



REPUBLIC OF NAMIBIA
MINISTRY OF ENVIRONMENT,
FORESTRY AND TOURISM



WATER USE EFFICIENCY AND ECONOMIC CONTRIBUTION OF LIVESTOCK PRODUCTION UNDER DIFFERENT GRAZING SYSTEMS IN OTJOZONDJUPA REGION, NAMIBIA

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This series of Survey report is intended to present preliminary new or topical information and ideas for discussion and debate. The contents are not necessarily the final views or firm positions of the Ministry of Environment Forestry and Tourism. Comments and feedbacks are welcomed

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ABBREVIATIONS

CF	Central Framework
FAO	Food and Agriculture Organization
LWP	Livestock Water Productivity
LU	Livestock Unit
MAWLR	Ministry of Agriculture, Water and Land Reform
MEA	Millennium Ecosystem Assessment
MEFT	Ministry of Environment, Forestry and Tourism
NDP6	Sixth National Development Plan
NSA	Namibia Statistics Agency
SEEA	System of Environmental-Economic Accounting
SEEA-EA	System of Environmental-Economic Accounting – Ecosystem Accounting
SMS	Short Message Service
WUE	Water Use Efficiency

EXECUTIVE SUMMARY

Livestock production remains a central pillar of rural livelihoods and economic activity in Namibia, particularly in the semi-arid Otjozondjupa Region. This study evaluates water-use efficiency and the economic contribution of livestock production under rotational, continuous, and mixed grazing systems, using farm-level data from 69 livestock producers and applying the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA) framework. The SEEA-EA approach strengthens the analysis by linking ecosystem condition, ecosystem service flows, and economic outcomes in a structured and policy relevant manner.

The results reveal clear differences across grazing systems. Rotational grazing demonstrates superior ecological and economic performance, including healthier rangelands, improved vegetation cover, stronger livestock offtake, higher weight gain, and greater water-use efficiency. Continuous grazing, by contrast, is associated with degraded rangelands, higher rainfall dependence, lower productivity, and weaker income outcomes. Mixed grazing systems show moderate results, reflecting partial adoption of improved management practices. These findings highlight the direct influence of grazing management on ecosystem functioning and livestock provisioning services.

Water scarcity emerged as a major constraint, with 53.6 percent of farmers reporting shortages in the past year. Farmers overwhelmingly preferred rotational grazing (46.4 percent) and expressed strong demand for government support, particularly in water infrastructure, rangeland rehabilitation, and training. Nearly all respondents (98.6 percent) emphasized the need for institutional assistance to strengthen grazing systems and improve production resilience.

From a SEEA-EA perspective, the study demonstrates how ecosystem condition particularly vegetation cover, soil structure, and water retention directly influences ecosystem service flows such as forage biomass and livestock production. Healthy ecosystems support stronger economic contribution, illustrating the value of integrating natural capital into national planning and resource management.

The study concludes that promoting rotational grazing, improving water infrastructure, rehabilitating degraded rangelands, and integrating SEEA-EA indicators into national development frameworks are essential steps for enhancing livestock productivity and long-term ecosystem sustainability in Namibia's semi-arid rangelands.

ABSTRACT

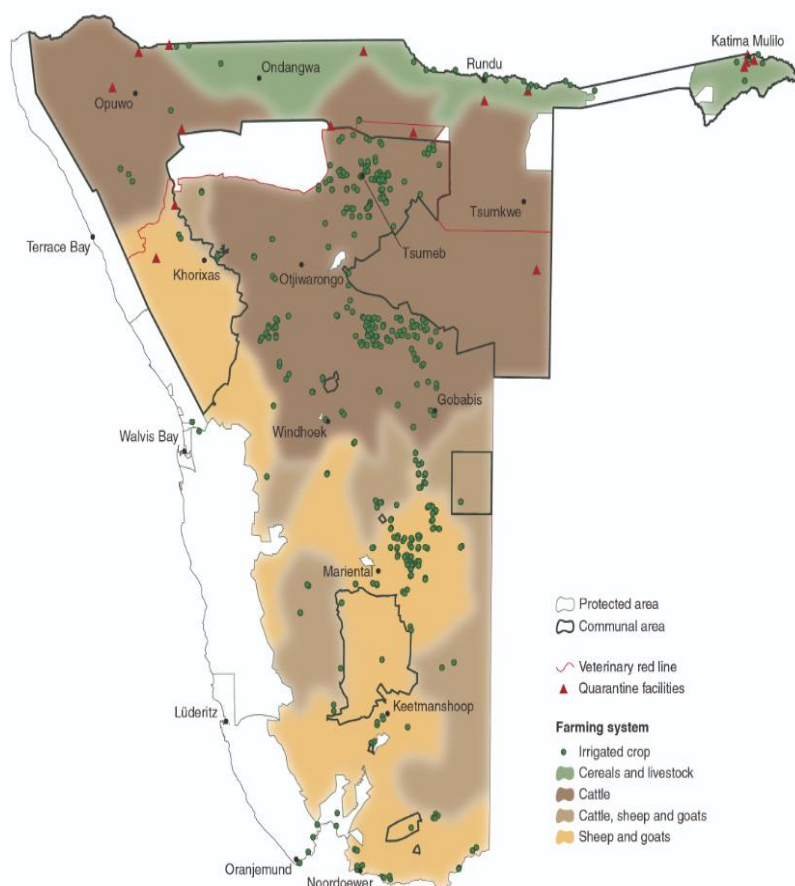
This study assesses water-use efficiency and the economic contribution of livestock production under continuous, mixed, and rotational grazing systems in the Otjozondjupa Region of Namibia, using a primary data approach aligned with the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA) framework. Primary data from 69 livestock farmers were analysed to evaluate water abstraction, rainfall dependence, livestock productivity, rangeland condition, and household income. The results reveal clear and consistent differences across grazing systems: rotational grazing demonstrates higher water-use efficiency, stronger livestock offtake and weight gain, healthier rangelands, and greater economic contribution, while continuous grazing is associated with degraded rangelands, lower productivity, higher rainfall dependence, and weaker income outcomes. Water scarcity remains a major constraint, with 53.6 percent of farmers experiencing shortages in the past 12 months and identifying water infrastructure as the most urgent support need. Farmers overwhelmingly prefer rotational grazing (46.4 percent), followed by mixed systems (34.8 percent), and nearly all respondents (98.6 percent) agree that government support is essential for improving grazing systems. The study illustrates how SEEA-EA strengthens ecosystem accounting by linking water provisioning and biomass production to livestock outputs and economic performance. The findings provide evidence-based guidance for improving water infrastructure, promoting rotational grazing, enhancing rangeland management, and integrating ecosystem service values into Namibia's national planning frameworks. Overall, the study highlights the central role of water efficiency and sustainable grazing in improving livestock productivity and resilience in semi-arid rangelands.

Keywords: *Water-Use Efficiency; Livestock Production; Grazing Systems; Rotational Grazing; Continuous Grazing; Mixed Grazing; Rangeland Condition; Livestock Productivity; Water Scarcity; Ecosystem Services; SEEA-EA Framework; Ecosystem Accounting; Biomass Provisioning; Groundwater Use; Semi-Arid Rangelands; Namibia; Otjozondjupa Region; Economic Contribution; Natural Capital Accounting; Water Infrastructure*

1. INTRODUCTION

Livestock production is a cornerstone of Namibia's rural economy, supporting household livelihoods, food security, employment, and national income. Yet the sector operates within one of the world's most water-scarce environments, particularly in semi-arid regions such as Otjozondjupa, where increasing climate variability, recurrent droughts, and pressure on groundwater resources intensify the need for efficient and sustainable production systems. Understanding water use patterns across grazing systems and how these patterns translate into economic output is essential for evidence-based resource management and policy formulation.

The Otjozondjupa Region is one of Namibia's most significant livestock-producing areas, hosting an estimated 796,948 head of cattle, sheep, and goats, the highest livestock population nationally.

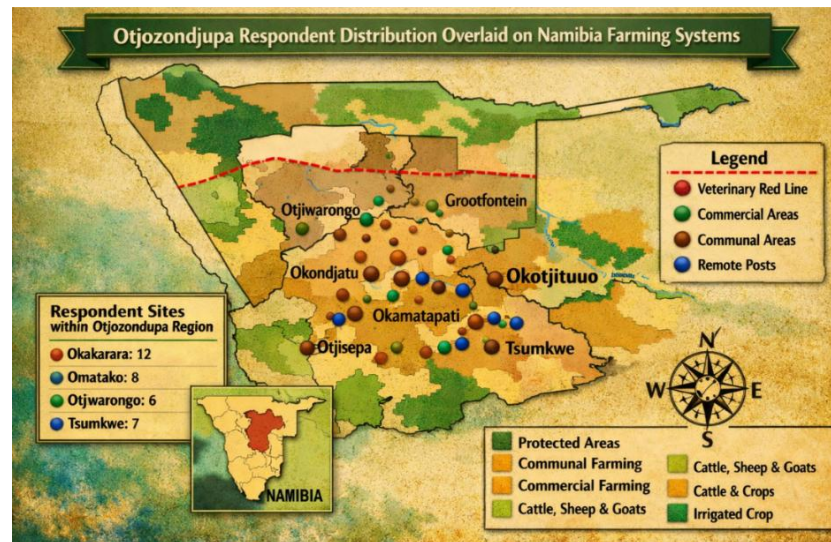


Approximately 70.0 percent of the region's population depends directly or indirectly on agriculture for income and livelihood. The coexistence of commercial and communal farming systems provides an ideal setting for examining how grazing practices influence water-use efficiency, rangeland condition, livestock productivity, and economic performance under contrasting production environments.

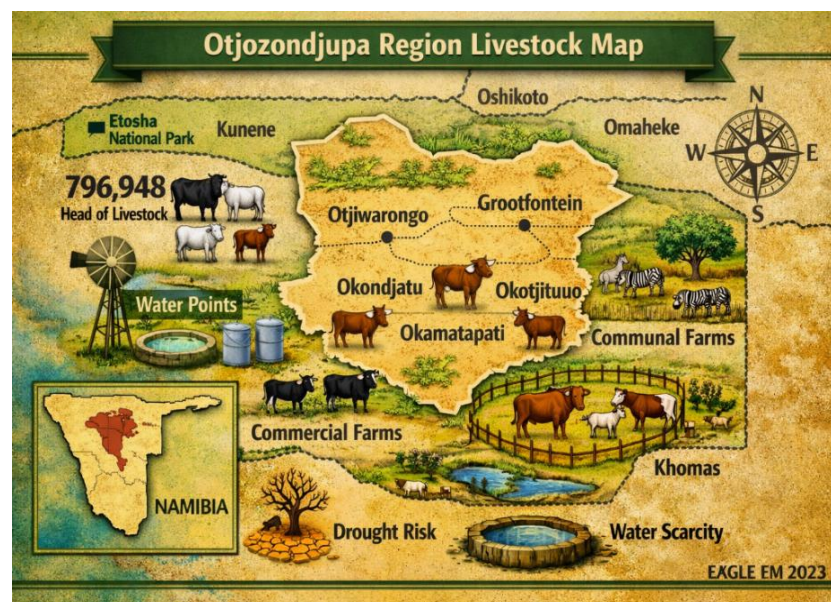
This study applies the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA) framework to assess linkages between water

use, ecosystem services, livestock production, and economic outcomes. SEEA-EA offers an internationally recognized structure for integrating environmental information with economic accounts, supporting Namibia's efforts to strengthen natural capital accounting and embed environmental sustainability within national development planning. By linking water provisioning and biomass production to livestock outputs, SEEA-EA enables a comprehensive understanding of how ecosystems support

economic activity and how management practices influence ecosystem service flows. A key strength of this study is the use of primary farm-level data collected from 69 livestock producers across Otjozondjupa. Such data enhance analytical accuracy and policy relevance in a context where detailed



environmental-economic information at farm level remains limited. The analysis is further supported by spatial information from the Namibia Farming Systems Map, which illustrates the distribution of farming systems, communal areas, protected areas, and veterinary boundaries, including the Veterinary Cordon Fence ("Red Line"). These spatial features provide essential context for understanding differences in production systems, resource availability, and ecosystem pressures.



To complement this, the study maps the geographical distribution of survey respondents across Otjozondjupa constituencies, distinguishing commercial farms, communal settlements, and remote livestock production sites. A final composite map integrates respondent locations with the national farming systems base map, producing a SEEA-EA-ready spatial visualization that links grazing

systems, water use, and economic performance. This integrated spatial approach strengthens the environmental-economic analysis by illustrating how livestock production interacts with land-use patterns, water availability, and ecosystem management across the region.

Overall, the introduction establishes the importance of water-use efficiency and sustainable grazing for livestock productivity and resilience in Namibia's semi-arid rangelands, while positioning SEEA-EA as a critical tool for advancing ecosystem-based planning and national accounting.

Objectives of the Study

The overall aim of this study is to assess water use efficiency and the economic contribution of livestock production under different grazing systems in the Otjozondjupa Region of Namibia, using a primary

data-driven approach aligned with the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA) framework.

The specific objectives of the study are:

1. *To quantify water use efficiency across grazing systems by measuring groundwater and surface water abstraction, rainfall dependency, and water consumption per livestock unit, and by developing indicators such as litres of water per kilogram of live weight gain and litres of water per unit of economic output.*
2. *To estimate the economic contribution of livestock production in both physical and monetary terms, including income from livestock sales, the value of livestock assets, contributions to household livelihoods, and the valuation of ecosystem services specifically water provisioning and biomass production as defined under the SEEA-EA framework.*
3. *To compare the performance of rotational, continuous, and mixed grazing systems in terms of water use efficiency, livestock productivity (offtake rates, weight gain, herd composition), and rangeland condition, while accounting for differences in farm size, herd size, and water sources.*
4. *To identify trade-offs and synergies between productivity, resource-use efficiency, and ecosystem sustainability across grazing systems, with emphasis on long-term rangeland health and resilience to climate variability.*
5. *To develop policy relevant recommendations for promoting sustainable livestock production in Namibia, including the integration of ecosystem service valuation into national planning frameworks such as the Sixth National Development Plan (NDP6) and the development of national water accounts.*

Research Questions

Based on these objectives, the study addresses the following research questions:

1. Who are the livestock farmers in the Otjozondjupa Region, and what types of production systems do they operate?
2. What are the main water sources, levels of availability, and consumption patterns associated with livestock production?
3. How do different grazing systems influence livestock productivity, water use efficiency, and rangeland condition?
4. Which grazing system demonstrates higher water use efficiency and stronger sustainability performance under varying production conditions?
5. What economic contributions and livelihood benefits are generated from livestock production in terms of household income, livestock assets, and economic resilience?
6. What factors determine water use efficiency, and which policy interventions are required to promote sustainable livestock production and ecosystem management?

