Advancing a holistic systems approach for sustainable cattle development programmes in South Africa: Insights from sustainability assessments

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Abstract

Efforts to exploit the central roles of cattle to drive agriculture and rural development in low-income countries recorded limited success owing to their narrow focus on modernizing and commercializing low-input cattle farming. Most programmes failed to take cognisance of the heterogeneous range of complex relationships between the environmental, economic, social and institutional challenges that limit low-input cattle farming. The current qualitative literature review evaluates the environmental, economic and social sustainability delivery impacts of the leading cattle development programmes in the low-input farming sector in South Africa using a holistic systems approach. A mixed method procedure involving stratified sampling was used to allocate local and international-based programmes while, purposive sampling was used to select programmes with wider scale of operation. The review then draws on the crosscutting key constraints emerging from the case studies to provide a better grounding for subsequent sustainability sensitive recommendations. Local-based cattle development programs advanced more market-led interventions while, their international-based counterparts had more

interventions including, soil and rangeland improvement. The narrow focus by both local and international developmental programs is inadequate to address a wide array of environmental, economic, social, technical and institutional challenges faced by low-input cattle producers in South Africa.

Keywords: Cattle development programmes; low-input farmers, sustainability, holistic systems approach.

1. Introduction

Cattle production has been identified as a core source of food, disposable income, critical socio-cultural functions as well as a major capital reserve that can be used to finance other farm investments in low-input farming systems (Herrero et al., 2014). In South Africa, the low-input farming sector comprises of subsistence farmers on communal land and commercially-oriented farmers on either communal or private land (Netshipale et al., 2017). The latter are beneficiaries of the post-independence land reform programmes and are collectively referred to as emerging farmers (Cousins, 2008). Commercially-oriented farmers on communal land were offered small grants under Settlement Land Acquisition Grant (SLAG) scheme (Netshipale et al., 2017). As a result, several SLAG beneficiaries pooled their grants to purchase and share a single commercial farm (Netshipale et al., 2017). Commercially-oriented farmers on private land received large grants under the Land Redistribution for Agricultural Development (LRAD) scheme to purchase individual farms (Netshipale et al., 2017).

Constraints to low-input cattle farming restrict the benefits accruing to the whole farming system. In light of this, many low-income countries, either with their own resources or with the assistance of local and international funding organizations, have embarked on approaches to

strategically exploit the central role of cattle to influence wider agricultural and rural development in low-input farming systems (Tedeschi et al., 2015). In many cases, however, the cattle development interventions have prioritised economically driven benefits of cattle at the expense of environmental and social principles and have not directly translated to improved household food, income and social security (Tedeschi et al., 2015). As a result, low-input farmers remain entangled in persistent 'poverty traps' (Tedeschi et al., 2015).

According to Oosting et al. (2014) the discourses proposed and implemented by most cattle development programmes have not been connected to the realities of low-input cattle producers. In particular, the narrow focus on commercialization of the low-input cattle farming system suggests a lack of understanding of the complexities and diversity of constraints surrounding these systems (Oosting et al., 2014). In this regard, Gerber et al. (2013) suggested a focus that transcends just economic benefits to also consider the environmental and social impacts of beef cattle farming. The economic, environmental and social components represent the three dimensions of sustainability (Latruffe et al., 2016) with governance sometimes added as the fourth one (Graeub et al., 2016). Figure 1 presents the con-ceptual interrelation of different dimensions.

Low-input cattle farming is a complex system where numerous factors and processes interact, often across geographic, institutional and governance scales (Herrero et al., 2009). Such complex causal structures often imply trade-offs between the positive and negative consequences of fragmented actions (Herrero et al., 2009). As such, managing cattle development programmes in low-input cattle farming sector requires that interlinked planning and regulatory actions be tackled simultaneously and considered for their long-term impacts, and preventative rather than remedial actions are required (Tendeshi et al., 2011). The traditional single-faceted and fragmented approaches forego numerous synergistic benefits

