Australian Government

Australian Centre for International Agricultural Research

Final report

Project full title

High quality markets & value chains for small-scale & emerging beef cattle farmers in South Africa (Stage 2)

project ID	LS/2016/276
date published	14 December 2022
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approved by	Dr Anna Okello
final report number	FR2022-037
ISBN	978-1-922787-62-0
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

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1 Acknowledgments

The High Value Beef Partnerships (HVBP) project wishes to acknowledge and very sincerely thank a wide range of significant contributions to this project, including:

- All of the project's collaborating smallholder farmers in Eastern Cape, Mpumalanga, Limpopo, North West, Gauteng and Free State Provinces – without the willingness of these farmers to collaborate, the project simply would not have been possible;
- The project's collaborating commercial retailer, Woolworths, which provided generous price incentives for smallholder farmers' cattle that were able to achieve free range market specifications. Woolworths is also acknowledged for its strong and unwavering focus on identifying and delivering beef products that meet consumer specifications – without their unwavering approach to high quality beef, it would not have been possible for the project to identify and monitor the factors required for smallholder farmers to achieve those market specifications;
- Cavalier Meats in Gauteng and Cradock Abattoir in Eastern Cape, who slaughtered all project cattle being targeted for Woolworths' free range beef brand and who regularly hosted groups of visiting farmers and project team members wanting to better understand the processes needed to deliver high quality beef;
- The Departments of Agriculture in each of the six provinces targeted by the project, who not only encouraged their researchers and extension officers to fully engage in the project but also funded most of those officers' travel and operating expenses associated with project activities. The National Department of Agriculture /DALRDD also fully funded all project travel and operating expenses incurred by their staff as well as fully funding the research undertaken with poultry farmers as part of the High Value Poultry Partnerships project in collaboration with HVBP;
- Researchers and trainers from North West University, University of Fort Hare, Stellenbosch University, FANRPAN and the University of Queensland who contributed directly to the project in their particular areas of expertise;
- Researchers and extension officers from Botswana, Malawi and Zimbabwe, as well as additional contributors from across South Africa, for conducting behaviour change surveys amongst smallholder farmers across a number of different livestock industries (beef and dairy cattle, sheep and goats, pigs and poultry) to test the effectiveness of a shorter psychological profiling instrument. The costs for these new surveys was met by combining those surveys with other activities being implemented by those researchers and extension officers in their own countries; and
- Members of the project's industry and scientific advisory council who actively contributed to 6-monthly ISAC meetings through the project until travel to participate in those meetings was no longer possible.

When this project was initially developed, it was estimated the in-kind contributions of the South African partners would be of the order of $12 for every $1 invested by ACIAR. Based on the many additional and significant contributions acknowledged above, it is clear the level of co-investment by partners across southern Africa greatly exceeded this original estimate. The project team is enormously grateful for those significant contributions of time, labour and operating funds, all of which allowed us to achieve more than would otherwise have been possible under the particularly challenging conditions experienced by the project during the Covid-19 pandemic and through the difficulties experienced by the South African partners in accessing the project's operating funds.

2 Executive summary

The High Value Beef Partnerships (HVBP) project addressed the question: *'Can high-value free-range beef products be developed from cattle from smallholder farms to cost-effectively meet the preferences of South African consumers?'*

Project collaborators included a commercial retailer (Woolworths, South Africa) and abattoirs nominated by Woolworths (Cavalier Meats in Gauteng and Cradock Abattoir in Eastern Cape). Stage 1 of the project (2015-2017) demonstrated that cattle from smallholder herds could meet high value free-range market specifications. Stage 2 worked with large numbers of smallholder farmers, researchers and extension officers across six South African provinces to help the farmers supply an expanding market for high-value, free-range beef from cattle up to 3 years of age. Those animals were 12-24 months older than cattle supplying South Africa's traditional grain-fed beef markets.

The overall goal was to improve the profitability of smallholder farmers in South Africa by developing cost-effective and environmentally sustainable beef value chains supplying cattle meeting the specifications of high-value, free-range beef markets.

Additional research focused on identifying key factors (gender, primary language and culture) affecting the success of all sectors of the Cavalier and Cradock value chains. It also developed and evaluated new on-farm production systems and methods to customise interventions for farmers to maximise adoption of proven technologies and improve farm business performance. This research also delivered strong benefits to smallholder poultry (broiler and layer) farmers.

Unfortunately, the project experienced two major disruptions to its activities. The first of those was the Covid-19 pandemic that began in March 2020 and continued throughout the remainder of the project, though travel to project sites was able to resume on an intermittent basis towards the end of 2021. The second major disruption arose when two of the project partners (ARC and NAMC) were unable to access project funding that was expected to be distributed to them on a regular basis by DAFF/DALRRD and one of the partners justifiably banned project activities by their staff in mid-2021 until payment was received. At the completion of the project, neither partner had received any of the project's Payments 1 to 8 and have significant project expenses that will be reimbursed once the funds are returned to Australia by National Treasury.

The Covid-19 disruptions meant some research was cancelled completely due to the project's inability to collect sufficient data for the purpose (e.g. Objective 1.5.3), whilst other research activities (e.g. Women's Empowerment in Livestock – WELI - surveys, gender Focus Group Discussions (FGDs) and the behaviour change intervention experiment) were initially deferred until engagement with farmers could resume safely. However once travel was able to resume, the project team was then unable to access project operating funds to allow those activities to be completed.

Of greatest concern was the project's inability to directly engage with collaborating farmers, to routinely monitor the growth rates and body condition scores of cattle owned by those farmers as well as the rangelands on which those cattle grazed, and to fully establish the planned farmer demonstration sites designed to train farmers how best to manage their animals and rangelands. Those activities were all critical to the success of the project but they were unable to be adequately achieved due to the disruptions.

Despite the disruptions, the project achieved success in several areas where data were available prior to the Covid-19 pandemic. They included identification of relationships between farmer profiles and their farm business performance, the VAIMS surveys providing value chain benchmarks and identifying areas of improvement, completion of WELI surveys and gender FGDs in Kwa-Zulu Natal, policy development proposing a new meat grading scheme, development of a new team-based model of farmer engagement and significant capacity building at farmer, extension officer and researcher levels.

3 Background

South Africa's beef industry is segregated into three 'economies': i) a commercial sector with well-developed value chains, industry infrastructure and production systems equal to most developed countries; ii) an 'emerging farmer' sector comprising smallholder farmers who own or lease land and are commercially-oriented but lack the training, infrastructure and production systems available to the commercial sector; and iii) a third 'communal farmer' sector, where farmers do not own or lease land but graze their cattle on communally-owned land and operate mainly as subsistence farmers.

In 2016, there were 13.6 million head of cattle in South Africa, with 42% (5.7 million head) owned by emerging and communal farmers. Emerging and communal farmers marketed less than 10% of their animals each year, compared to 25% in the commercial sector, showing the enormous potential for improvement. Development of the emerging and communal farm sectors was a very high priority for the South African Government.

Annual per capita beef consumption in South Africa was 16.7 kg in 2015 and was projected to increase by a further 20% by 2023. To meet this growing demand, South Africa is a net importer of beef and live animals to supply grain-fed beef to supermarkets and weaner cattle for feedlots. Although some emerging farmers supply weaners to the feedlots, most have strong social and cultural preferences for keeping older animals.

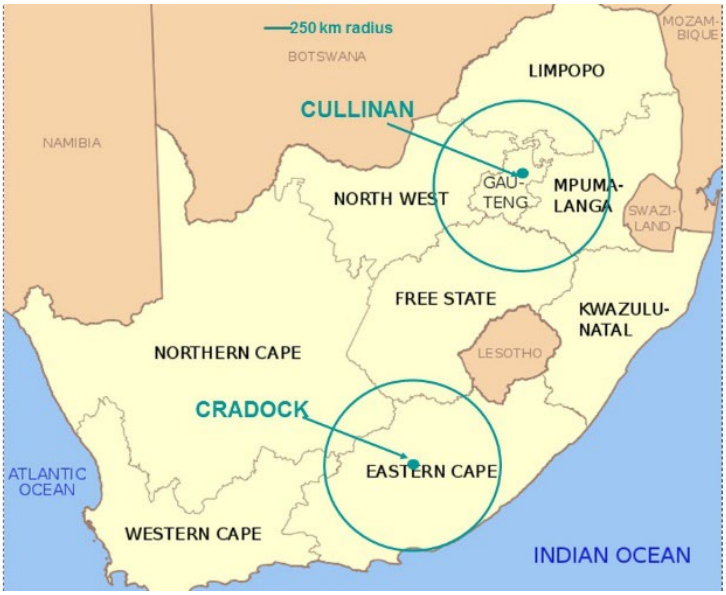
Research in the Stage 1 project (LPS/2005/128) showed there was a new, but largely untapped and almost unlimited opportunity for farmers to supply beef into a new free-range beef market being developed by commercial supermarkets and targeting the growing middle-higher income classes. While consumer demand for free-range beef is very high, South Africa's beef production is dominated by high-input, grain-finished beef from young animals (<18 months). South Africa's beef carcass classification system strongly discounts beef from older animals, so Woolworths is operating independently to provide generous financial incentives for farmers who can grow and finish their cattle to free-range market specifications by 3 years of age. If smallholder farmers can meet the specifications of this free-range market, it provides strong opportunities to improve the profitability of their herds whilst also accommodating their preferences for selling cattle off pasture and at older ages.

The Stage 1 project demonstrated that a relatively small number of emerging farmers were able to successfully supply cattle for the new free-range markets, achieving significant price premiums for carcasses complying with specifications. To achieve a consistent year-round supply of compliant carcasses to sustain the market though, several major constraints still needed to be addressed. Overcoming those constraints was the major focus of the Stage 2 project, which aimed to answer the question: *'Can high-value free-range beef products be developed from cattle from emerging and communal farmer herds to cost-effectively meet the preferences of South African beef consumers?'* The overall goal of the project was that:

> *'By December 2021, at least 2,000 emerging and communal farm businesses would be cost-effectively, and in an environmentally sustainable way, supplying cattle on a year-round basis to Cradock Abattoir and Cavalier Meats and achieving at least 70% compliance with Woolworths' high-value, free-range market specifications'.*

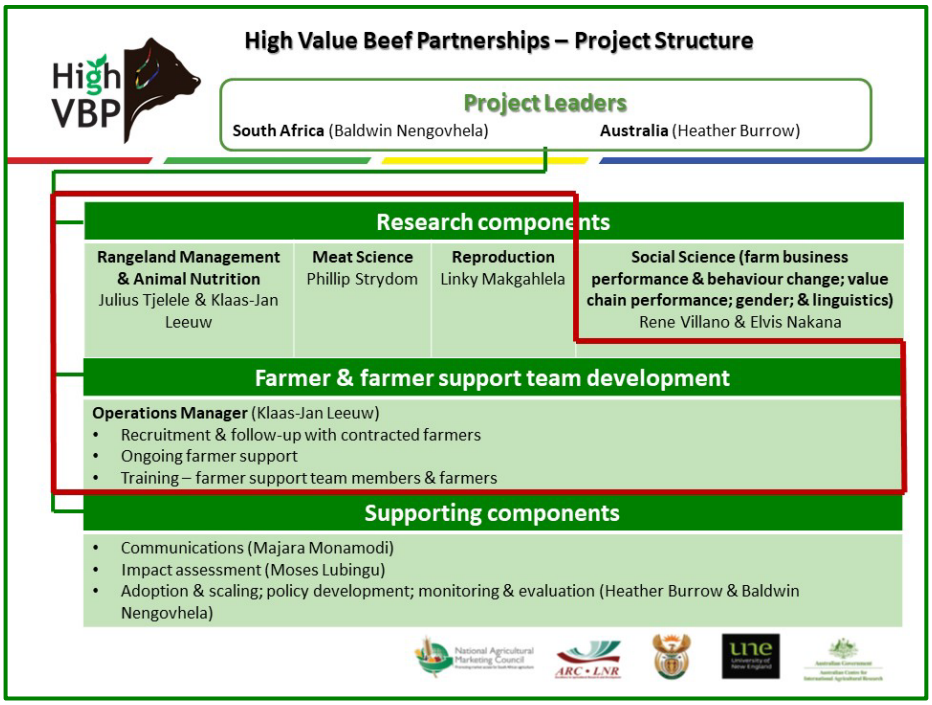
The research was undertaken in partnership with Woolworths and two collaborating abattoirs nominated by Woolworths (Cavalier Meats in Gauteng and Cradock Abattoir / Stormberg Meats in Eastern Cape). It was also linked to Operation Phakisa – Fortified Veld Management. Primarily the project aimed to assist small-scale cattle farmers to work

with these commercial partners to supply a growing premium market for high-value, free-range beef from animals slaughtered up to 3 years of age. Additional cutting-edge research focused on identifying the key factors that impacted on the success of individual farmers, farmer co-operatives, abattoirs and retailers throughout the two beef value chains. It also developed and evaluated new ways to customise interventions for farmers to enable them to maximise their uptake of proven technologies and improve farm business performance.



3.1 Project structure

Based on the ambitious overall goal that required whole-of-farm solutions to be applied by collaborating farmers, the project took a multi-disciplinary, multi-organisational approach. That approach necessarily required a multi-disciplinary, multi-organisational structure as summarised in the following diagram. Project components within the red frame address Objective 1, whilst Objective 2 comprises all social science activities and Objective 3 comprises all supporting components (see following Section 4 for the Objectives.



Roles and responsibilities of the project's collaborators

3.2 Targeted Outputs and Impacts

Achieving the project's overall goal was designed to simultaneously improve the profitability and productivity of smallholder farmers' businesses through higher prices for cattle meeting free-range specifications and improved on-farm production systems that increased animal performance and supply of cattle. The natural resource base would be maintained or improved through use of environmentally sustainable production systems. Business capacity of smallholder farmers and the capacity, knowledge and skills of the project's extension officers would be enhanced by training provided by the project. The two commercial beef value chains would benefit from an improved supply of cattle meeting free-range market specifications. Scientific impact would be achieved through wider use by the scientific community of new knowledge, practices, processes and technologies, particularly relating to adoption and scaling out. With a growing but under-

supplied free-range market, the opportunities to scale out the project's results to other value chains in South Africa and other southern African countries was deemed to be considerable.

3.3 Industry and Scientific Advisory Council

To develop new market systems and value chains, and to ensure end-user involvement from the outset, the project established an Industry and Scientific Advisory Council (ISAC) in 2015 to actively partner with the project team to achieve the project's goals and objectives and to provide ongoing and relevant advice and expertise to the project in the areas of market systems and value chains. The ISAC comprised representatives of all the project's collaborating partners, invited members with specialist discipline expertise relevant to the project as well as representatives from industry (Cavalier and Cradock) and farmer representatives (2 male and 2 female farmers).

The ISAC met every 6 months following its formation and provided written feedback to the project, which the team incorporated into their revised activities until the onset of Covid-19 in 2020. Following the outbreak of Covid-19, the project team was unable to physically meet and so provided 6-monthly progress reports to the ISAC until June 2021. However due to the further disruption of the project resulting from the failure of the administering agency (DALRRD) to disburse project funds to ARC and NAMC, project activities were forced to wind back or cease altogether due to the lack of operating funds for the South African partner agencies. Resolution of this funding issue was not achieved during the project's contracted period.

4 Objectives

The Stage 2 project had three objectives, namely to:

1. **Improve on-farm animal health, nutrition, management and breeding systems to enable smallholder farmers to cost-effectively deliver a year-round supply of high-value, free-range beef whilst simultaneously improving their natural resource base** i.e. to train farmers in best-practice herd management and use of improved farm management systems, to undertake on-farm participative action research to evaluate alternative systems to those already available at the start of the project and to analyse project data to identify factors impacting on cow reproductive performance with the aim of improving year-round cattle supply for the free-range brand (65% of project effort).

2. **Improve the profitability of all sectors of the project's beef value chains through increased adoption of proven interventions by farmers and implementation of practices that create efficiencies and effectiveness across the entire value chains** i.e. implement the project's Behaviour Change, Value Chain and Women's Empowerment surveys and analyse the data from those surveys to identify areas of improvement and to design and evaluate customised strategies to increase adoption and overcome inequities identified by the surveys (25% of project effort).

3. **Develop scaling out strategies and guidelines that enable application of the project's results to other value chains** i.e. use established scaling out processes as well as trialing new methods developed by the project and undertake retrospective analyses of the projects' decision making processes to develop guidelines and recommendations for commercial sectors wanting to establish new agricultural value chains that reward smallholder farmers for the quality of their products relative to market specifications (10% of project effort).

Following the project's mid-term review in May 2020, three additional activities were added to Objective 1:

- Undertake a qualitative research study aimed at identifying reasons why farmers do or do not adopt proven animal production and rangeland management technologies;

- Re-establish the farmer demonstration sites to directly meet the learning needs of collaborating project farmers within the geographical regions of the sites and to leave them as project legacy sites under the management of the local Provincial Departments of Agriculture; and

- Conduct 'Visioning' workshops targeting senior managers of the National and Provincial Departments of Agriculture and other critical stakeholders with the aim of better positioning government-funded agricultural extension services as 'facilitators of peer learning' rather than their current roles as 'vehicles of knowledge transfer'.

5 Methodology

5.1 Objective 1

This objective represented the largest component of project effort (65%), comprising:

- Engagement and training of specialist extension officers from the Provincial Departments of Agriculture in the six provinces targeted by the project;
- Farmer- and farm-related activities including recruitment, training and support of collaborating farmers; and
- On-farm animal nutrition, rangeland management and reproduction research.

Following the project's mid-term review in May 2020, the project added three additional activities to this objective, namely to: 1) undertake training of project team members in qualitative research methodologies and conducting a qualitative study aimed at identifying reasons why collaborating farmers did or did not adopt proven animal production and rangeland management technologies after they participated in at least 4 x 2- or 3-day training workshops focused on those technologies; 2) re-establish the project's farmer demonstration sites in line with the project's new team-based approaches to farmer engagement, to ensure those sites met the needs of farmers within the geographical regions of the demonstration sites and to leave them as legacy sites under the management of the relevant Provincial Department of Agriculture at the end of the project; and 3) conduct 'Visioning' workshops targeting senior managers of the National and Provincial Departments of Agriculture and other critical stakeholders with the aim of better positioning government-funded agricultural extension services as 'facilitators of peer learning' rather than their current roles as 'vehicles of knowledge transfer'.

The methodology used for these activities included:

- Development and regular updating of a Farmer Training manual specifically targeting free-range beef with the manual accredited by South Africa's vocational training program, AgriSeta and also made freely available to all of the project's farmers and farmer support team members;
- Using the Farmer Training manual as the basis of initial and regular ongoing training of all project extension and farmer support team members;
- Conducting bi-annual 2- or 3-day intensive training of collaborating farmers at central locations in each of the Cavalier and Cradock value chains, with regular follow-up training of farmers by extension officers in the farmers' local regions;
- Regularly monitoring progress of cattle nominated by collaborating farmers for free range markets to ensure they are progressing towards market specifications, assisting farmers to implement changes to both animal and rangeland management on their farms and after slaughter of cattle, meeting with the owners of those cattle to discuss the economic and cattle management implications of the abattoir feedback sheets;
- Undertaking a review of the scientific and other literature to identify the best nutritional and farm management options available to farmers, as well as examining the role of organisational structures such as cooperatives or segregation of herds into specialist management functions (breeding, growing, finishing) as a way of improving cattle and rangeland management to meet market specifications;

- Use the results to identify the best options for use at farmer demonstration sites and plan and establish such sites at relevant locations across the 6 provinces;
- Once the farmer demonstration sites have been established, conduct regular field days and farmer information sessions to enable farmers to understand the requirements for establishing similar system(s) on their own farms;
- To the extent possible at these farmer demonstration sites, design and establish comparative growing and finishing systems that can be evaluated on the basis of cost-effectiveness and compliance with free range market specifications for smallholder farmers
- Collect and analyse data from the farmer demonstration sites and publish the results in popular press articles and where feasible in scientific publications
- Train groups of reproductive technicians in pregnancy diagnosis, foetal ageing, body condition scoring and related measurements so they can measure cattle in smallholder farmer herds for these traits;
- Undertake repeated reproductive measures on at least 1,000 heifers and cows in smallholder herds twice per year across representative production systems;
- Analyse, collate, interpret and publish the results in popular press and scientific publications;
- To the extent possible, secure funding for ongoing measurements in smallholder farmer herds (beyond the life of the project);
- Develop and test a rangeland management assessment system to undertake initial benchmarking of selected farms or communities
- Train regional extension officers in the use of the selected rangeland management tool and those extension officers subsequently train smallholder farmers so they can establish benchmarks for their own farms and monitor rangeland condition at least twice per annum at the time of seasonal change (from wet to dry seasons) and evaluate the effectiveness of the monitoring process
- Use data from KyD and commercial herds already available on Intergis to undertake a preliminary analysis of reproductive data to develop initial guidelines and recommendations in regionally representative product systems on options to best manage breeding herds to optimise cow reproductive performance and calf growth rates in smallholder farmer herds
- Repeat the analysis once the project has sufficient reproductive data in order to develop production benchmarks by region with the aim of optimising herd reproductive performance and calf growth rates; and
- Develop recommendations, guidelines and a decision-support tool to assist farmers in different regions of South Africa to optimise their herd growth and reproductive performance.

5.2 Objective 2

Objective 2 comprised novel research aimed at increasing adoption of proven practices, processes, tools and technologies by smallholder farmers and beef value chain sectors servicing smallholder farmers. It had four sub-objectives:

- using the relationships between farmer psychological profiles (behaviour change) and farm business performance to develop novel interventions aimed at improving farmers' adoption of proven technologies (Objective 2.1);

- research to identify factors such as gender, culture and primary language that are creating inequities in farm business and value chain opportunities and performance and developing interventions to overcome those inequities (Objective 2.2);
- surveying the project's two beef value chains (Cradock and Cavalier) and similar value chains in the six provinces targeted by the project to identify improvement scenarios for the project's farmers and value chains using the VAIMS survey tool (Objective 2.3); and
- modifying or adapting successful intervention(s) developed in Objectives 2.1, 2.2 and 2.3 for use in the project's farmer support activities (Objective 1.1).

Methodologies for each of these sub-objectives are summarised below.

Behaviour change component

- Use surveys of farmer psychological profiles and their relationships with farm business performance to design interventions targeting improved adoption of proven tools, technologies, systems and practices relevant to smallholder beef and poultry farmers in South Africa;
- Train the project's farmer support team and provincial extension officers in the use of the customised interventions and/or preferred learning styles;
- Evaluate the designed interventions and/or preferred learning styles to determine their impact on farm business performance;
- Modify and iterate the interventions as required to identify optimal methods of learning for specific groups of farmers;
- Extend optimal methods across all the project's farmers;
- Re-design and simplify the behaviour change survey tool and repeat the survey with selected farmers;
- Scale out the findings to provincial departments of agriculture and other organisations responsible for extension and training of farmers; and
- Publish papers in the scientific literature

Gender component

- Design the Women's Empowerment in Livestock (WELI) survey tool and statistical sampling requirements;
- Identify and train project enumerators to administer the survey amongst selected farmers and value chain participants;
- Administer the WELI survey tool amongst selected farmers and value chain participants across all six provinces collaborating with the project;
- Analyse data from the WELI survey tool to identify gender-specific areas of inequity;
- Compare results from the WELI survey tool with gender-specific results from the VAIMS and behaviour change surveys;
- Engage South African centre(s) of gender studies and relevant government departments to collectively design new strategies to overcome gender-specific (and other) inequities found to be impacting on farmer business and value chain performance; and
- Develop and submit draft policy documents to relevant agencies for their consideration in overcoming gender-specific (and other) inequities found to be impacting on farmer business and value chain performance.

VAIMS component

- Where needed, train new survey enumerators to collect VAIMS survey data from the six provinces targeted by this project;
- Administer the VAIMS survey across participants of the project's two value chains and of other value chains in the same regions in which the project is operating;
- Analyse and interpret data from VAIMS surveys, publish results in scientific publications and where relevant, also in popular press articles; and
- Identify potential improvement strategies for the Cradock Abattoir and Cavalier Meats Value chains and provide the feedback to all sectors of those value chains (on a confidential basis where required).

Adapting successful interventions for use in other project areas

- Review and revise initial training methods applied elsewhere in the project and incorporate proven customised interventions with the aim of increasing the rate of adoption by farmers and value chain participants;
- Test new training methods with communication specialists, policy makers and/or the project's farmer support teams and provincial extension officers; and
- Implement proven new training methods through the project's farmer training activities.

5.3 Objective 3

Objective 3 comprised research to develop strategies and guidelines to enable non-project end users and other agricultural value chains to adapt and adopt learnings from the project for their own use. It had two sub-objectives to:

- Evaluate the project's decision-making processes to identify changes to the project that, with the use of hindsight, could have improved the efficiency and effectiveness of the value chains in a timelier manner; and
- Collate the recommendations, guidelines, management practices, training materials and intervention strategies developed by the project and make them freely available to a wide range of farmers, extension officers, agribusiness sectors, value chain stakeholders and policy makers.

Methodologies for each of these sub-objectives are summarised below.

Evaluate the project's decision-making processes

- Develop a qualitative narrative about decisions and decision-making process in the project from 2015-end of 2020;
- Engage a skilled systems analyst to undertake a systems analysis of the project's qualitative narrative;
- Use the results of the systems analysis to develop recommendations for other commercial and government organisations wanting to establish agricultural value chains supplied by smallholder farmers; and
- Publish the results in a peer-reviewed scientific or extension journal.

Communication activities

- Work with communication professionals to ensure the materials developed by the project are easy to use by a wide range of potential end users and do not breach confidentiality requirements of project's commercial partners and/or policy makers etc.;
- Work with one or more of project partners to secure an appropriate online repository for the ongoing storage of the project's materials beyond the life of the project;
- Upload materials to the repository as they become available;
- Implement a national communication strategy to make potential Next Users aware of the project's online repository of information;
- Prepare and submit draft policies relating to any areas of project interest to the most relevant organisation(s) to develop and implement;
- Organise and conduct a public forum or workshop towards the end of the project to make project results available to Next Users;
- Develop recommendations, strategies and guidelines for Next User supermarkets and processors requiring more consistent supply of higher value products from smallholder farmers;
- Draft & circulate potential new strategies for implementation by Next Users; and
- Develop guidelines for financial institutions providing finance to value chain sectors to enable scale out of the project's experiences and to short-cut formation of new value chains based on agricultural supply from smallholder farmers.