2. LITERATURE REVIEW

2.1 Water Use Efficiency in Livestock Production

Water is a critical input in livestock production, particularly in arid and semi-arid regions where scarcity limits productivity and resilience. Improving water use efficiency (WUE) is essential for sustaining livestock systems under increasing climate variability. The Food and Agriculture Organization emphasizes that enhancing agricultural water efficiency is fundamental for sustainable food production in water-stressed environments (FAO, 2019). Livestock Water Productivity (LWP) the ratio of livestock

outputs to water depleted provides a key indicator for evaluating resource-use efficiency (Descheemaeker et al., 2009). In semi-arid rangelands, forage production depends largely on rainfall (green water), making grazing land the largest component of livestock water footprints (Bosire et al., 2022). Improving grazing management therefore represents one of the most effective strategies for increasing WUE while reducing pressure on groundwater resources. Indicators such as litres of water per kilogram of live-weight gain and litres of water per unit of economic output allow comparisons across production systems and support evidence-based water management in water-scarce countries like Namibia.

2.2 Grazing Systems and Rangeland Management

Grazing systems strongly influence ecological sustainability, livestock productivity, and water use efficiency. Rotational grazing enhances vegetation recovery, soil structure, infiltration, and moisture retention, while continuous grazing often leads to overgrazing, soil degradation, reduced carrying capacity, and lower ecosystem resilience (Teague et al., 2013). Evidence from semi-arid rangelands shows that rotational grazing reduces trade-offs between livestock production and ecosystem services by improving water infiltration, reducing evaporation losses, and increasing forage production (Hulvey et al., 2021). Gallagher (2024) similarly found that improved grazing management enhances soil structure and water storage. Naderi et al. (2014) reported that improved water management can increase forage production by approximately 40.0 percent, while grazing management alone can increase forage production by about 30.0 percent. These findings highlight the importance of comparing grazing systems to identify practices that maximize productivity while conserving natural resources an essential consideration for Namibia's semi-arid rangelands.

2.3 Ecosystem Services and the SEEA Framework

Livestock production depends on ecosystem services such as water provisioning, forage production, nutrient cycling, and soil formation. Conventional economic systems often overlook these contributions, leading to unsustainable resource use (MEA, 2005). The System of Environmental Economic Accounting (SEEA) provides an internationally recognized framework for integrating environmental assets and ecosystem services into economic accounts (United Nations, 2021). The SEEA Central Framework records physical stocks and flows of resources, including water, while SEEA Ecosystem Accounting (SEEA-EA) measures ecosystem contributions to production. Within SEEA-EA, livestock provisioning services refer to ecosystem contributions supporting the production of meat, milk, hides, leather, and wool (United Nations, 2021). Integrating these accounts enables policymakers to understand natural capital contributions to economic development and supports sustainable resource allocation. Ekins et al. (2025) emphasize that combining SEEA-CF and SEEA-EA provides a comprehensive understanding of both physical water use and ecosystem services sustaining livestock production. However, applications using detailed farm level data remain limited in developing countries. This study addresses this gap by applying primary data to quantify WUE, ecosystem service values, and economic contributions under different grazing systems in Namibia

2.4 Water Governance and Sustainable Resource Management

Efficient water use in livestock production depends on both farm-level management and effective governance institutions. Anderson and Ostrom (2008) argue that sustainable management of common-pool resources such as groundwater requires polycentric governance systems that combine local participation with broader institutional oversight. Such arrangements improve monitoring, encourage locally appropriate management practices, and enhance long-term sustainability (Ostrom, 2005). In Namibia, where groundwater is the principal source of livestock water, effective governance is essential

for preventing over abstraction and ensuring equitable access. Integrating SEEA-based environmental economic information can strengthen water governance by providing evidence based indicators for sustainable allocation and long-term planning.

2.5 Water Pricing and Economic Incentives for Efficient Use

Economic instruments such as water pricing are widely promoted to encourage efficient water use. User pays principles aim to improve financial sustainability of water infrastructure while incentivizing reduced consumption (Cornish & Perry, 2003; Republic of Namibia, 2000). However, pricing alone is insufficient for ecological sustainability. Water tariffs typically reflect infrastructure costs rather than the environmental value of water or the ecological costs of groundwater depletion (Cornish & Perry, 2003; Muller, 2007). Pearce et al. (2007) argue that strengthening management capacity, improving governance, and promoting efficient resource practices often yield greater conservation benefits than pricing alone. This is particularly relevant for Namibia, where groundwater dominates livestock water supply and where sustainable management requires balancing economic efficiency with ecosystem conservation. Integrating water-use indicators, ecosystem service valuation, and SEEA-based accounting provides a more comprehensive basis for evaluating WUE than financial measures alone. This approach supports policies that enhance livestock productivity, conserve natural resources, and strengthen climate resilience.

2.6 Summary of Literature Review

The literature demonstrates that water use efficiency in livestock production is shaped by grazing management, ecosystem service flows, governance systems, and economic incentives. Rotational grazing consistently improves forage production, soil moisture retention, and WUE compared to continuous grazing. The SEEA-EA framework provides a robust structure for linking water provisioning and biomass production to livestock outputs, enabling integrated environmental economic assessments. Effective water governance and complementary policy instruments beyond pricing alone are essential for sustainable groundwater management in Namibia's semi-arid rangelands. This study contributes to the literature by applying SEEA-aligned, farm-level primary data to quantify WUE and economic contributions across grazing systems in the Otjozondjupa Region.

3. METHODOLOGY

3.1 Study Area

The study was conducted in the Otjozondjupa Region of central Namibia between May and June 2026. Otjozondjupa is one of Namibia's fourteen administrative regions, with Otjiwarongo as the regional capital and major towns including Okahandja, Grootfontein, Otavi, Okakarara, and Tsumkwe. According to the 2023 Namibia Population and Housing Census, the region has a population of 220,811, reflecting significant growth from 143,903 recorded in 2011. Approximately 62.9 percent of residents live in urban areas, while 37.1 percent reside in rural areas. The region is characterized by a semi-arid climate, highly variable rainfall, and heavy dependence on groundwater for livestock production. Livestock farming particularly cattle production is the dominant agricultural activity. Otjozondjupa hosts Namibia's largest livestock population, estimated at 796,948 head of cattle, sheep, and goats (Eagle FM, 2023). The coexistence of commercial and communal farming systems, combined with climate vulnerability and groundwater dependence, makes the region an ideal setting for assessing water use efficiency and economic contribution under different grazing systems within the SEEA-EA framework.

3.2 Research Design

A quantitative cross sectional research design was used to collect farm level data from livestock producers at a single point in time. This design enabled a comprehensive assessment of water use, grazing practices, livestock productivity, rangeland condition, and economic outcomes across rotational, continuous, and mixed grazing systems. The study was guided by the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA) framework, which integrates environmental resource use with economic performance. SEEA-EA provided a structured basis for evaluating water abstraction, water consumption, ecosystem service contributions, livestock outputs, and economic returns, ensuring that environmental and economic dimensions were analysed in an integrated manner.

3.3 Data Collection

Primary Data and Secondary Data

Primary data were collected using a structured electronic questionnaire administered through Google Forms. The questionnaire consisted mainly of closed-ended questions covering farm characteristics, livestock ownership, grazing systems, water sources, water availability, livestock productivity indicators, household income, and ecosystem service indicators relevant to SEEA-EA. The questionnaire link was distributed via WhatsApp, email, and SMS, allowing efficient electronic data capture and reducing manual entry errors. Secondary data were obtained from the Namibia Statistics Agency (NSA), MAWLR, FAO, SEEA publications, and scientific literature on livestock production, water resources, rangeland management, and environmental-economic accounting.

The study examined six key variables related to water use efficiency, livestock production, economic contribution, and ecosystem conditions. These included water use, livestock productivity, economic contribution, grazing system type, water-use efficiency, and rangeland condition. The Livestock Unit (LU) concept was applied to standardize comparisons across cattle, sheep, and goats. The target population consisted of approximately 5,000 livestock-producing households in Otjozondjupa. A stratified random sampling technique was used across six constituencies, and a total of 69 farmers completed the questionnaire, yielding a 69.0 percent response rate.

3.4 Sampling Procedure and Sample Size

The target population consisted of approximately 5,000 livestock-producing households in Otjozondjupa (NSA, 2019; NSA, 2026). A target sample of 100 farmers was set to ensure representation of both commercial and communal systems. A stratified random sampling technique was used across six constituencies: Otjiwarongo, Okahandja, Grootfontein, Otavi, Okakarara, and Tsumkwe. Farmer lists were obtained from agricultural offices, farmers' associations, and extension services. A total of 69 farmers completed the questionnaire, yielding a 69.0 percent response rate. Lower participation among commercial farmers was attributed to farming operations and limited availability during the survey period. Despite this, communal farmers demonstrated strong engagement, and the final sample provided sufficient data for robust descriptive analysis.

3.5 Data Analysis

Descriptive statistics were used to summarize socioeconomic characteristics, farm characteristics, grazing systems, water sources, livestock productivity, rangeland condition, and household income. All analytical procedures focused exclusively on descriptive patterns, and no inferential statistical tests were

applied. Relationships between grazing systems, water-use efficiency, livestock performance, and ecosystem condition were interpreted through SEEA-EA's conceptual framework, emphasizing ecosystem condition, ecosystem service flows, and economic contribution.

Finally, ecosystem service indicators related to water provisioning and forage production were interpreted within the SEEA-EA framework to demonstrate how natural capital supports livestock production and how grazing systems influence ecosystem service flows. This approach ensured that the analysis remained consistent with SEEA-EA requirements by focused on physical flows, ecosystem condition, and economic contribution rather than statistical significance testing.

4. VALIDITY AND RELIABILITY

The validity and reliability of the study were ensured through a systematic and rigorous instrument development process. The questionnaire was designed based on an extensive review of literature on livestock production systems, water resource management, water accounting, and the System of Environmental-Economic Accounting (SEEA) framework. This ensured that the instrument captured all key variables required to address the study objectives, including water use, grazing systems, livestock productivity, economic contribution, and ecosystem service indicators. To enhance content and construct validity, the questionnaire was pre-tested with a small group of livestock farmers in the Otjozondjupa Region. The pilot exercise assessed clarity, relevance, logical flow, and completeness of the questions. Feedback from the pre-test informed refinements to wording, sequencing, and structure, improving the suitability of the instrument for both commercial and communal farmers. Reliability was strengthened through the use of standardized questions and electronic data collection via Google Forms, which minimized transcription errors and improved consistency in responses. Prior to analysis, the dataset underwent thorough data cleaning, coding, and validation to ensure accuracy, completeness, and internal consistency. These procedures collectively enhanced the overall validity and reliability of the findings, supporting the robustness of the study's assessment of water use efficiency and economic contribution under different grazing systems.

5. ETHICAL CONSIDERATIONS

The study adhered to established ethical standards for social science research to ensure the rights, privacy, and dignity of all participants were protected. Before data collection, respondents received an official introductory letter from the Ministry of Environment, Forestry and Tourism (MEFT), signed by the Executive Director, explaining the purpose of the study, its relevance to national environmental-economic planning, and the voluntary nature of participation. Participation was entirely voluntary, and respondents were informed that the information provided would be used solely for research and policy development related to water use efficiency, grazing systems, and ecosystem accounting. The letter clarified that no data would be used for taxation, regulatory enforcement, or any purpose outside the objectives of the study. Confidentiality and anonymity were ensured by excluding personal identifiers from the dataset and presenting results only in aggregated form. Respondents were not required to disclose any information that could directly identify them, and all data were securely stored and handled to protect participant privacy. The study complied with ethical principles of informed consent, transparency, voluntary participation, and responsible data management. These measures ensured that the research was conducted with integrity and respect for all individuals contributing to the assessment of sustainable livestock production under the SEEA-EA framework.

6. RESULTS

The study analysed responses from 69 livestock farmers across Otjozondjupa, representing both communal and commercial production systems. Farmers varied in age, gender, and education level, with most respondents falling between 31 and 50 years and holding secondary education. This demographic profile reflects a typical mix of livestock producers operating within semi-arid rangeland environments. Farm sizes ranged widely, reflecting the coexistence of small communal holdings and large commercial ranches. Three grazing systems were identified: rotational, continuous, and mixed. Rotational grazing was more common among commercial farmers, while continuous grazing dominated communal areas. Mixed systems were primarily used by farmers transitioning toward improved rangeland management practices.

Livestock ownership patterns showed cattle as the dominant species across all systems, followed by goats and sheep. Herd sizes differed substantially between grazing systems, with rotational grazing farms maintaining larger herds and continuous grazing farms holding smaller but more diverse herds. Water sources included boreholes, dams, wells, and rainfall-dependent systems. Farmers practicing rotational grazing reported more reliable water access due to better infrastructure, whereas continuous grazing farmers experienced frequent shortages. More than half of all respondents (53.6 percent) reported water shortages in the past 12 months, underscoring the vulnerability of livestock production to water scarcity in semi-arid regions.

Rainfall dependence was highest in continuous grazing systems, indicating limited groundwater infrastructure and greater exposure to climate variability. Water-use efficiency (WUE) varied clearly across grazing systems. Rotational grazing demonstrated the highest WUE, characterized by lower water consumption per livestock unit and stronger weight-gain performance. Mixed grazing showed moderate efficiency, while continuous grazing had the lowest WUE due to higher rainfall dependence, degraded rangelands, and lower productivity. Livestock productivity indicators including offtake rates, weight gain, and herd performance were consistently higher under rotational grazing. Continuous grazing farms reported lower weight gain and reduced offtake, consistent with poorer rangeland condition, while mixed grazing farms showed intermediate productivity. These patterns highlight the direct influence of grazing management on livestock performance and ecosystem functioning.