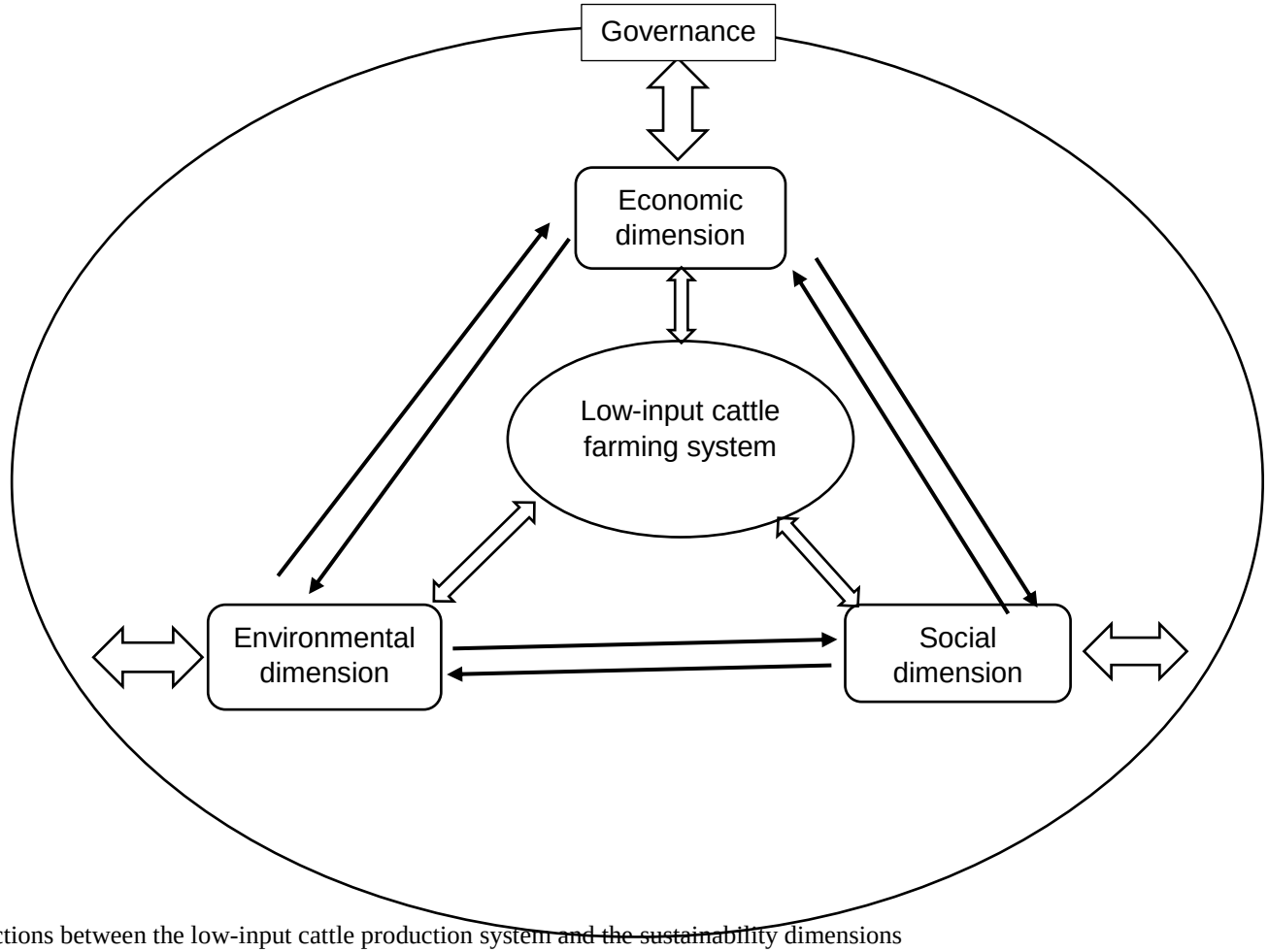

Figure 1: The interactions between the low-input cattle production system ~~and the sustainability~~ dimensions

arising from coordinated action across sustainability sectors (Dahal, 2011). As a result actions often fail to have the intended effect if changes on other parts of the system are not implemented at the same time (Dahal, 2011). The potential for harnessing positive synergies, may be a greater motivating factor for using a holistic systems approach than the identification of negative/cautionary trade-offs. Positive synergies advances the progress towards the sustainability of systems including, low-input cattle farming system (Astier and García-Barrios, 2012).