6 Achievements against activities and outputs/milestones

Objective 1: To improve on-farm animal health, nutrition, management and breeding systems to enable smallholder farmers to cost-effectively deliver a year-round supply of high-value, free-range beef, whilst simultaneously improving their natural resource base (65% of project effort)

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
1.1	Train farmers in best-practice herd management including: a) year-round feed supply (of pasture and supplementary feeds) for growing and finishing of sale animals; and b) breeder herd management to ensure cows and heifers are healthy and in good body condition for breeding. *This objective involves updating the training manual (developed in Stage 1) to include new research results as they become available and extension of existing knowledge.*			
1.1.1 *PC*	Monitor the accuracy and currency of the farmer training manual and update sections of the manual as required	At least once per annum, researchers responsible for relevant sections of the training manual to review the contents and update as required	Accurate and up-to-date farmer training manual (June 2018, June 2019, June 2020, June 2021)	The farmer training manual was regularly revised to accommodate changes in free range weight specifications; an Excel-based profit decision-making tool was also developed for training farmers and is freely available for all extension officers and farmers; AgriSETA accredited the use of this manual and associated tools (Learner Manual, Learner Guide and Price Model) as a vocational education package, level 3
1.1.2 *PC*	Update existing extension officers and train new KyD technicians and interns and extension officers as they join the project team using the farmer training manual	At least once per year, conduct an extension officer workshop to ensure existing and new team members are familiar with and understand the training manual	~150 existing and new KyD and extension officers trained using the up-dated training manual (Sept 2018, Sept 2019, Sept 2020, Sept 2021)	In May 2019, the project's focus on training its extension officers changed based on a skills audit of the farmer support team members and appointment of practical mentors in each of the 6 provinces to ensure support team members interacting with the farmers had the practical skills needed to provide effective advice to the farmers. The changes were based on team-based farmer-to-farmer learning at provincial or regional levels, using a Continuous Improvement and Innovation (CI&I) approach. Since March 2020, this training was largely based on virtual interactions due to the Covid-19 pandemic, with limited access to the internet by grassroots officers sometimes affecting participation.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
1.1.3 *PC*	Extension officers train farmers in their local regions about the opportunities to target free-range market specifications and maximise calf outputs and calf growth rates	Extension officers conduct regular farmer training workshops with farmers in their local regions to outline the opportunity for those farmers to improve profitability of their herds by targeting free-range market specifications and improving the performance of their breeding herds Once farmers commit to target free-range markets, extension officers visit their herds to evaluate the changes needed to their management practices to enable them to deliver cattle to market specifications	At least 1,000 farmers participate in a 2-day introductory training workshop and at least 50% of them sign a contract with Cavalier or Cradock Abattoirs (June 2018). Each year thereafter, an additional 1,000 farmers participate in the introductory training, with at least 50% contracting with one of the abattoirs (i.e. total of 2,000, 3,000 and 4,000 farmers participate in an introductory workshop by June 2019, June 2020 and June 2021 with at least half of them contracting to supply cattle for free-range markets) Working directly with farmers who have committed to target free-range markets, develop a farm management plan that will enable those farmers to meet free-range market specifications (KPI – number of farmers per year with farm management plan) Each extension officer to schedule regular (e.g. quarterly) group meetings of local farmers or develop alternative forum to allow discussion and solutions around any issues impacting on implementation of farm management plan (KPI – number of meetings per year & number of farmers participating per meeting)	In November 2018, the project began revising the processes it used to engage and train farmers due to a generally unsatisfactory engagement of the farmers by the project's farmer support team (reflecting a traditional extension approach by those officers rather than the more successful participative action model of the earlier ACIAR project). By May 2019, it was formally agreed there was a need to change from the initial plan of using trained provincial extension officers as 'experts' to train and support the farmers to a team-based farmer-to-farmer learning approach. The new method has evolved towards a team-based approach using the Continuous Improvement and Innovation (CI&I) framework, with farmers and extension officers meeting as a team in their local regions to identify actions and training requirements. In the new model, the extension officers were trained as team facilitators rather than (unsuccessfully) providing support to individual farmers as was expected to have been the case for the first 50-100 farmers engaged. Since then, two groups of farmers in the value chain sites were trained in CI&I and were helped to develop focuses. However, ongoing farmer training was severely impacted initially by the Covid-19 pandemic and over the final year of the project by the lack of access to project operating funds due to the failure by the administering organisation (DALRRD) to transfer project funds to ARC and NAMC.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
1.1.4 *PC*	As smallholder farmer cattle are slaughtered through Cradock or Cavalier Abattoirs, extension officers meet with those farmers to ensure the farmers understand the feedback about the performance of their cattle in meeting market specifications	Extension officers meet with farmers to discuss the implications (economic and cattle management) of the abattoir feedback sheets	KPI – accurate record of the number of cattle slaughtered per farmer per year through each of the collaborating abattoirs and their compliance rates with free-range market specifications	Two farmers from Limpopo and Mpumalanga slaughtered cattle in three batches in 2019 and early 2020. Since March 2020, it was difficult for the project's farmer support team to visit the farmers to continuously monitor the farmers' cattle due to the Covid-19 pandemic. As a result, most collaborating farmers chose not to allocate and monitor cattle to evaluate progress towards free range markets for the remainder of the project, primarily due to the inability of the project to support those farmers.
1.2	Develop new or alternative cost-effective on-farm cattle management systems that will improve the reproductive performance of breeding cattle and/or increase the growth rates of sale cattle and also comply with free-range market specifications and natural resource management requirements. This objective involves reviewing and adapting existing knowledge to develop new or alternative management systems relevant to smallholder farmers.			
1.2.1 *PC*	Undertake a comprehensive review of the scientific, management and other literature to identify the best nutritional and farm management options available to improve performance of growing, finishing and breeding animals within representative regions across the 6 collaborating provinces. The review will also examine organisational structures such as cooperatives and AgriParks for their potential to allow more efficient segregation of herds into specialist management functions (breeding, growing, finishing)	Formal review of the scientific, management and other literature	Review report (June 2018)	A comprehensive review of the scientific, management and other literature was undertaken to identify the best nutritional and farm management options available to improve performance of growing, finishing and breeding animals within representative regions across the 6 collaborating provinces. It was then used to develop the research questions for on-farm experiments. Two farms were initially identified in each of Mpumalanga, Limpopo, Gauteng and Eastern Cape provinces for on-farm experiments. In addition to the farms in the four provinces, three ARC experimental farms were also selected to serve as benchmarks and allow for both pen and field studies as might be needed in the protocols. Initial project efforts examined engagement of cooperatives and AgriParks. Cooperatives were not initially deemed useful because small numbers of collaborating farmers were widely spread across the 6 provinces and that was not conducive to formation of cooperatives. This situation remained

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
				unchanged after March 2020 due to the inability of the farmer support teams to routinely travel to collaborators' farms because of Covid-19 restrictions. The concept of AgriParks was a Land Reform initiative in South Africa around the time of commencement of this project, but they did not eventuate as envisaged at that time.
1.2.2 PC	Use the results from Objective 1.2.1 to identify the best options for use by farmer demonstration sites (regional research stations or collaborating farm(s)) and develop and implement a plan to establish at least one demonstration site per regionally representative cattle production system (or collaborate with farm(s) which have existing sites that could be used for this purpose)	Engage with farmers and/or research stations in regionally representative production areas to identify and/or establish farmer demonstration sites	At least one farmer demonstration site identified or established in each of the regionally representative production systems (Dec 2018 if existing sites available, June 2019 if sites need to be established)	Six potential farmer demonstration sites were identified in the Eastern cape (East London & Balfour), Mpumalanga (2 x Breyten) and Limpopo (Modimolle & Marblehall). Veld assessments were done on each farm in Nov-Dec 2019 with the plan to continue monitoring the farms over subsequent wet & dry seasons. However, the Covid-19 pandemic disrupted the ongoing monitoring of the farms and in May 2021, it was agreed that the best option to establish the farmer demonstration sites would be to directly engage the Provincial Departments of Agriculture to establish and monitor the sites (rather than the ARC Rangeland Management team, which was impacted by their inability to travel across provincial borders during Covid-19 restriction periods). The transfer process of these farmer demonstration sites to the administrative responsibility of the Provincial Departments of Agriculture could not subsequently proceed due to the failure of DALRRD to transfer project operating funds to ARC and NAMC, meaning ARC was unable to provide the funds needed by the Provincial Departments to assume responsibility.
1.2.3 PC	Once the farmer demonstration sites have been established or identified, conduct regular field days and farmer information sessions to enable farmers	Depending on demand from farmers, conduct at least two field days or farmer	At least two field days or farmer information sessions per farmer	Selected farms were visited to take farmers through the trial protocol. Provincial Department of Agriculture officers were formally trained in

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
	to understand the requirements to establish similar system(s) on their own farms	information sessions per annum at each of the farmer demonstration sites	demonstration site per annum over the four years of the project	participative action research approaches in anticipation of assuming ongoing responsibility for these farmer demonstration sites. However due to the failure of DALRRD to transfer project operating funds to ARC and NAMC, it was not possible to organise a formal transfer of responsibility during the life of the project, with unspent funds for these activities to be returned to ACIAR.
1.3	Conduct on-farm participative action research to investigate a) the effects of different growing and finishing systems on the compliance of sale animals with free-range market specifications; and b) the effects of cow body condition, pregnancy diagnosis, foetal aging and calf weaning on cow reproduction and the impact of different control strategies for venereal diseases. This research is being modelled on the 'Cash Cow' project (McGowan et al., 2014). Objective 1.3a requires applied research at farmer demonstration sites (either research stations or collaborating farms); Objective 1.3b requires applied research in collaborating farmer herds			
1.3.1 PC	To the extent possible at the farmer demonstration sites (activity 1.2.2), design and establish comparative growing and finishing systems which can be evaluated on the basis of cost-effectiveness for smallholder farmer use and on compliance of animals grazed on those different systems with free-range market specifications	Undertake a simple experimental design to allow the comparison of two or more different growing/finishing systems identified as having potential for smallholder farmer use and if required seek sponsorship to establish and implement those comparative treatments	Comparative trials established (Dec 2018 on existing demonstration sites, June 2019 on new sites)	Due to the Covid-19 pandemic restrictions, it was agreed that these comparative trials had to be re-established under the operational control of the Provincial Departments of Agriculture, with the aim of having them established as legacy sites following the end of the current project in June 2022. However due to the failure of DALRRD to transfer project operating funds to ARC and NAMC over the life of the project, this transfer to the Provincial Departments could not occur during the life of the project.
1.3.2 PC	Data collection and analyse results	Analyse comparative treatment data as they become available on the different regionally representative sites; use the data to undertake benefit: cost analyses for each treatment being evaluated; where applicable, collect meat samples from animals slaughtered from the comparative treatments and undertake meat quality analyses	Results from data analyses and benefit: cost analyses for use in Activity 1.3.3 (from June 2019, with data accruing at differential rates from the various demonstration sites)	As indicated in Activity 1.3.1, these comparative trials could not be re-established under the operational control of the Provincial Departments of Agriculture due initially to disruptions caused by the Covid-19 pandemic, but more importantly due to the project's inability to access project funds from DALRRD. The field trials at Roodeplaat Research Station did continue and the data were used as part of a PhD study by a student based at ARC Irene.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
1.3.3 *PC*	Collate, interpret and publish the results in popular press articles and where feasible, in scientific publications (likely to be multiple sites with different comparisons on each)	Analyse available nutritional treatment data from 2019; use results of analyses to develop recommendations for farmers; publish the results in scientific journals (where feasible) and popular press articles	Recommendations and guidelines for farmers (from Dec 2019), scientific publications and popular press articles (from June 2020 through to the end of the project	Generic recommendations based on the literature review in Objective 1.2.1 are readily available to farmers.
1.3.4 *A, PC*	Train two groups of reproductive technicians in pregnancy diagnosis, foetal ageing, body condition scoring and related measurements to provide them with the skills needed to undertake the measurements in smallholder farmer herds	Initial training with reproductive technicians held at ARC Irene in June 2017; application for additional funding to establish 2-3 accredited technical groups in different areas of South Africa and provide annual training for 3 years submitted to RMRD July 2017; if funded, these technical groups will service this project and BGP with each project paying operating costs for the technicians	ARC technicians accredited to standard required (June 2018)	ARC reproductive technicians were trained to accredited standards by Prof Michael McGowan (University of Queensland) in 2017 and subsequent checking undertaken by Dr Jean Rust. The funding application to RMRD was not successful.
1.3.5 *PC*	Undertake repeated reproductive measurements on at least 1,000 heifers and cows in smallholder farmer herds each year across different representative production systems before the start of the joining period (Nov-Dec) and at weaning (May-July)	Accredited reproductive technicians will undertake repeated measurements on breeding heifers and cows in smallholder farms in representative production systems in the project's regions of interest	Detailed reproductive measurements on breeding heifers and cows (late 2017, 2018, 2019 and 2020 and mid- 2018, 2019, 2020 and 2021)	Reproductive measures in breeding heifers and cows were collected once in 2017 and 2018 and twice for the 2019 breeding and calving seasons for herds in Mpumalanga, North West, Limpopo, Free State and Eastern Cape. Measurements in these herds was due to continue from April-June 2020 but had to be cancelled due to travel restrictions caused by the Covid-19 pandemic. This meant that only a single cycle of joining, preg-testing and calving records would be possible over the life of the project and that was insufficient to develop the decision support tool indicated in Activity 1.5.3. Analyses of available data in early 2020 provided a series of recommendations about how smallholder farmers could improve the reproductive performance of their herds. Those recommendations have since been widely disseminated to farmers through the project's communication activities. It was therefore agreed at the project's mid-term review in May 2020 that

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
				ongoing reproductive measurements would be discontinued.
1.3.6 *A, PC*	Analyse, collate, interpret and publish the results in popular press and scientific publications	Analyse available reproductive data from 2020; use results of analyses to develop recommendations for farmers; publish the results in scientific journals and popular press articles; use the data to develop a decision-support tool through Activity 1.5.3	Recommendations and guidelines for farmers (June 2021), scientific publications and popular press articles (June – Dec 2021)	Despite the limited amount of reproductive data available to the project, three scientific papers have been published as part of a PhD student's research activities.
1.3.7 *PC*	To extent possible, work with farmers and others (e.g. NERPO) to secure funding that will enable farmers to continue measuring their breeding animals beyond the life of the project	Work with the collaborating farmers and/or their agribusiness organisations to identify mechanisms that would enable them to continue measuring their breeding herds for ongoing herd management purposes beyond the life of the project	Secure mechanisms to allow ongoing measurement of smallholder farmer herds beyond the life of the project (Dec 2021)	Activities in this objective could not be progressed due initially to the Covid-19 pandemic, but more significantly due to the project's lack of access to operating funds over the final year of its operation.
1.4	Develop and implement a rangeland management and monitoring system for use by smallholder farmers that includes measuring and monitoring the condition of the natural resource base (e.g. pasture and land condition including erosion and if irrigated pasture is used, the status of drainage to avoid salinisation etc.) on a regular basis throughout Stage 2 of the project. This objective requires existing knowledge be adapted for smallholder farmer use, with implementation and monitoring to occur thereafter			
1.4.1 PC	Develop and test system to undertake initial benchmarking of selected farms or communities	Adapt existing methods of monitoring rangeland conditions for research purposes for use by farmers having no technical training; test the accuracy of the adapted system relative to proven research techniques; use the new (adapted) system to establish initial benchmarks of rangeland conditions in selected regions in the project's operating regions	Practical system of rangeland monitoring for use by unskilled farmers developed and tested for accuracy relative to proven scientific methods; benchmark rangeland assessments available in selected regions (June 2018)	The project used DAFF's Veld Condition Assessment Tool (VCAT) for its rangeland monitoring. Initial use of the tool was by trained researchers to establish farm benchmarks, but farmers were simultaneously trained to use the tool to help them evaluate and interpret the reports provided to them by the researchers (as well as for ongoing use to monitor rangeland condition and estimate optimum stocking rates of their farms at times of seasonal change through the year. However, most farmers failed to use the tool themselves, so reasons for their failure to adopt was a focus of an adoption qualitative research activity that was fully designed but could not be implemented during 2021/22 due to the lack of access by the project team to project operating funds.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
1.4.2 *PC*	Train regional extension officers in the use of the practical tool developed in Activity 1.4.1	Project researchers train the regional extension officers to use the practical tool so they are able to assess the condition of rangelands in their own region	Regional extension officers trained in the use of the practical tool (Sept 2018)	Rangeland researchers from the six Provincial Departments of Agriculture were co-opted to undertake rangeland assessments in their local regions. Those researchers were already trained in the use of the VCAT at the time they were co-opted to the project.
1.4.3 *PC*	Extension officers train smallholder farmers in their regions in the use of the practical system developed in Activity 1.4.1; smallholder farmers use the system to establish benchmarks of the condition of the rangeland on their farm; benchmark assessments formally recorded on Intergis for each farmer	Extension officers train the farmers in their region in the use of the practical tool, then work with individual farmers to establish benchmarks of the rangeland condition of their farm and to upload the benchmark assessments to Intergis for each farm	Farmers trained in the use of the practical tool, which they use to establish benchmarks of the condition of the natural resource base on their farm (Sept 2018 – June 2019); initial benchmarks uploaded to Intergis for each farmer (Sept 2018 – June 2019)	Farmers in both the Cavalier and Cradock Value Chains were trained in the use of the Veld Condition Assessment Tool (VCAT) at 2-day workshops held in 2019 and 2020. Those farmers were encouraged to use the tool to assess their own farms and compare their assessments with those made by the project team, and to seek further information from their provincial rangeland officer or researcher if they had further queries about the use of the tool. Additionally, they were trained to interpret their own results and about the benefits of applying basic principles of veld/range management, including among others adhering to correct stocking rate and being aware of the fluctuating forage quality and quantity that negatively affects animal condition. However, we subsequently realised that very few farmers actually used the tool themselves, so reasons for their failure to adopt was a focus of the qualitative research study that was designed but not implemented due to lack of access to project operating funds by the project team.
1.4.4 *PC*	Train extension officers and farmers to use results to modify their rangeland management systems and evaluate the effectiveness of the changes made to improve the condition of the rangeland	Through training provided in Activity 1.1, extension officers and farmers will be trained in alternative production systems designed to maintain or improve the condition of their rangelands; this activity will focus on training farmers in the use of the practical tool not only to	Farmers routinely evaluate and record the condition of their rangeland at least annually and at times when extreme events (flood, drought, fire) are likely to have impacted, with KPI being at least an annual assessment of rangeland condition uploaded to Intergis for each	In addition to the project team providing a report and recommendations on strategies to best manage the rangeland on each collaborating farm, the farmers were trained to use the VCAT tool themselves (milestone 1.4.3). The reports were shared and explained to the

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
		establish benchmarks (Activity 1.4.3) but also to use the practical tool to monitor the effect of changes to their management practices on rangeland condition	collaborating farmer or community (June 2019, June 2020, June 2021)	farmers through the Provincial Rangeland Coordinators in Mpumalanga, Gauteng, North West, Eastern Cape and Free State Provinces. Provincial Coordinators and Extension Officers/Agricultural Advisors were also trained on Visual Veld Condition tools where needed. However, the whole process was faced with challenges including sharing of reports by coordinators to the farmers, monitoring the implementation of recommendations by Extension Officers and Agricultural Advisors and failure of the farmers themselves to use the VCAT after they had been trained in its use.
1.4.5 *PC*	Extension officers to cross-check farmer evaluations with their own assessments on an annual basis to ensure farmers are using the system accurately	Extension officers undertake representative sampling of the farmers' use of the practical tool to ensure the farmers are accurately using the too; if errors are identified, implement additional training to ensure ongoing accuracy	Routine cross-checking to ensure the farmers are using the practical tool correctly and if errors are occurring, additional training provided to farmers (June 2019, June 2020, June 2021)	There was no progress on this milestone given the challenges described in objective 1.4.4, the travel restrictions resulting from the Covid-19 pandemic and the lack of access to project operating funds over the final year of the project.
1.5	Identify the factors with the greatest impact on cow reproductive performance and develop liveweight production benchmarks by region This objective will use on-farm data derived from objective 1.3b and from existing commercial industry and KyD data to undertake applied research to develop recommendations, guidelines and decision-support tools for farmers in different regions of South Africa			
1.5.1 A, PC	Use data from KyD and commercial herds already available on Intergis to undertake a preliminary analysis of reproductive data to develop initial guidelines and recommendations in regionally representative production systems of how best breeding herds in those regions can best be managed to optimise reproductive performance and calf growth rates in smallholder farmer herds	Analyse existing liveweight and calf data from KyD and commercial herds to develop initial guidelines on best-practice management systems to improve reproductive performance and calf growth rates in specific regions within the supply area of the project's two value chains	Initial guidelines available for farmers on the best management systems to optimise cow reproductive performance and calf growth rates in smallholder farmer herds in those specific regions (Dec 2018)	A review of the Intergis database indicated there were insufficient data available from smallholder farmer herds to enable this planned data analysis to occur. Hence, initial guidelines were developed for farmers based on the best management systems to optimise cow reproductive performance and calf growth rates using results from similar beef production environments (though very different beef production systems) in northern Australia.
1.5.2 *A, PC*	Repeat the analysis using additional data from Intergis + data collected through Activity 1.3.6 to develop liveweight production benchmarks by	Once data are available from Activity 1.3.6, repeat the analyses undertaken in Activity 1.5.1 by combining all available Intergis and project data to develop	New knowledge about different management practices and other factors impacting on heifer and cow reproductive	Preliminary analyses of data described in Objective 1.3.5 was undertaken in early 2020. Recommendations for ways that farmers could improve the reproductive

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
	region, which can then be used to optimise herd reproductive performance and calf growth rates	liveweight project benchmarks for specific production regions in the project's value chain operating areas	performance in smallholder farmer herds (July 2021)	performance of their herds were disseminated widely to participating farmers and the general agricultural community in South Africa.
1.5.3 *A, PC*	Develop recommendations, guidelines and a decision-support tool to assist farmers in different regions of South Africa to optimise their herd performance (cow reproductive performance and calf growth rates)	Using the liveweight production benchmarks developed in Activity 1.5.2, develop recommendations, guidelines and a decision-support tool that will help smallholder farmers optimise their cow reproductive performance and calf growth rates	Recommendations, guidelines and a new model to predict reproductive performance and calf growth rates from different regions based on cow live weights, body condition scores and pregnancy status (Dec 2021)	As described in Objective 1.3.5 the project developed some recommendations and guidelines for farmers based on published scientific reports and preliminary analyses of project data, but as described in Objective 1.3.6 there were insufficient data available to develop the decision support tool because of the Covid-19 pandemic. Hence, it was agreed at the project's mid-term review in May 2020 that this activity would not continue as originally planned.

Objective 2: To improve the profitability of all sectors of the project's beef value chains through increased adoption of proven interventions by farmers and implementation of practices that create efficiencies and effectiveness across the entire value chains (25% of project effort)

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
2.1	Evaluate the customised interventions and/or preferred learning styles developed in Stage 1 of the project to determine their application and value in improving farm business performance and increasing farmer practice change. Objective 2.1 combines two methods developed outside agriculture (psychological profiling and behavioural-science informed strategies) in entirely novel research			
2.1.1 *A, PC*	Specifically design interventions using the farmers' psychological profiles derived from analyses of the behaviour change survey data	A facilitated workshop will be held with the UK Centre for Behaviour Change (UKCBC) assisting the project team to use their tools to specifically design interventions for trialling with the project's farmers. The intervention design method will be repeated in different regions around Cradock and Cavalier at least once	Customised intervention strategies for field evaluation (Dec 2018, June 2020)	Behaviour change survey data from smallholder beef and poultry farmers were analysed to develop farmer psychological profiles, which were then correlated with the farmers' business performance. Results from these analyses have been published and were used to design customised interventions and an experimental protocol for implementation amongst poultry farmers (because the quantity and frequency of their sales would deliver a much quicker result than would be possible amongst beef farmers). Experimental data collection commenced in late 2019, but Covid-19 travel restrictions meant the intervention treatments (treated / control) were deferred because there were very significant differences in business environments before and during the pandemic and they would impact on any experimental results. The experiment re-commenced from scratch in late 2021, with data collection now complete. Data analyses and publication of the results will continue beyond the formal completion of the project in June 2022.
2.1.2 *A, PC*	Train the farmer support team and Provincial extension officers in the use of the customised interventions and/or preferred learning styles	Members of the farmer support team and Provincial extension officers participate in the regional design activities so they become familiar with the use of farmer psychological profiles and designed interventions. Depending on the interventions that are agreed for evaluation, the next step would be to: a) modify training packages, materials and methodologies to meet the requirements of the intervention(s); and/or b) train the farmer support team and extension officers in the use of new materials and/or methods; and/or c) co-opt different types of expertise (e.g. policy,	Training materials prepared and/or modified and team members responsible for delivery of specific interventions in 3-4 trial regions trained in use of materials (Sept 2018, Dec 2020) If different types of expertise are needed to trial a particular intervention, co-opt the expertise to provide materials ready for delivery or implementation (Sept 2018, Dec 2020)	The training materials initially available for farmer support team members and provincial extension officers are all based on the project's farmer training manual. However, following the intervention design workshop (2.1.1) in March 2019, new training materials were developed for use in the training experiment with poultry farmers to determine whether the interventions are useful in improving farmers' business performance. Even though results are not yet available from the experimental protocol amongst poultry farmers described in Activity 2.1.1, aspects of the intervention have already been used in the new farmer training model used by beef farmer teams based on participative action research approaches.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
		communication) which might be required to implement the designed intervention		
2.1.3 *A, PC*	Evaluate the designed interventions and/or preferred learning styles to determine their impact on farm business performance	Analyse business performance data from farms participating in the designed intervention trials to determine whether the customised interventions improve the adoption of proven technologies by those farmers	Comparisons of the effectiveness of the different interventions (June 2019, June 2021)	As outlined in milestones 2.1.1 and 2.1.2, the experimental interventions were designed in March 2019, with training materials developed thereafter. Data collection protocols were compromised by the differing business performance environments before and during the Covid-19 pandemic, so the experimental interventions only re-commence in late 2021 with data analyses and publication of results to continue beyond the completion of the project in June 2022.
2.1.4 *A, PC*	Modify and iterate the evaluations in 2.1.3 until optimal methods are identified	If required, repeat Objective 2.1.3 to modify the interventions to improve their suitability for farmer use	Modified interventions undergo further evaluation (Sept 2019, Sept 2021)	Due to delays resulting from Covid-19 travel restrictions, data analyses will only occur after June 2022, so there has been no opportunity to modify the interventions as planned in this objective.
2.1.5 *A, PC*	Extend 'best' methods for use across all of the project's farmers including repetition of the preparation processes required to achieve the earlier evaluations of designed interventions	Repeat activities in Objectives 2.1.1, 2.1.2 and 2.1.3 to the extent required (depends on results of earlier data analyses) to extend the optimal methods to all project farmers	Jan 2020 – Dec 2021, with success of this milestone being assessed by the overall project measurement, monitoring and evaluation	Determination of the 'best' methods could not be achieved in the life of the project, primarily due to Covid-19 travel restrictions that delayed data collection.
2.1.6 *A, PC*	If feasible, re-design and simplify the behaviour change survey tool and repeat the survey with a selected group of farmers using the simplified tool to determine a) effectiveness of the new tool and b) whether farmers' psychological profiles have changed over the project period (and hence whether the customised interventions also need to change)	Review the psychological profiles to determine which components of the survey tool are contributing to the results (and which are not, thereby allowing deletion of those components not adding value to the data).	Report on the effectiveness of the simplified survey tool (Dec 2020)	The behaviour change tool was re-designed and simplified following completion of the initial survey analyses. Farmers in the poultry intervention experiment have been using the simplified tool since the start of the intervention experiment and have continued to use it during the re-commenced experiment. Data collection based on the simplified tool was also extended to several additional southern African countries in late 2021 (self-funded by those countries), with data collection now complete and data analyses and publication of results to occur beyond the project's completion date in June 2022.
2.1.7 *A, PC*	Scale out findings to Provincial Departments of Agriculture and other organisations responsible for extension and training for farmers and if required, develop and implement training of non-	In conjunction with Objectives 2.4 and 3.2.1, transfer results from this component of the project to other organisations in South Africa and potentially also other southern African countries	Jan 2021 – Dec 2021	Some scaling out has already occurred through the poultry intervention experiment, where Provincial Department of Agriculture extension officers have been involved in implementing the different interventions for treated and control farmers. However, broader scaling out will only occur once results from the poultry intervention experiment are available

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
	project participants to give them the confidence to implement the new methods in their own area(s) of responsibility			after the end of the project in June 2022, though aspects of the interventions were adapted for use amongst beef farmer teams in 2020/2021.
2.1.8 *A, PC*	At least five peer-reviewed scientific manuscripts published in international journals (literature review; methodology paper; role of language and culture on farm business performance; relationships between farmer business performance and their psychological profiles; farm business decision-making; evaluation of designed interventions; simplified behaviour change survey tool if simplification is feasible)	Analyse and interpret results of all project behaviour change survey data and customised intervention trials and publish them in peer-reviewed manuscripts	Scientific publications (monitored annually, with at least 5 manuscripts published by Dec 2021)	Results from the first stage of this research were presented at the 'Seeds of Change' Conference with a particular focus on gender and at the AARES 2020 conference, primarily focused on the relationships between farmer psychological profiles and their farm business performance. Additional papers relating to the impact of ethnicity on farmer business performance and an entirely new application of the stochastic frontiers methodology to rangeland management and communal farmer cattle herds have also been published, with other papers submitted to journals for consideration of publication or prepared for publication beyond the project's term.
2.2	Examine the role of a wide range of factors (gender, disability, culture, primary language, business decision making processes etc.) on farm business and beef value change performance using data from the Behaviour Change, VAIMS and WEAI surveys. The aim is to use the results to develop and implement interventions designed to address and overcome the inequities that are found by the analyses to be impacting on farm business and value chain performance. This objective uses survey tools developed in the project and elsewhere to undertake new research (for South Africa) to identify factors that may disadvantage farmers' business performance			
2.2.1 A, PC	Design the WEAI survey tool and statistical sampling requirements; identify and train project enumerators to administer the survey amongst selected farmers and value chain participants	A livestock-specific WEAI tool will be provided by IFPRI and customised (if required) for use in South Africa. A planning meeting will be held to design the experiment and estimate the sampling requirements to ensure statistical validity of the design; enumerators will be selected from amongst the project's field technicians and trained in the administration of the WEAI survey	WEIA tool customised for use in South Africa, experimental design process completed and enumerators identified and trained to administer the survey amongst selected farmers and value chain participants (Nov 2017)	In conjunction with IFPRI, ILRI and the former ACIAR program manager, it was agreed the livestock-specific WELI (Women's Empowerment in Livestock Index) tool would be used in South Africa in lieu of the WEAI, to allow direct comparisons with other cultures/countries in Eastern Africa and Indonesia. A PhD student from NAMC undertook this research in South Africa, with data collection completed in KZN. Data analyses and publication will continue by the student beyond the life of the project. Additional project enumerators were identified and trained in the use of the WELI tool to assist with data collection across the project's 6 provinces, but the data collection was initially impacted by Covid-19 restrictions. Hence, following the mid-term review in May 2020, it was agreed that WELI data collection would be restricted to representative sampling of farmers in the two value chains (Cradock and Cavalier) but unfortunately this data collection could not proceed due to lack of project access to the project's operating funds.
2.2.2	Administer the WEAI survey tool amongst selected farmers and	Enumerators trained in Activity 2.2.1 will administer the survey	Completed WEAI surveys in line with statistical requirements	The WELI instrument was initially administered to 229 selected farmers in Kwa-Zulu Natal, due to difficulties encountered in