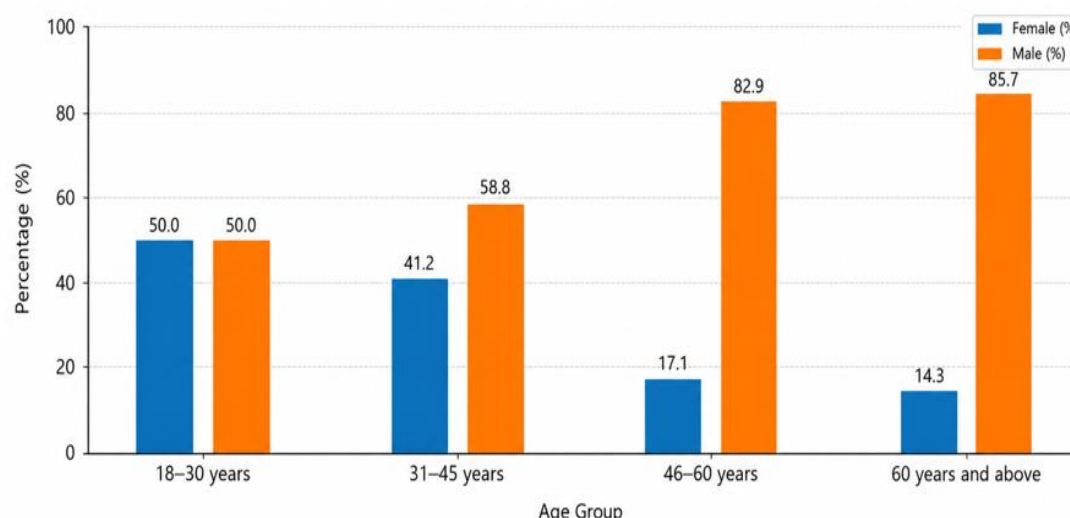
Economic contribution also differed across grazing systems. Rotational grazing generated the highest annual livestock income, followed by mixed systems, while continuous grazing produced the lowest earnings. Livestock contributed significantly to household income across all systems, with rotational grazing providing the strongest economic resilience. This demonstrates the economic benefits associated with sustainable grazing practices and improved ecosystem condition.

Rangeland condition ratings revealed clear differences: rotational grazing supported healthier vegetation cover, better pasture availability, and lower grazing pressure; continuous grazing was associated with degraded rangelands and reduced carrying capacity; mixed grazing showed moderate condition. Farmers using rotational grazing also reported more active rangeland management practices, including controlled stocking, pasture resting, and water-point rotation. These practices contribute to improved ecosystem condition and enhanced livestock provisioning services.

Farmer perceptions strongly favoured improved grazing management. Rotational grazing was preferred by 46.4 percent of respondents, followed by mixed systems at 34.8 percent. Nearly all respondents (98.6 percent) agreed that government support is essential for improving grazing systems, particularly through water infrastructure development, training, and rangeland rehabilitation. Overall, the results demonstrate clear and consistent differences across grazing systems in terms of water-use efficiency, livestock productivity, rangeland condition, and economic contribution, reinforcing the importance of sustainable grazing for ecosystem resilience and rural livelihoods.

1.1 Respondent Characteristics

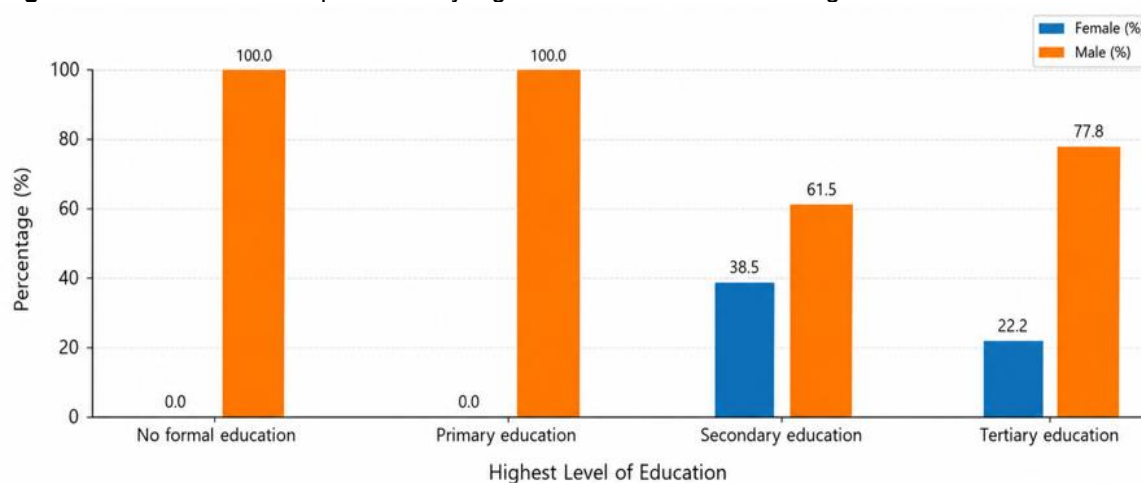
Figure 1: Distribution of respondents by Age group and gender



Source: Author's own analysis based on survey data, 2026.

Figure 1 shows, the demographic profile of respondents shows clear gender and age patterns within livestock farming in the Otjozondjupa Region. Equal participation was observed among the youngest farmers (18 - 30 years), where males and females each represented 50.0 percent of respondents. From age 31 onward, male participation increased steadily and dominated the older age groups. In the 31 – 45 years' category, males accounted for 58.8 percent of respondents, rising sharply to 82.9 percent in the 46 – 60 years' group and 85.7 percent among those aged 60 years and above. Female representation declined correspondingly across these age groups. Overall, the results indicate that livestock farming is predominantly male-led, especially among older farmers, reflecting traditional ownership and management patterns in the region. However, the equal gender representation among younger respondents suggests a gradual shift toward more inclusive participation, which may influence future livestock management practices, water use decisions, and adoption of improved grazing systems.

Figure 2: Distribution of respondents by highest level of education and gender

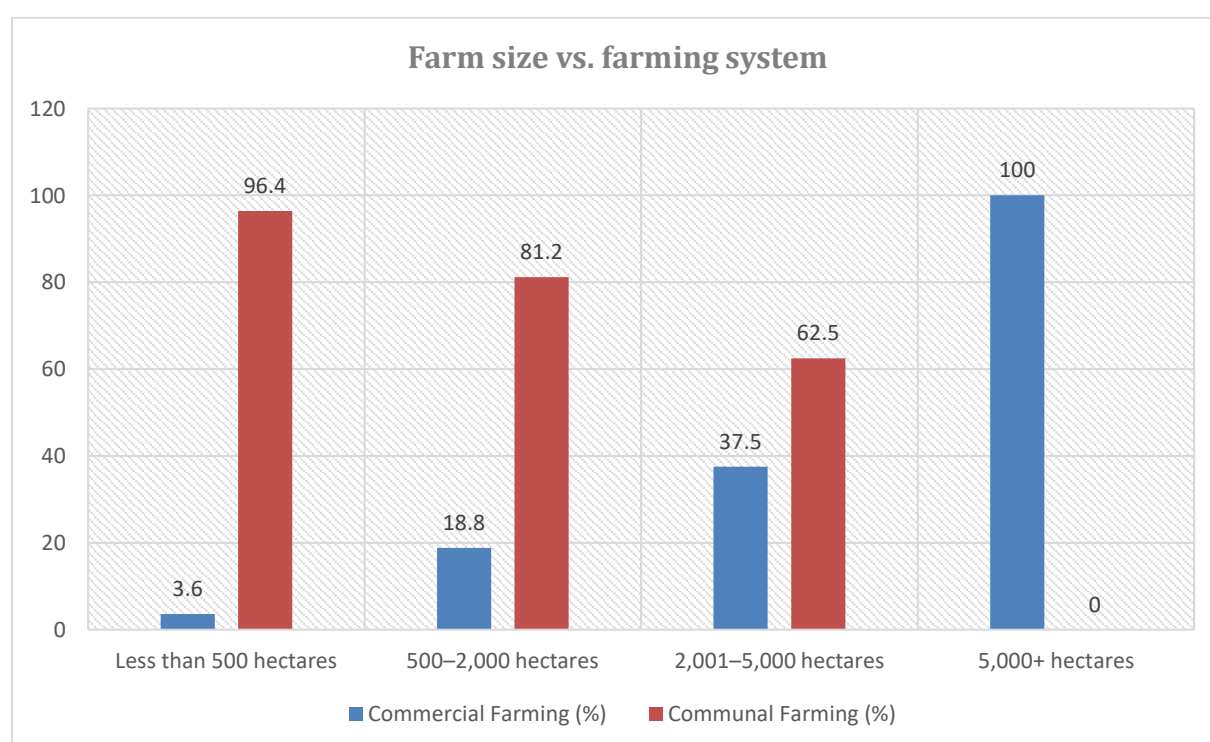


Source: Author's own analysis based on survey data, 2026.

Figure 2 shows that respondents generally have a relatively high level of formal education. The majority had completed tertiary education, with males representing 77.8 percent of this group and females 22.2

percent. Secondary education formed the second-largest category, where males accounted for 61.5 percent and females 38.5 percent, indicating broader male participation across formal education levels. Only a small proportion of respondents reported education below secondary level, and those with no formal education or primary education were exclusively male. This suggests that lower educational attainment is uncommon among surveyed farmers but remains present within older or traditionally male-dominated segments of livestock production. Overall, the results indicate that livestock farmers in Otjozondjupa possess relatively strong educational backgrounds, which may support better adoption of improved grazing practices, water management strategies, and SEEA-aligned ecosystem accounting approaches. However, the dominance of male respondents across all education categories reflects broader gender patterns in livestock ownership and decision-making within the region.

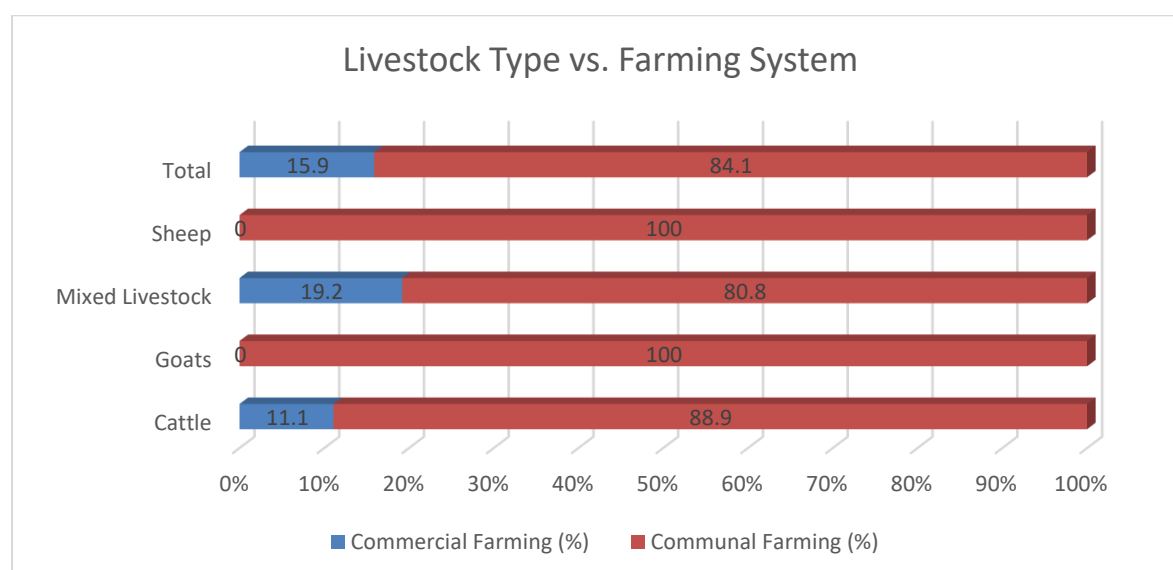
Figure 3: Distribution of respondents by farm size and type of farming system



Source: Author's own analysis based on survey data, 2026.

Figure 3 shows a clear and consistent relationship between farm size and the type of farming system practiced in the Otjozondjupa Region. Communal farming overwhelmingly dominates smaller landholdings, accounting for 96.4 percent of farms below 500 hectares and 81.2 percent of farms between 500 – 2,000 hectares. This reflects the structure of communal tenure systems, where limited access to private land restricts expansion into larger commercial operations. As farm size increases, commercial farming becomes more prevalent. In the 2,001 – 5,000-hectare category, commercial farmers represent 37.5 percent of respondents, indicating a gradual shift toward more investment-driven and structured livestock production. The largest farms - 5,000 hectares and above are exclusively commercial (100 percent), demonstrating that extensive landholdings are strongly associated with commercial livestock enterprises. Overall, the results show that communal farming is concentrated on smaller farms, while commercial farming dominates larger landholdings. This pattern suggests that farm size is a key determinant of production system type, with larger farms offering greater opportunities for improved grazing management, higher water use efficiency, and stronger economic contribution to the regional livestock sector.

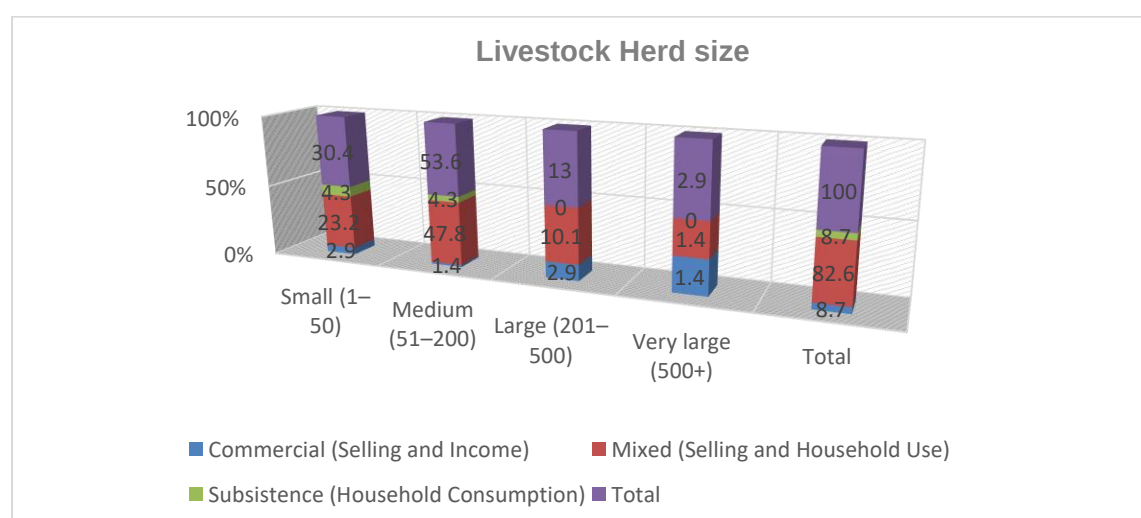
Figure 4: Distribution of respondents by main livestock type and farming system



Source: Author's own analysis based on survey data, 2026.

Figure 4 shows clear differences in livestock enterprise types across communal and commercial farming systems in the Otjozondjupa Region. Mixed livestock farming was the most common production system, with 80.8 percent of mixed-enterprise farmers operating under communal tenure and 19.2 percent under commercial systems. This indicates that communal farmers tend to diversify their herds by keeping multiple livestock species. Cattle production was also predominantly communal, with 88.9 percent of cattle farmers belonging to the communal system and only 11.1 percent operating commercially. The pattern was even more pronounced for small stock: all goat farmers (100 percent) and all sheep farmers (100 percent) were communal, with no commercial respondents reporting goats or sheep as their primary enterprise. This reflects the role of small stock in household livelihoods, income generation, and adaptation to semi-arid conditions typical of communal farming. Overall, 84.1 percent of all respondents were communal farmers, compared with 15.9 percent commercial farmers. This dominance of communal producers is important for interpreting subsequent results on water use, livestock productivity, and water-use efficiency, as communal and commercial systems differ significantly in management practices, resource access, and production objectives.

