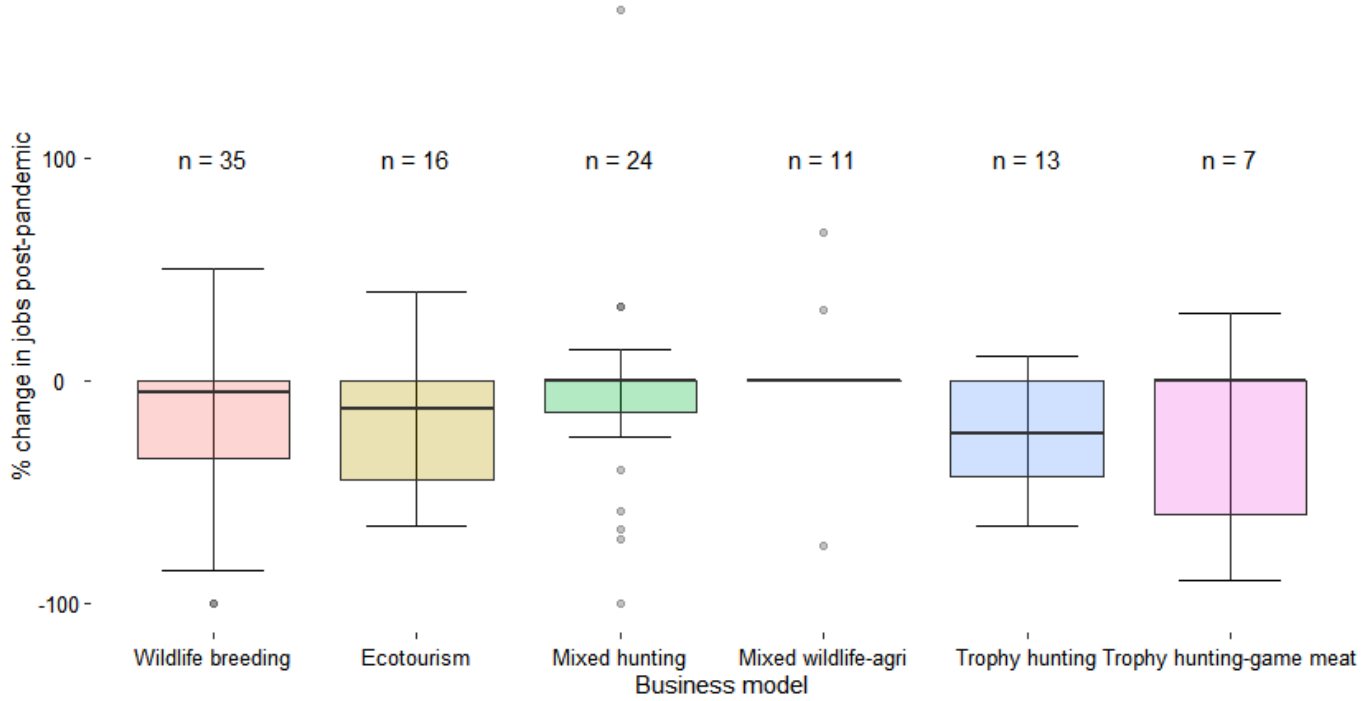


Figure 16: The percentage change (where change refers to increase and decrease) in the number of jobs provided per business model prior to the pandemic (2019/2020) to the present post-pandemic state (2021/2022).

The percentage change in the number of jobs provided pre-pandemic relative to the present did not vary significantly between the different business models (x^2= 7.58, df = 5, p = 0.18).

4.4. Perceived viability of main revenue-generating activities

The proportion of all respondents that perceived the most common revenue-generating activities to be financially viable in the future (10 years or more) did not differ greatly between wildlife-based land uses (Figure 17). The difference between perceived viability of some wildlife-based activities and some agricultural activities was greater, however. Trophy hunting was perceived to be viable in the long-term by 50% of respondents, whereas livestock farming and cultivation was perceived as viable by 36% and 11% of respondents, respectively.

A significant association was found between the perceived viability of different revenue-generating activities (x^2 = 23.18, df = 6, p < 0.001). Pairwise Chi-square comparisons were performed, at an adjusted significance level of 0.006; however, pairwise significance was not detected.