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
PC	value chain participants across all six provinces collaborating with the project	tool amongst selected farmers and value chain participants across all six provinces collaborating with the project	identified in Activity 2.2.1 (June 2020)	engaging with other provinces collaborating with the project. Those surveys were completed well ahead of the proposed time, with data collection in other provinces delayed by Covid-19 travel restrictions. In addition to the face-to-face WELI surveys, 3 focus group discussions were completed, with the data now being validated prior to data analysis. However ongoing gender data collection in the two value chains (Cradock and Cavalier) could not be completed due to lack of project access to the project's operating funds since July 2021.
2.2.3 *A, PC*	Analyse data from WEAI survey tool to identify gender-specific areas of inequity; compare to gender-specific results from VAIMS and behaviour change surveys	Analyse data collected in Activity 2.2.2 to identify gender-specific areas of inequity; compare the results from the WEAI survey to gender-specific results derived from the project's Behaviour Change (Objective 2.1) and VAIMS (Objective 3.1) surveys to interpret the collective results	Gender-specific areas of inequity impacting on women farmers and value chain participants identified (Dec 2020)	Data collection at the value chain level was initially deferred due to Covid-19 travel restrictions and then ultimately because of the project's lack of access to project operating funds since July 2021.
2.2.4 *A, PC*	Engage South African centre(s) of gender studies and relevant government departments to collectively design new strategies to overcome gender-specific (and other) inequities found to be impacting on farmer business and value chain performance	Present the project's results to the South African Centre(s) of gender studies and relevant government departments to seek their input to development of new strategies, practices, processes and policies aimed at overcoming the gender-specific inequities found to be impacting on farmer business and value chain performance	New strategies, practices, processes and draft policies developed (June 2021)	The need for new strategies, practices, processes and draft policies was to be assessed once the analyses in objective 2.2.3 were complete. However, those analyses were initially delayed due to Covid-19 travel restrictions and then by the project's inability to access project operating funds from July 2021. Hence this activity was not able to be achieved.
2.2.5 *PC*	Implement strategies developed in Activity 2.2.4 through Activity 2.4	New strategies, practices, processes or policies identified in the previous activities will be implemented through Activity 2.4 using best-practices interventions and training methods	New strategies, practices, processes and draft policies implemented (July-Dec 2021)	As indicated in Activity 2.2.4, the new strategies, practices, processes and draft policies could not be achieved due to the inability of the project to collect the data required to underpin them.
2.2.6 *A, PC*	Submit draft policy documents to relevant agencies for their consideration in overcoming gender-specific (and other) inequities found to be impacting	Prepare and submit draft policy documents to relevant government agencies for their consideration and implementation	Draft policy documents submitted to relevant government agencies for their consideration (July-Dec 2021)	As indicated in Activity 2.2.4, the new strategies, practices, processes and draft policies could not be achieved due to the inability of the project to collect the data required to underpin them.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
	on farmer business and value chain performance			
2.3	Use the results from the VAIMS survey data to benchmark and identify improvement scenarios across all sectors of the project's two value chains. These improvements could include for example, improved input or supply patterns, value-addition opportunities, delivery efficiency (product quality attributes), inventory efficiency (seasonality), risk attitudes and management, channel reliability (changes), development indicators (employment, gender, income generation) or areas of competitiveness. This objective uses a survey tool developed by ILRI to undertake new research for agricultural value chains in South Africa			
2.3.1 *PC*	Where needed, train new survey enumerators to collect VAIMS survey data from the six provinces targeted by this project	Existing enumerators mentor new team members to administer the survey	Trained enumerators (ongoing as required)	Initially the project planned to undertake representative VAIMS surveys across the 6 collaborating provinces, but only at the level of the project's 2 value chains centred on Cavalier Meats (~150 surveys across 5 provinces within a 250 km radius of Cavalier) and Cradock Abattoir (another ~150 surveys in Eastern Cape). However, that plan was changed at the request of the provinces who requested the surveys be undertaken at whole-of-province level across all 6 provinces (requiring ~150 surveys from each of the 6 provinces). That request was met in Eastern Cape and Limpopo with input from their respective Provincial Department of Agriculture officers. Engagement of enumerators from the other provinces (and particularly from Free State and North West) was not as effective. Hence results were presented to the mid-term review based on analyses at the two value chain (Cavalier and Cradock) levels. Papers have been published based on these results.
2.3.2 *PC*	Administer the VAIMS survey across participants of the project's two value chains and of other value chains in the same regions in which the project is operating	Survey collaborating farmers and private sector agribusinesses and retailers	Data collection in each of the six provinces to continue from Jan 2018 to Dec 2020	As indicated in Activity 2.3.1, data analyses at the project value chain levels (Cavalier and Cradock) were completed by the mid-term review in May 2020, with results now published.
2.3.3 *PC*	Analyse and interpret data from VAIMS surveys, publish results in scientific publications and where relevant, also in popular press articles	Analyse VAIMS data and prepare scientific publications and popular press articles based on results of the analyses	Scientific publications and popular press articles (June 2021)	A total of 130 questionnaires were analysed and reported for the Cradock (Eastern Cape) value chain. A further 244 questionnaires were analysed and reported for the Cavalier value chain. Separate reports are available for Limpopo (n=150) and Mpumalanga (n=60). Publication of the results in scientific journals is now underway.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
2.3.4 *PC*	Identify potential improvement strategies for the Cradock Abattoir and Cavalier Meats Value chains and provide the feedback to all sectors of those value chains (on a confidential basis where required). Where the improvement strategies impact on the project's collaborating farmers, implementation will occur in Activity 2.4	Use results from Activity 2.3.2 to identify a range of improvement strategies for all sectors of the project's two value chains and prepare reports customised for each sector of the value chain. Where the improvement strategies impact on farmers, reporting and implementation will occur through Activity 2.4	Customised improvement strategies prepared and delivered to the different sectors of the project's two value chains (July – Dec 2021)	New strategies to improve value chain performance were identified as part of the publication of the VAIMS results.
2.4	Use the method (developed in Stage 1) of developing customised intervention strategies to specifically design and implement the interventions to overcome constraints or implement new opportunities identified in Activities 2.2 and 2.3. This objective will use intervention strategies evaluated in Objectives 2.2 and 2.3 and adapt them for application (extension) on a broader scale amongst collaborating farmers			
2.4.1 A, PC	Review and revise existing training methods applied in Activities 1.1.3, 2.2, 2.3 and 2.4 and incorporate proven customised intervention strategies with the aim of increasing rate of adoption by farmers and value chain participants	As the evaluations of designed interventions in Objectives 2.1.3 and 2.1.4 are completed, modify the training methods used in Objectives 1.1.3, 2.2, 2.3 and 2.4 to ensure the training methods are based on approaches that have the greatest likelihood of maximising adoption of proven practices, processes, tools and technologies by smallholder farmers	New methods of training farmers to maximise the likelihood they will adopt proven practices, processes, tools and technologies (September 2019 through to the end of the project)	These new methods will only become available as data from Objectives 2.1, 2.2 and 2.3 are completed. However as indicated above, data collection against these objectives was delayed by Covid-19 travel restrictions and hence final results will only be available once data analyses and publication of results continues after the end of the project's term in June 2022.
2.4.2 *A, PC*	Test new training methods with communication specialists, policy makers and/or the project's farmer support teams and Provincial extension officers	Evaluate the new training methods developed in Activity 2.4.1 with communication specialists, policy makers and/or the project's farmer support teams and extension officers as appropriate to ensure the changes made to the training methods match their experience in achieving farmer practice change	Evaluate the new training methods identified in Activity 2.4.1 in conjunction with specialists having expertise and experience in best-practice extension methods (Sept 2019 through to the end of the project)	These new methods will only become available as data from Objectives 2.1, 2.2 and 2.3 are analysed and reported, after the end of the project's term in June 2022.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
2.4.3	Implement proven new training methods through Activity 1.1.3	The proven new training methods will be implemented through Activity 1.1.3	New training methods designed to maximise adoption of proven technologies by smallholder farmers will be implemented through Activity 1.1.3 (Sept 2019 through to the end of the project)	These new methods will only become available as data from Objectives 2.1, 2.2 and 2.3 are analysed and reported, after the end of the project's term in June 2022.

Objective 3: To develop scaling out strategies and guidelines that enable application of the project's results to other value chains (10% of project effort)

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
3.1	Describe and analyse the decision making processes that led to the successful development of the two free-range beef value chains. The aim is to determine whether better or different processes could have been identified earlier in the project to improve the effectiveness of the value chains in terms of the speed of development, engagement and organisation of farmers, constraints that needed to be overcome and opportunities which were missed or not implemented effectively etc. Recommendations and guidelines will be developed for future value chains from this analysis. This objective is based on novel systems research using qualitative data from the project to identify new knowledge about improved ways of implementing effective agricultural value chains with supply provided by smallholder farmers			
3.1.1 A, PC	Develop a qualitative narrative about decisions and decision-making process in the project from 2015-end of 2020	Over the life of the project, develop a qualitative narrative about decisions and decision-making processes in the project	A qualitative narrative documenting key project decisions (Dec 2020)	A detailed narrative covering the period from 2015 to May 2020 was developed and updated through to the end of the project. The narrative proved very useful even in the early stages of the project in evaluating aspects of the project's performance and identifying early changes to the project's operating practices, particularly the need for significant changes in the way the project supports the farmers. However, the planned analyses of the narrative based on Multi-Criteria Decision Making methods towards the end of the project did not proceed as planned because the project's decision points since March 2020 (particularly those relating to the project's farmers and value chains) were severely impacted by Covid-19.
3.1.2 *A, PC*	Engage a skilled systems analyst to undertake a systems analysis of the project's qualitative narrative	Identify a skilled systems analyst from amongst the project's research partners or a consultant who can be engaged on a short-term basis to undertake a systems analysis of the project's qualitative narrative	Completed systems analysis of the project's qualitative narrative (June 2021)	A UNE post-doctoral fellow was engaged to undertake the qualitative analysis of the detailed narrative collated in objective 3.1.1, using proven Multi-Criteria Decision Making methods. However as indicated in objective 3.1.1, the data required for such analyses was not able to be completed as planned due to the impacts of Covid-19. Instead, the post-doctoral fellow completed additional analyses of the project's behaviour change data, as indicated in objective 2.1, with data analyses continuing beyond the project's term for aspects of project 2.2.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
3.1.3 *A, PC*	Use the results of the systems analysis to develop recommendations for other commercial and government organisations wanting to establish agricultural value chains supplied by smallholder farmers	Using the results from Activity 3.1.2, develop recommendations for other commercial and government organisations wanting to establish or improve agricultural value chains supplied by smallholder farmers	Recommendations available for commercial and government organisations (June 2021)	These recommendations could not be developed due to the lack of relevant data as a result of the Covid-19 pandemic since March 2020.
3.1.4 *A, PC*	Publish the results in a peer-reviewed scientific or extension journal	Use the results from 3.1.2 and 3.1.3 to prepare a publication for a peer-reviewed journal	Scientific paper submitted to peer-reviewed journal (Dec 2021)	As indicated against the previous objectives, insufficient data could be collected to enable analyses to occur.
3.2	Collate the recommendations, guidelines, management practices, training materials and intervention strategies developed for farmers and value chain sectors in Objectives 1, 2 and 3.1 and, where appropriate, make them freely available to a wide range of farmers, extension officers, agribusiness sectors, value chain stakeholders, policy makers etc. This objective involves widespread extension and scaling out of the project's results			
3.2.1 PC	Work with communication professionals to ensure the materials developed by the project are easy to use by a wide range of potential end users and do not breach confidentiality requirements of project's commercial partners and/or policy makers etc.	Identify and engage communication professional(s) to modify materials developed by the project to ensure they are easy to use by a wider range of end users whilst meeting the needs of all of the project's partners	Project materials modified for ease of use by potential Next Users (ongoing throughout the final two years of the project)	Project materials such as the farmer training manual and profit calculation spreadsheet, the VCAT tool and a range of other resources were developed and loaded onto the project website for free download (or where training is needed in the use of the materials, links are provided to ensure farmers are able to access both the materials and the training). Unfortunately, though, due to lack of the project's access to project operating funds the project website has not been accessible since mid-2021 when funds were not available to pay for the website's domain name.
3.2.2 *PC*	Work with one or more of project partners (e.g. DAFF, Provincial Departments) to secure an appropriate online repository for the ongoing storage of the project's materials beyond the life of the project; upload materials to the repository as they become available	Identify a partner agency or agencies willing to host a web-site as a secure repository of project materials for an agreed period (e.g. 5-10 years) after the end of the project; thereafter upload relevant materials as they become available1	Agreement with partner organisation(s) to host an online repository of the project's materials (Dec 2020) and relevant project materials uploaded to the repository (Dec 2021)	A project website was developed by the NAMC Communication team and officially 'launched' in January 2020 with the domain name https://www.highvbp.co.za. However, the website has not been available since mid-2021 due to the lack of project funds to pay for the continuing use of the domain name. The lack of those funds arose from DALRRD's failure to transfer project funds to ARC and NAMC.
3.2.3 *PC*	Implement a national communication strategy to make potential Next Users aware of the project's online repository of information	Engage a communications professional to develop and implement a communication strategy to make potential Next Users award of the project's online repository of information	National communication strategy implemented over final 6 months of the project (July-Dec 2021)	NAMC's communication team led the development of this national communication strategy based on results, practice change and materials developed through the project's term.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
3.2.4 *PC*	Prepare and submit draft policies relating to any areas of project interest to the most relevant organisation(s) to develop and implement	Prepare and submit draft policies relating to any area of improvement needing policy intervention identified by the project to the most relevant organisation (s) for further development and implementation	Draft policies submitted to relevant organisation(s) as project results needing policy development become available	The project developed a draft policy paper aimed at changing South Africa's Carcass Classification scheme to appropriately reward (through improved pricing mechanisms) high meat quality of grass- and grain-fed cattle slaughtered up to 36-42 months of age, providing they are managed according to proven best-practice. The draft policy was subsequently incorporated for implementation by DALRRD as Pillar 5 (Implement upgraded meat grading scheme with international accreditation/ compliance for export market APFSNRDM) into South Africa's Agriculture and Agro-Processing Master Plan (AAMP), which is a compact aimed at providing practical actions and reforms designed to address growth, transformation and developmental challenges in agriculture, food and beverage sectors.
3.2.5 *PC*	Organise and conduct a public forum or workshop towards the end of the project to make project results available to Next Users	Widely-advertised public forum or workshop conducted around each of the project's value chains to make project results available to Next Users	Public forum or workshop held around each of Cavalier and Cradock value chains to deliver project results to Next Users (July-Dec 2021)	This public forum or workshop could not be delivered due to lack of access by the project to project operating funds since July 2021.
3.2.6 *PC*	Develop recommendations, strategies and guidelines for Next User supermarkets and processors requiring more consistent supply of higher value products from smallholder farmers	Use results from Activities 2.3 and 3.1.3 to develop recommendations, strategies and guidelines customised for potential Next User supermarkets and processors wanting to engage more effectively with smallholder farmers to supply higher value products through their own value chains	Recommendations, strategies and guidelines customised for Next User supermarkets and processors in South Africa and other southern African countries (Dec 2021)	This objective could not be met due to disruptions to data collection amongst project farmers since March 2020 resulting from the Covid-19 pandemic.
3.2.7 *PC*	Draft & circulate potential new strategies for implementation by Next Users e.g. a) encourage Provincial Departments of Agriculture to expand or replicate the project's value chains to demonstrate value created by farmers directly targeting high-value markets; b) encourage project's commercial partners	Develop a range of possible new strategies for implementation by potential Next Users and engage with those potential Next Users to ensure they properly understand the opportunities for their businesses	New strategies developed and potential Next Users engaged to ensure they understand the opportunities for their businesses (July – Dec 2021)	This objective could not be met due to disruptions to data collection amongst project farmers since March 2020 resulting from the Covid-19 pandemic.

No.	Activity	Method	Output and due date of output/ milestone	What has been achieved
	to add value chains for other agricultural commodities modelled on their beef value chains; c) demonstrate and promote new technologies developed in the on-farm component of the project to commercial agribusinesses to generate additional business for their own companies whilst encouraging uptake by new farmers; and d) the success of the project's value chains could be implemented in some of the 20% of South Africa's ~580 abattoirs which slaughter 80% of its beef to improve their profitability			
3.2.8 *PC*	Develop guidelines for financial institutions providing finance to value chain sectors to enable scale out of the project's experiences and to short-cut formation of new value chains based on agricultural supply from smallholder farmers	Draft and submit guidelines for financial institutions who could provide finance to value chain sectors to enable scale out of the project's experiences and to short-cut formation of new value chains based on supply by smallholder farmers	Draft guidelines submitted to a range of financial institutions for further development and implementation (Dec 2021)	This objective could not be met due to disruptions to data collection amongst project farmers since March 2020 resulting from the Covid-19 pandemic.

PC = partner country, A = Australia

7 Key results and discussion

7.1 Objective 1

Objective 1 represented the largest component of the project's effort (65%), comprising:

- Engagement and training of specialist extension officers from the Provincial Departments of Agriculture in the six provinces targeted by the project;
- Farmer- and farm-related activities including recruitment, training and support of collaborating farmers; and
- On-farm animal nutrition, rangeland management and reproduction research

A number of major challenges to implementation of Objective 1 emerged since the start of Stage 2 of the project, which commenced in January 2018. These are summarised briefly below, together with potential strategies to overcome them.

7.1.1 Free range market specifications targeted by collaborating smallholder farmers

For cattle to meet free range beef market specifications, steers or heifers (no bulls allowed) must weigh 400 kgs or more by 3 years of age, with at least some fat cover. This means that when an animal is slaughtered it will have a minimum carcass weight of 200 kgs and no more than 4 permanent incisors (teeth), though the 5th and 6th incisors can be erupting. No Brahmans or dairy breeds are allowed due to their known poorer meat quality and the inability of the meat processors to routinely apply additional post-mortem treatments required to improve beef quality in those breeds. Additionally, the animals must have grazed freely for their entire lives, though supplementary feeding and licks are permitted within guidelines (e.g. feeding animal by-products and hormonal growth promotants etc. are not allowed). Free range market specifications and guidelines to meeting those specifications are described in detail in the AgriSeta-accredited[1] Learner Guide developed by the project team at the start of the project and refined throughout the project term as market specifications or production systems changed.

To achieve free range market specifications of at least 400 kgs live weight by 3 years of age, cattle must gain at least an average of 0.5. kg/head/day over their lifetime. Ideally, higher average growth rates should be targeted by the farmer, because that then allows farmers a choice of whether to sell their animals at heavier weights (with even greater price premiums) or sell them at younger ages to allow them to conserve feed for the remaining animals in their herds. The heavier the animals are at slaughter, the greater the

[1] *AgriSeta is South Africa's vocational education system and in the case of the HVBP project, the project developed a very comprehensive training manual (labelled by AgriSeta as a "Learner Guide", together with a Learner Workbook comprising learning exercises that farmers (and others) work through as they progress through the manual. These materials were accredited by AgriSeta and made available through their training system. The project also uploaded them onto the HVBP website for free access by anyone wishing to access them, though unfortunately the website is no longer accessible due to difficulties incurred in the project accessing project operating funds. Additionally, the project developed an excel-based pricing model for use by the farmers and their supporting extension officers, to enable farmers to determine whether targeting free range market specifications would increase their profit margins cf. traditional and other markets such as sale of weaners to feedlots.*

likelihood their carcasses will also have acceptable fat cover to meet free range market specifications.

Over Stage 2 of the project, thirty-nine (39) and seventy (70) animals (109 animals in total) from Limpopo and Mpumalanga were presented for slaughter at Cavalier abattoir during 2018 and 2019, respectively. Eighty-six (86) of those cattle qualified conditionally as potential Free Range cattle at time of trucking from the farm, while 23 were C-class (older) cattle added to the batches to fill the trucks. Only two farmers presented cattle, with 59 coming from one farmer (in two batches) and 50 from the other. Of the 86 prospective Free Range cattle, 36% (31 carcasses) complied with Free Range specifications. Forty-eight (48) animals achieved the Woolworths PW (Process Woolworths) classification used for trimmings only, while the remaining seven failed altogether and were classed as “normal” slaughter cattle. Eighty percent (80%) of failures (n=44) were due to weights being below the required minimum, while one animal failed on fat code, 3 on age (having more than 6 permanent incisors), 1 on conformation and 4 on Paraphilaria bruises resulting from nematode infestation. The large numbers of under-weight carcasses were no surprise to the project, with the farmers choosing not to accept the project’s pre-slaughter recommendations to retain the animals for a further 1-2 months and provide supplementary feed to ensure the cattle reached minimum slaughter weights.

Following the Covid-19 pandemic outbreak in March 2020, the project subsequently struggled to monitor cattle committed by the collaborating farmers to target free range market specifications. Over the period March 2020 – June 2022, 24 farmers committed cattle to the Cradock value chain and 6 committed cattle to the Cavalier value chain. In total, they committed 204 cattle to the program and the project attempted to support those farmers. Over that period, 46 farmers were visited by the project’s farmer support team, but other farmers could not be visited due Covid-19 limitations. With the project’s general inability to monitor the cattle or even engage on a regular basis with the farmers due to harsh travel restrictions, feedback from the farmers suggested most other farmers had largely resorted to their traditional markets because they had no scales to weigh their cattle to determine whether supplementary feeding might be required or adjusting their farms’ stocking rates to ensure adequate nutrition for cattle being targeted for free range market specifications. However, during that period, farming tips and abattoir price lists continued to be circulated via WhatsApp, SMS and/or email for farmers engaging in both value chains. One-on-one telephone calls were also conducted with farmers requesting advisory services.

Over the full project period, 135 farmers directly participated in the program (106 male, 29 female), but over 2018 and 2019 the project engaged with 1,143 male farmers and 456 female farmers for training and farm visits to determine whether the farmers were interested and capable of supplying cattle for free range markets. The farmer selection criteria favoured larger farming operations (i.e. those with more than 30 breeding cows) and they tended to be operated more by male farmers.

The main challenges indicated by the farmers in their quest to supply free range markets included:

- Costs of transporting finished cattle to Cradock and Cavalier abattoirs relative to local sales;
- Drought during much of the project period;

- The length of time it takes cattle to reach market weight specifications, with concerns about increased risk of stock theft, cash flow issues and the difficulty of providing supplementary feed to maintain growth rates (most farmers were not willing to buy supplementary fodder);
- Lack of interest in record-keeping, with some farmers choosing not to keep any records;
- During the Covid-19 pandemic and recurrent outbreaks of food and mouth disease (FMD), many farmers ended up selling cattle to local markets, including a local abattoir that offered premium prices because of the difficulty of securing cattle due to FMD transport restrictions;
- Some farmers indicated they simply preferred traditional farming over modern farming; and
- The lack of expert advice on free range beef production from the government extension officers.

Lessons learned

In future, farmers need to have access to portable scales that could be shared amongst farmers in their local regions and be trained to weigh their cattle, calculate the average daily gains between weighings and determine whether nutritional and/or stocking rate adjustments are needed to ensure cattle are growing at the rates required to meet free range market specifications. Relying on access to scales operated by extension officers is an inadequate approach because those officers cannot be relied on to be available to weigh cattle on a sufficiently regular basis to enable timely adjustments to animal management.

In addition, farmers require greater training in animal handling and health to minimise bruising on the carcasses due to poor handling during the transport period or Paraphilaria infestation. They also require additional practical training in the use of dentition to determine the age of animals prior to slaughter, to ensure cattle are sold within the market-specified age restrictions. This training needs to extend to farmer support team members and extension officers, because it also became clear through the project that even though this topic was covered in detail in the training manual and had been covered in practical demonstrations during training activities, neither the farmers or farmer support officers were confident in using dentition to age cattle when faced with this need on-farm (e.g. they were unable to differentiate between young weaners with ‘milk teeth’ and mature animals with full dentition because they relied solely on the number of visible teeth rather than using a combination of teeth number and cattle weights or body sizes to differentiate between markedly different classes of animals).

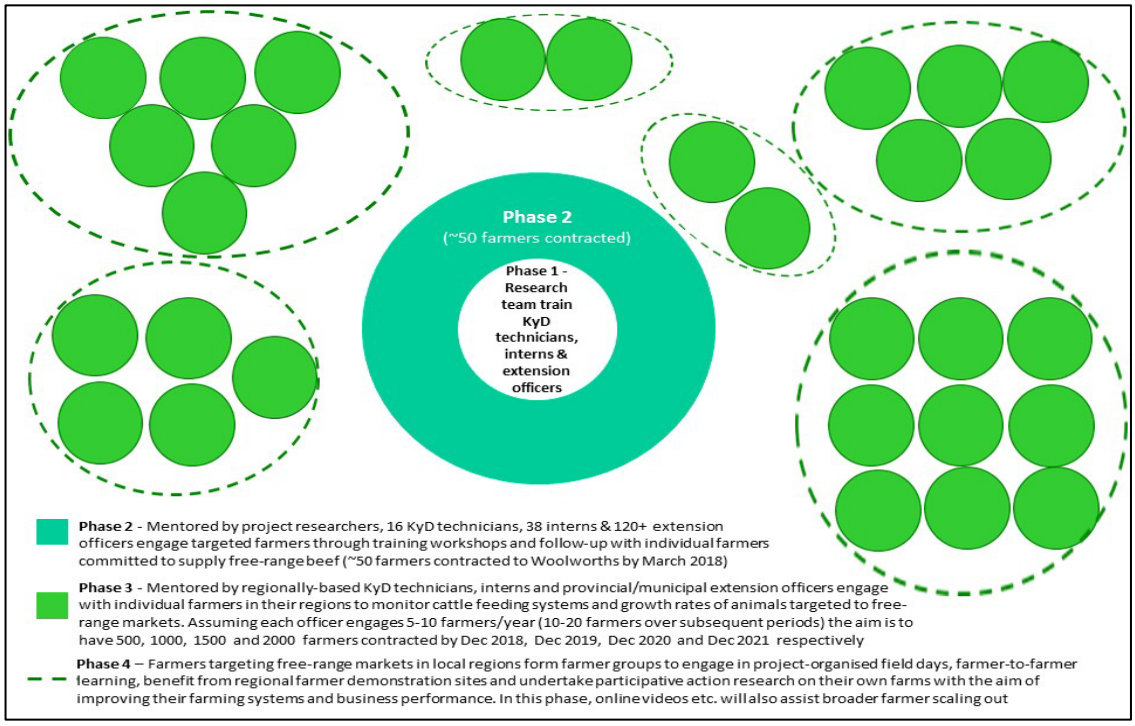
7.1.2 Recruitment, training and ongoing support of farmers to meet free range market specifications

The project’s contract outlined an ambitious overall goal for the project that *‘By December 2021, at least 2,000 emerging and communal farm businesses will be cost-effectively, and in an environmentally sustainable way, supplying cattle on a year-round basis to Cradock Abattoir and Cavalier Meats and achieving at least 70% compliance with Woolworths’ high-value, free-range market specifications’.*

The project operationalised the targeted number of farmers to ~350 farmers per province (Gauteng, Mpumalanga, Limpopo, North West, Free State and Eastern Cape) contracted

to supply free range beef to either Cavalier Meats or Cradock Abattoir. However, it also recognised that having all of those farmers actually supplying 3-year-old sale animals by December 2021 was not feasible because when they are recruited, most farmers only have weaner animals available to grow for free-market specifications (i.e. animals nominated by the farmers still require an additional 2-2.5 years to grow from the time of recruitment of the farmers until the animals are ready for slaughter).

Prior to the onset of the Covid-19 pandemic, the project had >100 farmers contracted to supply free range beef across the six provinces. The process of recruiting farmers was much slower than initially anticipated for reasons described below and in late 2019, the project changed the processes outlined in the following diagram extracted from the project contract.



Phase 1 of this diagram (training of farmer support team members including KyD technicians, interns and extension officers) was believed to have been largely completed in the project's Stage 1 and in the first half of 2018. However, the lack of engagement and deficiency of on-farm implementation expertise amongst the farmer support team members was clearly apparent by a late 2018 farmer training workshop conducted by the project.

In Phase 2 of the diagram above, the project specifically targeted larger or more experienced farmers who could provide a small truckload of cattle per consignment to the abattoir. The change in the farmer engagement approach involved encouraging those small number of Phase 2 farmers to identify and mentor additional, suitable farmers from their own districts so the project could by-pass Phase 3 of the diagram entirely, thereby establishing the planned Phase 4 farmer groups more quickly than outlined in the contract.

This changed approach implemented in late 2019 aimed to use activities such as farmer-to-farmer learning, on-farm research sites and local field days etc. to at least partially replace the lack of adequate farmer support by the regional extension officers that

became apparent by late 2018. As well, all farmer training was to include ongoing training of farmer support team members, KyD technicians and provincial extension officers to simultaneously build capacity across the Cavalier and Cradock value chains. However, the onset of the Covid-19 pandemic in March 2020 and subsequently, the lack of access of the project team to project operating funds, has meant that no further 2- and 3-day training workshops have been able to be conducted by the project.