Figure 5: Distribution of livestock herd size by main purpose of livestock production

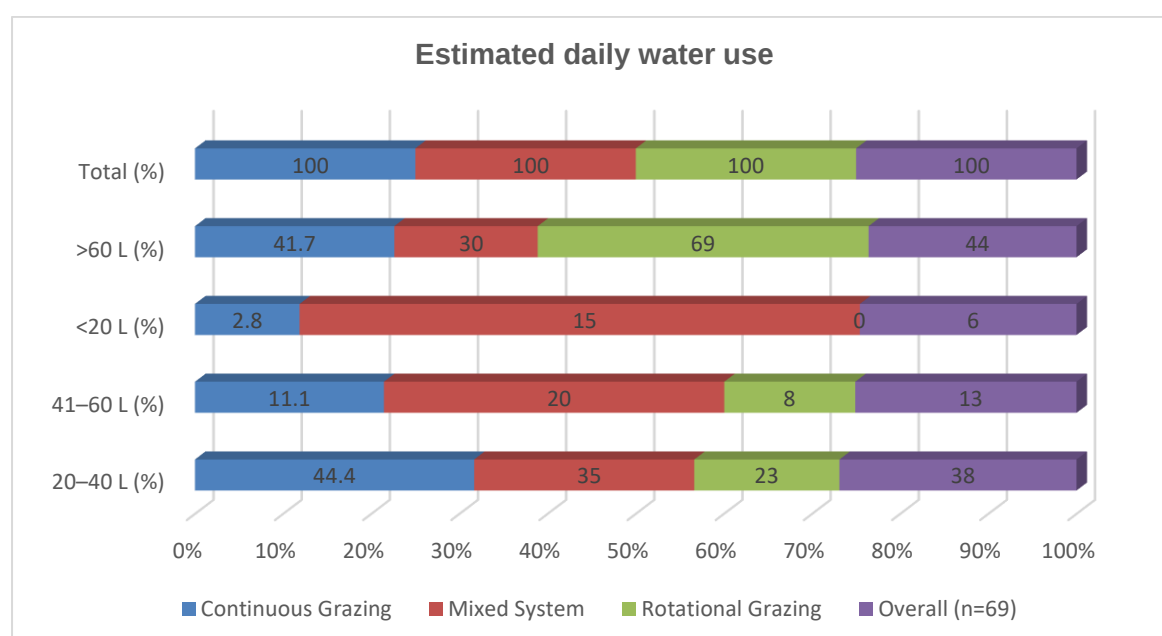


Source: Author's own analysis based on survey data, 2026.

Figure 5 shows that livestock production in the study area is largely mixed purpose, with 82.6 percent of respondents using their herds for both household consumption and income generation. This pattern is strongest among medium-sized herds (51 - 200 animals), which form the largest group of farmers and where mixed production alone accounts for 47.8 percent. Commercial production is present across herd sizes but remains limited at 8.7 percent, indicating that fully market oriented livestock enterprises are relatively uncommon. Subsistence production is similarly small (8.7 percent) and occurs only among small and medium herds, suggesting that households with larger herds tend to shift toward more economically oriented systems. Overall, the results reflect a livestock sector dominated by semi commercial, mixed use practices, with medium scale farmers forming the core of production and very large herds being rare. These patterns are important for understanding water use efficiency and grazing management, as mixed purpose systems may differ from purely commercial or subsistence systems in resource use and production objectives.

6.2 Water Use Efficiency Across Grazing Systems

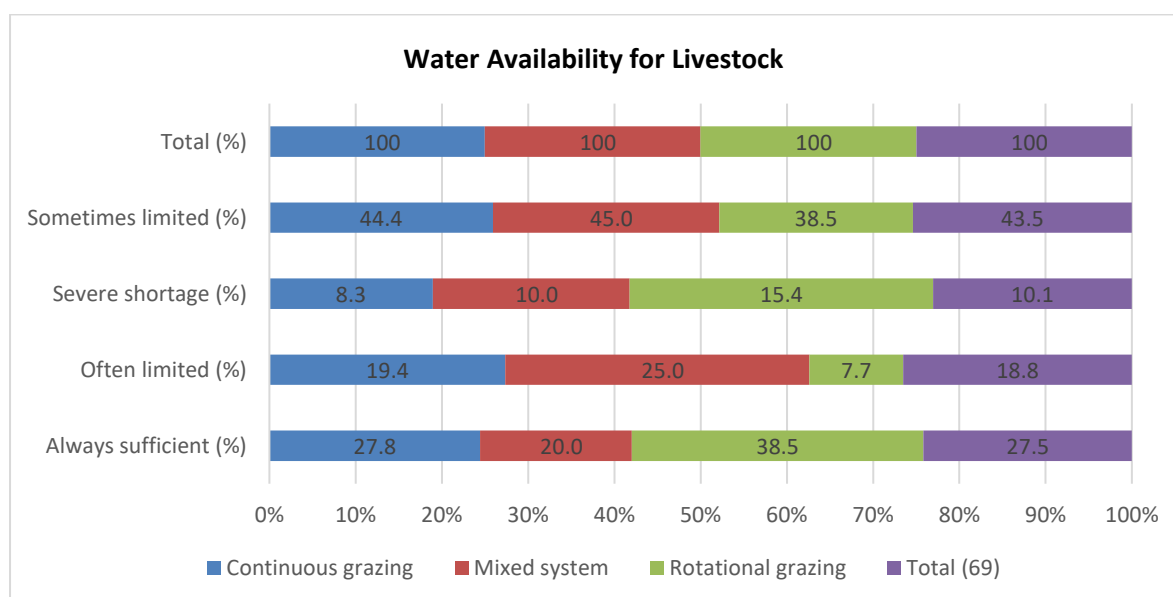
Figure 6: Distribution of water use efficiency across grazing system



Source: Author's own analysis based on survey data, 2026.

Figure 6 shows distinct differences in daily water use across grazing systems in the Otjozondjupa Region. Continuous grazing displays a mixed pattern, with 44.4 percent of farmers using 20 - 40 litres/day and 41.7 percent exceeding 60 litres/day, indicating inconsistent water use efficiency within this system. The mixed grazing system demonstrates more balanced water use: 35.0 percent of farmers fall within the 20 - 40 litres/day range, while 30.0 percent use more than 60 litres/day, suggesting moderate efficiency but with notable high use cases. Rotational grazing shows the highest water consumption, with 69.2 percent of respondents using more than 60 litres/day and none using less than 20 litres/day. This indicates that rotational systems - despite their ecological benefits are associated with substantially higher daily water requirements. Overall, 44.0 percent of all farmers across systems consume more than 60 litres/day, highlighting a strong reliance on high water volumes and potential pressure on groundwater resources. These differences in water use across grazing systems are important for understanding water use efficiency and the sustainability of livestock production in the region.

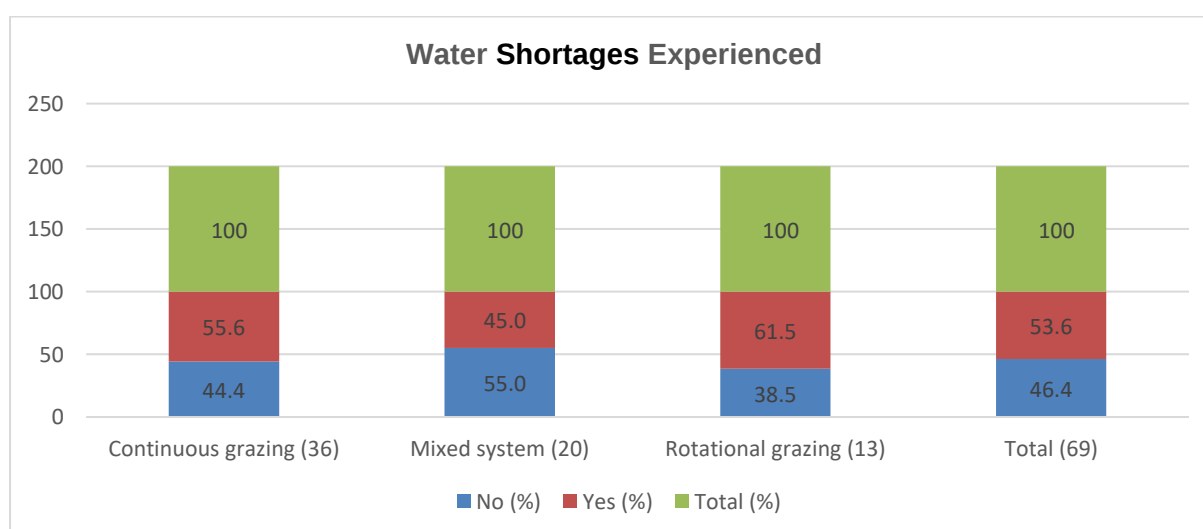
Figure 7: Distribution of water availability for livestock by grazing system



Source: Author's own analysis based on survey data, 2026.

Figure 7 shows clear differences in perceived water availability across grazing systems in the Otjozondjupa Region. Farmers practicing continuous grazing reported the highest levels of water limitation, with 44.4 percent indicating water was sometimes limited and 19.4 percent reporting frequent limitations. A similar pattern was observed among mixed system farmers, where 45.0 percent experienced occasional limitations and 25.0 percent reported often limited water availability. In contrast, rotational grazing farmers reported comparatively better access to water. 38.5 percent described water as always sufficient, and only 7.7 percent experienced frequent limitations. Although severe shortages occurred across all systems, they remained relatively low overall. These results indicate that water scarcity is a common challenge for livestock farmers in the region, but rotational grazing appears to provide more stable water access compared to continuous and mixed systems. This difference in water availability is important for interpreting water use efficiency, as reliable access to water may influence daily consumption patterns, herd management decisions, and overall sustainability of grazing systems.

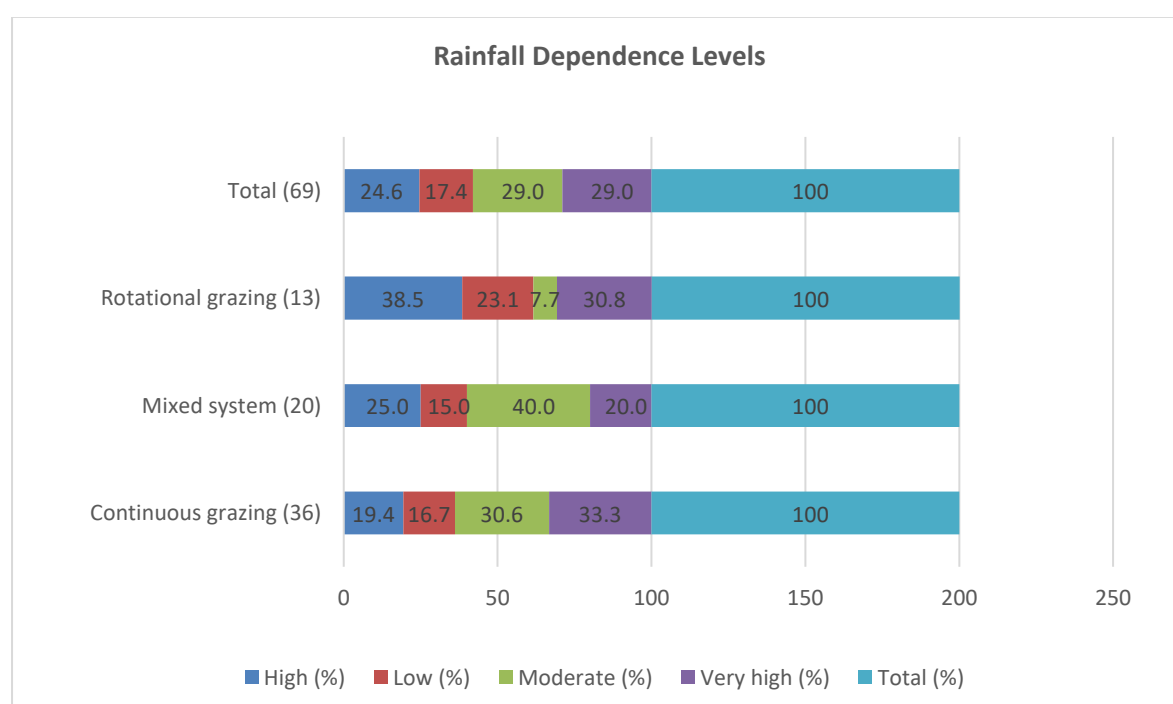
Figure 8: Distribution of water short experienced across grazing systems in the last past 12 month



Source: Author's own analysis based on survey data, 2026.

Figure 8 shows that water shortages were experienced across all grazing systems in the past 12 months, highlighting the widespread nature of water scarcity in the Otjozondjupa Region. The highest proportions of shortages were reported under rotational grazing, where 61.5 percent of farmers experienced water scarcity, followed closely by continuous grazing, with 55.6 percent reporting shortages. Mixed-system farmers showed comparatively lower exposure, with 45.0 percent indicating water shortages. Overall, 53.6 percent of all respondents experienced water scarcity during the past year, confirming that limited water availability is a persistent challenge across livestock production systems. The results suggest that continuous and rotational grazing systems are more vulnerable to shortages, while mixed systems appear slightly more resilient. These differences are important for understanding water-use efficiency and the sustainability of grazing practices in semi-arid environments.