Sustainable cattle farming implies improving productivity through more efficient use of locally available natural resources, environmental stewardship and social justice (Gayatri, 2016). Integrating the concept of sustainability may, however, not be a panacea for successful delivery of cattle developmental programmes but could facilitate holistic intervention strategies that might result in a wide range of benefits for low-input producers (Bernués et al., 2011). A systems approach is economically sustainable as it is inclusive of different types and a wider range of economic values attached to goods and services provided by low-input cattle farming (Searcy et al., 2014). In this context, it is recommended to analyze the sustainability of cattle development programs from a holistic systems perspective. The current qualitative literature review, therefore, evaluates the economic, environmental and social delivery impacts of the major cattle development programmes in low-input cattle farming areas of South Africa using holistic systems approach. The review then proposes a set of key agricultural sustainability sensitive recommendations that can be drawn on during the designing, implementation and exiting phases of cattle development programmes in low-income countries.

2. Selection of case studies of cattle development programmes in South Africa

Cattle development programs critically analysed in the current study were initially allocated to the local and international strata using the stratified sampling technique. From each stratum, two programs were purposively selected based on their wider implementation in various communities South Africa. Ultimately, the selected cattle-based development programmes were; the Nguni Cattle Programme, The National Red Meat Development Programme (NRMDP), the Australian Centre for International Agricultural Research (ACIAR) programme and the Heifer Project South Africa (HPSA). The two local and two international-based programmes selected in the current review are by no means exhaustive of all the interventions by cattle development programmes conducted in South Africa. However, their general attributes summarised in Table 1 are typical of various development programmes in South Africa.

2.1 The Nguni cattle programme

The Nguni cattle programme was initiated in Amathole District Municipality of Eastern Cape Province (ECP) in 2004 (Mapiye et al., 2007). It was then expanded to other district municipalities in Eastern Cape Province and later to six other provinces; Limpopo (2006), North West (2006), Northern Cape (2006), Free State (2008), Mpumalanga (2008) and KwaZulu Natal (2008; DeWaal, 2014). The objective of the programme was to establish and conserve Nguni nucleus herds and/or upgrade the cattle herds to Nguni type for both subsistence and commercially-oriented cattle producers (Tada et al., 2012). In each province, a tripartite partnership was established among Industrial Development Cooperation (IDC), Provincial Department of Agriculture and a local university. The IDC was the main contributor, which provided financial assistance to acquire Nguni cattle and additional grants for support services. The Provincial Department of Agriculture provided technical support staff and

Table 1: Attributes of selected cattle development programmes in South Africa

	Nguni cattle programme	**National Red Meat Development Programme (NRMDP)**	**Australian Centre for International and Agricultural Research (ACIAR) programme**	**Heifer project**
Aims	To establish Nguni nucleus herds and upgrade the cattle herds to Nguni type in low-input communities	To develop red meat production hubs to improve productivity, increase income and employment for rural folk	To investigate the potential of introduced forage and ley-legume species as fodder banks for improving feed supply and animal nutrition for low-input cattle producers	To reduce hunger and poverty
Partners	Industrial Development Coorporation, the Department of Agriculture and a local university	National Agricultural Marketing Council, Department of Rural Development and Land Reform	Agricultural Research Council, Limpopo Department of Agriculture, Centre for Scientific and Industrial Research Organization	Heifer Project South Africa, Department of Rural Development and Land Reform, Miseror, EU and Wesbank
Target area	National	National	Limpopo and North West provinces	Eastern Cape and KwaZulu Natal provinces
Target producers	Subsistence and commercially-oriented producers	Subsistence and commercially-oriented producers	Subsistence and commercially-oriented producers	Subsistence and commercially-oriented producers
Approach	Top-down approach	Top-down approach	Top-down approach	Community-based
Number of beneficiaries	233 by 2012	13 communities	Not specified	8 030 households by 2012
Rangeland management plan	Yes	No	Yes	Yes
Cattle breeds promoted	Nguni	Not specified	Indigenous breeds and their crosses	Indigenous

facilitates relevant infrastructural development in beneficiary communities. The local university provided research and training services on cattle farming including reproduction, animal health, rangeland production, marketing and financial management.

Selection of beneficiaries was based on key pre-existing conditions including cattle farming and entrepreneurships skills, ownership or proven physical access to sufficient fenced grazing areas, rangeland management plan with specified stocking rates and existence of a development committee (Mapiye et al., 2007). The development committee was in charge of rangeland management, lobbying for government support services and overseeing the redistribution of animals to subsequent beneficiaries upon repayment of loans (Tada et al., 2012). In addition, a local programme manager was employed as a link person between beneficiary communities and the programme partners.