As indicated above, the project faced substantial challenges relating to the identification, engagement, training and support of farmers with the capability of managing their cattle to meet the requirements of free range market specifications. Those challenges are summarised briefly below, with farmers meeting the following guidelines representing those most likely to be able to meet free range market specifications and targeted for recruitment by the project, which suggested those farmers should:

- Be willing to keep their sale cattle for 2-3 years;
- Have control over the land on which their cattle graze (so they can control cattle growth rates);
- Be willing to follow free-range production systems;
- Communal farmers need to be part of a very well-organised association; and
- Initially, farmers should have 30+ breeding cows with enough land available for free grazing their herd (to ensure sufficient sale animals for cost-effective transport).

Challenge 1: Recruitment of suitable farmers

The greatest initial challenge to implementation of the project was the difficulty in recruiting farmers capable of managing their cattle sufficiently well to be able to achieve free-range market specifications. For the first 18 months of the project (January 2018 to June 2019) the project provided recruitment training to 12-15 farmers for every farmer who subsequently contracted to supply free range beef. Although that training may have been beneficial for the farmers involved, it occurred at the expense of project labour and financial resources and caused delays in providing support to those farmers who had contracted to supply free range beef. Development of farmer selection criteria allowed the type of farmer most likely to benefit from the project to be identified but it did not significantly improve the ratio of farmers receiving recruitment training to those contracting to supply free-range beef, primarily because the provincial officers identifying the farmers for training appeared to have conflicting objectives i.e. within their own organisations they were rewarded for the number of farmers being trained and the project's requirements for specific types of farmers suggested they were being asked to discriminate against most farmers in their local regions. As a result, project efforts to recruit new farmers were largely put on hold in mid-2019 to consolidate support for those farmers already contracted to supply free range beef and pending development of new recruitment strategies focused on engagement of pre-screened farmers (see section on new approaches below).

Challenge 2: Effective engagement of provincial extension officers

Engagement between the project team and provincial Department of Agriculture extension officers and researchers nominated to participate in the project was not as effective as needed. Meetings with the senior managers of all Provincial Departments of Agriculture in the second half of 2019 identified a range of issues primarily around the need for the provincial extension and rangeland officers to have their project roles formally recognised

in their employment contracts. This challenge was largely overcome as part of the new approaches to farmer engagement described below.

Challenge 3: Effective coordination of farmer-related activities

The project was challenged by a lack of effective coordination of farmer-related activities after Dr Nengovhela transferred from ARC to a new role in DAFF in early 2018. Effective coordination across the project-funded support team, DAFF-funded and ARC-managed KyD technicians and interns and provincial department extension officers was essential to the project's success. Dr Klaas-Jan Leeuw was appointed as the project's Operational Manager in late 2019 and he then worked with Dr Nengovhela to restructure the way in which the project engaged with the provincial officers and farmers.

Challenge 4: Effective support of collaborating farmers by the project team

In late 2018 it became very clear to the project leaders that many or most of the project's farmer support team had a good theoretical understanding of the project's objectives based on the project's Farmer Training Manual, but far less practical on-farm experience and expertise with implementation. Deficiencies were identified in these support team members in fundamental aspects such as weighing and ageing cattle, assessing cattle body condition score, calculating average daily gains, assessing the condition of the rangelands and ultimately providing reliable feedback to farmers to help them manage their cattle to achieve free range market specifications. Hence, project efforts focused on providing more practically-oriented and intensive training of farmer support team members to equip those team members with the skills needed to adequately support the farmers in their local areas. Whilst that solution applied to the ARC-based field officers, scaling that solution to also include the ~180 regionally based KyD and extension officers represented a major undertaking in terms of cost and identifying personnel to undertake the training. As part of the farmer engagement re-structure process described below, a skills audit of those provincial officers was undertaken and Practical Mentors appointed in each of the six provinces to help develop the skills of the provincial extension officers.

Challenge 5: Lack of timely recommendations on cost-effective nutritional supplements

A further challenge that became evident in 2019 was the lack of timely recommendations about cost-effective nutritional supplements for cattle to ensure they continued to gain weight at a minimum average daily gain of 0.5 kg. Initially this problem arose because cattle were not being weighed frequently enough to assess the need. However, as some farmers started to provide supplementary feed for their cattle, it became clear that the supplements provided were inadequate to maintain cattle growth. This was believed to be due to a combination of poor quality and/or quantity of pasture and use of lower quality, probably relatively inexpensive supplements, together with poor monitoring of weights to ensure growth was being achieved. That challenge was addressed as part of the training of farmer support team members, to ensure they recognised the problem(s) and sought solution(s) if they were unsure of the recommendations themselves. An associated challenge though was the reluctance of farmers to provide supplementary feed to young growing animals over the dry seasons due to cost, preferring instead to supplementary feed animals as they neared slaughter weights. It was difficult to convince those farmers that feeding young animals would actually be less expensive than feeding older animals, and that additionally, keeping animals growing at younger ages would provide them with a

choice of either selling animals at market weights at younger ages or slaughtering them at heavier weights and higher prices within the 3-year age limit on slaughter cattle.

Challenge 6: Uncertainty around free range markets and prices in Eastern Cape

In 2018, an issue relating to Cradock Abattoir not providing a price premium or even a price grid for free range beef was satisfactorily resolved with assistance from Woolworths. At that time, the project investigated the possibility of engaging with an alternative free range-accredited meat processor in Western Cape. Unfortunately, the distance to transport cattle from Eastern Cape to Western Cape proved not to be cost-effective, leaving Cradock Abattoir as the only free-range accredited slaughtering facility for project farmers in Eastern Cape. In an effort to reduce the risk of smallholder farmers in Eastern Cape not having access to free range markets in future, the project fast tracked its policy development efforts with the aim of introducing a new meat grading scheme to South Africa that recognised high quality beef from animals grown under a diverse range of production systems up to 36 months of age (see report for Objective 3).

7.1.3 New approaches implemented to overcome the challenges experienced in engagement and training of farmers

As described above, the project experienced significant difficulties in recruiting farmers capable of managing their cattle sufficiently well to be able to achieve free-range market specifications. The farmers' needs for technical knowledge became very clear. The project also identified serious deficiencies in the support provided by the project to farmers contracted to supply cattle for free-range beef markets, with a clear deficiency in both critical thinking and on-farm practical experience amongst most of the farmer support team members who had been trained using desk-top training based on the AgriSeta-accredited Farmer Learner Guide developed by the project. The project team responsible for undertaking the initial assessments became overwhelmed with training needs (even though they also lacked the critical thinking and on-farm practical experience skills needed to support the farmers.) Two x 2- or 3-day training workshops were conducted twice per year in 2018 and 2019, based on knowledge needs observed at the farm level. However, it became clear that not much knowledge transfer actually happened at the farm level through the farmer support teams.

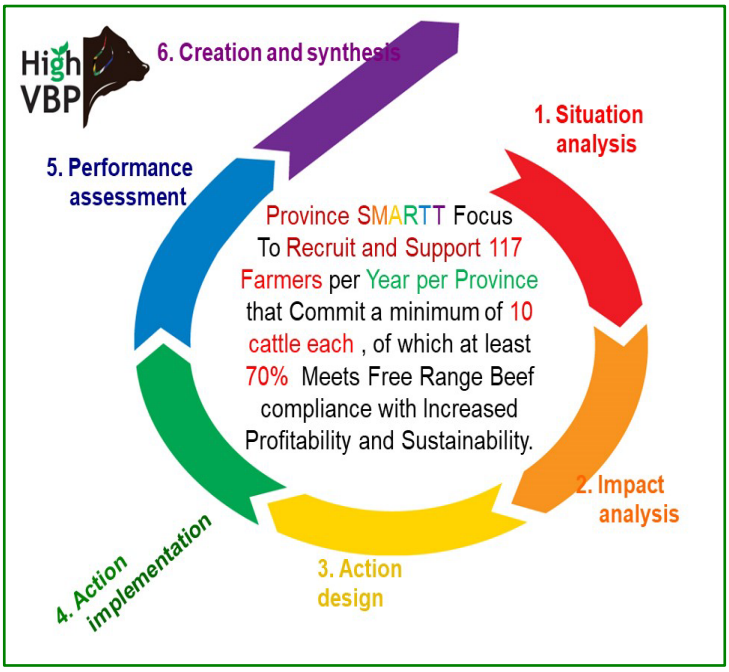
The challenges were structural in nature, as skilled researchers involved in the project could not participate in all on-farm activities as those activities were deemed to be the responsibility of the provincial or district officers who had been nominated to be part of the project. One hundred and eighty (180) provincial officers had been trained in Stage 1 of the project to form farmer support teams, but they failed to be active at farm level in Stage 2. Critical skills needs were identified within these trained officers. This included KyD (animal improvement scheme) technicians, interns, and extension officers from the six provincial departments of agriculture. The project subsequently hired three fulltime technicians to support the coordinator at provincial levels.

A new team-based approach

By May 2019, the project had determined it needed to shift its mode of operation from individual farmers and officers to the use of team-based approaches. The process to commence that transition to ensure the implementing institutions operated as a team was initiated with a workshop that exposed all participants involved to the methodology of

Continuous Improvement & Innovation, which had had been used very successfully in an earlier ACIAR-funded project (LPS-1999-036). The methodology had been contracted to be continued through the KyD scheme funded by DAFF and implemented by ARC. However, it became very clear at the start of this project that the methodology had not been sustained by the KyD scheme. Regardless of the fact that CI&I had been discontinued, perhaps for legitimate reasons around difficulty of implementation, the HVBP project team decided it needed to use aspects of the CI&I method to specifically develop and facilitate teams of farmers and support team members at provincial and regional levels. The opportunity was used to review the project's implementation by using the early steps of the 6-step CI&I process to: 1) Develop a Focus and undertake a Situation Analysis (step 1); 2) Undertake an Impact Analysis (Step 2); and 3) Develop an Action Design (Step 3). All provinces adopted the following Focus for the period September 2019 until August 2020:

'*HVBP TEAM Focus: To Recruit and Support 700 (116 per province) Farmers per Year that Commit a minimum of 10 cattle each, of which at least 70% meet Free Range Beef Compliance with Increased Profitability and Sustainability*' (see diagram below).



Using the cyclic steps of Continuous Improvement & Innovation

The processes used to train collaborating farmers subsequently evolved towards a team-based approach using the CI&I framework, with farmers and farmer support team members moving towards meeting as teams on a regular basis in their local regions to identify actions and training requirements. The transition to a team approach proceeded steadily with Free State province being the only province not to fully engage because, geographically, only small areas of that province fell within the 250km radius of the Cavalier value chain. Provincial champions in all of the provinces completed the project ownership stage that was critical to ensure teamwork occurred across all critical partners. The focus to equip all those to use CI&I in the implementation of the project was planned to continue until mastery was achieved. However, in November 2019, an outbreak of FMD disrupted the team-based activities mainly in Limpopo, but nationally there was a ban on the movement of livestock that also resulted in limited marketing of cattle. The ban was

lifted in the first week of February, only to be followed by ongoing bans for most of the remainder of the project period due to the Covid-19 pandemic. Both scenarios resulted in a high demand for animals that were finished on-farm and as a consequence, the project lost animals that had been committed to free range markets to competitors willing to pay high prices for local slaughter.

Despite the difficulties incurred during the Covid-19 pandemic, the changed approaches have helped access expertise within all critical roles required by the project i.e. provincial economists, animal scientists, veterinarians, communications experts, Cavalier agents, etc. Covid-19 halted the physical meetings but the champions continued to actively engage as real owners of the project. At the end of this project, the implementing knowledge of CI&I is still at its infancy but its impact is clear at the level of interactions across teams.

Lessons learned

Lessons learned from the project's farmer and farmer support team member training, recruitment and engagement activities include:

- Engagement of collaborating team members needs to be secured through formal line-management channels (including recognition in job roles and responsibilities), not simply by assignment of staff by managers, without appropriate buy-in from the team members at the outset of a project;
- Clear guidelines need to be developed at the outset of any project about the characteristics of the farmers suitable for engagement in the project, with all project team members understanding the rationale for those guidelines and willing to comply with them during farmer recruitment and training activities;
- Classroom-style training of farmers and farmer support team members may be useful in providing technical knowledge, but at least in our project's experience, has little value in delivering farmers and farmer support team members with appropriate practical and critical thinking skills required to effectively manage a whole-of-farm production system such as that required to deliver cattle that meet free range market specifications;
- Team-based approaches where teams have access to the full range of expertise needed to achieve project objectives is likely (but still yet to be proven due to disruptions caused by Covid-19) to be more effective at achieving farmer uptake of proven technologies than the current system in South Africa, where extension officers are regarded as 'vehicles of knowledge transfer' and experts in their own right of all aspects of technology adoption rather than as 'facilitators of peer learning' as is the expectation under this project's new approach to farmer engagement.

7.1.4 Rangeland and forage management

The project used DAFF's Veld Condition Assessment Tool (VCAT) as the basis of its rangeland monitoring on smallholder-owned farms. The VCAT is a proven tool that was developed to allow trained farmers to undertake their own rangeland assessments, without the need for specialised equipment or expert scientific knowledge. Initial use of the tool was through trained researchers who established farm benchmarks, but farmers were also trained to use the tool to help them evaluate and interpret the reports provided to them by the researchers (as well as for ongoing use to monitor rangeland condition and estimate optimum stocking rates of their farms at times of seasonal change through the

year). This tool highlights the importance of farmers knowing or recognising palatable grasses, level of weed encroachment, plant cover, soil surface condition and other attributes. Rangeland researchers from the six Provincial Departments of Agriculture contributed to this work in conjunction with ARC's Rangeland Management research team.

A summary of the farms that had veld assessment done and reports prepared from five South African provinces is shown in the following table.

Provinces	Farms surveyed	Reports issued	Average Grazing capacity (ha/LSU)	Veld condition score (%)	Veld condition status	Concluding remarks
Mpumalanga	28	27	4	48.5	Moderate	Understocked
Eastern Cape	36	32	12	44.7	Moderate	Overstocked
Free State	4	3	5	58	Moderate	Understocked
North West	13	12	8	48.2	Moderate	Understocked
Limpopo	11	11	13	39.4	Poor	Overstocked

Some of the factors that contributed to poor veld condition on these farms included:

- Woody plant encroachment: Most farms in the Eastern Cape were encroached by *Elytropappus rhinocerotis* popularly known as Rhino bush whereas in the Free State, Limpopo, North West and Mpumalanga provinces the common encroaching species was *Seriphium plumosum* commonly known as Bankrupt bush. Woody plant encroachment has the potential to negatively affect herbaceous layer and reduce carrying capacity of grazing lands;
- No established planted pastures: Most project farmers relied on natural veld as the main source of feed for their livestock, but the deteriorating quality and quantity of grasses was a limiting factor. Most farms in this study did not have planted pastures to close the feed gap especially during winter or prolonged drought; and
- Lack of knowledge on veld assessment and management: Farmers were trained on the importance of veld condition assessment and application of visual assessment condition tool to determine grazing capacity of the farms and/or camp for optimal stocking rate, but it appeared they chose not to use the tool on an ongoing basis. This was an issue to be investigated in the qualitative research adoption activity described in a separate section below.

Development of a cost-effective feeding strategy to enhance free range beef production for commercially-oriented cattle producers in the Eastern Cape Province

Commercially-orientated beef cattle producers own 47% of the South African cattle herd. The farmer's livelihood relies totally on the production of animals raised under extensive production systems. The productivity of the animals varies widely with changes in quantity and quality of natural pasture across seasons. In an effort to enhance productivity, this study was conducted to develop cost-effective feeding strategies to enhance free ranging beef production for commercially-oriented cattle producers. The study has two sections, the baseline survey which includes chemical analysis of locally available forage resources (LAFRs) and a trial to evaluate the effect of feeding Nguni heifers with diets containing graded levels of cactus prickle pear (*Opuntia ficus-indica*) cladodes on animal performance, carcass characteristics and profitability.

A baseline-survey of farms in a 250km radius around Cradock and Middleburg in the Eastern Cape Province was conducted using a semi-structured questionnaire. Forty free-ranging individual and commonage beef farmers were interviewed to identify the LAFRs and beef breeds. Six feed samples; [reed (*Phragmites australis*), African sheep bush (*Pentzia incana Kuntze)*, Sweet thorn tree (*Vachellia karroo)* leaves and pods, Lucerne hay (*Medicago sativa*), natural pasture grass and prickle pear cactus (*Opuntia ficus-indica*)] were collected from twelve participating farms with key informants for vernacular names and identification. Most of these farmers were men (95%) who managed livestock on both the government leased and communal land. Feed shortages were reported as the most important constraint on beef productivity. Chemical composition and *in vitro* NDF digestibility values of the collected LAFRs were evaluated across pasture species from the surveyed farming areas. Farming areas had no effect ($P \geq 0.05$) on the chemical composition of the collected LAFRs while forage species and farming area interaction had significant effects on the DM, CP, starch, NDF and ADL content ($P \leq 0.05$). Natural pasture grasses and *Pentzia incana Kuntze* had the highest DM content, *Vachellia karroo* pods observed to have the highest OM and CP content than other pasture species by farming areas interactions. Interactive effects of forage species and farming areas were significant for NDF and ADL ($P \leq 0.05$) with most forage species from the Middleburg area having higher NDF content than the other interaction. For the *in-vitro* NDF digestibility (*in-vitro* NDFd), *Opuntia ficus-indica* had the highest ($P \leq 0.05$) content while *Phragmites australis* had the lowest ($P \leq 0.05$) *in-vitro* NDFd for 12h, 24h and 48h, respectively, for each forage species from farming areas and their interaction. There was a significant forage species □ farming area interaction observation for the 12hr ($P \leq 0.001$) and 24hr ($P \leq 0.05$) *in-vitro* NDFd.

As indicated earlier, nutrition is a major constraint for livestock production in these farms; hence, a selection of one alternative source from the feed sources evaluated above, which is adaptive to long dry seasons, is imperative. Therefore, a study was conducted to establish options of improving nutrition by incorporating cactus in ruminant diets. The effect of feeding diets containing incremental levels of *Opuntia ficus-indica* was evaluated using a total of thirty two 24-month old Nguni heifers (*Bos indicus*) of similar weight (172.2 ± 27.1 kg). The animals were randomly assigned for dietary treatments namely: control diet (with pasture-based energy + protein sources), 10% cactus diet, 20% cactus diet and commercial diet (with crop-based energy and commercial protein source) for a 90 day period. Daily experimental diet intake was measured and live mass was measured at fortnight intervals. Daily diet intake was significantly different ($P<0.05$) among treatments. The commercial and control diets had the higher ($P \leq 0.05$) DMI, ADG and fat thickness, carcass conformation scores and lower ($P \leq 0.05$) feed conversion ratio (FCR) than other diets. The 20 % cactus diet had lower ($P \leq 0.05$) dressing percentage than the other diets. The cactus diets had greater gross margins than the commercial and control diets ($P \leq 0.05$). The inclusion of cactus in beef cattle diets under controlled animal house conditions improved the profitability without compromising animal performance and carcass characteristics.

Beef quality, oxidative stability and fatty acid composition of Nguni heifers fed diets with incremental levels of Opuntia ficus-indica (cactus) cladodes

The objective of the study was to determine meat quality, fatty acid (FA) composition and shelf-life stability of longissimus muscle of Nguni heifers fed incremental levels of *Opuntia ficus-indica* (cactus) cladodes under controlled animal house conditions. A total of 32 heifers aged 36 months were allocated randomly to four dietary treatments: 10% cactus, 20%

cactus, commercial and control diets for 90 days. The *longissimus thoracis et lumborum* (LTL) samples were taken from each carcass for the determination of meat quality, retail shelf-life stability and FA composition. Diet had no effect (P > 0.05) on pH and drip display, however, there was an increase in drip display with ageing time (P ≤ 0.05). Meat colour attributes (L* a* b* and C*) were influenced by diet, with 20% cactus diet having lower L* values compared to other diets (P ≤ 0.05). During a 14-day retail display, a diet × day interaction was observed for hue angle with the cactus diets having the lowest values at day 14 of display compared to the other diets (P ≤ 0.05). Differences in meat from heifers fed different diets were observed with 20% cactus accounting for significantly (P ≤ 0.05) higher levels of deoxymyoglobin and the lowest levels of oxymyoglobin. Thawing loss and Warner Bratzler shear force decreased (P ≤ 0.05) with ageing period. Meat from heifers fed cactus diets had lower (P ≤ 0.05) proportions of oleic acid (C18:1n9c) and total MUFA, higher (P ≤ 0.05) proportions of total SFA, C15:1, C17:1, linoleic acid (C18:2n6c) and total PUFA. The control diet produced meat with the highest thiobarbituric acid reactive substances (TBARS) values compared to other diets (P ≤ 0.05) and with ageing TBARS values increased (P ≤ 0.05). Diet showed an effect (P ≤ 0.05) on sensory attributes such as overall tenderness and mouth feel with cactus diets accounting for lower scores. However, juiciness, overall tenderness, grassy and animal like attributes increased with ageing (P ≤ 0.05). Inclusion of cactus in the diet did not produce any adverse effects on meat quality, fatty acid composition, lipid oxidation and sensory quality. Therefore, it can be concluded that inclusion of cactus in Nguni heifer finisher diets up to 20% can improve meat quality.

The effect of Seriphium plumosum meal inclusion level in diets on productivity, carcass characteristics, methane production and emission by Nguni steers – preliminary results

The aim of the study is to investigate optimal animal performance and reduction in methane production and emission by Nguni steers fed at different dietary *S. plumosum* meal inclusion levels. The proliferation of bush encroachment is caused by among others erratic rainfall, suppression of fire and anthropogenic factors such as poor rangeland management. It is for this reason that bush encroachment is one of the major challenges to farmers' particularly those who rely on natural grazing to sustain their livestock. For instance in South Africa, *Seriphium plumosum* (also known as Bankrupt bush) has converted the extensive areas of the grassland into less productive rangelands and consequently reducing the grazing capacity.

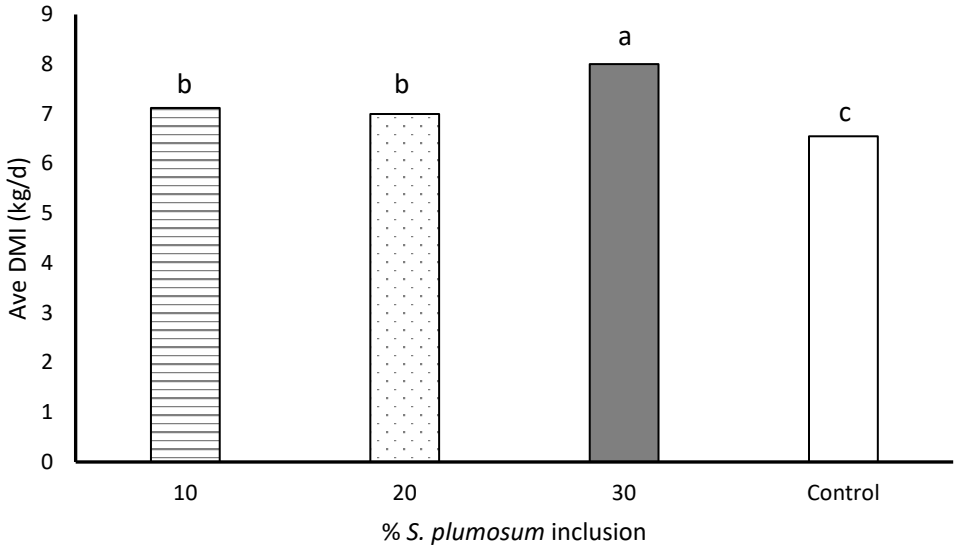
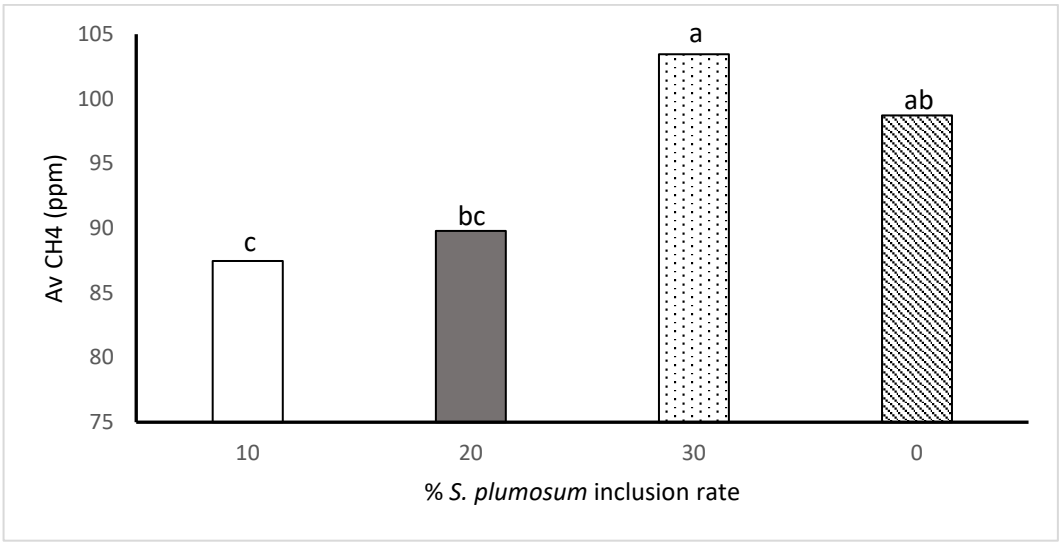


Figure 1: Dry matter intake of Nguni steers fed varying inclusion of *S. plumosum* meal



Nguni steers fed 30% *S. plumosom* meal had a relatively high dry matter intake than 10, 20 and 0% (control) inclusion rate. This is a positive sign that s. plumosum inclusion does not deter consumption especially at the high rate. The same pattern was observed with 10 and 20% compared with the control (0% *S. plumosum* inclusion).

Although Nguni steers fed 30 % S. plumosum meal yielded high intake than other treatments, the opposite was true when coming to methane emission. In this case, Nguni steers fed 10% S. plumosum yielded relatively low methane emission compared to other treatments. These results however, are promising when compared to methane emission produced from animals that were fed a control diet.

7.1.5 On-farm cow reproduction research

Cow reproductive performance is a key driver of the economics of cattle herds in commercial, smallholder and communal ‘economies’ and it becomes increasingly more important in herds where animals are sold or turned off at younger ages. Decreasing sale age also increases the drought susceptibility of beef herds because higher proportions of the herds are lactating cows and young animals. The need for very high reproductive

performance to maintain herd profitability is greatest when animals are sold at young ages.

Reproductive performance of South African smallholder beef herds is sub-optimal and annual calving percentages in many smallholder herds are reported to be less than 35%, bringing into question the economic viability of those herds and whether farmers could significantly increase the profitability of their herds if they replaced their breeding animals with weaners that they could grow and finish for premium market prices.

As with the management of sale animals, effective breeding systems must be underpinned by effective rangeland and pasture management systems and possibly also supplementary feeding of breeding animals (animal nutrition), with the need to effectively manage the entire cattle herd, not just the sale animals being targeted for free range markets. Hence the apparent blurring of research across the rangeland management and reproductive performance aspects in this project.

This project therefore undertook measurements of reproductive performance in smallholder herds in the six provinces targeted by the project, to develop new recommendations on how best to manage breeding herds in those regions to maximise annual weaning rates and calf growth rates.

Measurements were initially designed to be recorded in the participating breeding herds twice per year (before joining and around the time of calf weaning) for three years, though some logistical constraints meant that the repeated measurements in the same herds through until the project's mid-term review in May 2020 had only occurred once. Data recorded included cow breed, liveweight, body condition score, lactation status (lactating/not lactating) and ovarian ultrasound scan images to detect oestrus (oestrus/anoestrus), pregnancy (pregnant/not pregnant) and if pregnant, age of foetus at the start of the first joining period. Repeated measures in the same herds (that were all tested to be free of reproductive disease) over three years would allow accurate estimations of all individual reproductive traits, though they would not provide details about timing or causes of calf losses either pre- or post-birth. These measurements were used to develop recommendations for farmers to improve breeding cow reproductive performance.

At the time of the project's mid-term review in May 2020, it was recognised that ongoing disruptions to project data collection due to the Covid-19 pandemic would prohibit collection of sufficient data needed to develop the previously planned decision-support tool. Hence data collection ceased following the mid-term review and the results of analyses of data collected to that point in time were subsequently used to develop recommendations for smallholder farmers on how best they could improve their herd reproductive performance. Farmers are also being trained and encouraged to manage their rangelands and animal nutrition and to manage the time of breeding and weaning of cows so that breeding cows have average body condition scores of 3 (on a 1-5 scale) throughout the year. Results on analyses undertaken in early 2020 are summarised in the following tables.

Table 1. Description of the dependent variables

Traits (Dependent variables)	**Description**
Pregnancy status	Success of pregnancy at pregnancy diagnosis is defined as 1= Pregnant or 0= not pregnant
Inter-calving period	Interval between 2 consecutive calving (CI) is defined as 1 = if cow became pregnant every year and 2 = if cows become pregnant every two years.
Foetal age	Foetal age at time of pregnancy test, ranging from 1-9 month and non-pregnant are coded as 10
Body condition score	Body condition score range from 1= lean animal to 5=obese animal
Hip height	Cows are categorised as short (<125 cm), moderate (125 to <140 cm) and tall (≥140 cm).