Figure 9: Distribution of rainfall dependence levels across grazing systems

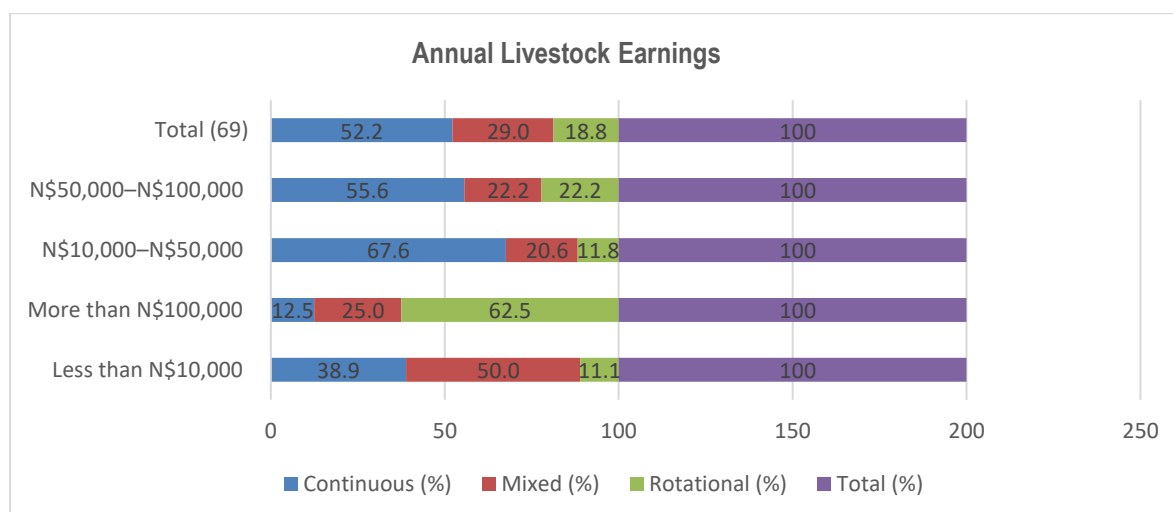


Source: Author's own analysis based on survey data, 2026.

Figure 9 shows clear differences in how strongly livestock production depends on rainfall across grazing systems in the Otjozondjupa Region. Farmers practicing continuous grazing reported high sensitivity to rainfall variability, with 33.3 percent indicating very high dependence and 30.6 percent reporting moderate dependence. Mixed system farmers displayed a more balanced pattern: 40.0 percent reported moderate dependence, while smaller proportions fell into the high and very high categories. This suggests that mixed systems may offer slightly greater resilience to rainfall fluctuations. Rotational grazing farmers showed the strongest rainfall dependence, with 38.5 percent reporting high dependence and 30.8 percent indicating very high dependence. Only 7.7 percent reported moderate dependence, highlighting the system's sensitivity to rainfall availability. Overall, the results indicate that rotational and continuous grazing systems are more vulnerable to rainfall variability, while mixed systems demonstrate comparatively greater stability. These differences are important for understanding water use efficiency and the sustainability of grazing practices under semi-arid conditions.

1.2 Economic Contribution of Livestock Production

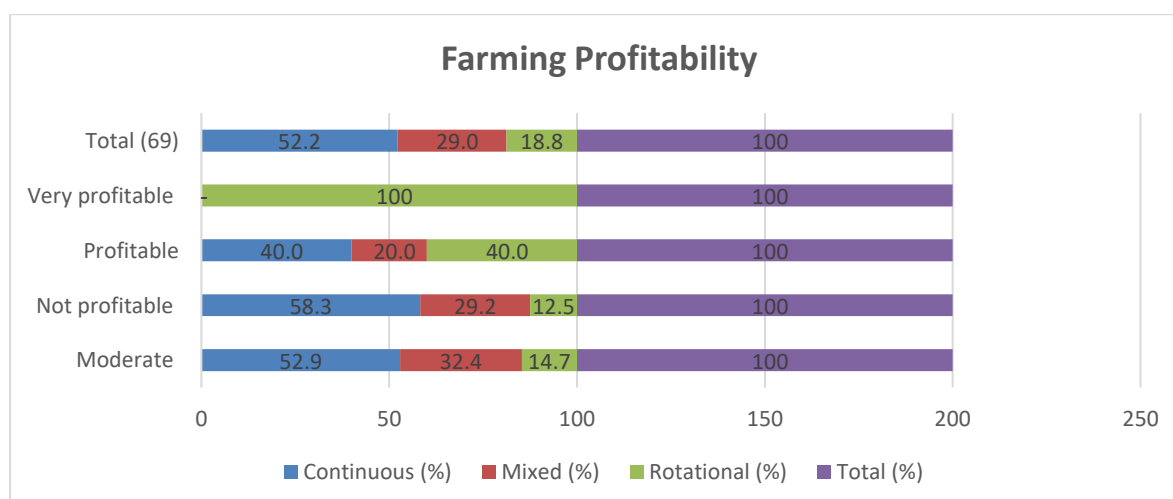
Figure 10: Distribution of annual livestock earnings by grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 10 shows clear income differences across grazing systems in the Otjozondjupa Region. The largest income group consists of farmers earning N\$10,000 - N\$50,000, and most of them (67.6 percent) practice continuous grazing, indicating that this system is dominant among lower to mid-income producers. Mixed-system farmers are more concentrated in the lowest income category, with 50.0 percent earning less than N\$10,000 annually. This suggests that mixed systems are more commonly associated with small-scale or resource constrained farmers. Rotational grazing displays a different pattern: 62.5 percent of farmers earning more than N\$100,000 use rotational grazing, indicating that higher-income farmers are more likely to adopt this system. This aligns with the resource and management requirements typically associated with rotational grazing, which may demand greater investment and structured management. Overall, continuous grazing dominates across most income groups, but higher income farmers tend to prefer rotational grazing, while lower-income farmers are more represented in mixed systems. These patterns highlight how grazing systems relate to economic outcomes and suggest that management intensity and investment capacity may influence both grazing choices and income levels.

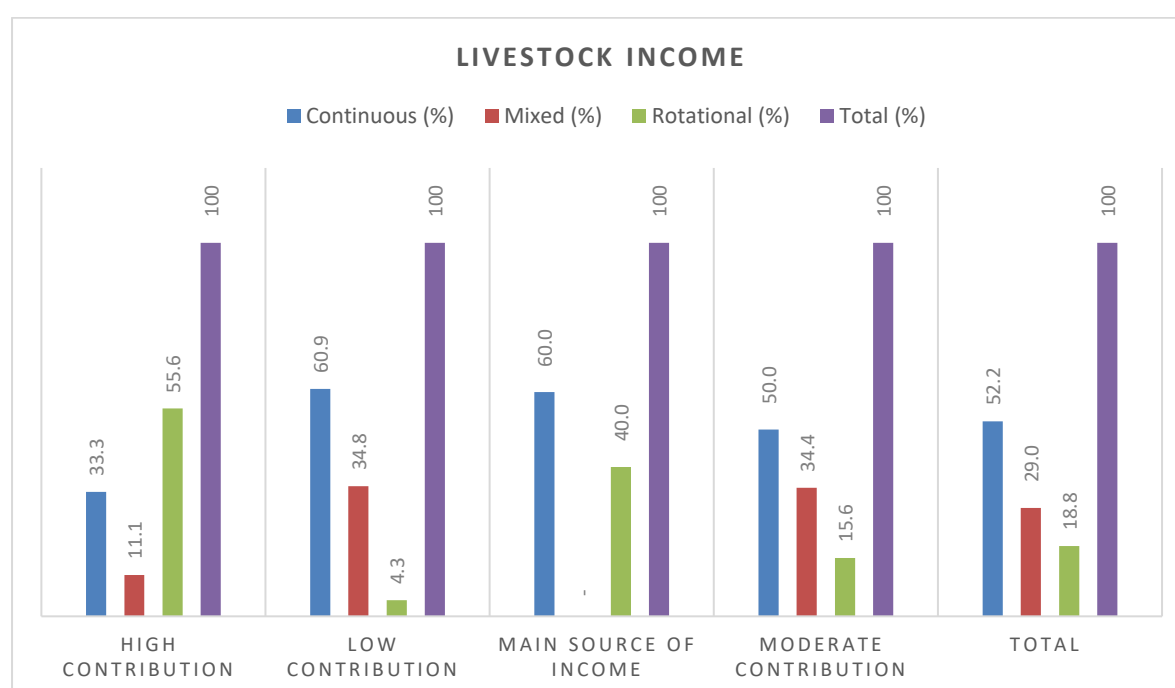
Figure 11: Distribution of livestock farming profitability across grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 11, show that most farmers across all grazing systems described their livestock farming as either moderate or not profitable. Among continuous grazing farmers, 52.9 percent reported moderate profitability and 58.3 percent reported no profitability, indicating generally lower financial performance. Mixed-system farmers showed a similar pattern, with 32.4 percent reporting moderate profitability and 29.2 percent reporting no profitability. In contrast, rotational grazing farmers displayed a more favourable profitability profile: 40.0 percent described their farming as profitable, and the only farmer who reported “very profitable” also practiced rotational grazing. Overall, while moderate and low profitability dominate across systems, rotational grazing appears more strongly associated with higher profitability outcomes compared to continuous and mixed systems.

Figure 12: Distribution of livestock income contribution among grazing systems

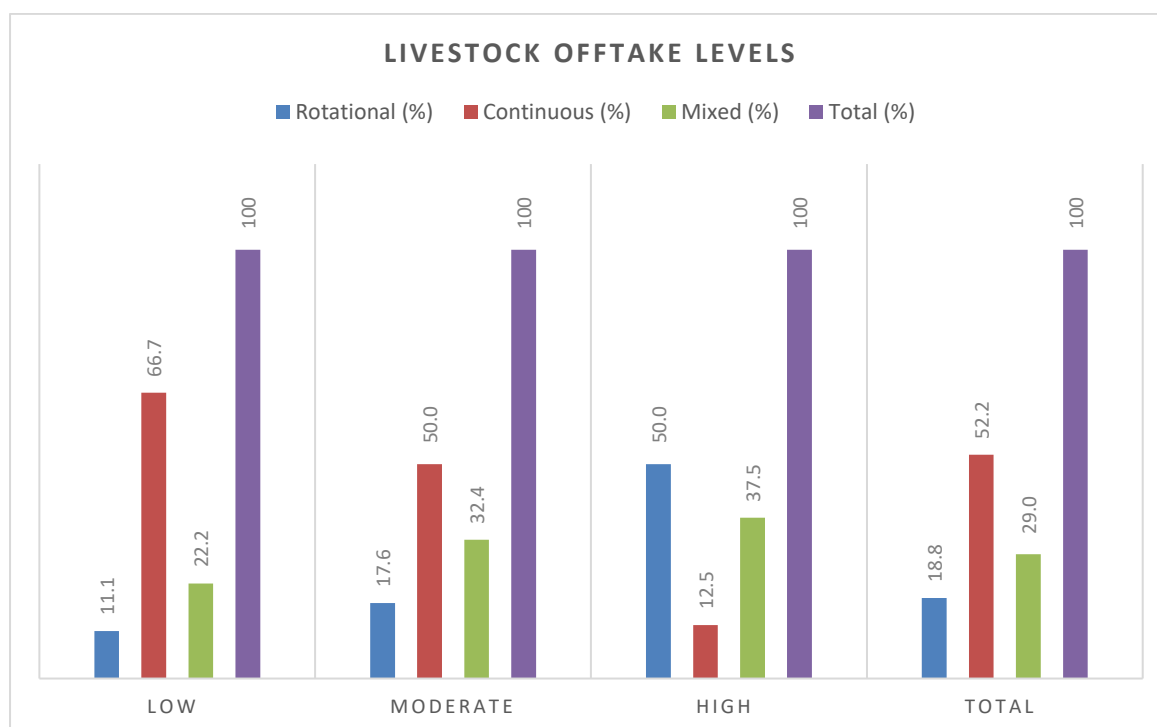


Source: Author’s own analysis based on survey data, 2026.

Figure 12 shows clear differences in how livestock contributes to household income across grazing systems. Farmers practicing continuous grazing most commonly reported livestock as a *moderate* (50.0 percent) or *low* (60.9 percent) contributor to household income, indicating that livestock plays a supportive rather than dominant role in their livelihoods. Mixed-system farmers showed a similar pattern, with 34.8 percent reporting low contribution and 34.4 percent reporting moderate contribution. In contrast, rotational grazing farmers displayed a much stronger reliance on livestock income. 55.6 percent of farmers who reported a high contribution of livestock to household income practiced rotational grazing, and 40.0 percent of those who identified livestock as their main source of income also used rotational grazing. Overall, continuous and mixed systems are associated with lower or moderate income contribution, while rotational grazing is more strongly linked to households where livestock plays a central economic role.

1.3 Livestock productivity and grazing systems

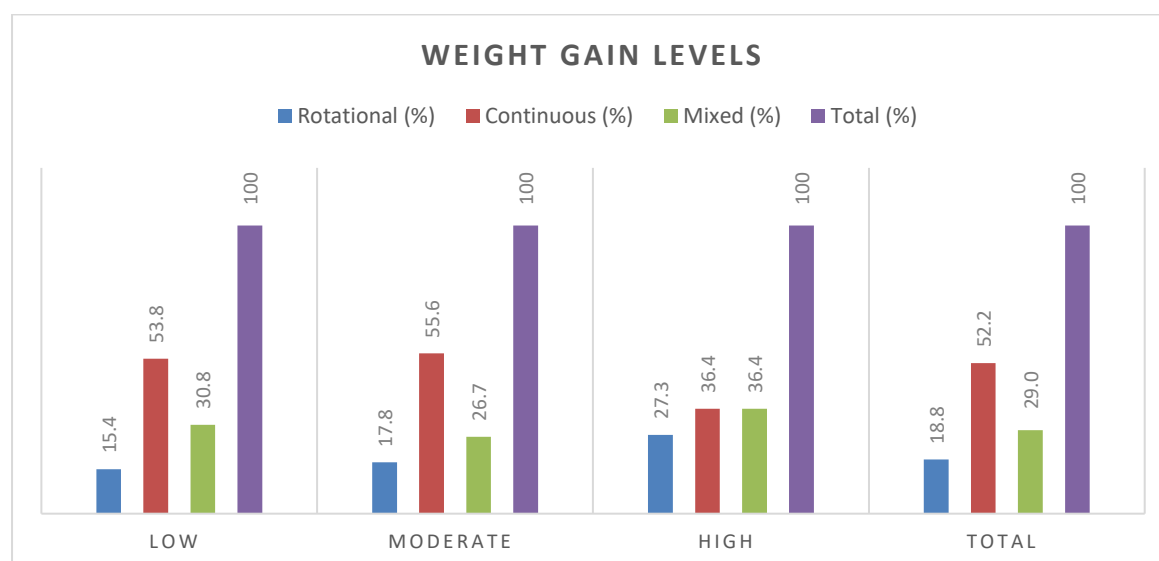
Figure 13: Distribution of livestock offtake levels by grazing system



Source: Author's own analysis based on survey data, 2026.

Figure 13 shows clear differences in livestock offtake across grazing systems. Farmers practicing continuous grazing mostly reported *low* (66.7 percent) or *moderate* (50.0 percent) offtake, with very few achieving high offtake (2.8 percent). This pattern suggests that continuous grazing may limit productivity due to overgrazing, reduced pasture recovery, and lower forage quality. Mixed-system farmers reported more balanced outcomes, with 32.4 percent achieving moderate offtake and 37.5 percent achieving high offtake, indicating that combining grazing approaches may support better herd performance. Rotational grazing farmers showed the strongest productivity outcomes: 50.0 percent reported high offtake, and only 11.1 percent reported low offtake. This suggests that rotational grazing supports higher livestock productivity through improved pasture rest periods, better forage availability, and more efficient herd management. Overall, the distribution indicates that rotational grazing is associated with higher livestock offtake, continuous grazing with lower offtake, and mixed systems fall in between.