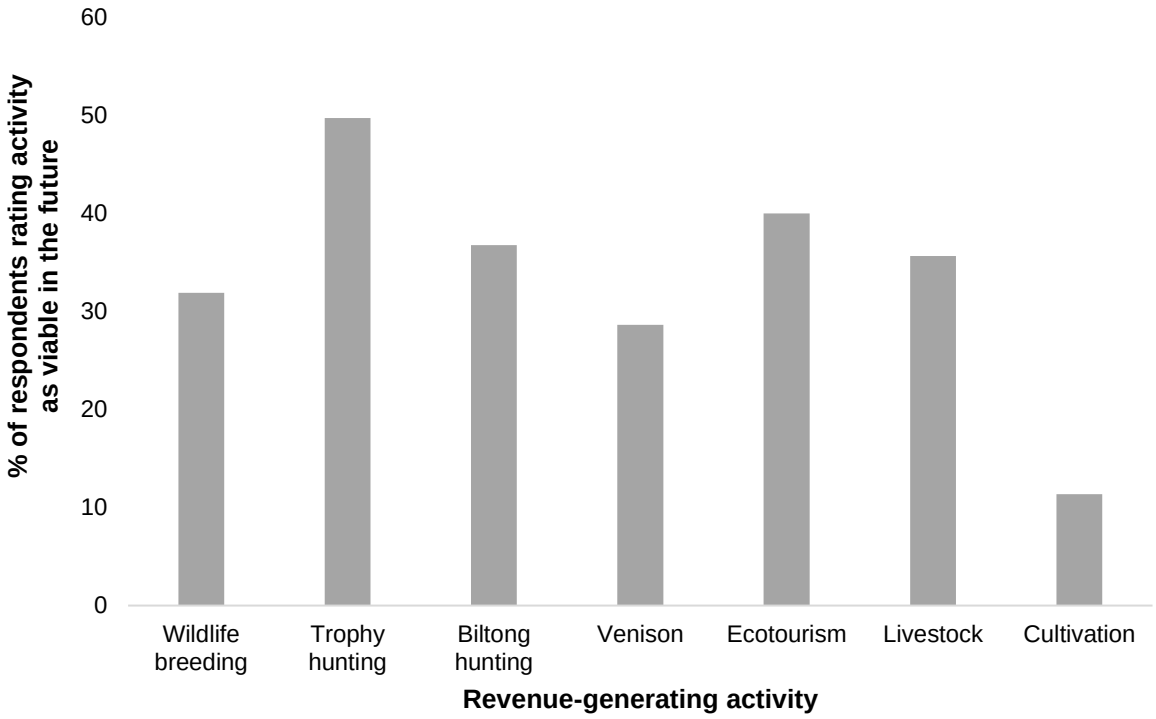


Figure 17: The proportion of wildlife ranch landowners/managers (n = 186) that perceive the seven most common revenue-generating activities as financially viable in the future

Discussion

The socio-economic contributions of wildlife ranches are under-represented, especially in terms of comparisons between the contributions of different business models to the economy, people and their livelihoods (Taylor *et al.*, 2020). Using hierarchical clustering analysis, I was able to distinguish six wildlife-based business models: ecotourism, trophy hunting, mixed hunting, mixed wildlife-agriculture, wildlife breeding and trophy hunting-game meat focused models. I was able to determine that wildlife ranches make positive economic contributions, although the scale thereof differs according to business model. Trophy hunting and ecotourism focused business models had the largest ranches and the highest revenues and running costs on average. I was able to compare the contributions that different business models make to the livelihoods of local people. Service-oriented business models (trophy hunting and ecotourism) employed more people than production-oriented models. These two models also employed more people than the conventional agriculture model. The ecotourism model employed 41% female employees, provided only permanent jobs and employed the most skilled workers on average. The conventional agriculture model employed significantly less women than ecotourism and provided no skilled jobs. Wildlife ranches commonly provide food and housing as non-salary benefits, whilst trophy hunting

and mixed hunting ranches provide the greatest variety of non-salary benefit themes. Lastly, this study found that, just as the socio-economic contributions of wildlife ranches differ, the financial viability and response to large-scale threats, e.g. Covid-19, of these ranches also differ. I found that, pre-pandemic, profitability of ranches was highly variable and that ecotourism was not profitable whilst trophy hunting was highly variable. Although all models had reduced profits after Covid-19, the mixed hunting model was impacted the least, which highlights diversification of revenue-generating activities as a key strategy to increase sustainability. Understanding the socio-economic contributions of different business models in the wildlife economy can better inform policy and management related to the sector, which will benefit a diverse variety of stakeholders.

Different wildlife ranching business models

This study has been the first to delineate wildlife ranching business models based on their revenue-generating activities, as others have grouped ranches according to main land-use types (Taylor *et al.,* 2016; Taylor *et al.*, 2020) or a combination of characteristics including biophysical aspects, affordability, accessibility, activities, infrastructure and target market (Clements *et al.*, 2016). The approach used here to deduce business models allows for a more nuanced approach to investigating the differences and similarities between business models, which have been shown to rely on a variety of combinations of activities (Figure 3). Certain business models, like trophy hunting-game meat and mixed hunting focused models, are more diversified in terms of revenue generation than others, like ecotourism and trophy hunting focused models. This diversification may be due to secondary activities that result from aspects of some models' main activities. For example, the wildlife breeding focused model earns a higher proportion of revenue from cultivation than other non-agriculture-focused models. This is likely because crops (e.g., lucerne) must be cultivated as fodder for their animals, which are more intensively managed than is the case for other models (Taylor *et al.*, 2016). The proportion of revenue generated by trophy hunting in the trophy hunting-game meat focused model is just less than revenue from venison. Trophy hunters do not keep the meat of hunted animals (Taylor *et al*., 2016), and trophy hunting-game meat focused ranches can therefore capitalize on this by-product of hunting by selling it.