Individuals or communities that met the selection criteria received an interest-free loan of pregnant Nguni heifers and a bull for a period of five years (Dean, 2017). The number of heifers received varied with provinces, for example 30 were given in Eastern Cape and 50 in Limpopo. An attempt was made in Limpopo to replace the Nguni bulls with an Angus bulls to produce F1 crosses with high nutrient utilisation efficiency, growth rates and carcass yields (Mapiye et al., 2018). Formal arrangements were made with commercial feedlots to buy the F1 crosses for finishing and retail supermarkets to market meat as Angus beef (Dean, 2017). However, the Angus bulls failed to survive under the harsh climatic conditions and low management levels of commercially-oriented cattle producers (Mapiye et al., 2018). The Angus bulls were subsequently replaced by Nguni bulls and previous arrangements made with retail supermarkets nullified (Mapiye et al., 2018).

Loan repayment after five years was through a similar herd or cash equivalent of the herd at the set repayment date (Fakudze, 2015). The herd or its cash equivalent would be passed on to other beneficiaries for horizontal expansion of the programme. According to Dean (2017) a total of 3 661 head of cattle valued at about R39,7 million had been distributed to 113 farmers on 96 different farms comprising of individual commercially-oriented cattle producers, community trusts and co-operatives since the inception of the programme in Limpopo province. The loan repayment was reported to be slow with less than 20% of the beneficiaries having completely repaid after the first ten years and the majority still at various stages of repayment (Mapiye et al., 2018).

2.2 The National Red Meat Development Programme (NRMDP)

The Eastern Cape Red Meat Project was initiated by ConMark Trust in 2005 to provide an ordered informal marketing system for low-input producers through organised cattle auctions (ConMark, 2013). The programme was then changed to the NRMDP in 2013 after the Department of Rural Development and Land Reform (DRDLR), in conjunction with the National Agricultural Marketing Council (NAMC) and local municipalities expanded the programme nationally (Nyhodo et al., 2014). The fundamental goal of the programme was to develop red meat production hubs which were primarily used to connect subsistence and commercially-oriented cattle producers to formal markets (NAMC, 2013). This was achieved through bringing the point of cattle sales closer to farmers by establishing or renovating auction pens, assisting farmers to organize auctions and buyers days and negotiating pre-slaughter sale agreements between farmers and abattoirs (NAMC, 2013).

The NRMDP facilitated the construction of low-cost custom feeding centres (CFCs) in the recipients' communities where cattle were managed and finished using commercial feed for 90

to 120 days prior to marketing (NAMC, 2013). The NAMC provided subsidised commercial feed for cattle and salaries for personnel working at the centres (Myeki et al., 2014). The programme was attractive to farmers as it improved cattle condition thereby enhancing local markets, formal marketing opportunities and creating employment for local people (Mkhabela, 2013). Capacity building was achieved through undertaking guided visits to feedlots, auctions and abattoirs to offer on-site training (NAMC, 2013).

The programme was designed to build cattle producers' understanding of the structure, operation and requirements of formal markets (NAMC, 2013). There are currently 22 CFCs across South Africa with carrying capacities of between 150 and 400 cattle. The CFCs provide services to communities within an average radius of 100 km. The CFCs encounter common challenges including violation of induction conditions by farmers who bring old and/or sick cattle, inadequate feed, inconsistent feed deliveries, inability to supply the high volumes to formal markets, insufficient breeding stock (supply base), high staff turnover and a lack of production and marketing information. However, CFCs have successfully provided convenient marketing places with low transaction costs and an improved bargaining power for producers who, subsequently, receive high prices for their cattle than they would through formal marketing channels.

2.3 Australian Centre for International Agricultural Research (ACIAR) projects

The ACIAR jointly initiated a binational project for northern South Africa and Zimbabwe in the mid-1990s (MacLeod et al., 2008). South African partners included the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Limpopo Department of Agriculture (LDA) and the University of Limpopo (MacLeod et al., 2008). The project explored the suitability of a range of ley-legume species for improving forage availability for ruminant

livestock in low-input farming areas (MacLeod et al., 2008). Tropical legumes, including *Chamaecrista rotundifolia* (Wynn cassia) and *Stylosanthes scabra* (shrubby stylo) were identified to have considerable potential for improving forage availability in both South Africa and Zimbabwe (Whitbread and Pengelly, 2004). However, the communal land tenure system and limited financial resources of low-input cattle producers were the major barriers to the successful adoption of the legume technologies in the sector (MacLeod et al., 2008). Recommendations were then made to redirect the legume technology project to commercially-oriented producers who were presumed to be more favourably endowed with land and financial resources (Winter, 2011).