Table 2. Description of the independent variables

Variables	**Description**
Collection period	Collection period during pregnancy diagnosis (PD): 1=April to June,2 =September to November
Province	Province of selected herds during PD: 1=North West, 2=Limpopo, 3=Mpumalanga, 4=Eastern Cape, 5=Free State
Herd	Name of the herd owner
Age	Age of the cow
VCA scoring	Veld condition assessment scoring
Bull to cow ratio (BCR)	Number of bull allocated to cows during breeding season is defined as 1=Under, 2= Ideal, 3= Over
Breed	Type of breed identified
Lactation status	Lactation status defined as 0=Heifer,1=Wet, 2= Dry during pregnancy diagnosis
Udder structure	Udder structure is define as: Normal=0, Abnormal=1
Age of last calf (ALC)	Age of the last calf during pregnancy diagnosis
Brucellosis (CA) test	CA test define as: 1=Positive,2=Negative
Heifer selection	Heifer selection: 1=No, 2= BCS, 3= Parent information
Parity	Number of different times a female has had offspring
BCS prior breeding	BCS measurements prior breeding season:1=Yes, 2=No
Calving rate records	Measurements of calving rate is define as: 1= Yes, 2=No
Culling Non-productive cows	Culling of Non-productive cows is defined as 1= yes (culling is implemented), 2= No (culling is not implemented)
Selective breeding season	Breeding season is defined as: 1=seasonal, 2=Open
Culling old cows	Do you cull old animal: defined as 1= yes (culling is implemented), 2= No (culling is not implemented).

Table 3. Summary for cow reproductive performance data collected between April and June in 2018 and 2019 (MEAN ± SD)

Variable	MEAN ± SD	Median	Mode
Pregnancy status	1.45±0.49	1.0	1.0
Lactation status	1.45±0.67	2.0	2.0
Culling Non-productive cows	1.78±0.41	1.0	1.0
Culling old cows	1.38±0.49	1.0	1.0
BCS	2.72±1.02	3.0	3.0
CA Test	1.98±0.10	2.0	2.0
Bull to cow ratio	1.81±0.64	2.0	2.0
Hip height	131.57±23.52	130.0	135.0
Foetal age at pregnancy test	6.57±3.35	6.0	10.0
Heifer selection	1.47±0.49	1.0	1.0
BCS prior breeding	1.76±0.42	2.0	2.0
Calving records	1.68±0.46	2.0	2.0
Selective Breeding	1.29±0.45	1.0	1.0

Table 4. Summary for cow reproduction performance collected between April and June in 2018 and 2019

Provinces	Cumulative pregnancy status		Lactation status			Cumulative Inter-calving		BCS				CA test		BCS prior breeding		Calving records	
	Preg	Not	Wet	Dry	Heifer	Every year	Every 2 years	1	2	3	4	+	-	Yes	No	Yes	No
1	45	55	49.2	37.9	12.9	52.1	47.9	-	5.8	71.2	22.8	4.8	95.2	65	35	65	35
2	36	64	62	19	19	0	100	-	38	59	3	0.26	99.74	-	100	-	100
3	58	42	30	66	4	31	69	0.8	38	57.2	4	1.02	98.98	8	92	41	59
4	59	41	27	54	19	55	45	-	31	65	4	-	100	52	48	26.45	73.55
5	61	39	22	57	21	67	33	-	27.27	72.73	-	-	100	66.67	33.3	-	100

Provinces	Heifer selection		Culling non-productive cows		Culling old cows		Bull to cow ratio			Breeding Season	
	Yes	No	Yes	No	Yes	No	Ideal	under	Over	Yes	open
1	65	35	65.3	34.7	65.3	34.7	65	35	-	52	48
2	18	82	18	82	18	82	69	39	-	18	82
3	54	46	67	33	11	89	55	30	15	65	35
4	63	37	71	29	26	74	39	40	21	74	26
5	66	34	66	34	66	34	66.67	33.3	-	65.6	34.3

Table 5. Interaction summaries between lactation status (LS), pregnancy status, BCS, BCS prior breeding, inter-calving period and culling non-productive cows

Traits		**North west(1)**			**Limpopo(2)**			**Mpumalanga(3)**			**Eastern Cape(4)**			**Free State (5)**		
		LS			**LS**			**LS**			**LS**			**LS**		
Pregnancy		0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
	1	4.50	22.83	17.7	7.4	18.2	10	1.9	8.6	47.5	12.5	17.04	29.36	15.2	5.2	40.4
	2	8.36	26.37	20.26	11.5	43.3	9.5	1.66	21.8	18.5	6.51	9.7	24.9	6.1	17.1	16.2
BCS	1	-	-	-	-	-	-	-	18	-	-	-	-			
	2	0.64	4.18	0.96	4.87	24.4	8.97	18	0.27	0.54	2.1	5.7	23.4	3.03	15.2	9.1
	3	9.32	30.55	31.51	13.1	35.9	9.5	48	16.7	20.7	15.1	20.5	28.9	18.2	7.7	47.5
	4	2.89	29.41	5.47	1.03	1.29	1.03	1	13.2	41.5	1.8	0.4	1.9	-	-	
Culling non-productive	1	4.5	40.19	20.58	3.1	14.6	0	2.2	22.2	42.4	11.36	3.6	11.5	17.7	2.2	46.5
	2	8.36	9	17.36	15.90	46.9	19.5	1.5	8.2	23.6	7.6	23.1	42.8	4.4	20.2	10.1
Inter-calving	1	6.4	31.2	14.5	-	-	-	1.24	8.16	21.2	14.4	20.1	20.9	17.2	3.03	46.5
	2	6.4	18.1	23.5	18.9	61.5	19.5	2.4	22.2	44.7	4.6	6.7	33.4	4.04	19.2	10.1

Table 6. Odds ratios (OR), 95% confidence intervals and P value from a binary stepwise logistic regression model summarizing associations between risk factors and the odds of probabilities of cows becoming pregnant in smallholder herds

Variable	**SE**	**OR**	**95% CI of OR**		***P value***
			Lower	**Upper**	
Lactation status	0.0645	1.973	1.738	2.239	***<.0001***
Veld type					***<.0001***
Baseline Ref Wakkerstroom Montane Grassland					
Aliwal North Dry Grassland vs Wakkerstroom Montane Grassland	0.6366	0.015	<0.001	1.028	*0.7348*
Thornveld vs Wakkerstroom Montane Grassland	0.4294	0.006	<0.001	0.281	*0.1039*

Variable	**SE**	**OR**	**95% CI of OR**		***P value***
			Lower	**Upper**	
Central Sandy Bushveld vs Wakkerstroom Montane Grassland	0.3657	0.009	<0.001	0.318	*0.5651*
Drakensberg grassland vs Wakkerstroom Montane Grassland	0.4805	0.007	<0.001	0.360	*0.3196*
Dry grassland vs Wakkerstroom Montane Grassland	0.7982	0.007	<0.001	0.360	*0.0558*
Eastern Highveld Grassland vs Wakkerstroom Montane Grassland	1.6705	1.041	0.487	2.226	*0.0072*
Eastern Upper Karroo vs Wakkerstroom Montane Grassland	0.8623	0.002	<0.001	0.161	*0.2078*
Great Fish Thicket vs Wakkerstroom Montane Grassland	0.4673	0.003	<0.001	0.170	*0.0095*
Karoo Escarpment Grassland vs Wakkerstroom Montane Grassland	0.6164	<0.001	<0.001	0.037	*<.0001*
Queenstown Thornveld vs Wakkerstroom Montane Grassland	-1.3231	0.003	<0.001	0.173	*0.0020*
BCS					***<.0001***
BCS 4 baseline Ref					
BCS 1 vs 4	0.4263	0.260	0.081	0.833	*0.0430*
BCS 2 vs 4	0.1586	0.512	0.346	0.759	*0.2427*
BCS 3 vs 4	0.1560	1.083	0.755	1.555	*0.0003*
Veld condition					***<.0001***
Very poor baseline Ref					
Good vs Very poor	0.3574	0.199	0.044	0.898	*0.1090*
Moderate vs Very poor	0.1919	0.353	0.107	1.165	*0.9943*
Poor vs Very poor	0.1561	0.222	0.085	0.578	*0.0028*
Province					***0.0345***
Eastern Cape vs Northwest	0.6045	5.501	2.017	15.003	*0.0018*
Free state vs Northwest	0.5981	4.223	1.595	11.180	*0.0067*
Limpopo vs Northwest	0.2866	0.857	0.479	1.532	*0.9280*
Mpumalanga vs Northwest	1.4982	0.015	<0.001	0.281	*0.7348*
Heifer selection	0.1838	0.719	0.501	1.030	***<.0.0588***
Breed					***0.0015***
Afrikaner Type vs Simmentaler Type	0.3215	0.481	0.192	1.204	*0.9076*
Angus Type vs Simmentaler Type	0.2682	0.326	0.139	0.765	*0.1911*
Beefmaster Type vs Simmentaler Type	0.1470	0.495	0.241	1.017	*0.6549*

Variable	**SE**	**OR**	**95% CI of OR**		***P value***
			Lower	**Upper**	
Bonsmara Type vs Simmentaler Type	0.1235	0.288	0.159	0.522	*0.0001*
Boran Type vs Simmentaler Type	0.3368	0.360	0.147	0.880	*0.4517*
Brahman Type vs Simmentaler Type	0.1724	0.336	0.165	0.683	*0.0623*
Drakensberg Type vs Simmentaler Type	0.1906	0.368	0.171	0.791	*0.2259*
Hereford Type vs Simmentaler Type	0.5049	0.239	0.070	0.821	*0.1902*
Hogenout Type vs Simmentaler Type	0.3618	0.860	0.316	2.340	*0.0876*
Nguni Type vs Simmentaler Type	0.1665	0.491	0.243	0.993	*0.7275*
Simbra Type vs Simmentaler Type	0.2551	0.975	0.498	1.910	*0.0035*
Calving records	0.1450	1.454	1.094	1.932	***0.0161***
Collection year	0.1477	1.807	1.353	2.414	***<.0001***
Veld Condition score	0.0195	1.040	1.001	1.081	***0.0005***
Awareness of BCS Prior breeding	0.2797	1.582	0.914	2.737	***0.1008***

Bold values are generalised Wald-test P values; others are Wald-test P values. BCS (Body condition score)

The stepwise procedure required a significance level of (P ≤ 0.3) to be required to allow a variable into the model. Risk factors derived from candidate variable screened were being added to a starting model, non-significant variables with the highest P value were dropped one at a time. A significance level of (P ≤ 0.35) was required for a variable to remain in the final model. The final stepwise regression model fitted Lactation status (P<.0001), Veld type (P<.0001), BCS (P<.0001), Veld condition (P<.0001), Collection year (P<.0001), Veld condition score (P=0.0005), Breed (<.0001), Calving records (P=0.0161), Heifer selection (P=0.0588), Province (P=0.0345) and Awareness of BCS Prior breeding (P=0.1008) as factors associated with pregnancy rate in smallholder herds.

The results demonstrated that cows and heifers in BSC 3 (OR=1.170) score had a higher probability of becoming pregnant than cows in BSC 1[OR= 0.281] and BSC 2 [OR= 0.555]. Cows in the Eastern Cape (OR=4.699) and Free State (OR= 3.334) had a higher probability of pregnancy than cows in Limpopo (OR= 1.036). Moreover, herds that kept calving records [1.454] and selected cows on BSC prior to breeding [1.582] had a higher probability of becoming pregnant compared to herds without record keeping and awareness of body condition scoring. The model further demonstrated that herds in Eastern Highveld Grassland veld type [OR=1.6705] and veld condition score [OR=1.40] had higher chances of becoming pregnant. Amongst the breeds, Bonsmara breed type (P=*0.0001*) had a higher association of pregnancy rate than other breed types.

7.1.6 Qualitative research to identify reasons why farmers do/do not adopt proven animal production and rangeland management technologies

Over Stage 1 and the early years of Stage 2 of the HVBP project, between 1,500 and 2,000 smallholder farmers have been trained in a range of practices, processes and technologies relevant to delivering cattle that meet high value beef market specifications. Farmers that contracted with Woolworths to supply free range market specifications were subsequently offered more intense training opportunities in 2- or 3-day practical sessions at central locations, with ongoing support on their farms by local extension officers. However, despite many farmers participating in up to 6 of these intensive workshops between 2018 and 2020 and all of them having received Veld Condition Assessments (VCA) and recommendations on options for best managing their rangelands, by mid-2020 most farmers had failed to implement the training and the recommendations they had been given.

Hence, a recommendation from the mid-term review in May 2020 was that the project should undertake qualitative research aimed at identifying why the project's farmers did or did not adopt proven animal production and rangeland management technologies. To achieve this recommendation, two groups of 10 project team members were trained in separate groups using virtual training methods by Dr Erika Valerio with support from Professor Julian Prior over consecutive four-week periods. The training initially focused on qualitative research methodologies during the 4-week training period. Thereafter the team members designed two separate studies to investigate factors influencing farmers' uptake of: a) animal production techniques presented to them during the HVBP farmer training workshops; and b) recommendations made to them by the project's rangeland management research team. A third group of team members investigated opportunities for re-establishing the project's farmer demonstration sites to specifically meet the needs of the farmers in their local regions (see following section).

The animal production and rangeland management studies were designed around the conduct of Key Informant Interviews (KIIs) with up to 100 collaborating project farmers and extension officers. Farmers selected for the studies had participated in at least 4 x 2- or 3-day training workshops and all had been provided with the project's customised Rangeland Management recommendations for their own farm. Separate literature reviews of animal production and rangeland management techniques were completed to underpin the design of the KIIs and development of a theoretical framework for the studies, team members were trained in qualitative interviewing techniques and human ethics approval for the studies was achieved through UNE. The plan was for all interviewees to undertake a one-on-one interview with a project team member at the location of their choosing, based on a range of questions elicited through the literature reviews and that were focused on reasons why farmers do or do not adopt proven technologies. Each interview topic was to comprise interviews with representative male farmers, female farmers and local extension officers or researchers who had previously trained the farmers. Each interview was expected to last between 1-2 hours per participant.

Once the KIIs were completed, the results were to be transcribed and analysed using software such as NVivo, with the aim of publishing the results in a scientific journal as well as using them to modify the approaches taken by the project to training farmers in future. The aim was to develop training methods that met the needs and learning styles of the farmers to ensure greater adoption of practices that were important to the farmers.

Results of the study were to enable our project, and other related research projects, to better understand the reasons why farmers in the target regions are willing to participate in repeated practical training activities designed to improve their farm businesses but then choose not to implement the training on-farm. That better understanding should enable the training to be re-structured to better meet the farmers' needs and thereby increase the uptake of technologies with capacity to improve their farm businesses.

Unfortunately these studies were not able to proceed beyond the training and design stages due to lack of access to project operating funds as described in Section 7.4. However we believe completion of these studies represents a critical and unique opportunity to understand reasons why farmers do or do not adopt training they undertake, simply because we know that each of the targeted interviewees has voluntarily travelled to undertake at least 4 x 2- or 3-day training periods and we also know through the project's monitoring processes whether or not they had adopted any of the practices, tools or technologies they were trained to use on their own farms. Hence we will attempt to identify new funds to ensure those studies can be completed for the benefit of other training organisations across South Africa and probably also other African countries.

7.1.7 Re-establishing farmer demonstration sites as project legacy sites under the management of Provincial Departments of Agriculture

As described in the Activities table (Section 6), when the project's farmer demonstration sites were being established, a dual-purpose role was envisaged for them i.e. it was thought possible to use the sites as provide farm-based research facilities for post-graduate research studies on rangeland and forage science options as well as providing learning opportunities for farmers in the local regions. However during their establishment it became clear the sites could not satisfy the dual purpose requirements and hence the comparative research studies were re-located to research stations. Under the project's farmer engagement models (both the initial and the new models), farmer demonstration sites were critically important to enable farmer to learn collectively and at sites within their local regions. Hence it was agreed that the project's farmer demonstration sites needed to be re-established in line with the project's team-based approaches to farmer engagement, to ensure those sites met the needs of farmers within the geographical regions of the demonstration sites and to be operated under the management of the relevant Provincial Department of Agriculture. At the end of the project, these sites would continue as project legacy sites.

Hence during the qualitative research training described in the previous section, a third group of team members worked directly with farmers in Mpumalanga, Eastern Cape, Limpopo and North West Provinces to re-design farmer demonstration sites in those provinces with the sole aim of maximising capacity development opportunities for local farmers. Unfortunately the very well-designed farmer demonstration sites were not able to be completely re-established due to the lack of access to project operating funds by the project's partner organisations over the final year of the project (see Section 7.4). However the farmers who control those sites continue to support their establishment if new funds can be found to complete their establishment.

7.1.8 'Visioning' workshops

Following the project's mid-term review in May 2020, an additional activity was included in Objective 1, whereby the project was to conduct 'Visioning' workshops targeting senior

managers of the National and Provincial Departments of Agriculture and other critical stakeholders with the aim of better positioning government-funded agricultural extension services as 'facilitators of peer learning' rather than their current roles as 'vehicles of knowledge transfer'. This activity was envisioned as a project legacy activity, with the intent of inspiring critical change amongst agricultural extension agencies across South Africa. Unfortunately though, this activity was unable to be undertaken due to lack of access to project operating funds by the South African partners (see Section 7.4).

7.2 Objective 2

7.2.1 Farmer behaviour change component

Relationships between farmer psychological profiles & farm business performance

Adoption of proven interventions by farmers and implementing practices that create efficiencies and effectiveness across livestock value chains are important mechanisms to improve the profitability of all sectors of the beef and poultry value chains in South Africa. The overarching research question of this component is to determine whether particular types of on-farm interventions and training methods work better for different segments of farmers, based on the farmers' responses to a behaviour change survey and measurements of their farm business performance.

The study used data from behaviour change surveys completed by 480 beef farmers in this HVBP project and 435 poultry farmers from a DAFF-funded poultry value chain project High Value Poultry Partnerships (HVPP project). The main aim of the behaviour change components of both projects is to understand whether customised on-farm interventions and training methods improve farm business performance for different segments of farmers, based on the farmers' responses to the behaviour change survey.

The behaviour change survey instrument has two components: i) farmer-supplied information about aspects of farm business performance; and ii) farmers' self-scores on a range of psychological aspects including attitudes, values, perceived behavioural control, agreeableness, receptiveness to new experiences, time orientation (present or future) and self-efficacy (the farmers' belief or otherwise that they can succeed with the tasks they are faced with).

The survey instrument was developed in English to avoid potential errors of translation into the multiple other languages used by smallholder farmers across South Africa. However, those surveys were administered by trained enumerators who were fluent in the local language where the research occurred. The survey instrument was initially administered to selected beef and poultry farmers across several provinces by 15 project enumerators who had been trained to administer the survey. Responses from the preliminary surveys were checked for consistency and to ensure that the questions were not misinterpreted. Based on those initial responses, some minor changes were made to the questionnaire. The revised questionnaire was transferred to electronic format using Kobo-collect and 14 enumerators were trained on to gather the survey data electronically. Data analysis was conducted in two segments: psychological profiling was conducted using SPSS and farm-business performance indicators was obtained using STATA. The profile of survey respondents is shown in the table below.

Table 1: Classification of farmer respondents in the behavioural change survey.

Item/Attributes	Number	%*
Number of respondents		
Beef	480	58.68
Poultry	435	53.18
Number of sole producers		
Beef	339	41.44
Poultry	326	40.3

**Proportion of the total respondents of 818.*

Of the total 818 respondents, there were 480 farmers who were cattle producers and of those, 339 were sole cattle producers. Among the 435 poultry farmers, there were 326 sole poultry producers.

Cattle Farmers

Basic descriptive statistics of cattle producers are provided in Tables 2(a) to 2(c). Approximately 92% of the respondents were full-time beef producers. Farmers kept cattle for different purposes. Of the total beef sample, 86.42%[2] of producers raised cattle with the intention to sell, for home consumption (20.18%) and as savings (indicator of wealth, 15.29%). However, only 71% of farmers actually sold cattle during the study period. 54% of respondents also kept cattle for cultural reasons.

Only 24% of the respondents were female farmers. The majority of respondents completed at least high school certificates and were mostly engaged in some form of employment. There are diverse languages spoken.

Table 2 (a): Basic socio-demographic characteristics of surveyed beef cattle farmers.

Item/Attributes/Variable	Observations	Number	% of responses
Engagement			
Full time		435	92.36
Part time	471	36	7.64
Reasons for keeping cattle			
Wealth		31	6.58
Sale		315	66.88
Home consumption		33	7.01
Sale & household cons		51	10.83
Wealth & Sale		30	6.37
Wealth & Sale & household cons		11	2.34
Keeping cattle for cultural reasons		255	54.14
Farmers who actually sold cattle		336	71.34
Demographic characteristics			
Male farmers		366	76.25
Female farmers	480	114	23.75
Education			
No school		29	6.04

[2] *The proportion of farmers who raise cattle for sale is derived by summing up 66.88, 10.83, 6.37 and 2.34 since their intentions overlap.*

Item/Attributes/Variable	Observations	Number	% of responses
Primary		100	20.83
Secondary		94	19.58
High school	480	164	34.17
College/University		93	19.38
Language			
Sepedi		73	15.21
Setswana		106	22.08
Isizulu		66	13.75
Isixhosa		115	23.96
Sesotho		45	9.38
Xitsonga		7	1.46
Swati		5	1.04
Ndebele		34	7.08
Afrikaans		2	0.42
English		2	0.42
Venda	480	25	5.21
Occupation			
Employed		297	61.88
Unemployed		74	15.42
Other	480	109	22.71
Race			
Black		474	98.75
White		2	0.42
Coloured	480	4	0.83

On average, farmers were 54 years old, with nearly 18 years of farming experience. The average household size was over 5 members with an almost an equal split between adults and children. Aside from labour availability from family labours, there was also an average of 1.9 hired labourers per household.

Table 2 (b): Basic socio-demographic characteristics of surveyed beef cattle farmers.

Item/Attributes	Obs	Mean	Standard Dev
Age of farmer	472	54.2	14.4
Years in farming cattle	471	17.48	14.98
Household size	480	5.64	3.46
Number of adults living at home	480	2.71	1.67
Number of children living at home	480	2.92	2.77
Number of hired labourers	471	1.9	3.73
Gross off-farm income	480	39313.63	204396.9

Eliciting household income was difficult. Based on different categories, more than 50% of respondents indicated they do not have any agricultural income. This is counter-intuitive, given that almost 70% of the farmers indicated they sold at least one animal. Aside from formal employment, there is also a strong reliance on pensions, social grants and other sources of income.

Most beef farmers indicated they had access to information with regards to their farming operations, with 67% from government extension officers. These results highlight and emphasise the important role of extension officers in disseminating information, practical guidelines and policy changes that have significant effects on practice change. While only 2% of the farmers indicated their main source of information was through financial institutions, approximately 12% had access to credit for farming purposes.

Table 2 (c): Households access to services and income structure.

Item	N	Number	%
Farmers with access to credit	471	58	12.31
Farmers with access to information	471	383	81.32
Source of information			
Market	480	53	11.04
Extension	480	323	67.29
Financial institutions	480	9	1.88
Others	480	142	29.58
Agricultural income		102	21.66
Zero		279	59.24
R1-R50,000		62	13.16
R51,000-R10,0000		28	5.94
More than R100,000	471	102	21.66
Main source of off-farm income			
Pension		82	17.08
Social grant		131	27.29
Employment		137	28.54
Others	480	130	27.08

Of the 480 cattle producers, 71.34% indicated they had sold their cattle. The proportion of farmers selling cattle by province was 24.25% in both Eastern Cape and Limpopo, 16.77% in Gauteng, 12.57% in North West and 9.88% in Mpumalanga. Of the 336 cattle producers who sold their cattle, 78% were males and 22% were females, whereas those who did not sell (135 cattle producers) comprised 71% males and 29% females. The results suggest that there is an opportunity to increase women's participation in selling cattle.

Poultry Farmers

The demographic and socio-economic profile of poultry farmers are shown in Tables 3(a) to 3(c). The proportion of poultry farmers who were full-time producers was 90.8% while females made up 54.48% of the total poultry farmer sample. Most (35.63%) of the farmers had attained high school education while those who actually sold broilers constituted 59.54%.

Table 3 (a): Basic socio-demographic characteristics of surveyed poultry farmers.

Item/Attributes/Variable	N	Number	%
Engagement			
Full time		395	90.8
Part time	435	40	9.2
Alternate chick supplies	435	143	32.87
Alternate pullet supplies	435	48	11.03
Farmers who actually sell broiler		259	59.54
Demographic characteristics			
Male farmers		198	45.52
Female farmers	435	237	54.48
Education			
No school		13	2.99
Primary		92	21.15
Secondary		94	21.61
High school		155	35.63
College/University	435	81	18.62
Language			
Sepedi		155	35.63
Setswana		103	23.68
Isizulu		45	10.34
Isixhosa		45	10.34
Sesotho		42	9.66
Xitsonga		10	2.3
Swati		4	0.92
Ndebele		3	0.69
Afrikaans		1	0.23
English		3	0.69
Venda	435	24	5.52
Occupation			
Employed		226	51.95
Unemployed		51	11.72
Other	435	158	36.32
Race			
Black		431	99.08
White		3	0.69
Asian			
Coloured	435	1	0.23

Of the 435 poultry producers who were surveyed, 59.54% were selling their birds and the remaining (40.46%) were not selling. Most of those who were selling their birds were located in Limpopo (27.8%), Mpumalanga (25.87%), North West (23.94%), Free State (9.65), and Gauteng (7.72). Of the 259 poultry producers selling their livestock, 37.84% were males and 62.16% were females, whereas those who were not selling (176 poultry producers) comprised 56.82% males and 43.18% females. Compared to the cattle

farmers, poultry farmers were younger, with an average age of 47 years (SD=13.58). The results suggest there is an opportunity to increase women's participation in selling poultry.

Table 3 (b): Basic socio-demographic characteristics of surveyed poultry farmers.

Item/Attributes	Obs	Mean	Standard Dev
Age of farmer	433	47.24	13.58
Years in farming poultry	435	4.25	11.5
Household size	435	5.45	2.54
Number of adults living at home	435	2.9	2.17
Number of children living at home	435	2.69	1.91
Number of hired labourers	435	3.19	5.35
Gross off-farm income	435	18082.4	59967.94

Overall, the profile of poultry farmers' access to information and credit and economic profile were similar to the cattle farmers. The results show that extension officers are the main source of information. Two-thirds of poultry farmers indicated they earned up to ZAR 50,000 from broilers. There was some difficulty in obtaining information regarding earnings from sale of eggs (layers). However, more than 45% of respondents indicated they also had other forms of on non-farm income.

Table 3 (c): Access to information and income structure of poultry farmers.

Item	N	Number	%
Farmers with access to credit	435	84	19.31
Farmers with access to information	435	311	71.49
Source of information			
Market		59	13.56
Extension		242	55.63
Financial institutions		33	7.59
Others	435	154	35.4
Agricultural income (broiler sales)			
zero		164	37.7
R1-r50,000		137	31.49
R51,000-R100,000		63	14.48
More than 100,000	435	71	16.32
Agricultural income (egg sales)			
zero		315	72.41
R1-r50,000		67	15.4
R51,000-R100,000		17	3.91
More than 100,000	435	36	8.28
Main source of off-farm income			
Pension		74	17.01
Social grant		119	27.36
Employment		42	9.66
Others	435	200	45.98

Beef and Poultry Farmers' Psychological Profiling

Before developing profiles of the farmers, a series of descriptive analytics and data checking was conducted, with inter consistency of data checked using Cronbach's alpha. Latent profile analysis (LPA) was used to generate the behavioural profiles of the farmers. LPA is a person-centred technique, which combines the different responses for each individual and then examines for patterns of similarity. A range of indices was used to test for goodness of fit of the data.

Based on the results of the LPA, three distinct psychological profiles were obtained from both beef and poultry farmers, namely:

1. a relatively small proportion of farmers who scored themselves negatively on their ability to control and succeed in their business enterprises;
2. a group comprising the majority of farmers who were generally neutral about their ability to control and succeed in their businesses; and
3. a relatively small group of farmers who were confident of their ability to succeed.

The profiles of poultry and cattle farmers are depicted in Figures 1 and 2 below.