This diversification of revenue generating strategies has been noted in other studies and is used to buffer against economic instability in the relatively young ranching sector (Taylor *et al.*, 2020). While some activities are complementary, others may be in conflict with each other. Some business models may not practice certain activities due to incompatibility with their main income stream. Ecotourism focused ranches had low proportions of hunting and agriculture, as these would contrast with the experience of natural wilderness preferred by

the largely foreign client base attracted to this model (Sims-Castley *et al.*, 2005). Ecotourism and trophy hunting focused ranches had the highest proportion of foreign visitors, which was unsurprising as ranches with these land-use types have been found to rely on an international market (Clements *et al*., 2016; Taylor *et al.*, 2016). Mixed hunting focused ranches had the lowest proportion of foreign visitors. This is likely due to their reliance on biltong hunting, which is practiced by South Africans (Taylor *et al.*, 2016) as well as perhaps a targeted emphasis on the local ecotourism market.

Economic contributions of wildlife ranches

Although business model was not a significant predictor of the size of ranches, this was likely due to high variability in ranch size within some models. Despite this, there was a large difference between the largest median ranch size, which was for the trophy hunting focused model, and the smallest size, for the mixed wildlife-agriculture focused model. The large size of trophy hunting ranches found here concurs with Clements *et al*. (2016) who showed that hunting reserves were associated with high capital costs, including a large land area and several species of game. The smaller size of mixed wildlife-agriculture ranches may indicate a conversion of these ranches from purely conventional agriculture focused operations (which were similarly small on average), with no additional land being purchased. The proportion of revenue from hunting on mixed wildlife-agriculture ranches is low, which would negate the need for a larger ranch size. Although the size of ranches in combination with the value of the land, associated infrastructure and wildlife would provide a more comprehensive assessment of upfront capital investment (Clements *et al.*, 2016), ranch size was used here as a proxy as the costs of land, infrastructure and wildlife were not included in the survey. Ranch size is important as several other factors depend on and are related to this variable. These factors include capital upfront investment and costs associated with improvements to land, infrastructure and mechanisation requirements, labour and fixed costs and production area (Chiyangwa, 2018).

Total revenues per year (in a non-pandemic year) were highest on average for the trophy hunting focused model, followed by the ecotourism focused model. My results differ from the most recent assessment of revenues across land-use types, where revenues were measured as median annual revenue per hectare of land, and found to be highest for properties focused on live sales of game, followed by trophy hunting (Taylor *et al.*, 2016). The wildlife breeding focused model in my study most closely resembles the live sales model in their study. Although this result is not significant, my finding that wildlife breeding has lower revenues than trophy hunting and ecotourism is likely due to a sustained decline in live sales prices of many game species since 2019 (Taylor *et al.*, 2020). Although ecotourism

revenues in the Eastern Cape have been found to be high, these studies were based on a small sample of high-end ecotourism properties (Taylor *et al.*, 2016). While the ecotourism focused model in my study also had high annual revenues, it had high variability, as my sample included low-end ecotourism properties instead of analysing the two types of ecotourism separately as was done by Clements *et al*. (2016). My study represents the most recent findings comparing the annual revenues of different wildlife-based business models. However, to assess the financial viability of business models accurately and understand their contributions to the economy (as opposed to money simply accrued to the owner) revenue results should only be considered in conjunction with operating expenditure and profitability.

In terms of running costs, which are used here as a proxy for expenditure in the economy, the highest expenditure by a business model was for the trophy hunting focused model. Ecotourism focused ranches also had high operating expenditure, but the business model had considerable variation which is likely due to it containing both high-end and low-end establishments, as the costs would differ greatly between these two categories. A plausible explanation for high operating expenditure for these two models, especially when compared with the significantly lower operating expenditure associated with mixed hunting focused ranches, is that both these models are more service-oriented, as opposed to production-oriented. Creating wildlife experiences for customers on ranches should be expected to carry higher running costs. Service-oriented ranches still carry the operational costs that other ranches do but with additional costs incurred by services such as professional hunters (PH), guides, trackers, accommodation, food, beverages and transport for clients (Taylor *et al.*, 2016). Although the mixed hunting model also relies on trophy hunting for revenue, it does so to a lesser extent and also generates revenue from biltong hunting, which is associated with lower expenses. The mixed hunting model had a far lower proportion of foreign visitors than both ecotourism and trophy hunting (Appendix 3), and foreign visitors expect more high-end experiences that would cost more to provide (Clements *et al.*, 2016). Studies analysing the operating expenditure of wildlife ranches are limited, either because data on costs were only used for profit analyses (Clements *et al*., 2016; Taylor *et al.*, 2020), or because there was a lack of answers pertaining to sensitive financial information (Taylor *et al.*, 2016). My results show that due to high capital costs associated with purchasing land for ranches, and the high costs associated with running these ranches, wildlife ranches make positive economic contributions to the economy. These findings are in agreement with those of others, who have shown that wildlife ranching makes a significant contribution to the economy, especially when compared to other land uses, like livestock production (Cloete and Rossouw, 2014; Chiyangwa, 2018). Importantly, these contributions vary by business model.