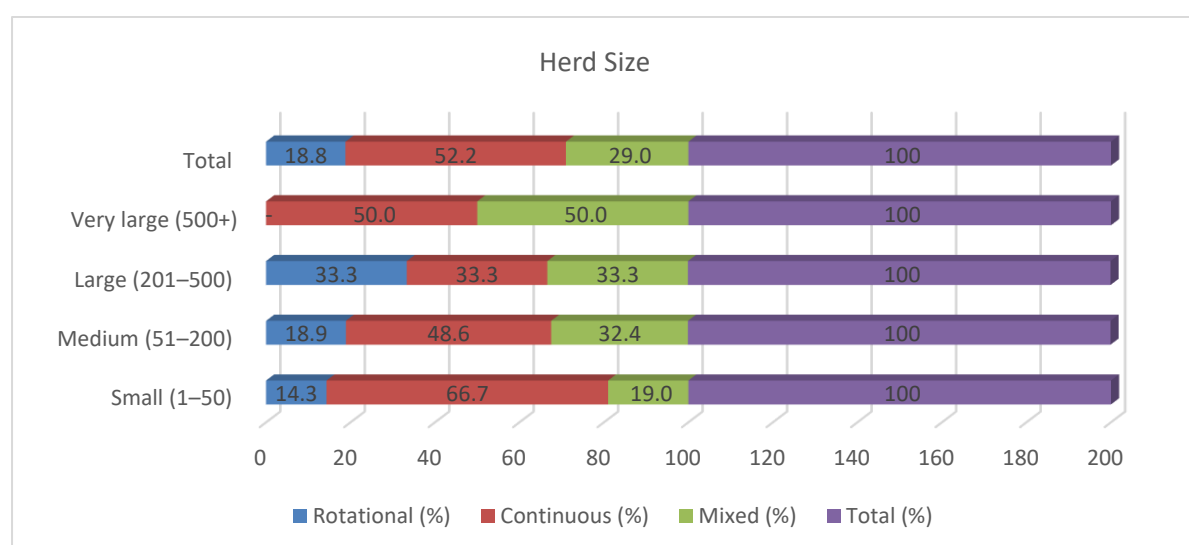
Figure 14: Distribution of weight-gain levels by grazing system



Source: Author's own analysis based on survey data, 2026.

Figure 14 shows that moderate weight gain is the most common outcome across all grazing systems. Farmers practicing continuous grazing reported the highest proportion of moderate weight gain (55.6 percent) but also the highest proportion of low weight gain (53.8 percent), indicating inconsistent growth performance under this system. Mixed-system farmers showed a more balanced distribution, with 26.7 percent reporting moderate weight gain and 36.4 percent reporting high weight gain. This suggests that combining grazing approaches may support improved forage access and better livestock growth. Rotational grazing farmers demonstrated the strongest performance: 27.3 percent reported high weight gain, compared with only 11.1 percent under continuous grazing. This pattern indicates that rotational grazing may enhance pasture recovery, improve forage quality, and support better livestock growth outcomes. Overall, the descriptive results suggest that rotational and mixed grazing systems are associated with better livestock weight gain, while continuous grazing shows weaker performance.

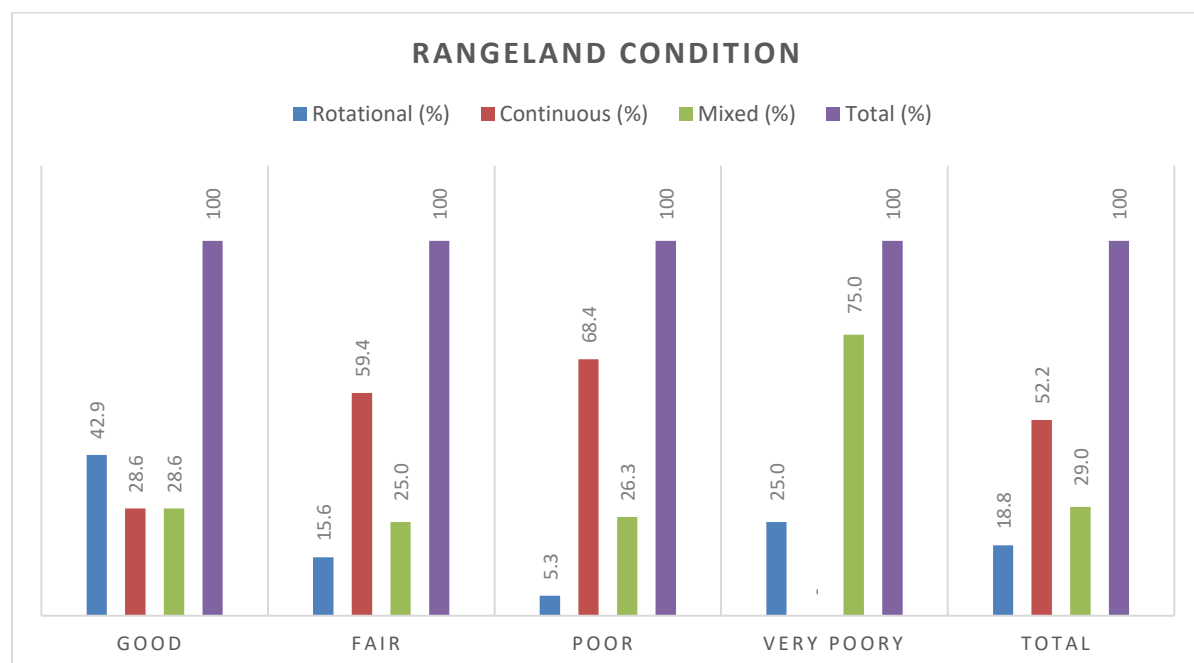
Figure 15: Distribution of herd size across grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 15 shows clear differences in herd size distribution across grazing systems. Farmers practicing continuous grazing have the highest proportion of *small herds* (66.7 percent), suggesting that continuous grazing may be associated with lower carrying capacity or more constrained herd expansion. Continuous grazing also has the lowest proportion of large herds. Mixed-system farmers show a more balanced herd structure, with 32.4 percent having medium herds and 33.3 percent having large herds. This indicates that combining grazing approaches may support moderate to strong herd growth. Rotational grazing farmers display a relatively even distribution across herd sizes, but notably 33.3 percent have large herds similar to mixed systems and higher than continuous grazing. This suggests that rotational grazing may support larger herd sizes through improved pasture recovery, better forage availability, and more efficient grazing management. The very large herd category is too small (only two farmers) to draw firm conclusions, but both cases occur in continuous and mixed systems. Overall, the descriptive results indicate that rotational and mixed grazing systems are associated with larger herd sizes, while continuous grazing is linked to smaller herds.

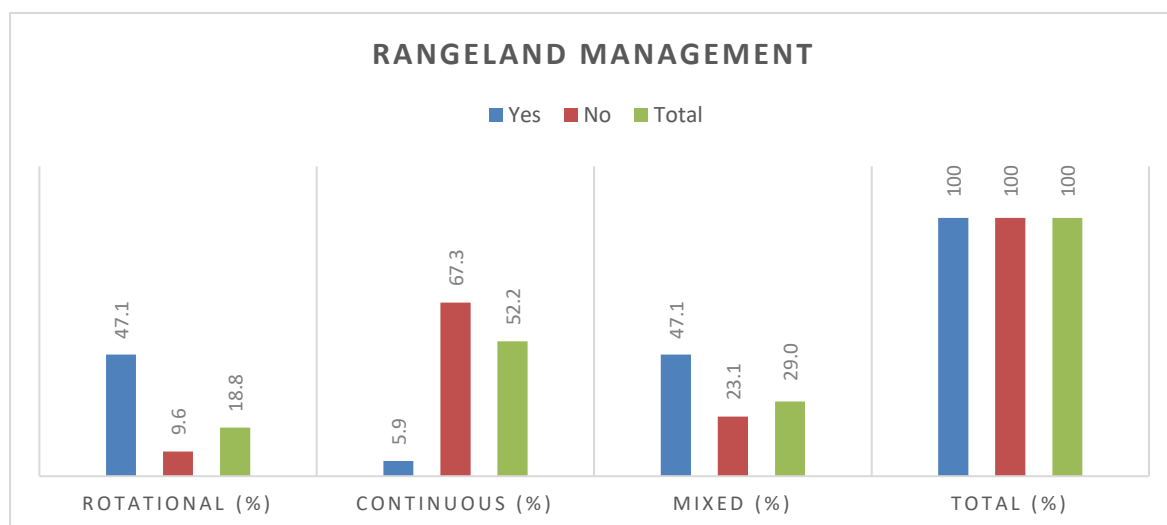
Figure 16: Distribution of rangeland conditions ratings by grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 16 reveals clear differences in rangeland condition across grazing systems. Farmers practicing continuous grazing reported the highest proportion of *poor* rangeland condition (68.4 percent) and the lowest proportion of *good* condition (28.6 percent), indicating strong links to rangeland degradation likely driven by overgrazing and insufficient pasture recovery. In contrast, rotational grazing produced the most favourable outcomes: 42.9 percent of farmers rated their rangeland as *good*, and only 5.3 percent reported *poor* condition. These results reflect the benefits of structured rest periods, improved vegetation recovery, and more sustainable grazing pressure. Mixed-system farmers showed intermediate results, with 25.0 percent reporting poor condition and 28.6 percent reporting good condition, suggesting that combining grazing approaches may help maintain moderate rangeland health. Although the *very poor* category was small, it is notable that none of these farmers practiced continuous grazing, with most falling under mixed systems. Overall, the descriptive evidence indicates that rotational grazing is associated with healthier rangelands, mixed systems support moderate condition, and continuous grazing is linked to poorer rangeland health.

Figure 17: Distribution of rangeland management practices by grazing system

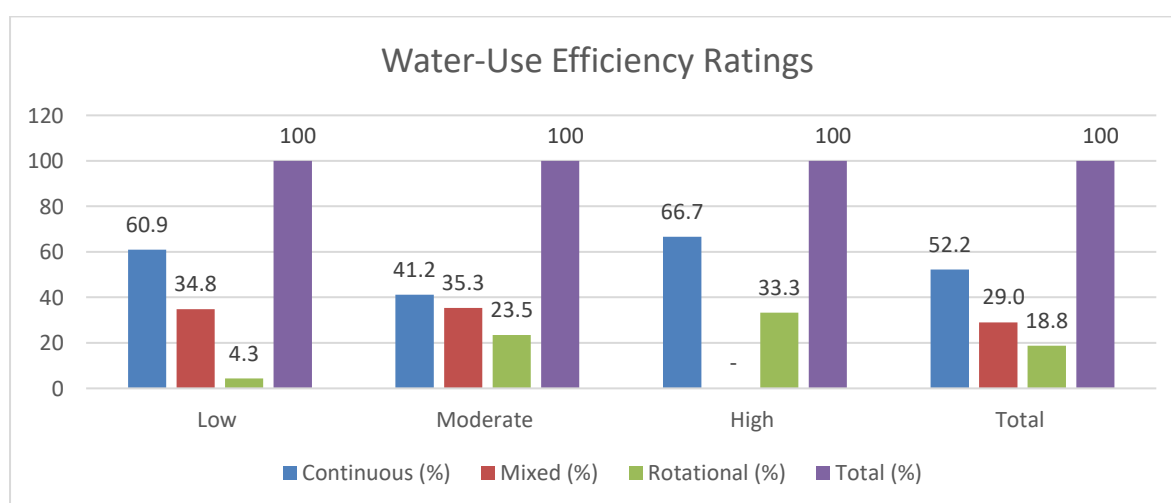


Source: Author's own analysis based on survey data, 2026.

Figure 17 shows clear differences in farmers' engagement in rangeland management activities across grazing systems. Rotational grazing farmers reported the highest participation, with 47.1 percent practicing rangeland management and 61.5 percent of all rotational farmers falling into the "Yes" category. This reflects the structured nature of rotational grazing, which requires active monitoring, planning, and pasture management. Mixed-system farmers also demonstrated substantial engagement, with 47.1 percent reporting that they practice rangeland management. This suggests that combining grazing approaches encourages more deliberate stewardship of rangeland resources. In contrast, continuous grazing farmers showed extremely low involvement, with only 5.9 percent practicing rangeland management and 97.2 percent reporting no engagement. This aligns with the minimal intervention nature of continuous grazing, which can contribute to rangeland degradation when unmanaged. Overall, the descriptive results indicate that rotational and mixed grazing systems are strongly associated with active rangeland management, whereas continuous grazing is linked to very low levels of management activity.

1.4 Water efficiency and sustainability

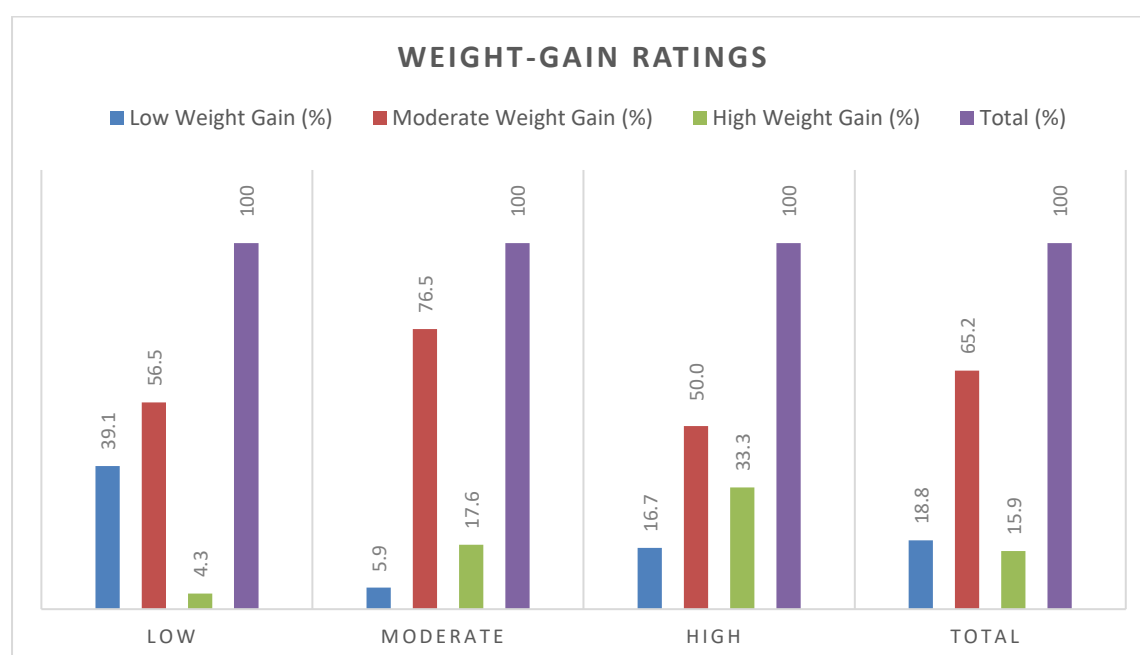
Figure 18: Distribution of water-use efficiency ratings across grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 18 shows clear differences in farmers' perceptions of water use efficiency across grazing systems. Farmers practicing continuous grazing most commonly rated their water use efficiency as low (60.9 percent) or moderate (41.2 percent), indicating that water use under this system is generally viewed as less efficient. Mixed-system farmers showed a similar pattern, with 34.8 percent reporting low efficiency and 35.3 percent reporting moderate efficiency. Notably, none of the mixed-system farmers rated their water use efficiency as high. In contrast, rotational grazing farmers reported noticeably better water use efficiency: 23.5 percent rated their water use as moderate and 33.3 percent rated it as high. This suggests that rotational grazing is more strongly associated with higher perceived water use efficiency, likely reflecting improved resource management, structured livestock movement, and better pasture recovery. Overall, the descriptive results indicate that rotational grazing is linked to higher water-use efficiency, while continuous and mixed systems are associated with lower or moderate efficiency levels.