Figure 1: Profile of poultry farmers (Profile 1: n=25, Profile 2: n=233, Profile 3: n=177)

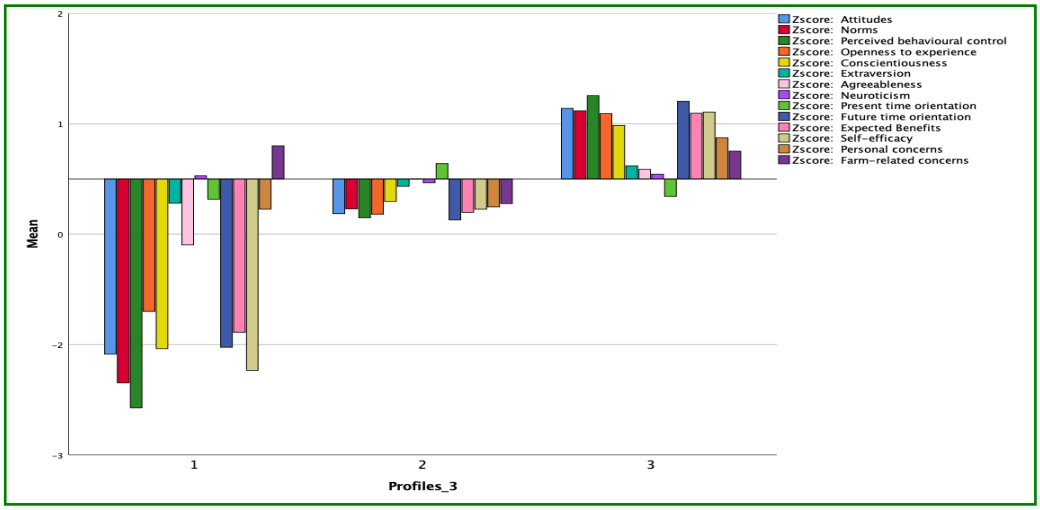
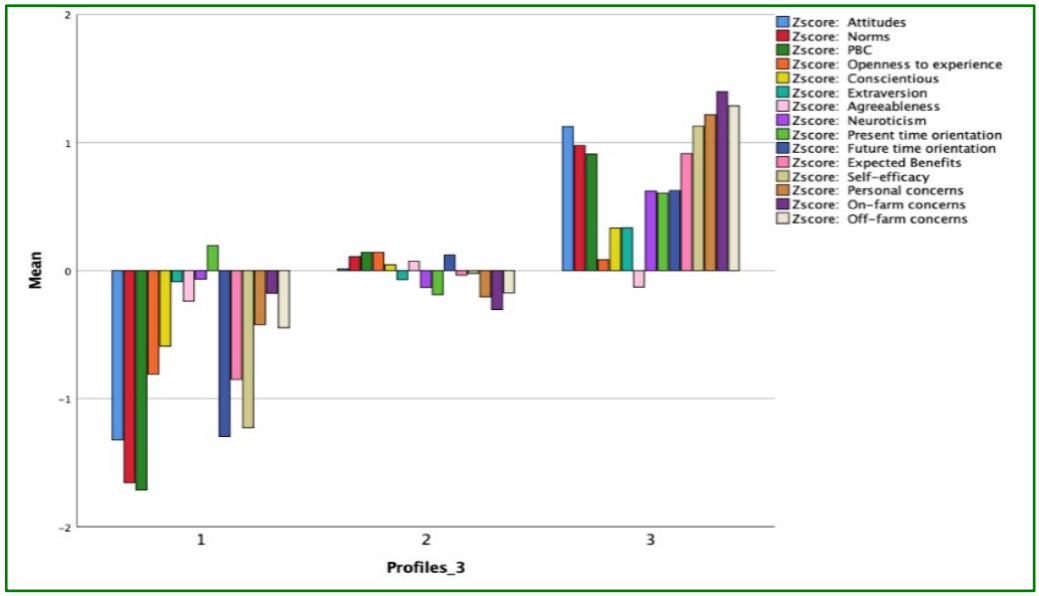


Figure 2: Profile of cattle farmers (Profile 1: n=69, Profile 2: n=333, Profile 3: n=69)



Farm-Business Performance Indicators

For the purpose of this study, we used three sets of performance indicators:

1. On-farm indicators: To depict the performance of farmers in terms of cattle holdings, calving rate, mortality rate and numbers sold. This also includes cost indicators. As only income ranges were obtained in the survey, precise income from cattle sales and egg sales were not available and we were unable to compute the cost and returns for either cattle or poultry production.

2. Market participation: The primary focus of HVBP is on commercially-oriented smallholder farmers who own or lease land but lack the training, infrastructure and production systems available to the commercial sector. In our sample, 68% of farmers kept cattle with the intention to sell, and 71% are actually selling cattle. There is evidence that market participation remains relatively low, especially for those selling to auctions, feedlots, abattoirs and commercial markets. Therefore, we modelled the likelihood of farmers to engage in the market and if they did, which market they were likely to prefer.

3. Efficiency and productivity: These key indicators are defined as:

   Productivity is measured as partial productivity measures (hereafter, referred to simply as productivity), which provides a similar measure as long as all farmers have access to the same production technologies and there are not scale economies. Examples of productivity indicators are number of calves/year and number of cattle sold/household.

   Efficiency measures the performance of farmers based on their existing resources. A farm is technically efficient when it achieves the maximum possible output for a given set of inputs used in production. A technically inefficient farm can increase output without requiring any more inputs. Technical efficiency shows the capacity of farmers to reach the maximum attainable output.

   Survey data derived from both cattle and poultry farmers were used to obtain the above indicators. Because there were some missing data, the number of observations varied depending on the completeness of information used.

On-farm indicators

On average, the total number of cattle owned is 44 head, with the herd size being lower for those who did not sell cattle. However, there were significant number of farmers who kept their stock for consumption and other purposes such as wealth/asset holding, which implies an opportunity exists to encourage these farmers to be more market-oriented, while those who are already selling should be primarily targeted for commercialisation. On an annual basis, there is a significant difference in the calving rates between the two groups, but the mortality rate is almost similar.

Cattle producers selling their livestock on average were investing ZAR 23,927.57 (SD = ZAR70,474.64). This level of investment was higher compared to those who did not sell (M=ZAR 4,414.33, SD =ZAR12,707.41) and the total (M=ZAR18,334.6, SD =ZAR60532.11).

On average, those who sold had a higher average farm size of 1565.29 ha, compared to those who did not sell (M=257.09, SD =538.14) and total (M=1190.32; SD=17696.97).

Table 4: Selected on-farm key indicators.

	Don't sell (n=135)		Sell cattle (n = 336)		Total cattle producer (n = 471)	
Indicators	**Mean**	**St.Dev**	**Mean**	**St.Dev**	**Mean**	**St.Dev**
No. cattle owned	21.21	28.41	53.33	76.28	44.12	67.74
No. calves born/year	4.52	9.24	16.76	28.24	13.25	24.97
No. cattle deaths/year	2.36	4.15	3.37	5.6	3.08	5.24
No. purchased cattle	2	9.18	65.01	1091.32	46.95	921.81
No. cattle sold/year	0	0	13.23	28.1	9.44	24.47
Farm size (ha)	257.09	538.14	1565.29	20947.14	1190.32	17696.97
Labour	1.21	3.11	2.17	3.92	1.9	3.73
Total cost of feed	3218.26	10880.59	17352.65	65046.37	13301.39	55591.58
Total cost of vet services	1196.07	3391.59	6574.91	14261.01	5033.21	12416.43
Total costs (feed & vet)	4414.33	12707.41	23927.57	70474.64	18334.6	60532.11

Market Participation

In order to evaluate farmers' likelihood to engage in the market, we use the concept of limited dependent variable models to ascertain the decisions of farmers with respect to: (a) whether to sell or not to sell cattle; and (b) the decisions on where to sell the livestock. Ideally, we would have modelled the choices between different market outlets. However, the choices are not entirely independent of each other, given that some farmers are selling in more than one outlet. Of the farmers who sold cattle, the distribution of choices of different market outlets are provided in Table 5.

Table 5(a): Distribution of farmers according to market outlets.

Market outlet	Number of farmers	% of farmers
Informal	182	43.03
Auction	184	43.50
Feedlot	25	5.91
Abattoir	19	4.49
Other	13	3.07

Table 5(b): Distribution of farmers according to number of market outlets.

Number of markets	Number of farmers	% of farmers
1	279	80.87
2	57	16.52
3	8	2.32
4	1	0.29

Most farmers sold to either informal or auction markets. Of the total farmers selling, more than 16% were engaged in selling into multiple markets. To estimate the probability of the cattle farmers either selling or not selling their livestock, a binary probit regression (with marginal effects) was conducted to estimate the probability of cattle farmers to sell or not sell. Results are presented in Table 6.

Table 6: Regression for number of Beef/Cattle sold, propensity to sell & willingness to sell

	Log(Actual number of Cattle sold)	Probability to sell
		ME
Access to credit (0/1)	0.469**	0.100*
	(0.182)	(0.058)
Access to agric info (0/1)	0.107	0.014
	(0.106)	(0.045)
Age of farmer	0.008**	0.003**
	(0.004)	(0.002)
Educational Status (Base=Tertiary)		
No school	-0.169	-0.011
	(0.237)	(0.093)
Primary	-0.383**	-0.083
	(0.153)	(0.057)
Secondary	-0.419***	-0.106*
	(0.155)	(0.055)
High school	-0.275*	-0.041
	(0.142)	(0.047)
Farming not on basis of culture (0/1)	0.025	-0.141***
	(0.106)	(0.040)
log(number of hired labourers)	0.331***	0.075***
	(0.071)	(0.024)
log(total exp on electricity)	-0.022	-0.016***
	(0.016)	(0.006)
Female famer (0=male; 1=female)	-0.151	-0.079**
	(0.093)	(0.040)
Years of farming	0.008**	0.004**
	(0.004)	(0.001)
Household size	0.000	0.003
	(0.013)	(0.005)
log(exp on veterinary purchases)	0.124***	0.030***
	(0.014)	(0.005)
Province (Base= Eastern Cape)		
Limpopo	0.582***	0.165***
	(0.139)	(0.059)
Free State	0.608***	0.118*
	(0.174)	(0.071)
Mpumalanga	0.228**	0.075
	(0.114)	(0.059)
North West	0.567***	0.220**
	(0.214)	(0.090)
Gauteng	0.455***	0.085
	(0.147)	(0.057)
Northern cape	0.234	0.049
	(0.218)	(0.079)

	Log(Actual number of Cattle sold)	Probability to sell
		ME
Constant	-0.185	—
	(0.292)	—
Observations	471	471
R-squared	0.505	0.350

The variables that had the capability of improving the model's predictive power were access to credit, age of farmer, education, hired labourers, years of farming, expenditure on tertiary services and location of farmer. Farmers who have access to credit were 10% more likely to sell their cattle. Older farmers were likely to increase the probability of selling cattle by 0.3%. This is anticipated because age is associated with experience. As expected, farmers who had attained tertiary levels of education were more likely to sell than those with other levels of education. Those who kept cattle for cultural reasons were 14.1% less likely to sell. In addition, an increase in hired labours by one person increased the likelihood of selling by 7.5%. This is expected because hired labourers are associated with higher per unit output, which increases the intention to sell. Descriptive statistics and distribution of predicted probabilities of selling cattle are provided in Table 7 and Figure 4 below.

Table 7: Summary of probabilities of selling cattle.

Item	Don't sell (135)	Sell (n=336)
Average	0.524	0.755
Standard deviation	0.252	0.208
Minimum	0.013	0.149
Maximum	0.964	0.995

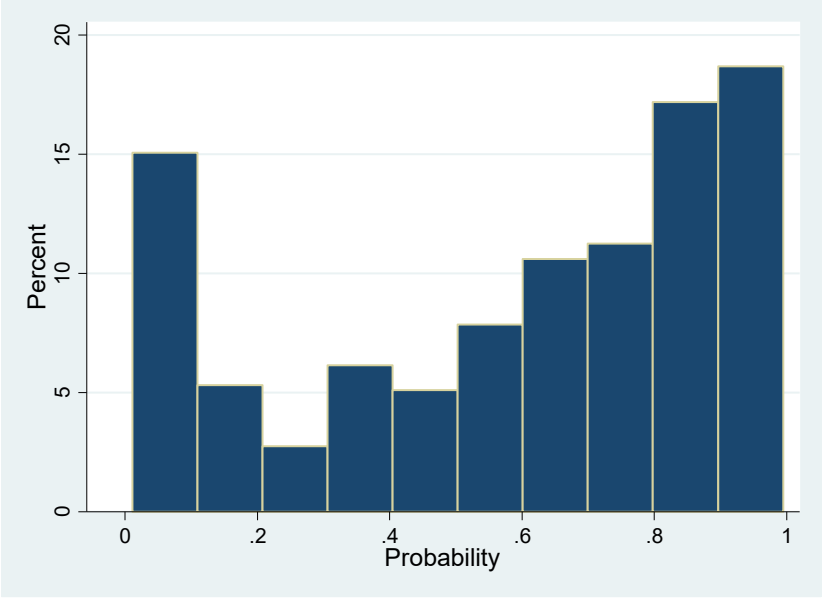


Figure 3: Distribution of probabilities of selling cattle (whole sample n = 471).

The above results indicate that more than 70% of farmers had a very high probability of selling their cattle. It can be deduced that government interventions aimed at commercialisation should primarily target those farmers. As expected, the average

probability was higher for those who were already selling cattle. There were wider variations of predicted probabilities for those who did not sell cattle.

We modelled the factors determining the choice of particular market outlets. If choices were purely independent, then we could have modelled the decisions on which outlet was chosen. As an alternative, we examined the factors affecting the decisions to sell in each outlet. Descriptive statistics of predicted probabilities of selling cattle by market outlet are provided in Table 8.

Table 8: Probability of selling at different market outlets.

Item	ALL	INFM	AUC	FEDL	ABT
Mean	0.832	0.377	0.360	0.053	0.069
Standard Deviation	0.192	0.198	0.282	0.124	0.094
Minimum	0.057	0.011	0.001	0.000	0.000
Maximum	1.000	0.931	0.978	0.735	0.487

Table 9 provides the results of the analysis of the choices of market outlet by these farmers. The findings indicate that selling at informal markets was positively influenced mainly by farming experience (years of farming), which also implied the usage of traditional forms of selling. On the other hand, the decision to sell at auction markets and abattoir was influenced positively by the number of hired labourers, expenditure on veterinary services, and location and education. The role of education and training about the benefits of selling in these market outlets is crucial for farmers. Thus, appropriate information dissemination strategies and role of extension workers will be fundamental in this aspect.

Table 9: Probit models for predicting selling in different markets.

	Willingness to Sell (WTS) in Market			
	Sale as reason for farming	WTS in Informal mkt	WTS in Auction mkt	WTS in Abattoir
	ME	ME	ME	ME
Access to credit (0/1)	0.028	-0.014	0.086	-0.020
	(0.048)	(0.070)	(0.058)	(0.041)
Access to agric info (0/1)	0.084**	0.002	0.052	0.016
	(0.033)	(0.051)	(0.048)	(0.034)
Age of farmer	-0.000	0.001	0.002	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)
Educational Status (Base=Tertiary)				
No school	0.190***	-0.171*	0.068	—
	(0.069)	(0.095)	(0.096)	—
Primary	0.040	-0.116*	0.092	—
	(0.057)	(0.069)	(0.058)	—
Secondary	0.011	-0.117*	-0.025	—
	(0.058)	(0.068)	(0.054)	—
High school	0.062	-0.090	0.035	0.060**
	(0.049)	(0.062)	(0.046)	(0.028)
Farming not on basis of culture (0/1)	-0.074**	-0.157***	-0.058	0.040

	Willingness to Sell (WTS) in Market			
	Sale as reason for farming	WTS in Informal mkt	WTS in Auction mkt	WTS in Abattoir
	ME	ME	ME	ME
	(0.036)	(0.045)	(0.038)	(0.031)
log(number of hired labourers)	-0.015	-0.006	0.073***	0.065***
	(0.023)	(0.028)	(0.022)	(0.019)
log(total exp on electricity)	-0.019***	-0.006	-0.017**	0.001
	(0.005)	(0.009)	(0.007)	(0.004)
Female famer (0=male; 1=female)	-0.042	-0.107**	-0.025	-0.022
	(0.036)	(0.049)	(0.042)	(0.033)
Years of farming	0.005***	0.006***	-0.001	-0.003*
	(0.001)	(0.002)	(0.001)	(0.002)
Household size	-0.002	0.007	-0.003	0.002
	(0.005)	(0.006)	(0.005)	(0.003)
log(exp on veterinary purchases)	0.020***	0.002	0.031***	0.010**
	(0.004)	(0.006)	(0.004)	(0.005)
Province (Base= Eastern Cape)				
Limpoo	0.072	0.032	0.096*	-0.001
	(0.056)	(0.065)	(0.054)	(0.028)
Free State	-0.159	-0.072	0.217**	0.094
	(0.106)	(0.091)	(0.092)	(0.102)
Mpumalanga	-0.012	0.118*	-0.116**	
	(0.050)	(0.066)	(0.052)	
North West	0.009	-0.244***	0.376***	0.011
	(0.079)	(0.069)	(0.097)	(0.053)
Gauteng	-0.036	-0.131**	0.224***	0.025
	(0.053)	(0.059)	(0.057)	(0.039)
Northern cape	0.172***	0.047	0.108	0.031
	(0.055)	(0.087)	(0.077)	(0.047)
Constant	—	—	—	—
	—	—	—	—
Observations	471	471	471	221
R-squared	0.424	0.167	0.346	0.241

The cumulative distribution of probabilities associated with different markets are provided in Figure 5. As expected, most farmers had a high probability to sell at informal markets and auctions. These market outlets are easily accessible with fewer requirements than feedlots and abattoirs. These results indicate that most of the sampled respondents lacked market access to the mainstream value chain of South Africa's beef industry.

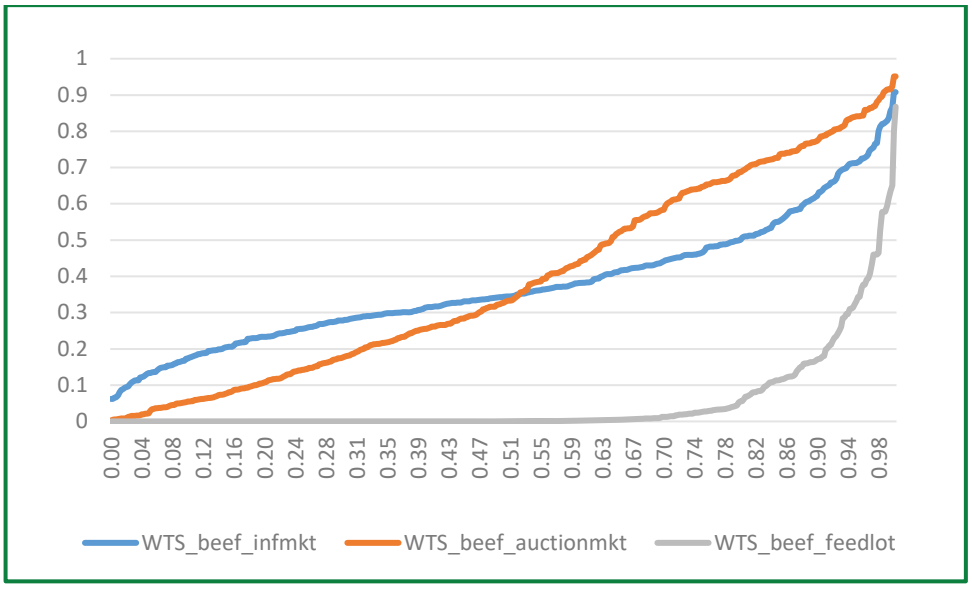


Figure 4: Cumulative distribution of probabilities of selling in different market outlets.

Efficiency and Productivity

We used the concept of technical efficiency as an indicator of business performance. Technical efficiency indices are calculated by estimating what is called a stochastic frontier production function. A production function expresses farm output as a function of the inputs used to produce that output. The production frontier function used in this study can be considered as an envelope around the relations between all inputs and outputs in production after allowing for random events (hence the inclusion of the term, stochastic). We can describe the producers on the production frontier as following best practice in a technical sense.

In this technical sense, output is defined as the total output produced per annum per household. We have used different indicators of output. First, the total livestock units net of purchases and trading. Second, the total number of cattle sold. For the purpose of this preliminary analysis, we used the total number of cattle sold per household as an output indicator. Inputs in cattle production were aggregated into the following categories: farm size (this will used to be an indicator of effective grazing area), labour inputs, stock measured in LSU (2 years old cattle=1.000 LSU); total costs (which is made up of feed and veterinary costs). One of the limitations of this definition of variables is the lack of consideration about the quality of stock.

For our purposes, we assume that farmers have access to the same set of production technologies (although they will not all make the same use of them). Satisfactory estimates were made of the stochastic frontier production functions of farmers in each benchmarking group that enabled calculation of individual technical efficiency indices for each farm in each year. The general representation of the stochastic frontier model is as follows:

$$lnY_i = \beta_0 + \sum_{j=i}^{4} \beta_j \, lnX_i + v_i - u_i \qquad (1)$$

where *ln* is a natural logarithm; *Y* represents the number of cattle owned (in n); X_1 is the farm size (in ha) for cattle production; X_2 is labour input (total of hired and family people); X_3 represents the total costs (in rand) for cattle production; and dummy for those who do

not spend in supplementary feeding and veterinary costs. The subscripts *j* and *i* refer to input and i-th farmer, respectively, whereas *v* denotes the 'noise error term; and u_i is a non-negative random variable associated with technical inefficiency.

The maximum-likelihood estimates of the stochastic frontier model are presented in Table 10. As expected, all factors of production are significant in improving productivity of cattle production. More importantly, those farmers who invest in supplementary feeding and veterinary expenses have the highest impact on production.

Based on the specifications of the empirical model, the estimated stochastic frontier model is used to obtain measures of technical efficiency for individual farmers. The results showed that technical inefficiency was present amongst the sampled farmers. The average score was 0.51 indicating a significant potential for all farmers to improve their current productive performance. There is a relatively high coefficient of variation (30%) indicating that some farmers are almost operating close to the maximum potential, but most are still performing below 50%. Summary and distribution of technical efficiency scores are provided in Table 11.

Table 10: Maximum-likelihood estimates of the Cobb-Douglas function.

Variable	Coef.	Std. Err.	Z	P>|Z|
Constant	0.6313	0.2913	2.1700	0.0300
Area	0.0729	0.0214	3.4200	0.0010
Labour	0.1917	0.0675	2.8400	0.0040
Total Cost[a]	0.3196	0.0281	11.3600	0.0000
Dummy – Cost[b]	2.2557	0.2595	8.6900	0.0000
Dummy – Area[c]	0.0707	0.1459	0.4800	0.6280
ln □v	-0.5942	0.1681	-3.5300	0.0000
ln □u	0.0983	0.2510	0.3900	0.6950
σ_v	0.7430	0.0625		
σ_u	1.0504	0.1318		
σ^2	1.6553	0.2126		
λ	1.4138	0.1848		
LLF	-648.653			
N	467			

[a] includes the cost of supplementary feeds and veterinary costs; [b] Dummy for those with feed and veterinary costs; [c] farmers without owned area.

Table 11: Descriptive statistics of estimated technical efficiency scores.

Item	Technical Efficiency
Mean	0.511
Median	0.529
Mode	0.722
Standard Deviation	0.154
Sample Variance	0.024
Range	0.786
Minimum	0.076
Maximum	0.862
N	467

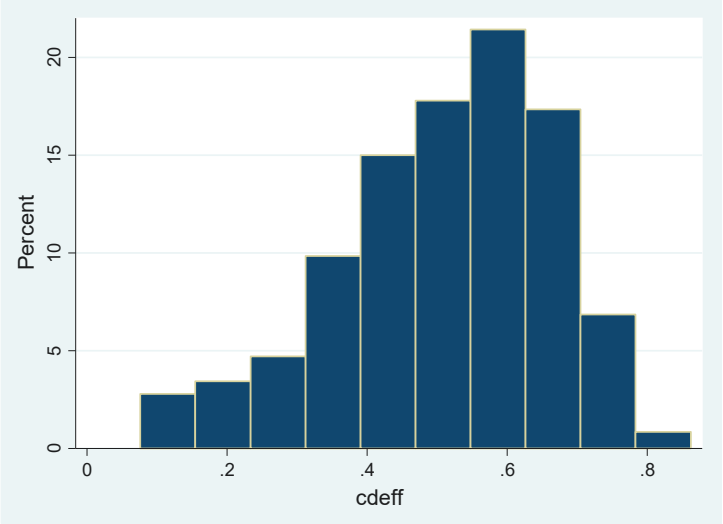


Figure 6: Distribution of estimated technical efficiency scores.

These results suggest the following implications:

- there is a strong potential to increase the number of cattle owned with the existing resources and technology;
- there is a wide variation in the scores among farmers. There is an opportunity to target and provide interventions to non-performing farmers in order for them to catch-up and also to all farmers in order to reach the maximum attainable target output;
- we have only assumed that all farmers are faced with the same production technology. No account for the intervention in production and in marketing was included in the model.

Given the high variability of efficiency scores, we examine the correlations between technical efficiency scores and the predicted probability of selling. It should be noted that these were only analysed using the scores for those who actually sold. Correlation between these two indicators are shown in Figure 6. The horizontal axis is the estimated technical efficiencies and the vertical axis shows the probability of selling. The distribution of these scores are divided into four quadrants:

I Low efficiency – low probability to sell

II High efficiency – low probability to sell

III High probability to sell – low efficiency

IV High efficiency – high probability to sell

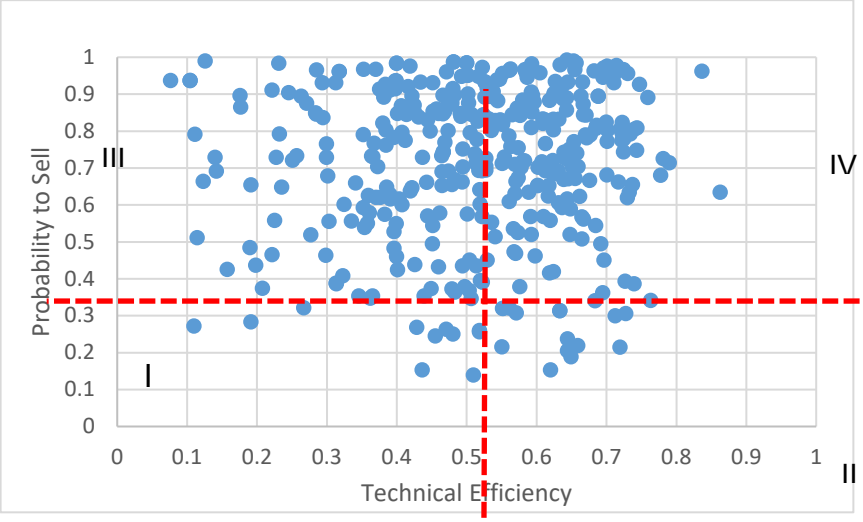


Figure 7: Correlation between technical efficiency scores and probability of selling.

Most farmers are located in the 4th quadrant (high probability of selling and high TE). There are several farmers who are located in the 1st quadrant, with low probability and low efficiency scores. In-depth analysis and understanding of the farmers in the 2nd and 3rd quadrants is required. Intervention strategies both in encouraging farmers to sell and increase the number of cattle production is a fundamental approach to improve the overall performance of farmers.

Correlations between Psychological Profiles and Farm Business Performance

We examined the relationship between the psychological profiles of farmers and selected farm business performance indicators. We would have preferred to evaluate more performance indicators, but due to incomplete data, we could not estimate those indicators. Nonetheless, based on the average values, the result showed there is an obvious favourable relationship between the profiles of farmers and the selected business performance indicators.

Table 12. Selected performance indicator by different profile of farmers.

Indicator	Profile 1	Profile 2	Profile 3	F-value	P-value
Cattle					
Cattle owned/household	30.49 (31.16)	55.37 (83.69)	65.43 (67.40)	2.98	0.052
Cattle sold/household	6.65 (10.22)	13.99 (32.24)	15.93 (16.85)	1.68	0.188
Likelihood to sell	0.669 (0.234)	0.737 (0.204)	0.896 (0.116)	16.91	0.000
Technical efficiency	0.511 (0.141)	0.532 (0.143)	0.507 (0.166)	0.95	0.389
Poultry					

No. of broilers sold/household	1202.40 (2540.20)	10367 (76.701.09)	16546 .51 (80800)	0.6	0.550
Likelihood to sell	0.386 (0.445)	0.554 (0.422)	0.654 (0.392)	5.83	0.003

We further examined the correlation between the selected business performance indicators and the psychological profiles of farmers. The *expected value* of the selected performance indicators increases, from Profile 1 to Profile 3. For example, the magnitude of cattle sold improves as the profile of farmers changes from profile 1 to profile 3. This result is evident for both cattle and poultry farmers.

Table 13: Relationship between performance indicators and profile of farmers.

Indicator	**Profile 1**	**Profile 2**	**Profile 3**
Cattle			
Cattle owned/household	-0.446 *** (0.150)	0.051 (0.131)	0.337 *** (0.170)
Cattle sold/household	-0.470 *** (0.134)	-0.099 (0.278)	0.599 *** (0.122)
Poultry			
No. of broilers sold/household	-2.061 *** (0.777)	-0.641 *** (0.401)	1.136 *** (0.406)

*** $p<0.01$

In the absence of the actual prices received by farmers, we estimated the average income for individual groups of farmers using an estimated price for broiler and cattle sold. The result is provided in Table 14.

Table 14: Expected income of farmers by different profile.

Cattle	Number of cattle sold	Income (in Rand) [a]
Profile 1	7	56000
Profile 2	14	112000
Profile 3	16	128000
Poultry	Number of broiler sold	Income (in Rand) [b]
Profile 1	1202	72120
Profile 2	10367	622020
Profile 3	16546	992760

[a] Assuming an average price of R8,000 per animal; [b] assuming an average price of R60 per broiler.