Employment across different business models

Wildlife ranches also make important socio-economic contributions through the quantity and quality of jobs they provide. Here, these contributions are shown to differ between business models. Again, the service-oriented models employ more people to cater directly to customers. For example, ecotourism focused ranches provided the highest number of jobs, followed closely by trophy hunting ranches. Ecotourism enterprises, especially high-end establishments, are characterised by the presence of expensive lodges, which can be expected to require more staff to operate efficiently. The differences between high-end and low-end ecotourism ranches were not analysed here, as done by Clements *et al*. (2016). This likely explains why high variability exists in the number of jobs and other analysed factors for the ecotourism focused model. My findings differ from those of Cloete and Rossouw (2014), who used a Social Accounting Matrix-based Leontief multiplier analysis to assess the economic contribution of South African wildlife ranches. They found that wildlife ranches only make a small contribution to direct job creation, especially when compared with extensive livestock production. I show that this difference is more nuanced than suggested by Cloete and Rossouw (2014). For example, both trophy hunting and ecotourism focused models provided a far higher median number of jobs than the conventional agriculture model (Figure 6). The number of jobs provided by agriculture ranches were similar to the wildlife breeding, trophy hunting-game meat, mixed hunting and mixed wildlife-agriculture focused models.

Although the total jobs per hectare results shown here were lower than results from previous studies, these studies also found that wildlife ranches employ more people than livestock farms but that this is management-specific, i.e., only for some business models or land-use types (Sims-Castley *et al.*, 2005; Child *et al.*, 2012; Taylor *et al.*, 2016; Taylor *et al.*, 2020). The mixed hunting focused model provided the lowest number of jobs, both in total and per hectare of land, but it was also the most labour-intensive model (Figure 8), meaning labour costs are proportionally higher per ZAR of operating expenditure than those of other models (Altbeker and Masiangoako, 2019), although these results were not significant. This could be due to a large proportion of mixed hunting ranch revenue coming from trophy hunting, which was also found to be labour-intensive, both here and by Taylor *et al.* (2016). Surprisingly, the wildlife breeding focused model did not have high labour intensity which was expected due to the industry being more management-intensive since many specialists are required for

translocations associated with wildlife breeding and live sales (Taylor *et al.*, 2016). Labour intensity may be lower than expected as these specialist roles may be assigned on a contractual basis by the party who purchased game and arranged translocation rather than the owner/manager of the ranch from where translocations of bred animals occur. As we only collected data from landowners and not from associated service providers, it was not possible to measure the full value chain. Ecotourism had the third highest labour intensity despite high operating costs and several jobs being associated with this model, however, variation in the business model due to the inclusion of both high-end and low-end establishments is likely why this model did not rank higher for labour intensity.

My findings represent the most comprehensive comparison of job quality metrics across business models, and in comparison to the conventional agriculture model. No previous studies analysing jobs provided by wildlife ranching assessed the proportion of female employees on ranches, except a case study from Limpopo that found women to form 40% of the workforce on a small game farm that was not operating commercially (Hall *et al.*, 2013). My findings showed that ecotourism focused ranches employed 41% female employees on average, which was significantly higher than both the conventional agriculture model and the wildlife breeding model. This result concurred with that of Spierenburg (2020), who stated that high-end ecotourism employs more people, and women. However, Spierenburg's (2020) case study based on one ecotourism reserve criticised ecotourism enterprises for providing temporary jobs.

Here, I show that all wildlife-based business models including ecotourism, but excluding trophy hunting, provide a median of zero seasonal jobs (Figure 10). While agriculture focused ranches also employed a median of zero seasonal workers, there was high variability across farms. Although the difference in the proportion of seasonal staff was not statistically significant, trophy hunters may employ a higher proportion of seasonal staff as specialist hunting staff (PHs, skinners, trackers etc.) are employed per client booking or for the hunting season. Previous studies that analysed the number of jobs on wildlife ranches did not assess the number or proportion of seasonal workers, or the proportion of skilled and unskilled employees (Driver *et al.*, 2019).

As classified by salary brackets, I found that the ecotourism focused model provided the most skilled jobs, closely followed by wildlife breeding. These models, therefore, likely provide a higher level of job satisfaction (Gammarano, 2020) than agricultural business models, including conventional agriculture and mixed wildlife-agriculture, which provided zero skilled jobs on average (Figure 11). My results concur with previous studies which also

found that ecotourism ranches provide higher wages to workers than agriculture does (Sims-Castley *et al.*, 2005; Taylor *et al.*, 2016).