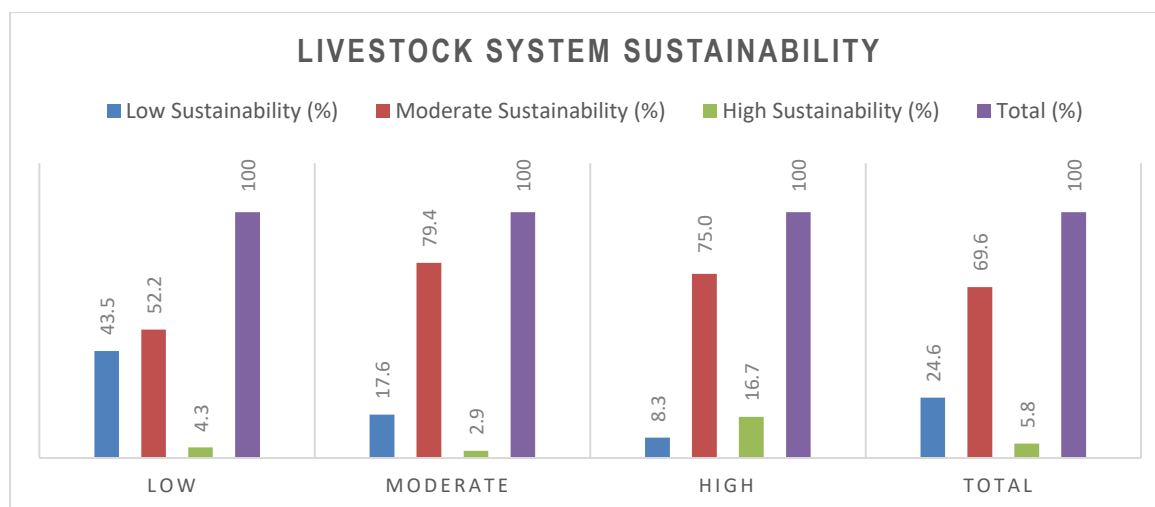
Figure 19: Distribution of weigh-gain rating by water-use efficiency



Source: Author's own analysis based on survey data, 2026.

Figure 19 shows a clear pattern between water use efficiency and livestock weight gain. Farmers who rated their water use efficiency as low mostly reported *moderate* weight gain (56.5 percent), with only 4.3 percent achieving high weight gain. This suggests that poor water use efficiency may be associated with weaker livestock performance. Farmers with moderate water use efficiency overwhelmingly reported *moderate* weight gain (76.5 percent), and 17.6 percent reported high weight gain, indicating a more favourable livestock growth profile. Farmers who rated their water use efficiency as high showed the strongest outcomes: one-third (33.3 percent) reported high weight gain, and half reported *moderate* weight gain. This pattern suggests that efficient water management supports improved forage access, better hydration, and stronger livestock growth. Overall, the descriptive results indicate that higher water use efficiency is associated with better livestock weight - gain outcomes, while low efficiency corresponds with weaker performance.

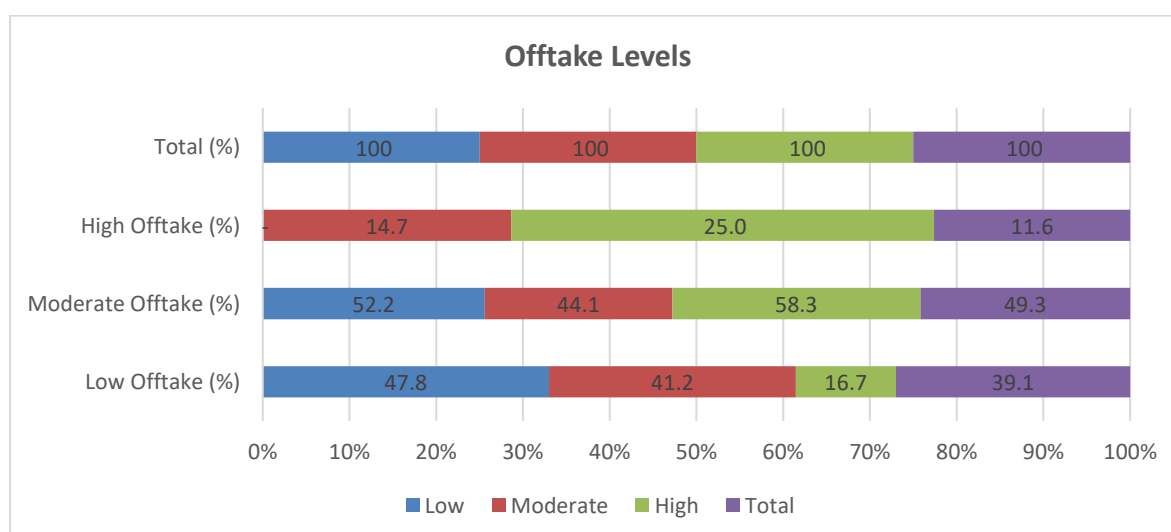
Figure 20: Distribution of livestock system sustainability by water-use efficiency



Source: Author's own analysis based on survey data, 2026.

Figure 20 shows a clear relationship between water use efficiency and the perceived sustainability of livestock production systems. Farmers who rated their water use efficiency as low mostly reported low (43.5 percent) or moderate (52.2 percent) sustainability, with only 4.3 percent indicating high sustainability. This suggests that poor water use efficiency is associated with weaker sustainability outcomes. Farmers with moderate water use efficiency overwhelmingly rated their systems as moderately sustainable (79.4 percent), with very few reporting high sustainability (2.9 percent). This indicates that moderate efficiency supports more stable and sustainable production practices compared to low efficiency. Farmers who rated their water use efficiency as high showed the strongest sustainability outcomes. Half (50.0 percent) of the farmers who reported high sustainability also rated their water use efficiency as high, and 75.0 percent rated their sustainability as moderate. This pattern suggests that efficient water management is closely linked to improved environmental stewardship, better herd management, and stronger long term production stability. Overall, the descriptive results indicate that higher water use efficiency is associated with higher sustainability ratings, while low efficiency corresponds with lower sustainability.

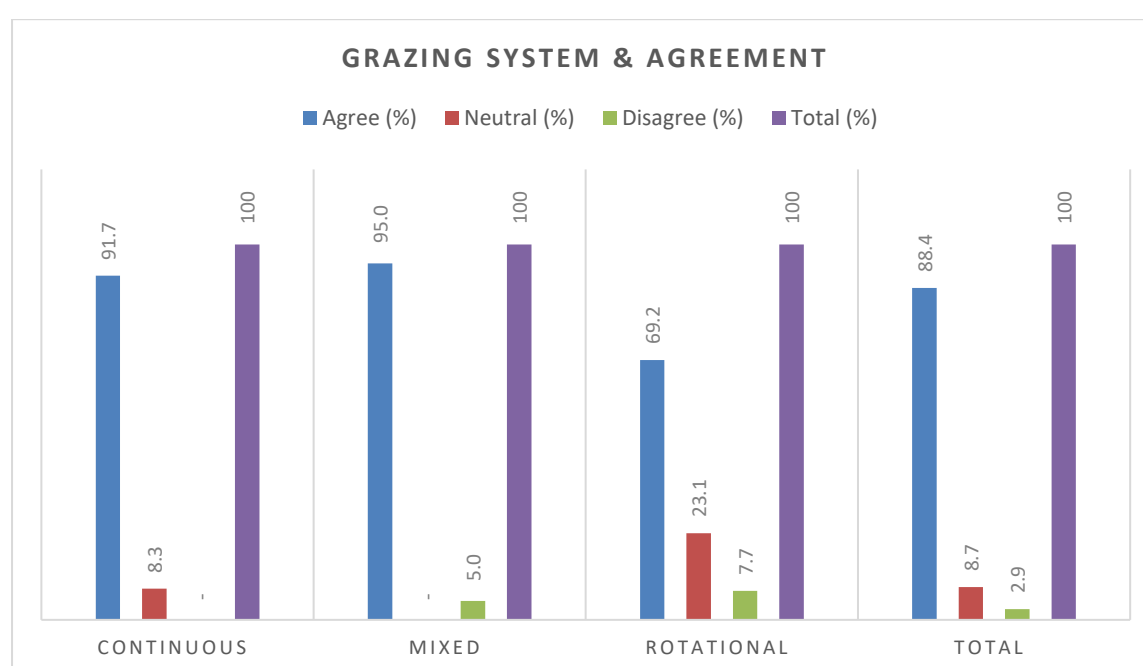
Figure 21: Distribution of offtake levels by water use efficiency



Source: Author's own analysis based on survey data, 2026.

Figure 21 shows clear differences in livestock offtake across water-use efficiency levels. Farmers with low water use efficiency reported predominantly low (47.8 percent) and *moderate* (52.2 percent) offtake, with none achieving high offtake. This suggests that poor water use efficiency may constrain livestock marketing performance and overall turnover. Farmers with moderate efficiency displayed a more balanced pattern: 41.2 percent reported low offtake, 44.1 percent moderate offtake, and 14.7 percent high offtake. This indicates that moderate efficiency supports better livestock productivity than low efficiency. Farmers who rated their water use efficiency as high demonstrated the strongest outcomes. One quarter (25.0 percent) achieved high offtake, and 58.3 percent reported *moderate* offtake, highlighting the role of efficient water management in supporting improved livestock productivity and marketable output. Overall, the descriptive evidence shows that higher water use efficiency corresponds with higher livestock offtake, while low efficiency is associated with reduced turnover.

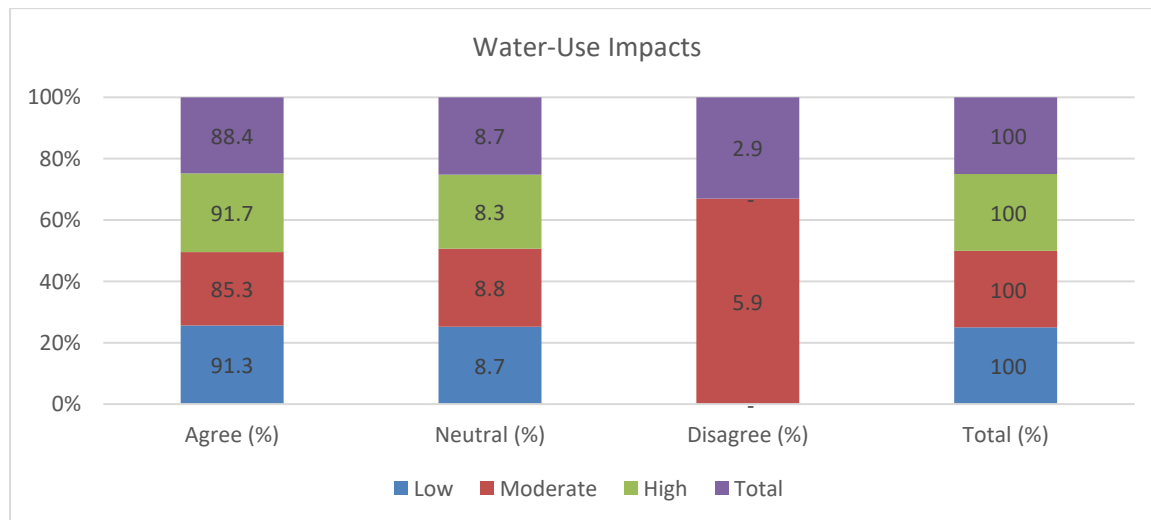
Figure 22: Grazing system and agreement on water-use impacts on livestock



Source: Author's own analysis based on survey data, 2026.

Figure 22 shows strong agreement across all grazing systems that water use affects livestock performance. Farmers practicing continuous grazing overwhelmingly agreed (91.7 percent), with only 8.3 percent remaining neutral and none disagreeing. Mixed-system farmers showed an even stronger pattern, with 95.0 percent agreeing and only 5.0 percent disagreeing. Farmers using rotational grazing also mostly agreed (69.2 percent), but displayed more variation than the other groups: 23.1 percent were neutral and 7.7 percent disagreed. This suggests that rotational grazing farmers may perceive water use impacts differently, possibly due to more structured water management practices or differing experiences with water availability. Overall, the descriptive results indicate that farmers across all grazing systems strongly believe that water use affects livestock, with the highest agreement found among mixed system farmers. Rotational grazing farmers show slightly more diversity in opinion, but still largely support the view that water use plays an important role in livestock performance.