Design of customised training methods based on farmers' psychological profiles

Using the farmer psychological profiles, we designed a new training method using the London School of Behaviour Change's approach through use of their 'Behaviour Change Wheel', with the aim of improving adoption of proven technologies in both beef and poultry industries. Our intention was to focus on Profile 2 (average farmers) through group-based learning and peer-support and Profile 3 (entrepreneurs) through mentoring processes.

We started our intervention only with poultry farmers in September 2019 because it would take longer than the project's contracted period for us to measure the impact on beef farm business performance (due to the much longer sale intervals and reduced sale quantities in cattle). If results of the new training methods improve the business performance of poultry farmers, the plan was to adapt the training methods used with our beef farmers. Although the profiles of beef and poultry farmers differ in some attributes, they are sufficiently similar that the same intervention design can be used for both industries.

The interventions are aimed at improving farmer self-efficacy using a combination of strategies including mastery, modelling, mentoring and facilitation. The design of these interventions conforms with the essential criteria of effective interventions including affordability, practicality, effectiveness, acceptability to farmers without negative side effects or compromising safety requirements and equity for all sectors.

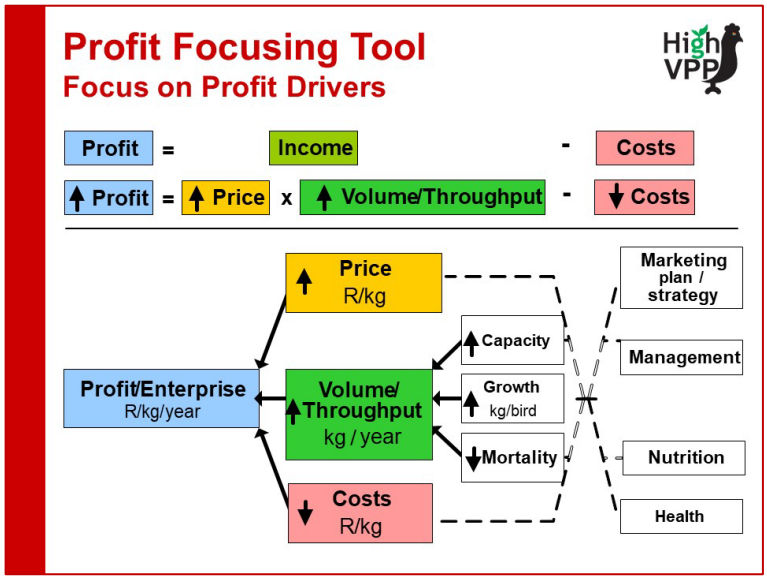
Although the initial intervention study commenced in September 2019, the study had to be abandoned in its original format because Covid-19 impacted on smallholder poultry farmers by completely disrupting their markets. This meant that baseline indicators of their performance would no longer apply to measurements taken during the pandemic. Hence, the intervention study was completely re-designed. Based on the Covid-19 situation in South Africa, it was able to re-commence in early 2022, with the aim of recording progress over 3 x 2-monthly intervention intervals, rather than the initial design of 4 x 3-monthly intervention intervals. We believe this reduced timing will nevertheless be effective amongst poultry farmers because of the frequency of their product sales (eggs on a daily basis and broilers on a 6-weekly basis).

The study uses a simple profit focusing tool (Figure 8) to identify the income and costs associated with smallholder farmer businesses, where Profit = Income – Costs, with Income influenced by the price received for the quality of the product sold and the quantity of the product sold. The aim of this tool is to identify ways of either increasing the price received or the volume sold or reducing the costs associated with the farming business. The following tables will be used to calculate gross margins for poultry farmers participating in the treatment groups.

Farmers in the ‘treated’ group meet every two months and use a specifically designed training process to determine the impact of this modified training design on their farms’ business performance. Farmers in the ‘control’ group also meet every two months, where they are offered specific training using traditional AgriSeta learning modules.

At the end of the project’s contracted period, data collection for the intervention study will be complete, with data analyses and publication of results to occur beyond the life of the current project.

Figure 8. Profit Focusing Tool used in the poultry intervention study



Revising the psychological profiling survey instrument

In the earlier project research described above, we showed that smallholder beef and poultry farmers in South Africa can be categorized into 3 profiles based on their personal characteristics. The profiles distinguish between 'fatalists' (farmers who believe they have little ability to control their farm business performance), 'traditionalists' (those who are accepting of their current business performance) and 'entrepreneurs' (those farmers aiming to improve the performance of their farming business). Knowledge of those farmer profiles helped us to develop customised training methods to best assist farmers in the different profiles to improve their business performance, with those methods now being evaluated for their effectiveness amongst poultry farmers in South Africa, as described in the previous section.

However, to develop those initial profiles, farmers needed to complete a very long survey form, including some questions that we subsequently realised our South African smallholder farmers struggled to interpret. To make it easier for farmers to complete the survey and hence, to benefit from customised training methods, we have now considerably shortened the survey and also reworded the section of the survey that farmers had difficulty in interpreting. To test the revised survey, as well as to evaluate its relevance to other smallholder livestock farmers (i.e. across beef and dairy, sheep and goats, pig and poultry farmers), we sought collaboration from other southern and eastern African countries. At least 200 smallholder farmers from each participating country completed the shortened version of the survey instrument, with funding provided by the organisations undertaking the surveys. At the end of the project's contracted period, surveys had been completed by researchers in Botswana, Malawi, Zambia and Zimbabwe, with additional participants from other industries in South Africa. Several other countries had expressed interest in participating in this study, but were unable to secure local funding to complete the surveys.

Data have been de-identified and pooled for data analysis, with the pooled results across all countries to be reported collectively. At the end of this project's contracted period, data collection for the intervention study is complete, with data analyses and publication of results to occur beyond the life of the current project.

7.2.2 Gender component

In recent years, research for development programs have placed greater emphasis on the implementation of interventions and measurement of results relating to women's empowerment. Recent evidence suggests that investing in women in smallholder-based supply chains helps deliver: improved product quality and enhancement of a product brand's ethical credentials; increased productivity; reduced management and coordination costs; a more secure supply base; a stronger brand and improved access to premium markets; and improved delivery of broader corporate social responsibility goals. However, international experience has shown that there are several challenges in integrating women into market systems programs that needs consideration especially in understanding the uptake of production and market-based innovations. These challenges have led to significant new experiences, grounded research and guidance that enables programs to integrate women into agricultural sectors both as farmers and as leaders in business and civil society.

In the HVBP project, we use a framework of gender inclusion and women empowerment strategies to accelerate the uptake of innovations in smallholder-based supply chains. The overall goal of the project is to improve the profitability of emerging and smallholder cattle farmers by developing cost-effective and environmentally sustainable beef value chains that supply cattle to meet the specifications of high-value, free-range beef markets. In this project, the primary aim of gender inclusion is to identify those factors that impact on smallholder farm business performance and to then design customised intervention strategies aimed at overcoming the barriers to practice change.

All aspects of the project are gender inclusive, recognizing that women and men are two separate target groups with differing roles, controls, challenges and opportunities. Taking women's situations and needs into account is especially important as mainstream / dominant systems in beef cattle production typically favour men. This means that if women are not considered during research and analysis, then strengthening the current system may further disadvantage women rather than empowering them. These dimensions offer a framework for research, capacity building design, scale out and M&E. To do this we add gender and family dimensions of the micro-foundations of entrepreneurship, develop a framework that considers the key dimension of women's empowerment and their contributions.

As this project is implemented in different provinces, the context for women and their roles, controls, opportunities and constraints varies. The gender component of this project therefore considers the distinct institutional (social and economic) contexts throughout the project life cycle (e.g. conducting separate research, designing different capacity-building activities, adapting the scaling-out plan and setting appropriate targets) to maximise results. It involves the different components with gender equality and women's empowerment addressed differently in each of the research, capacity building, scale-out and monitoring and evaluation (M&E), briefly described as follows.

Research

The focus in the HVBP is to develop a thorough understanding of women's roles and their influence in decision-making. Along with other factors, the main objective is to examine the role of gender on farm business and beef value change performance using data from the Behaviour Change, VAIMS and WELI surveys. The aim is to use the results to develop and implement interventions designed to address and overcome the inequities that are found by the analyses to be affecting farm business and value chain performance.

In addition to examining a wide range of factors affecting on-farm productivity, efficiency and performance of participating farmers, the project has a strong research focus on the role of gender in different stages in the market chain. A livestock-specific women's empowerment in livestock index (WELI), designed by the International Livestock Research Institute (ILRI) adapted from the women's empowerment in agriculture index (WEAI) developed by the International Food Policy Research Institute (IFPRI) was customised for use in South Africa. The index measures the roles and extent of women's engagement in livestock production in areas relating to decisions about agricultural production and marketing, access to and decision-making power over production resources, control over the use of income, leadership and time use. The WELI is combined with farm-household level production data to evaluate the impact of gender on

productivity and efficiency, thus providing information required in the formulation of appropriate scaling out strategies.

Research objectives and questions

As women are active in livestock rearing and household financial management in South Africa, it is not only an issue of gender equality but also an economic imperative that HVBP be gender inclusive. Our strategy follows a life cycle of research, capacity-building design, and scaling out research, monitoring, and evaluation. The primary aim of gender inclusion is to identify those factors that impact on smallholder farm business performance and to then design customised intervention strategies aimed at overcoming the barriers to practice change that are identified.

Specifically, our research objectives are to:

a) conduct a review of literature and examine the role of policy and government institutions in supporting women farmers;
b) analyse gender issues within the beef value chain; and
c) obtain indicators of women's empowerment in the beef value chain and examine their relationships with farm-business performance.

From the project's perspective, these research objectives are aimed towards addressing the following research questions:

a) Do women have access to resources (credit, finance, insurance land, recognition as head of the business) and the support needed to build their farm businesses?
b) Are legal or cultural constraints affecting land inheritance, ownership and use impacting on women's access to resources or decision-making bodies?
c) What is the role of women in production and marketing decision-making processes?
d) Do women have the same access as men to education, training, knowledge, skills, technological innovations, entrepreneurship and decision-making?
e) Do women have the same access to markets as men?
f) Do women have access to income-generating opportunities associated with the farm business and which provide an equitable return on labour relative to men?
g) In decision-making forums (e.g. village/communal meetings) to what extent are women represented in leadership roles that are normally held by men?
h) Can women's agribusiness performance be explained by their levels of empowerment

Research approach

Our study follows a mixed methods approach, combining the power of both qualitative and quantitative information. Collection of information and data are conducted using the following approaches:

- *Secondary data collection*. This involves content-based analysis of information pertaining to the role of gender in agriculture, more specifically in African and South African contexts. Qualitative methods are used to conduct the analysis.
- *Qualitative data collection.* Qualitative survey approaches employed are in-depth, unstructured and semi-structured interviews focusing on identifying socio-cultural and religious norms and values that define gender relations within beef value chain. These approaches allow us to have deeper understanding of the social architecture and identify the formal and informal institutional rules that contribute to gender gaps within value chains.

- *Quantitative data collection.* Household-level surveys are conducted to selected provinces and respondents. The WELI and business performance indicators are collected at the household level for the development of women empowerment and performance indicators.

Mainstreaming and capacity building

Gender mainstreaming is an international strategy towards realising gender equality. It involves the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures and spending programmes, with the aim of promoting equality between women and men, and combating discrimination. Five principles underpin gender mainstreaming, including:

- Gender-sensitive language, ensuring women and men are equally visible in all program documentation;
- Gender-specific data collection and analysis, whereby program data will be collected, analysed and presented by gender and other demographic variables such as age, ethnicity and level of education;
- Equal access to and utilization of services provided by HVBP;
- Equal involvement of women and men in HVBP program decision making; and
- Equal involvement of women, governance, and management (through the program leadership team, ISAC and research team).

In all of these activities, it is the aim of the HVBP project to ensuring women's active participation in all relevant program and project activities and encourage women to participate in trainings, workshops. Specific activities highlighting these principles are summarised in the following table.

Table 1. Summary of mainstreaming activities in HVBP

Phase	**Instruments/ Tools**	**Activities**
Project development and design	Document	• Inclusion of gender aspect and gender-specific research objectives and milestones
Project leadership, management and governance	Project Organisational Team	• Representation in leadership team; • Representation in Industry and Scientific Advisory Council; • Representation and participation in research team.
Project implementation	Team composition	• Formation of gender research group composed of researchers from Australia and South Africa; • Consultation with gender-expert from the International Livestock Research Institute (ILRI); • Engage South African centre(s) of gender studies and relevant government departments to collectively design new strategies to overcome gender-specific (and other) inequities found to be affecting farmer business and value chain performance.
Research implementation	Survey tools and instruments	• Gender-specific data collection and analysis, whereby program data are collected, analysed and presented by gender and other demographic variables such as age, ethnicity and level of education. These are implemented in the various research activities, including the implementation of: o Behavioural Change Survey (BCS);

Phase	Instruments/ Tools	Activities
		○ Value Added Information Management System (VAIMS); ○ Women Empowerment in Livestock Index (WELI) survey.
Capacity building	Training and workshops	• Participation of research and project team members in capacity-building training and workshops. • Participation of men and women in project-related trainings, workshops and meetings.
Monitoring and evaluation	M & E Framework	• Include gender-specific objectives, indicators and targets; • Measurement and analysis of women empowerment indicators; • Analysis of gender-disaggregated data.
Scaling out designs and interventions	Document	• Design new strategies to overcome gender-specific (and other) inequities found to be impacting on farmer business and value chain performance; • Submit draft policy documents to relevant agencies for their consideration in overcoming gender-specific (and other) inequities found to be affecting farmer business and value chain performance.

What was achieved?

There is strong evidence from cross-country studies of a positive correlation between measures of women's empowerment and other dimensions of human development (McGillivray, 2005; Fielding and Lepine, 2017). In this sense, women's empowerment is considered a pre-requisite to achieving global food security (Akter et.al., 2017). Women comprise about 45 per cent of the agricultural labour force and are considered integral but often neglected agents of change (Doss 2014). They play a critical role in decision-making within households, including decision-making about crop production, animal care, the use of livestock-farming by-products and household food security. Although the role of women in agriculture has received much attention in the literature, there remains a challenge regarding the state of inequity, not only in South Africa, but also in the rest of the developing world. According to Galie et al. (2019), the empowerment of women in the livestock sector is fundamental to achieve gender equality. Hence, in order to contribute in understanding gender roles and equality, this project aims to analyse gender issues and inclusion within the beef value chains and obtain indicators of women's empowerment that are expected to provide better information to develop strategies to accelerate the uptake of innovations in smallholder-based supply chains.

A number of capacity building activities for both men and women farmers in the project provinces. Those activities align with the mainstreaming activities of HVBP and include:

1) Active involvement and representation of women in the HVBP project leadership, research and operational team;
2) Recruitment of women represented in the project's Industry and Scientific Advisory Council (ISAC), with 25% of members being females;
3) Conducted literature reviews on the role of women in livestock farming systems and key success factors and constraints in integrating gender in agricultural value chain. These reviews of literature are integrated as part of a PhD thesis by Ms Nonhlanhla

Gwamanda and in a journal paper co-authored by Prof Villano is under review in an international journal;

4) Designed and customised the WELI survey tool and statistical sampling requirements. Dr Alexandra Galie of ILRI provided the team with the base instrument used in the survey. We have also coordinated with gender specialists in IFPRI who provided relevant resources. Accordingly, we customised and pre-tested the survey instrument in the context of South Africa. In addition, the instruments used for key information interviews (KII) and focus group discussions (FGDs) are developed and designed;
5) Identified and trained project enumerators to administer the survey amongst selected farmers and value chain participants. NAMC and ARC facilitated the training of enumerators;
6) Administered the WELI survey tool amongst selected farmers in KwaZulu-Natal (KZN) province and value chain participants. Initial deployment of the WELI instrument was being organised in Eastern Cape and other project provinces but was postponed due to logistical challenges and difficulties. As an alternative, the survey was deployed in KZN, providing us an opportunity to capture ethnic and cultural diversity, which could serve as a good benchmark for comparing the indicators amongst the project-based provinces. However the deployment of the WELI instrument is currently postponed until logistical, administrative and working situations are back to normal;
7) Completed three focus-group discussions (FGD) and key informant interviews (KII) to examine and analyse gender issues within the beef value chain. The FGDs were conducted with both male and female groups. They were delivered in local dialects, guided by a semi-structured questionnaire and list of questions.
8) Developed communication materials and actively engaged in communicating project activities. In collaboration with NAMC, UNE prepared an infographics outlining a brief overview and importance of gender aspects in the projects. These infographics were disseminated to farmers attending meetings and respondents of the FGD, KII and WELI surveys. Project team members also presented updates of the activities in the regular ISAC meetings (2018, 2019) and during the inaugural Seeds of Change Conference held in Canberra, Australia.
9) Conducted gender- training workshops to key research partners and collaborators. As part of the capacity building activities, UNE delivered a one-day socioeconomic and gender training and workshop held in NAMC in November 2018. During this workshop, participants were introduced to the concept of gender analysis and the methods of measuring women empowerment index. Twelve participants (including 5 females) from NAMC, ARC and DAFF attended the workshop.
10) Continued engagement of women farmers and stakeholders in operational, capacity building and research activities. In order for the project to be more gender inclusive, all operational and capacity building activities involve women farmers. The ultimate objective is to increase women's participation in all key areas. The key activities include participation in FGD, BCS, WELI and VAIMS surveys; on-farm activities including breed verification, cattle selection, veld condition assessment; briefings, meetings and presentations; and trainings and workshops. For the FGD, the session was conducted separately to men and women groups, of which each group were composed of 8-10 members. In the BCS survey, 31 per cent of the total respondents were female (152) but only 17 per cent (52 women farmers) participated in the

VAIMS survey. The WELI survey was implemented in 220 households of which the respondents were both male and female leads within the households.

A summary of women's participation in HVBP project activities appears in the tables below. Overall, approximately 29 per cent of the project reach in terms of operational activities are women. Interestingly, women's participation are highest in on-farm activities, while males dominate attendance in trainings.

Table 2. Gender-disaggregated summary of participants in various operational and capacity-building activities in HVBP provinces

Details of Events and Activities by Province	Number of Participants			% of Participants	
	Male	Female	Total	Male	Female
Cavalier	**683**	**276**	**959**	**71.2**	**28.8**
Eastern Cape	4	8	12	33.3	66.7
On-farm activities, breed verification and cattle selection	4	8	12	33.3	66.7
Free state	11	4	15	73.3	26.7
On-farm activities, breed verification and cattle selection	1	0	1	100.0	0.0
On-farm cattle weight measurements	1	0	1	100.0	0.0
Trainings	9	4	13	69.2	30.8
Gauteng	237	103	340	69.7	30.3
Briefing and presentations	13	6	19	68.4	31.6
Farmer Workshops	180	76	256	70.3	29.7
Meetings	21	12	33	63.6	36.4
On-farm activities, breed verification and cattle selection	3	2	5	60.0	40.0
Trainings	20	7	27	74.1	25.9
Limpopo	75	47	122	61.5	38.5
Meetings	13	14	27	48.1	51.9
On-farm activities, breed verification and cattle selection	1	3	4	25.0	75.0
On-farm cattle weight measurements	1	0	1	100.0	0.0
Trainings	60	30	90	66.7	33.3
Mpumalanga	162	76	238	68.1	31.9
Briefing and presentations	13	3	16	81.3	18.8
On-farm activities, breed verification and cattle selection	11	3	14	78.6	21.4
On-farm cattle weight measurements	28	18	46	60.9	39.1
Trainings	110	52	162	67.9	32.1
North west	194	38	232	83.6	16.4
Briefing and presentations	27	1	28	96.4	3.6
On-farm activities, breed verification and cattle selection	5	7	12	41.7	58.3
On-farm cattle weight measurements	1	0	1	100.0	0.0
Trainings	161	30	191	84.3	15.7

Details of Events and Activities by Province	Number of Participants			% of Participants	
	Male	Female	Total	Male	Female
Cradock	460	180	640	71.9	28.1
Eastern cape	460	180	640	71.9	28.1
Briefing and presentations	179	66	245	73.1	26.9
Farmer Workshops	166	33	199	83.4	16.6
Meetings	2	4	6	33.3	66.7
On-farm activities, breed verification and cattle selection	15	16	31	48.4	51.6
On-farm cattle weight measurements	12	19	31	38.7	61.3
On-farm veld condition assessment (VCA)	20	23	43	46.5	53.5
Training	66	19	85	77.6	22.4
Grand Total	**1143**	**456**	**1599**	71.5	28.5

Table 3. Summary of operational and capacity-building activities and gender-disaggregated number of participants.

Details of Events	Number of Participants			Participants (%)	
	Male	Female	Total	Male	Female
Cavalier	683	276	959	71.2	28.8
Briefing and presentations	53	10	63	84.1	15.9
Farmer Workshops	180	76	256	70.3	29.7
Meetings	34	26	60	56.7	43.3
On-farm activities, breed verification & cattle selection	25	23	48	52.1	47.9
On-farm cattle weight measurements	31	18	49	63.3	36.7
Trainings	360	123	483	74.5	25.5
Cradock	460	180	640	71.9	28.1
Briefing and presentations	179	66	245	73.1	26.9
Farmer Workshops	166	33	199	83.4	16.6
Meetings	2	4	6	33.3	66.7
On-farm activities, breed verification & cattle selection	15	16	31	48.4	51.6
On-farm cattle weight measurements	12	19	31	38.7	61.3
On-farm veld condition assessment (VCA)	20	23	43	46.5	53.5
Trainings	66	19	85	77.6	22.4
Grand Total	**1143**	**456**	**1599**	**71.5**	**28.5**

Key insights and lessons learned

As most of the WELI data are still being processed and to be collected, our key insights and lessons learned are based on the qualitative data collection and desktop research. Based on FGD sessions, insights include:

- The need to consider local definitions of “empowerment”;
- The decision-making process varies between activities. Very few male participants make decisions with their wives. Males are the dominant decision-makers with respect to income allocation;
- Decisions on household and health-related matters are dominated by females, where men are reluctant to go to the clinics;
- Livestock production, ownership and management is male-dominated.

Most of the above findings are influenced by social, cultural and ethnic considerations. Additional information from the quantitative survey will reinforce the importance of these findings.

Based on the desk stop studies and findings from the review of literature, the following key learnings are imperative:

- As livestock are considered a key asset for rural households and a primary source of livelihood for rural communities, it is imperative to evaluate the underlying role of women in the sector and consider livestock-related opportunities relating to women (Njuki and Sanginga, 2013).
- In South Africa, Reddy et al. (2015) recommended a number of strategies highlighting the role of gender in small-scale livestock farming opportunities:
    a) Given that some 70% of agricultural land is used for livestock faming, and that livestock accounts for 49% of all agricultural output, government policy around this agricultural sub-sector needs to be more robust, more integrated, comprehensive and increasingly long-term;
    b) The empowerment of women as smallholder livestock keepers/farmers needs to be continued through increased access to education, information, training in animal healthcare, and ownership of assets and land;
    c) Women also need to be empowered to take on leadership positions within rural livestock-farming communities, to play a role in intra-household and communal decision-making, and to exercise greater control over their time use;
    d) More robust statistics around smallholder livestock keeping are required to further understand how these farmers make choices and decisions. Sex-disaggregated data are crucial in the generation of these statistics. Further research to better understand local contexts and the social and gendered dimensions of small-scale livestock communities is needed; and
    e) The significance of women in smallholder livestock farming needs to be concretely established as a targeted policy imperative and as a part of a broader food-security strategy for the country.
- Access to, and ownership of, land is fundamental to empowering women and promoting gender equality. In South Africa, there have been some developments on this front, through land reform programs. The Land Reform Programme was initialised late 1994 and was formally launched on 28 February 1995. According to Davis et al. (2016) the government prioritized the Land Reform Policy with its three key focus areas which include restitution, land tenure reform and land.
- There is consensus that South Africa’s three-tiered land reform program has so far not achieved its originally intended objectives and targets due mainly to lack of policy coordination and ineffective post-settlement support for beneficiaries. Despite the program having been in existence since 1995, 72% of agricultural land is in the

ownership of white people (Department of Rural Development and Land Reform, 2017).

- While women also make up more than half of the population in the Eastern Cape and KwaZulu-Natal provinces, they own less than 10% of provincial land (Department of Rural Development and Land Reform, 2017).
- The provinces that have a relatively larger rural population tend to have the lowest share of women owning land or having access to land. This suggests that in the rural context where most land is under traditional leadership, there is a relatively large limitation to land access and ownership by women (Ntombela, Ngqangweni, Mkhabela and Nyhodo, 2019).

The initial aim for this gender component was to undertake WELI surveys in each of the project's six collaborating provinces (as well as in Kwa-Zulu Natal, where the surveys were completed ahead of the project's mid-term review) and enumerator training had been provided to allow that to occur. Following the mid-term review though, it was agreed that a combination of WELI surveys and Focus Group Discussions (FGD) should occur at the level of the Cradock and Cavalier value chains. However the onset of the Covid-19 pandemic delayed the resumption of WELI and FGD data collection and by the time it was safe for project enumerators to travel again, the project was severely hampered by its lack of access to project funding in South Africa. Hence at the end of the project, the planned WELI and gender FGDs remain incomplete.

7.2.3 VAIMS value chain component

This component of the HVBP project aims to further develop and apply the Value Addition Information Management System (VAIMS), which is a tool for the quantitative measurement of livestock value chain performance and identification and analysis of improvement scenarios. VAIMS was specifically designed to analyse the role of livestock in smallholder farm and food systems. Structured questionnaires were developed specifically for the HVBP project to allow project enumerators to interview project value chain respondents individually. The questionnaire focuses on production practices and aims to identify the sustainability of production as well as the performance within the value chain.

Initially the project planned to survey representative project and non-project smallholder farmers from within the Cradock and Cavalier Value Chains. However those plans were expanded at the request of the Provincial Departments of Agriculture representatives of the projects ISAC, who were keen to establish benchmark performance indicators for each of their provinces. Hence, enumerators from all provinces were trained to undertake the surveys in their provinces, though by March 2020 when the Covid-19 pandemic began, only Eastern Cape, Mpumalanga and Limpopo had collected sufficient data for a provincial-level analyses. Reports at provincial level are available and have been distributed to the provincial departments of agriculture.

Following the mid-term review in May 2020, it was agreed that instead of attempting to collect additional data from the remaining provinces during Covid-related travel restrictions, all available data would be analysed at the level of the Cradock and Cavalier Value Chains. At the outset of the project, the intent was to repeat the surveys in the final year of the project to allow an assessment of changes that were made over the duration of the project. However due to a combination of the Covid-19 pandemic and difficulties in

accessing project funds by the South African project partners, the repeat surveys were unable to be completed. The results presented as Appendix 1 and Appendix 2 therefore represent the complete analyses of baseline survey data at each of the Cradock (Eastern Cape) and Cavalier value chain levels. Appendix 3 and Appendix 4 contains the VAIMS results from Mpumalanga and Limpopo provinces respectively.

During the life of the project, consideration had also been given to pooling the data captured from the VAIMS surveys with actual data collected from the project's collaborating farmers and ongoing data collected through the beef behaviour change components. However the significant loss of contact with the project's farmers during Covid-19 travel restrictions meant insufficient on-farm data were available to allow these additional analyses to proceed.

7.3 Objective 3

7.3.1 Multi-criteria decision making

The aim of this component of the project was to evaluate the project's decision-making processes to identify changes to the project that, with the use of hindsight, could have improved the efficiency and effectiveness of the value chains in a timelier manner. Additionally the plan was to use the results of the study to develop recommendations for other commercial and government organisations wanting to establish agricultural value chains supplied by smallholder farmers.

A detailed and qualitative narrative about all decisions and decision-making processes was maintained from the beginning of Stage 1 of the project (2015) to the end of Stage 2 of the project (2022). The intent had been to use two different approaches to analyse this qualitative narrative, namely: 1) a factor analysis to identify different profiles of all sectors of the project's value chains; and 2) a multi-criteria assessment framework to conceptualise aggregated indicators for value chain end-users based on a tree-of-relationships between factors. The two methods are regarded as complementary when determining the causal processes of the assessment.

Unfortunately at the start of the Covid-19 pandemic in March 2020, significant contact was lost with the project's collaborating farmers due to travel restrictions and subsequently the farmers discontinued targeting the free range markets probably due to a combination of factors including lack of project support and the availability of alternative markets following the outbreak of FMD in South Africa that meant cattle were not permitted to travel to distant markets to prevent the spread of disease.

Hence at the end of the project, there was insufficient value chain data available to justify undertaking the planned multi-criteria assessment. However, a constructive but critical evaluation of the qualitative narrative each year did allow the project to identify at an early stage that the Stage 2 farmer engagement model (see figure in Section 7.2.1) was not delivering the farmer engagement as predicted during development of the Stage 2 proposal. It is therefore recommended that development of a qualitative narrative could be a useful tool for other situations where the outcomes of decisions are likely to be unpredictable at the outset.

7.3.2 Communication

The NAMC was tasked with the marketing and communication of the High VBP project. In Stage 1 of the project, the role was simply to produce the High VBP newsletter. However since the start of Stage 2 in 2018, the responsibilities of the communications team

One of the first priorities of the communications team was to conduct a brand exercise with the project team leaders. The outcome of this exercise created the brand name, High Value Beef Partnership (High VBP) and the High Value Poultry Partnerships (High VPP) and logos for each theme, as shown below.