Phase 2 of the ACIAR project dubbed the 'Beef Profit Partnerships' (BPP) was jointly initiated in 1999 by the Australia-based Cooperative Research Centre for Beef Genetic Technologies and the Agricultural Research Council (ARC) in Limpopo and North West provinces of South Africa (Burrow et al., 2008). The goal of the project was to improve indigenous cattle genotypes to enable low-input producers to achieve continuous improvement of profitable production and marketing of beef (Burrow et al., 2008). The selection criteria for recipient low-input cattle producers involved producers from a previously economically disadvantaged background who used indigenous breeds and/or their crosses and whose enterprises had the potential to become viable businesses (Burrow et al., 2008). Selected cattle producers made a commitment to measure their cattle through membership of the Beef Performance Testing Scheme in South Africa. In addition, producers were expected to demonstrate interest in improving profit and lifestyle by committing to meet the formal beef market specifications. Recipient producers and locally-based support staff had to be willing to work in self-selected local groups or networks which would hold continuous improvement meetings every 60-90

days for 5 years (Burrow et al., 2008). Finally, the cattle producers were required to be willing partners in a marketing group, alliance or beef improvement network (Burrow et al., 2008).

The project targeted six recipient teams in each Province (i.e., Limpopo and North West), with each team comprising up to 20 cattle producers but in some cases, the team represented an entire community of up to 400 people. A one-day workshop was conducted to develop the understanding necessary for programme activities and to give participants confidence in decision making (Burrow et al., 2008). Benchmark experiments showed that growth rates, feed efficiencies, incidence of diseases and meat quality of steers from low-input producers' herds mimicked that of commonly used commercial breeds, albeit, lighter induction and carcass weights (Burrow et al., 2008). An opportunity, therefore, exists for cattle breeds from low-input producers to meet the specifications of South Africa's commercial beef markets (Clark *et al*. 2005). Funds for this project ended in 2006 at a time when networks had been expanded to 24 BPP recipient teams across five new South African provinces namely; Mpumalanga, Gauteng, Eastern Cape, Free State and Kwa-Zulu Natal (Burrow et al., 2008). It was believed that adequate capacity was built to enable recipient communities to continue with the initiatives.

The third phase of ACIAR project was initiated in Limpopo Province in 2004 as a reappraisal of the first initiative. The objective was to promote sound rangeland management practices and investigate the potential of introduced forage legumes, in particular *Stylosanthes* species, as fodder banks for improving feed supply and nutrition for commercially-oriented cattle producers (Burrow, 2015). Selection of recipients was based on discussions with senior managers, local government extension staff, municipal authorities, and the recommendations of the previous ACIAR herd and market improvement project. Following this process, 300

commercially-oriented farmers on communal land and 72 commercially-oriented farmers on private land were selected (Fisher and Hohnen, 2012).

The programme focussed narrowly on rangeland improvement opportunities as organisers made critical assumptions that the recipient commercially-oriented cattle producers were familiar with basic animal production and financial management systems commensurate with commercial operations (Burrow, 2015). During the implementation of the programme it became evident that the participating commercially-oriented cattle producers and the local extension staff, had limited knowledge of rangeland management, cattle production principles and practices (Burrow, 2015). Central practices of sound grazing management, such as, feed budgeting were not appreciated and as a result calving rates remained low (MacLeod et al., 2008). The organisers then made conscious decisions to reappraise the approach taken by the programme and focus on developing capacity through a range of training courses in rangeland management, cattle husbandry and financial management.

2.4 The Heifer Project South Africa (HPSA)

The HPSA was initiated in 1999 in the Eastern Cape, Limpopo and KwaZulu Natal provinces (HPSA, 2008). The programme was run in partnership with the DRDLR and other non-governmental organizations, including, Miseror, EU and Wesbank (HPSA, 2008). The programme's aim was to use cattle to provide food and income, thus, alleviate hunger and poverty in low-input farming areas while, preserving the environment (HPSA, 2008). This was assumed to be achieved through training farmers on environmentally-friendly cattle farming practices and entrepreneurship skills, creating and operating businesses corresponding to their talents and skills. Beneficiaries were selected, through recommendations by the community

leadership, from the poorest communities and priority was given to women headed households (HPSA, 2008).