Although there is limited knowledge on the non-salary benefits provided to employees of wildlife ranches, these benefits should be studied further as they have the potential to contribute further to employees' livelihoods and wellbeing. Communal conservancies in Namibia provide non-financial benefits to conservancy members (not all of whom are employees), mainly in the form of game meat but also training, meals, compensation for human-wildlife conflict and donations to the community (Naidoo *et al.*, 2016). The Save Valley conservancy in Zimbabwe and Klaserie and Timbavati conservancies in South Africa provide non-salary benefits to the community in the form of income from hunting, HIV/Aids awareness programs, staff training and ecological training (Kreuter *et al.*, 2010). In this study, housing and food were the most common non-salary benefits received by ranch employees. Trophy hunting and mixed hunting focused models both had representation on some ranches of all nine themes of non-salary benefit types identified here. Furthermore, many wildlife-based ranch employees have the opportunity to benefit from further income from gratuities, which agriculture and trophy hunting-game meat focused ranches do not offer to employees. Several ecotourism ranches provided notable opportunities to employees in the form of financial insurance and upskilling programs. In addition to the in-kind benefits employees receive as found here and by other studies (Sims-Castley *et al.*, 2005; Taylor *et al.*, 2016), wildlife ranches also contribute to neighbouring communities through funding of local schools and medical services and by providing meat as a protein source (Lindsey *et al.*, 2013a). Besides the on-ranch skilled, semi-skilled and non-skilled jobs, the wildlife ranching industry also provides several off-ranch jobs to multiple sectors, especially community, social and personal services (Rossouw and Cloete, 2014). In addition to my findings, these benefits to communities represent a strong case for the positive social impacts of wildlife ranches. However, case studies of Timbavati and Klaserie conservancies in South Africa show that it is important for landowners or managers to include communities in decision-making processes if they are to feel that benefits from wildlife-based activities are not merely "hand-outs" (Kreuter *et al*., 2010).

Sustainability of different business models

My results show that, although wildlife ranches are potentially profitable, this differs among business models (Figure 13). As found in previous studies (Musengezi *et al.*, 2010; Clements *et al*., 2016; Taylor *et al.*, 2020), the profitability between properties was highly variable. Musengezi *et al.* (2010) assessed turnover, gross profit margin, which differs from operating profit margin by excluding fixed costs, and net profit margin, which excludes fixed

and variable costs, and found that wildlife ranches have a comparative economic advantage, meaning ranches are the best place for South Africa to allocate resources, especially land. Profitability was highly varied and differences between business models were not explicitly considered, however (Musengezi *et al*., 2010). Cloete and Rossouw (2014) also found that wildlife ranching is both profitable and more profitable than extensive livestock farming, although this was prior to the considerable decline in live game sales prices since 2017 (Taylor *et al.*, 2020).

More recent findings assessed differences in profitability (in profit/ha) between different land-use types and found that properties with wildlife-based land uses only were more profitable than mixed farms and that intensive breeding farms were highly profitable (Taylor *et al.*, 2020). My findings differed in that wildlife breeding focused ranches were not profitable on average, although I did not account for differences in intensity of breeding operations. My findings that trophy hunting was the most profitable business model and that ecotourism reserves were not profitable contrasts with previous findings that determine hunting reserves to be unprofitable and ecotourism reserves (high-end only) to be very profitable (Clements *et al., 2016)*. This could be because the business models developed in Clements et al. (2016) were based on several ranch characteristics, whereas in my analysis they were based on revenue-generating activities only. This result is also likely due to the variability within my ecotourism model, as I did not separate different types of ecotourism (i.e. high-end and low-end) as done by Clements *et al*. (2016). The influence of high variability in profitability can also result in significant differences in the financial viability of business models over time. The profitability results presented here agree with Clements *et al.* (2016) and suggest that profitability should be studied on a temporal scale, as socio-economic processes change frequently, causing financial viability to be highly variable over time. Profit from wildlife-based activities is also dependent on implementation effectiveness, as shown by the variability in profitability of vicuna ranching in Patagonia, which differed according to landowner experience with catching vicuna (Von Thungen and Lanari, 2010). Lastly, legislation and/or regulations of wildlife-based activities may preclude the profitability of ranching. In Cameroon, although less well-understood, trophy hunting appears to be thriving, but profitability from hunting is very low, due to non-transparency in the state allocation of hunting zones to professional guides and community-managed hunting zones to communities and complex regulations (Lescuyer *et al.*, 2016).