Figure 23: Water-use efficiency and agreement on water-use impact on livestock

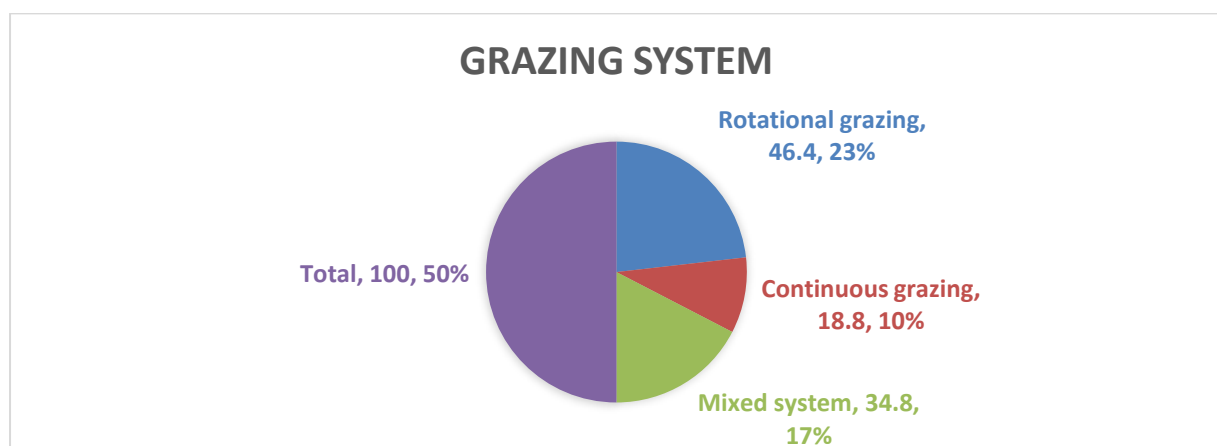


Source: Author's own analysis based on survey data, 2026.

Figure 23 indicates consistently strong agreement across all water use efficiency levels that water use affects livestock performance. Farmers with low water use efficiency overwhelmingly agreed (91.3 percent), with only 8.7 percent remaining neutral and none disagreeing, suggesting that even those experiencing inefficiencies recognise the critical role of water in livestock production. Farmers with moderate efficiency also showed high agreement (85.3 percent), although this group recorded the highest proportion of disagreement (5.9 percent). This may reflect differing perceptions of water impacts or more resilient production systems among moderately efficient farmers. The strongest consensus was observed among farmers with high water use efficiency, with 91.7 percent agreeing and no disagreement reported. This suggests heightened awareness of water's importance among farmers who manage water more effectively. Overall, the descriptive results demonstrate that agreement on the importance of water use is very high across all efficiency levels, with only minor variation. Farmers overwhelmingly believe that water availability and management directly affect livestock performance, regardless of their water use efficiency rating.

1.5 Farmer Preferences, Support Needs, and Perceptions of Grazing System Improvement

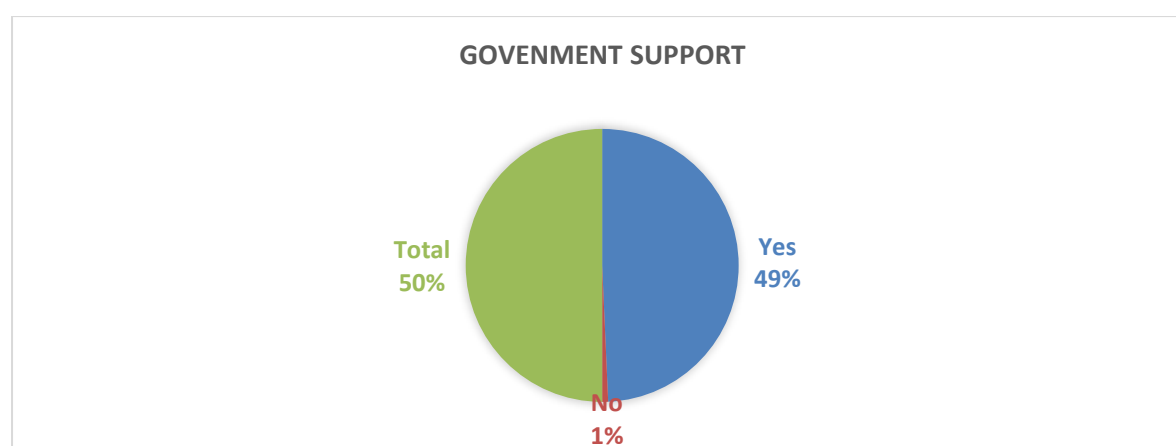
Figure 24: Best Grazing system preferred by farmers



Source: Author's own analysis based on survey data, 2026.

Figure 24 shows that rotational grazing is considered the best grazing system by nearly half of the farmers (46.4 percent). This strong preference reflects farmers' perceptions of rotational grazing as the most effective system for improving pasture recovery, livestock performance, and overall rangeland health. Mixed grazing systems are also widely supported (34.8 percent), indicating that many farmers value the flexibility and adaptability offered by combining grazing approaches. In contrast, only 18.8 percent of farmers prefer continuous grazing, demonstrating limited confidence in its effectiveness and aligning with earlier findings showing poorer rangeland condition and lower productivity under continuous grazing. Overall, the descriptive results indicate that farmers overwhelmingly favour grazing systems that promote better pasture management, improved livestock outcomes, and more sustainable production, with rotational grazing emerging as the most preferred option.

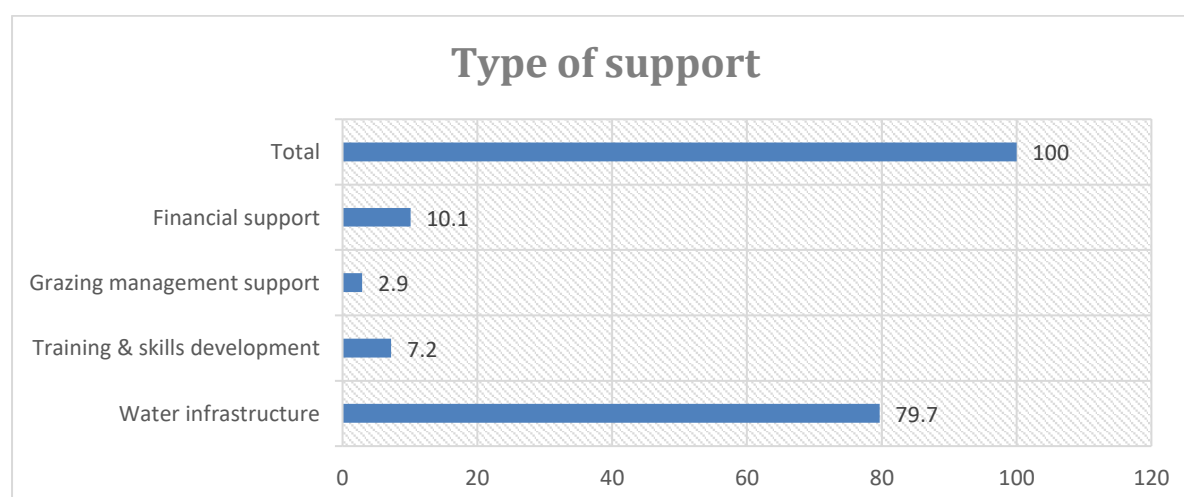
Figure 25: Government support needed for improved grazing systems



Source: Author's own analysis based on survey data, 2026.

Figure 25 shows near-unanimous agreement among farmers that government support is required to improve grazing systems, with 49.0 percent expressing this need. This overwhelming consensus underscores the critical role of institutional support in strengthening grazing practices, enhancing rangeland health, and improving livestock productivity. Only one farmer (1.4 percent) indicated that government support is not necessary, highlighting the widespread recognition that effective grazing management depends on coordinated assistance, policy backing, and sustained investment.

Figure 26: Type of support needed by farmers



Source: Author's own analysis based on survey data, 2026.

Figure 26 shows that farmers overwhelmingly identified water infrastructure as the most critical support need, with 79.7 percent highlighting it as essential. This aligns with earlier findings demonstrating the central role of water availability in livestock performance, grazing system effectiveness, and rangeland condition. Financial support was the second most cited need (10.1 percent), reflecting the costs associated with improving grazing systems, investing in water infrastructure, and maintaining livestock production. Training and skills development (7.2 percent) and grazing management support (2.9 percent) were mentioned less frequently, indicating that while capacity building is valued, farmers view physical infrastructure particularly reliable water systems as the most urgent requirement for improving grazing systems. Overall, the results show that strengthening water infrastructure is the top priority for farmers and is seen as fundamental to supporting sustainable livestock production and improved grazing management.

7. DISCUSSION

This study examined how grazing systems, water use efficiency, and rangeland management practices influence livestock productivity and ecosystem condition in Namibia's semi-arid rangelands. The findings reveal consistent patterns that align closely with the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA), which emphasises the relationship between ecosystem condition, ecosystem services, and the economic benefits derived from natural assets. Across all indicators, rotational grazing emerges as the system most strongly associated with improved ecological condition, higher livestock performance, and stronger sustainability outcomes, while continuous grazing is consistently linked to degraded rangelands and weaker productivity.

7.1 Grazing Systems and Ecosystem Condition

The findings of this study reveal clear differences in ecosystem condition across grazing systems. Rotational grazing is associated with healthier vegetation cover, improved soil structure, and stronger moisture retention, while continuous grazing shows signs of degradation, including reduced pasture availability and increased grazing pressure. These results underscore the importance of grazing management in maintaining ecosystem condition and sustaining rangeland productivity. Mixed grazing systems demonstrate moderate ecological outcomes, reflecting partial adoption of improved management practices.

7.2 Livestock Productivity as an Ecosystem Service

Livestock productivity indicators including offtake rates, weight gain, and herd performance—were consistently higher under rotational grazing. Continuous grazing systems exhibited lower productivity, consistent with degraded rangeland conditions. This pattern highlights the direct link between ecosystem condition and livestock provisioning services, demonstrating how healthier ecosystems support stronger biomass production and improved livestock outputs. Mixed systems showed intermediate productivity, indicating potential for improvement through enhanced management.

7.3 Water-Use Efficiency and Ecosystem Function

Water-use efficiency varied significantly across grazing systems. Rotational grazing demonstrated the highest efficiency, reflecting better water retention, improved forage quality, and stronger livestock performance. Continuous grazing showed the lowest efficiency due to higher rainfall dependence and degraded rangelands. These findings illustrate how ecosystem function particularly water provisioning

and soil moisture regulation directly influences livestock water requirements and overall production efficiency.

7.4 Sustainability and Long-Term Ecosystem Capacity

The results indicate that rotational grazing supports long-term ecosystem sustainability by allowing vegetation recovery, reducing soil erosion, and enhancing water infiltration. Continuous grazing, by contrast, places pressure on rangeland ecosystems, reducing carrying capacity and increasing vulnerability to climate variability. Sustainable grazing practices therefore play a critical role in maintaining ecosystem capacity and ensuring long-term resilience in semi-arid rangelands.

7.5 Farmer Preferences and Institutional Support Needs

Farmers overwhelmingly preferred rotational grazing, citing improved productivity, better rangeland condition, and stronger economic returns. Nearly all respondents agreed that government support is essential for improving grazing systems, particularly through water infrastructure, training, and rangeland rehabilitation. These perceptions highlight the need for institutional interventions that align farmer priorities with sustainable ecosystem management practices.

7.6 SEEA-EA Interpretation (Insert into Discussion Section)

The results of this study demonstrate clear linkages between ecosystem condition, ecosystem service flows, and economic contribution, consistent with the SEEA-EA framework. Under SEEA-EA, rangelands are recognized as ecosystem assets that generate provisioning services such as forage biomass and livestock production. The observed differences across grazing systems reflect variations in ecosystem condition: rotational grazing maintains higher vegetation cover, improved soil structure, and stronger moisture retention, while continuous grazing is associated with degraded rangelands and reduced carrying capacity.

These differences in ecosystem condition directly influence ecosystem service flows. Rotational grazing supports higher livestock offtake, stronger weight gain, and greater water-use efficiency, indicating more effective conversion of ecosystem inputs (water and biomass) into economic outputs. In contrast, continuous grazing shows lower productivity and higher rainfall dependence, reflecting weakened ecosystem functioning.

The economic contribution of livestock production mirrors these ecological patterns. Farms practicing rotational grazing generate higher income and stronger livelihood resilience, demonstrating how healthy ecosystems support sustained economic benefits. By linking physical ecosystem condition indicators with livestock outputs and household income, the study illustrates how SEEA-EA can be applied at farm level to quantify the contribution of natural capital to rural economies.

Overall, the findings confirm that sustainable grazing practices enhance ecosystem condition, strengthen ecosystem service flows, and improve economic outcomes — a core principle of SEEA-EA ecosystem accounting.

8. Conclusion and Policy Recommendations

8.1 Conclusion

This study assessed water-use efficiency and the economic contribution of livestock production under rotational, continuous, and mixed grazing systems in the Otjozondjupa Region of Namibia. The findings reveal clear and consistent differences across grazing systems in terms of ecosystem condition, livestock productivity, water-use efficiency, and household income. Rotational grazing demonstrated superior ecological and economic outcomes, including healthier rangelands, higher livestock offtake, stronger weight gain, and greater water-use efficiency. Continuous grazing, by contrast, was associated with degraded rangelands, higher rainfall dependence, lower productivity, and weaker income performance. Mixed grazing systems showed moderate results across all indicators.

Water scarcity emerged as a major constraint, with 53.6 percent of farmers experiencing shortages in the past year. Farmers overwhelmingly preferred rotational grazing and expressed strong demand for government support, particularly in water infrastructure, rangeland rehabilitation, and training. These findings highlight the central role of sustainable grazing and water management in strengthening livestock productivity and resilience in semi-arid rangelands.

From a SEEA-EA perspective, the study demonstrates how ecosystem condition directly influences ecosystem service flows and economic contribution. Healthy rangelands support higher biomass production, improved water retention, and stronger livestock performance, translating into greater household income and economic resilience. By linking physical ecosystem indicators with livestock outputs and economic benefits, the study provides a practical example of how SEEA-EA can be applied at farm level to strengthen natural capital accounting and inform national planning.

8.2 Policy Recommendations

Promote Rotational Grazing as a National Best Practice: Government and extension services should prioritize rotational grazing through training, demonstration farms, and incentives, given its clear ecological and economic advantages.

Strengthen Water Infrastructure for Livestock Production: Investments in boreholes, pipelines, storage tanks, and solar pumping systems are essential to reduce rainfall dependence and improve water-use efficiency.

Integrate SEEA-EA Indicators into National Planning (NDP6): Water-use efficiency, rangeland condition, and livestock provisioning services should be incorporated into Namibia's natural capital accounts and national development frameworks.

Support Rangeland Rehabilitation in Continuous Grazing Areas: Targeted interventions such as bush control, reseeding, and controlled stocking can restore degraded rangelands and enhance ecosystem service flows.

Enhance Farmer Training and Institutional Support: Extension programs should focus on sustainable grazing, water management, and ecosystem-based livestock production to strengthen long-term resilience.

Develop National Water Accounts for Livestock Production: SEEA-EA-aligned water accounts will enable evidence-based allocation, monitoring, and sustainable management of groundwater resources.

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