Development of these brand names allowed for further development of a communications strategy, website and social media platforms.

Activities undertaken within the communications strategy included:

- Tailoring messages with the aim of recruiting farmers to target higher value markets;
- Development of a project website, where resources relevant to smallholder beef and poultry farmers were freely accessible;
- Capturing videos for farmer recruitment and demonstration purposes;
- Capturing videos specifically for use in the project's Behaviour Change intervention study (these videos are used in the first instance by the project's 'treated' farmers – see section 'Design of customised training methods based on farmers' psychological profiles in Section 7.2.1 above);
- Writing popular press articles for distribution to the media and uploading onto the project website;
- Engaging in social media;
- Developing podcasts for local media and the project website;
- Promote the benefits of free range farming with the aim of changing farmers' mindsets or perceptions about engaging with free range markets;
- Increasing the public profile the High VBP project and communicating project outcomes to the broader publication; and
- Engaging with policy-makers, coordinators of target organisations, researchers, economists, farmer and business leaders, community leaders and the general public, with each stakeholder receiving different messages aligned to their own needs and values.

Unfortunately, the project's communications activities were forced to end abruptly in mid-2021 when the NAMC Board made a very justifiable decision that all project-related activities had to cease until the organisation received the project's allocated funds being held (but not released) by DALRRD under a new arrangement implemented by South Africa's National Treasury in 2015. The National Treasury had worked with some delays in funding flow to ARC and NAMC in Stage 1 of the project, but it failed completely in Stage 2 of the project, with all project payments (1 through 8) still waiting to be returned to UNE by National Treasury. Once UNE has received the funds, it will reimburse ARC and NAMC for funds already expended on the project by them, but that reimbursement is simply too

late for many of the project's activities over the past 12-18 months to be completed within the project's contracted timeframe.

7.3.3 Policy Development

At the start of the project, it was envisaged the project may be able to contribute to development of more effective policies in three specific areas:

1. Lease conditions of government-owned land for agricultural purposes: at the beginning of Stage 2 of the project, team members were aware of smallholder farmers who had very short-term leases on government-owned land that discouraged them in investing in critical fixed infrastructure (e.g. water, fencing, cattle handling facilities etc.). However project investigations in conjunction with FANRPAN were able to identify that the relevant government policy was a good policy, allowing reduced lease rates for the first few years of the farmers' leases, followed by a 25-35 year lease period at normal commercial leasing rates, before the farm ownership then reverted to the lessee. The problem we had encountered was a policy implementation problem that was in the process of being corrected at the time of the project's investigations;
2. Policies designed to better empower women smallholder farmers engaging in commercial beef value chains: based on the data available to the project, we believe these policies are likely to still be needed. However due to the Covid-19 pandemic and the lack of access to project operating funds in the final 12-18 months of the project's contracted period, the project lacks the data that would be needed to support the development of these policies; and
3. A policy aimed at changing South Africa's Carcass Classification scheme to appropriately reward (through improved pricing mechanisms) high meat quality from grass- and grain-fed cattle slaughtered up to 36-42 months of age, providing they are managed according to practices designed to produce beef that meets the palatability requirements of untrained consumers.

Professor Sikhalazo Dube from the International Livestock Research Institute was contracted by UNE to develop a policy brief and an 'elevator pitch' that advocates the need for a new, voluntary meat grading scheme outside the scope of South Africa's current carcass classification scheme. The existing beef carcass classification system strongly discounts beef from older animals up to 3 years of age, based on physical characteristics of the carcass rather than factors affecting meat-eating quality as assessed by consumer taste panels. Smallholder farmers are significantly disadvantaged by the carcass classification scheme, as they prefer to grow and finish their cattle on pastures, which then means their cattle are older at the time of sale than cattle sold through South Africa's traditional feedlot-finished markets.

The only premium market currently catering for these older animals is Woolworths' Free Range brand, but there are additional opportunities outside those specifications to produce high quality beef. However, carcasses based on those additional opportunities will continue to be significantly discounted unless a new meat grading scheme based on eating quality attributes can be introduced in South Africa.

Parallel to the project's policy initiative, the South African Meat Industry Company (SAMIC, responsible for carcass classification as well as auditing of all brand name schemes for meat in South Africa) established a South African Red Meat Grading

Committee. SAMIC appointed Professor Phillip Strydom (the project's meat science leader) as the lead scientist on the committee, which had the task of drafting a project protocol to develop a beef-grading scheme based on the principles of the Meat Standards Australia (MSA) grading system. The process commenced with a week-long workshop at MSA offices in Brisbane during February 2020 where Meat and Livestock Australia officials and academics involved in the development of MSA engaged with members of the South African meat industry (specifically from Woolworths and Cavalier Meats, the HVBP project's commercial partners), Professor Strydom and Professor Heather Burrow joined from UNE. This was followed by further discussions and the drafting of a protocol for the project that was circulated to the Grading Committee for discussion and approval at the end of April 2020.

Independently of the proposal being developed for implementation by SAMIC, Woolworths and Cavalier Meats had planned to undertake and complete preliminary MSA-type consumer testing by May 2020, but that testing had to be deferred due to restrictions on travel resulting from Covid-19 lockdowns. However the testing has been undertaken independently by Woolworths and Cavalier in conjunction with MSA since then.

The draft policy has subsequently been incorporated for implementation by DALRRD as Pillar 5 (Implement upgraded meat grading scheme with international accreditation/ compliance for export market APFSNRDM) into South Africa's Agriculture and Agro-Processing Master Plan (AAMP), which is a compact aimed at providing practical actions and reforms designed to address growth, transformation and developmental challenges in agriculture, food and beverage sectors.

7.4 Lessons learned across the project more generally

There are a number of lessons that have been learned across the project generally, rather than within specific project components. These include:

- For research or development projects specifically targeting impacts at end-user levels, there is great value in including strong social science expertise within the project team. The HVBP project had initially engaged social scientists with expertise in agricultural and behavioral economics, gender, psychology, linguistics, monitoring and evaluation, policy development and impact assessment. It subsequently increased its social science skill-set to also include additional expertise in qualitative research focused on reasons for farmers to adopt or dis-adopt proven technologies and training in facilitation and visioning skills. Our experience in the HVBP and HVPP projects, as well as the ACIAR-funded *IndoBeef* project where UNE researchers have a role in both South Africa and Indonesia, is that technical expertise in disciplines such as animal and crop production, animal health, nutrition and genetics, rangeland management etc. is often available in-country without the need for significant additional inputs from Australian partners. However the social sciences are less well represented in countries targeted by organisations such as ACIAR, and hence, we would recommend strong involvement of social scientists in projects that adopt a multi-disciplinary approach to achieving outcomes and impacts.
- As summarised in Section 7.3.1 above, development of a qualitative narrative documenting the project's decision-making process and regular (e.g. annual) constructive but critical evaluation of that narrative enabled the project to identify problems and potential solutions at a much earlier stage than would otherwise have

been the case. Hence we suggest that development of a qualitative narrative could be a useful tool for other projects or situations where the outcomes of initial decisions are likely to unpredictable at the outset.

- This project experienced a very high-impact disruption over the last 12-18 months of its contracted period as a result of a South African policy decision that all international funds intended for development projects were required to initially be transferred by the Commissioned Agent (in our case, UNE) to a Reconstruction and Development Programme (RDP) fund hosted by South Africa's National Treasury. Thereafter the funds were expected to be administered centrally by a National Government Agency (the 'Spending Agent'). In our project's case, the Spending Agent was initially the Department of Agriculture and Fisheries, which then merged in mid-2019 to become the Department of Agriculture, Land Reform and Rural Development. The Spending Agent was expected to oversight distribution and subsequent use of the funds by the project's remaining partners.

  It is not clear what problems led to the failure of DAFF/DALRRD to distribute project funds that it received in a timely way from National Treasury. The project leadership team only became aware of the problem around mid-2021, because prior to that, both ARC and NAMC had been operating using their own funds, a practice which had been common even in Stage 1 of the project due to delays in DAFF transferring the funds. However in mid-2021, the NAMC Board very justifiably banned NAMC staff from contributing to project activities on an ongoing basis until NAMC received the project funds it was already owed. Ongoing project (and subsequently organisational) efforts since mid-2019 failed to resolve the situation, again without any explanation from DALRRD about the administration problems that clearly existed within the organisation.

  At the time of writing this Final Report (end August 2022), National Treasury has received all project funds previously held by DALRRD and is undergoing its own internal processes to return the full Payments 1 to 8 to UNE (as the Commissioned Agent). Once the funds have been returned to Australia, UNE will then reimburse ARC and NAMC for the funds that are owed to them and return all remaining funds to ACIAR. But that timing was far too late to allow completion of some critical project activities.

  Hence in future, it is recommended that to the extent possible, agencies funding R&D internationally should require that all in-country project partners retain full autonomy of project funding allocated to those partners.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The component of the project already yielding a significant scientific impact is in the behaviour change area, where a new psychological profiling tool was developed to generate behavioural profiles of the project's beef (and linked poultry) farmers and determine the relationships between those profiles and their attitudes farm business performance. Those results provide the first known evidence from any industry or any country (developed or developing) where psychological profiles have been directly related to business performance. This same component of research has delivered additional scientific impacts through: i) a clear demonstration of significant associations between farmers' ethnicity and their farm business performance, leading to recommendations about how practice change might be increased through greater sharing of ideas amongst farmers of different cultural groups; and ii) a novel application of the existing stochastic frontiers methodology to estimate productivity and technical efficiency of livestock production amongst households in a communal production environment where native rangelands are the primary source of fodder, showing there is significant potential to improve livestock production using existing inputs and by directly addressing the wide variation in the performance amongst households.

There are likely to be significant economic impacts from the subsequent stage of this research, which used the behavioural profiles to design interventions customised to profile type, with the aim of significantly increasing adoption of proven technologies to improve farm business performance. Experimentally testing the interventions amongst poultry farmers (where it is far easier to measure impacts on profitability when product sales occur on a daily or weekly basis *cf.* beef farmers who sell animals on an infrequent basis), has been undertaken in a re-designed experiment since early 2022, with data analyses and report writing to be completed beyond the project's contracted timeframe. If the results are as successful as appears likely based on early evaluations of the study, this new method of customising training methods to farmers' preferred learning styles has potential to impact on behaviour change and adoption and scale out in both developed and developing countries.

Additionally, results from the VAIMS survey administered by the project are likely to deliver novel scientific impacts of direct relevance to South Africa and other developing countries, particularly those in Africa more generally.

Data from an earlier, related ACIAR project in South Africa (LPS/1999/036) was also used to undertake ground-breaking new genomic prediction analyses that demonstrated an ability to identify cattle that are genetically resistant to ticks across herds of unrelated cattle breeds across multiple countries. These results offer entirely new options for livestock farmers in both developed and developing countries to capture the benefits of genetic improvement using far fewer animals and in a much more cost-effective way than through traditional genetic improvement programs. The results from this study were also used to make recommendations on new, cost-effective and transformational technologies that could be used by smallholder farmers to achieve significant improvements in business productivity by 2050.

8.2 Capacity impacts – now and in 5 years

Over Stage 1 and the early part of Stage 2 of this project, extensive training was provided to ~180 KyD technicians, interns and extension officers from six Provincial Departments of Agriculture with the aim of equipping them with the skills needed to support the project's collaborating farmers. However, by June 2019 it had become apparent that those farmer support team members lacked the critical planning and thinking skills and practical farming expertise to provide timely, cost-effective and useful advice and feedback to the farmers. Hence, the project developed a regional, team-based approach that is now led by the Provincial Departments of Agriculture in the six provinces targeted by the project. As team members were identified, they were trained in the use of Continuous Improvement and Innovation methods and tools as well as team facilitation skills, but the opportunity for them to subsequently practice their newly-acquired facilitation skills with farmer groups was severely impacted because of Covid-19 travel restrictions, that also severely limited face-to-face farmer capacity building. An attempt was made to overcome that deficiency by increasing the project's communication directly with the farmers (e.g. via email and WhatsApp messaging) but the project team also recognises that is not the farmers' preferred learning style, so the approach has been less successful than direct interaction.

The project has also contributed to the post-graduate training of 7 x PhD students (Bukho Gusha, Motswapo Phoko, Gilbert Pule, Ngoako Letsoala, Marble Nkadimeng, Masindi Mphaphathi and Nonhlanhla Gwamanda) and 1 x MSc student (Lindikaya Myeki, who graduated from UNE in 2020).

The specifically designed Farmer Training Manual developed by the project was formally accredited by AgriSETA and its broader use by AgriSETA trainers is providing ongoing benefits to non-project stakeholders.

Following the recommendations of the project's mid-term review, two groups of 10 project team members were trained in qualitative research methodology by Erika Valerio and Julian Prior over consecutive four-week periods. As described in Section 7.1.6, those teams subsequently designed social science research studies to investigate factors influencing project farmers' uptake of improved animal production techniques that were presented to them during the HVBP farmer training workshops as well as the factors influencing farmers' uptake of recommendations made to them by the rangeland management research team. A third group of team members worked directly with farmers in Mpumalanga, Eastern Cape, Limpopo and North West Provinces to design farmer demonstration sites in those provinces to maximise value to the farmers. Unfortunately the very well-designed studies were not able to be completed due to the lack of access to project operating funds by the project's partner organisations (see Section 7.4).

8.3 Community impacts – now and in 5 years

Community impacts will only start to build if larger numbers of collaborating farmers sell their cattle through high value beef markets over coming years. Unfortunately the project's impetus and engagement with its collaborating farmers was significantly reduced as a result of the ongoing impacts of Covid-19.

8.3.1 Economic impacts

Because so few cattle from the project's collaborating smallholder farmer herds reached targeted slaughter weights and were evaluated for their compliance with free-range beef markets, the economic impacts of the project cannot be genuinely assessed. However, the project undertook an ex-post economic impact assessment using the Impact Tool ahead of the mid-term review in May 2020 to ensure monitoring and evaluation of impact points was occurring. As expected, there were no major economic impacts indicated from the use of the Impact Tool at that time, but its use represented good preparation and training of project team members for ongoing use in future.

If the project's policy paper designed to change South Africa's Carcass Classification Scheme is fully implemented through South Africa's Agriculture and Agro-Processing Master Plan as appears highly likely at this stage, that change will in future result in significantly enhanced opportunities for smallholder beef farmers (as well as commercial farmers) to meet the specifications of a much broader range of high value markets that reward farmers on the basis of the quality of the product they deliver.

8.3.2 Social impacts

Over time, it is expected there will be a significant increase in the social infrastructure and a strengthening of the cohesion of production and marketing efforts by collaborating smallholder beef farming communities, but to date those impacts are not evident.

8.3.3 Environmental impacts

There is some early evidence that several of the project's collaborating farmers identified the need to improve the environmental sustainability of their grazing lands. This was driven by the need for their cattle to achieve minimum average daily weight gains of 0.5 kg per day to meet free-range beef market specifications. However due to the disruptions arising from the Covid-19 pandemic, it was not possible for the project to continue monitoring the farmers' rangeland management activities. If the changes arising from a change in South Africa's Carcass Classification occur (see Section 8.3.1) as seems likely, then cost-effective pasture and rangeland management will be a critical component of farmers achieving high-value market specifications. Additionally, increasing the productivity of farmer herds by improving the growth rate of cattle to allow earlier turn-off of sale animals at target weights or sale of animals at heavier weights within the market specifications and/or improving the annual weaning rate of the breeding herds would significantly reduce the greenhouse gas emissions (particularly through reduction of methane emissions) per kg of product produced by these farmers. Both of these approaches would deliver strong evidence of environmental spin-off benefits through reduced grazing pressure, significant improvements to the resource base and reduced greenhouse gas emissions.

8.4 Communication and dissemination activities

In addition to specific project communication activities described in Section 7.3.2, general project communication activities included:

- Development and launch of a project website (www.highvbp.co.za**);**
- Social media posts through UNE's International Development portal, the project's website and since the onset of the Covid-19 pandemic through a WhatsApp group specifically targeting collaborating farmers;

- The project's Industry and Scientific Advisory Council (ISAC) met physically in May and November of 2018 and 2019. They met again virtually in November 2020 to receive an update on changes in the project arising from the project's mid-term review in May 2020 but since then they have only received written reports due to the ongoing Covid-19 pandemic and difficulties associated with accessing project operating funds;
- During the early period of 2020, there was significant traffic to the project's website and tentative interest amongst potential new farmers and academics. From website visits of 200 individuals per month at that time though, the numbers declined during Covid-19 government lockdowns even though new content was uploaded to the site as it was delivered by project researchers;
- Unfortunately the Covid-19 pandemic slowed the momentum of the project's communication activities as travel restrictions reduced the project team's interactions amongst themselves as well as with the collaborating farmers. Hence the communication team did not receive new stories of interest to the broader farmer group. However, it did use a wide range of existing information to publish a series of Monthly Tips for farmers;
- Prior to the Covid-19 pandemic, the communications team had set-up media plans with journalists interested in covering free ranging farming. Two SABC radio stations (Lesedi FM and Mostweding FM) were interested to cover the developments of the project. Farmers Weekly and Mzansi Agriculture Talk were also prepared to provide High VBP with a slot in their online publications. Both online magazines did report on High VBP stories. However there was little new content that went the way of the radio stations, again due to the impacts of the Covid-19 pandemic;
- The communications team and project researchers profiled farmers practicing free range farming in a series of videos that were made available on the HVBP project's YOUTUBE account and they are continue to receive viewership. However the videos and resources previously made available on the project's website are no longer available for viewing because the project's lack of access to project operating funds meant that the website's domain name could not be renewed when it expired due to lack of funds.

9 Conclusions and recommendations

9.1 Conclusions

The overall goal of the project was to improve the profitability of smallholder farmers in South Africa, by developing cost-effective and environmentally sustainable beef value chains supplying cattle meeting the specifications of high-value, free-range beef markets. The project was clearly able to demonstrate that smallholder cattle farmers could cost-effectively meet the preferences of South African consumers by delivering high-value free-range beef products that met market specifications. However, due to major disruptions to the project over which the project team had no control (the Covid-19 pandemic, the lack of access by the in-country partners to project funding and to a lesser extent, the outbreak of food and mouth disease that restricted farmers' ability to transport cattle, thus requiring farmers sell on local markets), the project lacked sufficient data to conclusively conclude that smallholder farmers would improve their farm business productivity and profitability by addressing these new markets.

Key conclusions relative to each of the project's objectives are summarised below.

Objective 1: To improve on-farm animal health, nutrition, management and breeding systems to enable smallholder farmers to cost-effectively deliver a year-round supply of high-value, free-range beef whilst simultaneously improving their natural resource base

- Over Stage 2 of the project, more than 1,500 smallholder cattle farmers underwent initial training based on the Farmer Training Manual developed by the project and designed to outline best-practice herd management and use of improved farm management systems. This training was undertaken to allow the farmers to assess whether they were interested and capable of supplying free range beef to Woolworths' premium markets. A large number of those farmers lacked control over the grazing lands utilized by their cattle and hence, they were unable to target the high value markets. However, those farmers who agreed to supply free range beef underwent repeated trainings (2- or 3-day training courses offered twice per annum until the Covid-19 pandemic, with 6 different courses designed specifically to address topics suggested by the farmers) were able to demonstrate they understood the concepts relating to animal health, nutrition, management, breeding and rangeland management systems, though not all farmers chose to adopt the new practices on their own farms, with reasons for the lack of adoption unable to be determined due to lack of access to project funds by the in-country project team.
- Initially more than 180 provincial department extension officers, KyD field officers and other farmer support team members were trained in the application of the project's Farmer Training Manual. However, once the project leadership team recognised those farmer support officers lacked the practical experience and critical thinking skills required to adequately support the farmers, those same field officers were then trained in facilitation and adult-learning skills and the use of on-farm participative action research to enable them to more effectively work with the farmers using team-based approaches. The success of this subsequent training could not be assessed due to the ongoing lack of access to the farmers during the Covid-19 pandemic.

- The project used the Veld Condition Assessment Tool to initially assess and monitor the rangelands grazed by cattle owned by smallholder-owned farmers. Farmers were also trained to use the tool to help them evaluate and interpret rangeland reports provided to them by the researchers as well as to monitor rangeland conditions and estimate optimum stocking rates of their farms at times of seasonal change throughout the year.
- The rangeland management team undertook research and demonstrated the value of using different plant species regarded as encroaching weeds (cladodes of cactus prickle pear and *Seriphium plumosum* or Bankrupt bush meal) for use in supplementary feeds to improve the nutritional value of cattle diets.
- The project's reproduction team initially undertook on-farm measurements of cow breeding performance twice per annum with the aim of developing recommendations for farmers on how best to manage smallholder farmer breeding herds to maximise annual weaning rates and calf growth rates and to develop a decision-support tool to allow farmer decision-making based on economic as well as cattle management factors. However, the Covid-19 pandemic disrupted the on-farm data collection and a decision was made to discontinue development of the decision-support tool due to lack of data. Data collected to data were then analysed and results from the analyses were used to develop a series of recommendations for farmers that were publicized widely through farmer newsletters, the project's website and social media platforms and also through South Africa's print media.

Objective 2: To improve the profitability of all sectors of the project's beef value chains through increased adoption of proven interventions by farmers and implementation of practices that create efficiencies and effectiveness across the entire value chains

Behaviour change component

- The project's behaviour change team used farmers' behavioural and farm business performance data from surveys completed by 480 beef farmers and 435 poultry farmers from a linked, DAFF-funded poultry value project. General results from the data analyses showed there were three distinct and similar psychological profiles amongst both beef and poultry farmers: i.e. 1) a relatively small proportion of farmers who scored themselves negatively on their ability to control and succeed in their business enterprises; 2) a group comprising the majority of farmers who were generally neutral about their ability to control and succeed in their businesses; and 3) a relatively small group of farmers who were confident in their ability to succeed. Further analyses demonstrated there were strong and favourable relationships between farmers' psychological profiles and the performance of their businesses, with business performance being greatest for group 3 and decreasing for group 2 and then group 1, which had the poorest business performance.
- Using these results, the team then designed a new training method using the 'Behaviour Change Wheel' with the aim of improving adoption of proven technologies in both the beef and poultry industries. The intervention study began with smallholder poultry farmers because results were expected to be available much earlier than from beef farmers (because of the far quicker business turnover in the poultry industry). However, that study was disrupted due to the Covid-19 pandemic and major changes in market conditions before and during the pandemic that would have impacted on the results. A re-designed study commenced in early

2022, with the aim of completing data analyses and report writing following the end of the project's contracted period.

- The team also used the opportunity to revise the initial very long survey form to a much more concise questionnaire based on the initial survey results. The revised survey has been tested amongst at least 200 smallholder livestock farmers from South Africa (non-project farmers and new regions) as well as Botswana, Malawi, Zambia and Zimbabwe. These new data are now being analysed and will be published after the end of the project's contracted period.
- Key findings from this behaviour change component of the project have delivered spill-over benefits in the form of new tools and capacity building approaches to South Africa's smallholder poultry industries, and strong potential to deliver benefits to a wide range of smallholder livestock industries across southern Africa more generally, particularly through the applicability of the results across genders and diverse multiple cultures in South Africa.

Gender component

- The project's gender team used a framework of gender inclusion and women's empowerment strategies to accelerate the uptake of proven technologies in the project's Cavalier and Cradock beef value chains. The team also undertook research aimed at development of a strong understanding of women's roles and their influence in decision-making in smallholder beef farming businesses. Data for the research was derived from a combination of the Behaviour Change, VAIMS and Women's Empowerment in Livestock (WELI) surveys, as well as Key Informant Interviews and Focus Group Discussions. Data collection was disrupted due to both the Covid-19 pandemic and in the final 12-18 months of the project's term due to the team's inability to access in-country project funds. However, at the end of the project term, data analyses are ongoing, whilst key findings from the early phases of data analysis are detailed within this report.

VAIMS component

- Initially this component of the project aimed to identify key baseline indicators across each of the six provinces in which the project operated, and to then repeat the surveys at the end of the project to measure changes achieved in the Cradock and Cavalier value chains over the life of the project. The VAIMS team used a proven tool to quantify the measurement of livestock value chain performance and analysis of improvement scenarios. Detailed baseline analyses and reports were achieved for Eastern Cape, Mpumalanga and Limpopo provinces but at the start of the Covid-19 pandemic there were insufficient province-level data available to complete analyses for Gauteng, North West and Free State provinces. Hence, baseline surveys were also finalised for each of the Cradock and Cavalier value chains. Due to a combination of the Covid-19 pandemic and difficulties in accessing project funds, the end-line surveys could not be repeated to enable measurement of changes over the life of the project.

Objective 3: To develop scaling out strategies and guidelines that enable application of the project's results to other value chains

- The major research output from this objective was development of a policy brief that advocates the need for a new, voluntary meat grading scheme outside the scope of South Africa's current carcass classification scheme, which strongly discounts beef from cattle up to 3 years of age even if they are capable of delivering high quality beef. The project's draft policy was subsequently incorporated for implementation by DALRRD as Pillar 5 into South Africa's Agriculture and Agro-Processing Master Plan (AAMP), aimed at providing practical actions and reforms designed to address growth, transformation and developmental challenges in the agricultural, food and beverage sectors of the economy.

Supplementary objectives (following the mid-term project review):

S1: To undertake a qualitative research study aimed at identifying reasons why farmers do or do not adopt proven animal production and rangeland management technologies;

- Twenty project researchers and farmer support team leaders were trained in two groups over 8 weeks in qualitative research methods. Thereafter, literature reviews were undertaken, human ethics approval for the research was achieved and two separate studies were designed by the project teams to identify why the project's farmers voluntarily participated in between 4 and 6 2- or 3-day training courses and most chose not to adopt either the proven animal production technologies or the rangeland management recommendations made by the project's rangelands' team. A third group of team members investigated opportunities to re-establish the project's farmer demonstration sites to meet the needs of the farmers in their local regions (objective S2). None of these studies was able to proceed beyond the training and design stages due to the project's lack of access to in-country project funds. The failure to complete this study represents a very significant lost opportunity not only for smallholder cattle farmers in this project, but also for other training organisations focused on livestock farmers across South Africa and possibly other African countries.

S2: To re-establish the farmer demonstration sites to directly meet the learning needs of collaborating project farmers within the geographical regions of the sites and to leave them as project legacy sites under the management of the local Provincial Departments of Agriculture; and

S3: To conduct 'Visioning' workshops targeting senior managers of the National and Provincial Departments of Agriculture and other critical stakeholders with the aim of better positioning government-funded agricultural extension services as 'facilitators of peer learning' rather than their current roles as 'vehicles of knowledge transfer'.

- Objectives S2 and S3 could not be achieved due to the project's inability to access in-country project funds over the final 12-18 months of the operational period.

9.2 Recommendations

9.2.1 Engagement and support of farmers and farmer support officers

There are several important recommendations arising from this project with respect to engagement and support of smallholder livestock farmers aiming to deliver animals meeting the specifications of high value commercial markets. They include:

1. From the outset of any future projects, it is essential to define and specifically identify the farmers to be targeted for the project to ensure project resources are expended only on farmers capable of meeting the targeted market specifications;
2. Additionally, extension and farmer support officers working with farmers in future projects should initially be secured through formal line-management channels that ensure their roles and responsibilities are formally recognised and agreed by the officers and their senior managers;
3. As farmers, extension officers and farmer support team members are engaged for involvement in future projects, they should be trained from the outset using team-based approaches based on facilitation, Participative Action Research (PAR) and adult-learning methods, rather than focusing on technical aspects as our project did using the project's Farmer Training Manual. Undertaking a skills audit of all team members at the outset would assist in identifying skills' deficiencies, with Practical Mentors appointed to the project team(s) to help develop the skills of all participants involved at farm levels;
4. To ensure timely monitoring of animal growth rates, farmers should have access to portable weighing scales rather than needing to rely on extension and farmer support officers to undertake monitoring of animal growth rates. This could be organised by a shared arrangement amongst local farmers, with farmers being trained to regularly weigh their animals, calculate the average daily gains between weighings and determine whether nutritional and/or stocking rate adjustments are needed to ensure their livestock are growing at the rates required to meet market specifications; and
5. Farmers recruited for new projects should be given greater training in animal handling and health to minimise bruising on the carcasses due to poor handling during transport or parasite infestation. They should also be given additional practical training in the use of dentition to determine the age of animals prior to slaughter, to ensure animals are sold within the market-specified age restrictions.

9.2.2 Recommendations across the broader project areas

6. For future research and development projects specifically targeting impacts at end-user levels, it is recommended that strong social science expertise be included within the project team. Our experience from this and other similar projects is that technical expertise in disciplines such as animal and crop production, animal health, nutrition and genetics, rangeland management etc. is generally available in-country but the social sciences are less well represented in countries targeted by organisations such as ACIAR. Hence, we recommend strong involvement of social scientists in projects that adopt a multi-disciplinary approach to achieving outcomes and impacts; and
7. It is recommended that, to the extent possible, agencies funding international research for development should engage all in-country project partners as signatories on formal agreements, with those project partners retaining direct access and full autonomy of project funds allocated to those partners.

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10.2 List of publications produced by project

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