The findings shown here demonstrate empirical evidence that, over a two-year period from March 2020-March 2022, the Covid-19 pandemic had multiple negative impacts on different actors within the wildlife economy, especially landowners and their staff. Financially, Covid-

19 resulted in a decrease of revenues, with wildlife ranchers cutting costs, marketing more to local tourists and biltong hunters, shifting their focus to agriculture or other wildlife-based activities that are less reliant on foreign tourists or hunters and relying on off-ranch income (Clements *et al.*, in press). My findings show that, despite these adaptations and risk management strategies, and a decrease in operating expenditure for ecotourism and trophy hunting focused ranches, wildlife ranches were still greatly impacted by the pandemic, with a decrease in revenues and profit post-pandemic (Figure 15) for all business models included here. As predicted by studies using data collected soon after the onset of the pandemic (Lendelvo *et al.*, 2020; Lindsey *et al.*, 2020; van der Merwe *et al.*, 2021), many ranches also had to retrench staff, specifically, trophy hunting, ecotourism and wildlife breeding focused models (Figure 16).

Of the four business models compared here, the mixed hunting focused model was impacted the least by the pandemic, although not significantly so. Their operating expenditure did not decrease, which is likely due to fewer staff retrenchments. Biltong hunting is an important contributor to this model's revenue, which may have increased its resilience by allowing an increased dependence on local hunting revenue. The performance of the mixed hunting focused model, which relies on a unique combination of diverse revenue-generating activities, may point towards diversification as a strategy to improve resilience on wildlife ranches. From the Eastern Cape sample of wildlife ranches including in my study, Clements *et al.* (in press) found that mixed wildlife-agriculture ranches adapted most successfully to the pandemic, which was also attributed to diversification. To ensure resilience to large-scale threats, as demonstrated by Covid-19, but also in the face of many potential threats, including drought, recessions, political instability and global preference changes (Clements *et al.*, in press), it is essential to establish key measures of adaptation for wildlife ranches. My results support the previous findings of diversification as an important measure to improve the long-term sustainability of ranches. However, sustainability will likely depend on a combination of measures including emphasising the importance of wildlife-based income in Africa to allow for increased social and governmental support during major periods of instability, e.g., pandemics, and improving appeal and affordability for local visitors (Lindsey *et al.*, 2020; Taylor *et al.*, 2020; Spenceley *et al.*, 2021).

The perceived viability of common revenue-generating activities in the wildlife industry is useful as it may indicate potential investor trends and point towards changes that some ranchers may be making to their activities to become more financially viable. Here, trophy hunting is perceived as the most financially viable revenue-generating activity which agrees

with my findings that also showed the trophy hunting focused model to be most profitable. There is a growing anti-trophy hunting movement internationally, as evidenced by a recent ban on trophy hunting imports by the UK (Webster *et al.*, 2022). In terms of my findings as related to the viability of trophy hunting, it seems that wildlife ranchers are not as concerned about these developments as could be expected, despite the potential impacts the industry may face due to reduced demand. Interestingly, ecotourism is perceived as the second-most financially viable activity. This is likely due to reports of high revenues for the ecotourism industry, although the profitability results presented here show that the profitability of ecotourism is highly dependent on the type of ecotourism which is undertaken. Future studies should measure the profitability of different wildlife ranching business models over time to provide a dynamic, temporal profile of the financial viability of wildlife ranching. Given the increased interest in wildlife ranching across Africa as a result of losses suffered from ecotourism during COVID-19, this research provides important baseline information and although the South African context is quite different to many other parts of Africa, due to many/most farms being fenced, it would be good to broaden the study beyond South Africa as well and to compare country data more broadly, as well as specifically related to the different business models, as well as in terms of enabling legislation for the different business models.

Limitations and future considerations

Sample sizes for certain business models were too small to be included in some sections of analysis, as interviewees declined to answer questions related to these contributions. In particular, many interviewees did not answer questions about financial metrics (total revenues and running costs). Bolstering sample sizes for these sections by completing additional follow-up surveys was not possible, as additional fieldwork was constrained by funding and time available for fieldwork. I did not analyse provincial differences between business models. Assessing different aspects of the wildlife ranching industry between provinces will be useful in future studies, as conservation, financial and social aspects may differ according to regional conditions. It has been argued that employment should not be used to measure social development on wildlife ranches, as rights-based measures, such as access to natural resources, are excluded from the employment approach (Spierenburg and Brooks, 2014). Future studies on the social contributions of wildlife ranches should consider these measures, such as access to natural resources and land, and gender disparities outside of job opportunities and equal pay (Hall *et al.*, 2013; Spierenburg and Brooks, 2014). This study did not assess all economic contributions of wildlife ranches, as a full-scale assessment would have required information on tourist expenditure and economic

multipliers, as included in an assessment of economic contributions of Kruger National Park and adjacent protected areas (Chidakel *et al.*, 2020). Here, I also assumed that all operating expenditure contributed to the local economy, although some expenditure may be offshore. Future studies on economic contributions of ranching should employ economic multipliers to assess expenditure across the supply chain and contributions to the local and national economy. It is also important to assess what proportion of revenue from ranching is re-invested into conservation or sustainable land management, to measure the long-term sustainability of the industry.

Conclusion

To consider wildlife ranching as a land-use model that promotes conservation, the social and economic contributions and sustainability of ranching must also be understood and considered relative to other land use options such as agriculture. This study identified six different business models that have different economic contributions and cater to different markets. The differentiation between these business models is important, as it affects the socio-economic contributions that they provide, and enables more effective policy design and investment to expand the wildlife ranching industry inclusively. This study provides evidence that wildlife ranches, particularly those that fall under service-oriented business models, make significant contributions to the economy and people's livelihoods through providing jobs and additional employee benefits. Several models of wildlife ranching also provide more jobs, and jobs of a higher quality, than conventional agriculture. The findings on financial viability and sustainability of ranches presented here may better inform decision-makers, investors and new market entrants to the industry to design viable, and more resilient, enterprises. This study provides new insights into the dynamic and burgeoning wildlife ranching industry. The social and economic benefits of wildlife ranches could complement ecological benefits of the industry, if the industry is sustainably and ethically managed, and if there is re-investment in conservation and the wildlife asset base of the industry. This makes it well-positioned as part of the conservation toolkit of state and private conservation role-players and policy-makers in southern Africa, and beyond.

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Appendix

Appendix 1: Economic activities section of the SWEP survey which contained all questions relevant to this study. The study objectives analysed for each main question are included in brackets after the questions.

Section 7: Economic Activities

In this final section, we will be discussing what economic activities you undertake and the number of jobs you create. We'll also be asking about how COVID has impacted your business and how wildlife ranching can become more resilient in future.

1. Please indicate all activities that directly generate revenues for this enterprise in the average year pre-COVID and now post-COVID and note any additional activities that aren't listed in the table. (Objective 1: Determining business models within the wildlife ranching industry)

[Note – let the landowner respond verbatim and then prompt if necessary.]

General activity	Specific activity	1. Present?	2. Proportion (%) of revenue pre-COVID	2. Proportion (%) of revenue post-COVID	3. Long-term viability of activity (1=low, 5=high) and why?
Game and wildlife	Live sales of stud animals that are intensively managed (typically fed year-round)	☐			
Game and wildlife	Live sales of stud animals that are extensively managed (typically not fed year-round)	☐			
Game and wildlife	Live sales of general game	☐			
Game and wildlife	Trophy hunting	☐			
Game and wildlife	Trophy hunting - outfitter	☐			
Game and wildlife	Biltong hunting	☐			
Game and wildlife	Venison	☐			
Livestock (Stud and commercial)	Sheep	☐			

Livestock (Stud and commercial)	Cattle	☐			
Livestock (Stud and commercial)	Goat	☐			
Livestock (Stud and commercial)	Dairy	☐			
Cultivation	Cash crops rainfed	☐			
Cultivation	cash crops irrigation	☐			
Cultivation	Fodder production	☐			
Cultivation	Nursery	☐			
Eco-tourism	Day visitors	☐			
Eco-tourism	Overnight visitors	☐			
Events (weddings etc.)		☐			
Leasing of land to another farmer (e.g. grazing)		☐			
Timeshare		☐			
Levees from homeowners on the property (e.g., a sectional title arrangement)		☐			
Other or alternative sources of revenue (Please specify)		☐			

2. ***What is the relative proportion of each activity to the enterprise's total revenue in the average year and now post-COVID?*** (Objective 1: Determining business models within the wildlife ranching industry)

[Note – for the 'other sources of revenue' please specifically ensure that if the landowner mentioned value-adding facilities or processes, such as on-site abattoirs, these contributions towards revenue are included.]

3. ***Please rank each listed economic activity according to how you perceive its likely long-term viability, where 1 = very low viability and 5 = very high level of viability.*** (Objective 4: Determining the sustainability of business models and their socio-economic contributions)

4. ***What proportion of your visitors are foreign?*** (Objective 1: Determining business models within the wildlife ranching industry)

5. ***Would you be willing to tell us the enterprise's total revenue in the 2019/2020 financial year (March 2019 to Feb 2020; i.e., pre-COVID) and the current revenue in the***

2021/2022 financial year? (Objective 2: Determining economic contributions of different business models)

6. ***Please indicate all running costs incurred by this enterprise in the average year pre-COVID, and now post-COVID. Note any additional running costs that aren't listed in the table.*** *(Objective 2: Determining economic contributions of different business models)*

Note – let the landowner respond verbatim and then prompt if necessary.

Running cost type	**Description**	**6. Incurred?**	**7. Proportion of total running costs pre-COVID**	**7. Proportion of total running costs post-COVID**
Maintenance	Including of infrastructure (e.g., lodges, roads, fences,) and equipment (e.g. vehicles)	☐		
Lodge staff salaries	Including front and back of house, plus field guides and professional hunters	☐		
Ranch/farm staff salaries	Including maintenance workers, builders, etc.	☐		
Anti-poaching / security	Including contracted companies, salaries and equipment	☐		
Game purchases	Including game stock for predators and stocking new game for genetics, breeding trophy hunting, etc (include game transport)	☐		
Game management	Including veterinary bills, feed for game	☐		
Marketing	Local and international advertising of enterprise activities	☐		
Food and beverages	For visitors	☐		
Insurance	Including infrastructure, equipment, etc.	☐		
Agricultural input costs	Fertiliser, seeds, feed for livestock, vet bills, etc.	☐		
Fuel		☐		
Water, electricity, rates		☐		
Community engagement / social investment	Such as school programs, clinics, etc.	☐		
Other major expenses		☐		

7. What is the relative proportion of each running cost incurred in the average year pre-COVID and now post-COVID?

8. Would you be willing to tell us your total running costs in the 2019/2020 financial year (March 2019 to Feb 2020; i.e., pre-COVID) and the current costs in the 2021/2022 financial year?? [Excluding depreciation, financing (loans and interest) and income tax] (Objective 2: Determining economic contributions of different business models)

Now we are going to ask you about how many people you employ on this property, and any benefits they may receive.

9. ***Please could you complete this table, indicating how many permanent and temporary employees you have pre and post COVID.*** (Objective 3: Determining the social contributions (quantity and quality of jobs) of different business models)

Monthly salary category	**9. Number employed**	**10. Number of women**	**11. Type of non-salary benefits**
<R3,500 (Permanent)			
R3,500- R5,000 (Permanent)			
R5,001- R10,000 (Permanent)			
>10,000 (Permanent)			
<R3,500 (Temporary)			
R3,500- R5,000 (Temporary)			
R5,000- R10,000 (Temporary)			
>10,000 (Temporary)			

10. ***How many of these are women?*** (Objective 3: Determining the social contributions (quantity and quality of jobs) of different business models)

Note – if you are speaking to the manager (not the owner), remind them to include themselves in this count.

11. ***Are there any non-salary benefits, such as game meat rations, upskilling programmes, community services etc. for any of these employees?*** (Objective 3: Determining the social contributions (quantity and quality of jobs) of different business models)

Appendix 2: Principal component (PC) scores of seven wildlife ranch characteristics used in the cluster analysis on the first two principal components.

Characteristic	**PC1**	**PC2**
% Foreign visitors	-0.58	0.32
Wildlife breeding	0.25	-0.20
Trophy hunting	-0.65	-0.19
Biltong hunting	0.16	-0.46

Venison	-0.23	-0.21
Ecotourism	0.23	0.73
Agriculture (livestock plus cultivation)	0.19	-0.17

Appendix 3: Characteristics of revenue-generating activities across six business model clusters (mean ±SE).

	Trophy hunting focus	**Mixed hunting focus**	**Mixed wildlife-agriculture focus**	**Ecotourism focus**	**Wildlife breeding focus**	**Trophy hunting-game meat focus**
Number of properties	36	29	20	26	42	11
Properties in Eastern Cape (%)	72	24	75	42	17	73
Properties in Limpopo (%)	28	76	25	58	83	27
PC1	-0.65	0.16	0.19	0.23	0.25	-0.23
PC2	-0.19	-0.46	-0.17	0.73	-0.2	-0.22
% Revenue from:						
Ecotourism	3.17 (±0.89)	11.34 (±2.29)	11.45 (±3.91)	88.85 (±2.51)	11.29 (±2.56)	10.82 (± 3.16)
Biltong hunting	3.72 (±0.71)	31.41 (±3.98)	7.15 (±1.68)	2.88 (±1.71)	5.05 (±1.01)	11.07 (±3.44)
Trophy hunting	74.03 (±1.85)	32.07 (±3.72)	8.2 (±2.62)	1.08 (±0.78)	19.52 (±2.72)	28.91 (±7.21)

Venison	4.47 (±0.76)	4.24 (±0.8)	2.25 (±1.12)	0.15 (±0.09)	1.57 (±0.43)	29.79 (±4.66)
Wildlife breeding	7.03 (±1.19)	9.28 (±2.39)	5.3 (±1.64)	2.96 (±1.01)	54.93 (±4.18)	10.82 (±4.87)
Agriculture (Livestock and cultivation)	5.83 (±1.51)	7.03 (±2.45)	64.4 (±2.66)	0.5 (±0.46)	3.79 (±1.31)	2.68 (±2.19)
Livestock	4.86 (±1.47)	6.38 (±2.22)	56.65 (±4.84)	0.5 (±0.46)	1.74 (±1)	2.64 (±2.18)
Cultivation	0.97 (±0.62)	0.66 (±0.52)	7.75 (±3.69)	0	2.05 (±0.94)	0.05 (±0.05)
Events	0.11 (±0.09)	1 (±0.71)	0.75 (±0.55)	2.96 (±1.26)	0.71 (±0.5)	0.91 (±0.91)
Other	1.69 (±1.13)	3.62 (±1.91)	0.5 (±0.34)	0.62 (±0.58)	3.14 (±1.32)	5 (±4.52)
% Foreign visitors	92.08 (±1.55)	17.38 (±3.13)	35.1 (±8.51)	52.27 (±7.63)	41.64 (±5.71)	51.36 (±8.37)