Selected households were trained and provided with gifts of seeds, tree seedlings and cattle to start their own small farming businesses (HPSA, 2008). Recipients were expected to share the skills acquired as well as to pass on their gifts to other households in need to ensure a ripple effect of benefits (HPSA, 2008). The project used community dip tanks as focal points to organize farmers into cattle associations. The project also created jobs at each dip tank in the form of some microbusinesses comprising block making, the production and sale of animal skins and haymaking. By the year 2012, a total of 8030 households had received assistance but the number of jobs or individual businesses created was not reported (HPSA, 2008). The heifer project has been criticized for its claims of promoting sustainable agriculture while the training offered to farmers, especially on animal health, was largely based on conventional cattle farming practices (HPSA, 2008).

3. A holistic systems approach to sustainable cattle development programmes

The polarized ideological and operational priorities of various cattle development programmes make it difficult to have common purpose engagement about how to effectively address concerns in the low-input cattle farming system. Thus, a discussion that looks at the programmes' respective impact on sustainability is helpful to bridging the ideological and operational divide between the programmes. Table 2 presents a summary of impacts of the major cattle development programmes in South Africa. Insights from holistic systems approach to sustainability assessments can help to shift discussions towards more open dialogue about context-specific cattle farming concerns (Shilomboleni, 2017). That may also provide the

Table 2: Economic, environmental and social impacts of selected cattle development programmes in South Africa

The Nguni cattle project			
	Ecological	*Economic*	*Social*
Positive	Promotes sustainability through facilitating ecologically friendly free-ranging conditions	Offers means of production through cattle loans	Offers training and skills development for capacity building
	Promotes use of adapted hardy breeds suited to low-input producers	Provides opportunities for improved household income	Strengthens social coherence and social networks through interaction of cattle producers
	Requires a rangeland management plan for effective use of natural resources	Proved market-related merits of the Nguni breed	Cattle offered elevates the social status of the programme recipients
			Engagement with local extension officers technical staff and researchers helps to motivate farmers
Negative	Lacks practical soil and rangeland improvement strategies	No clearly stated penalty against loan defaulters affects loan repayments	A top-down approach: lack of stakeholder consultation
	Monitoring of rangeland management not comprehensive	Market-led focus inadequate to address multiple challenges of producers	Disregards the breed preferences of cattle producers
	Promotion of a single breed is against low-input cattle producers practices of multiple breeds to improve resilience	Fuels economic inequity in communities	Exclusion of non-cattle owners aggravates societal inequity
	The Nguni x Angus Limpopo-IDC ideology could negatively affect conservation of indigenous genetic material		Requires castration of all other bulls in the community against cultural principle of some cattle producers
The National Red Meat Development Programme (NRMDP)			
	Ecological	*Economic*	*Social*
Positive	Custom feeding centres reduces grazing pressure	Improves body condition of market cattle	Job creation for locals
		Facilitates formal market access and systemize the informal market	Capacity building through training
		Improves cattle market offtake rates in low-input communities	Enhances social coherence and strengthens social networks through farmer interaction
Negative	Dependence on costly external inputs	Only concerned with market animals	A top-down approach: lack of stakeholder consultation
	Lacks practical soil and rangeland improvement strategies	No arrangements made with abattoirs for formal sales	Does not concur with the multifunctional roles of cattle in low-input production systems
		Exclusion of non-cattle owners aggravates economic inequity	High staff turnover which leads to a waste of resources through regular staff training

		The external inputs carry a heavy economic risk for cattle producers	Lack of proper knowledge among members on how the CFP operates
			Conflicts arising from different members opinions of how the CFCs should be operated
Australian Centre of International and Agricultural Research Project			
	Ecological	*Economic*	*Social*
Positive	Encourages rangeland management	Rangeland development translates to sustainable improvements in cattle productivity	Equips low-input producers with pasture development, cattle and financial management skills
	Improves biodiversity	A model to inform farmers' decisions about inputs and the mix of activities needed to maximise profit from commercial markets was produced	Enhances social coherence and strengthens social networks through farmer interaction
	Intends to improve animal nutrition	Used the continuous innovation and improvement strategy to manage, implement and continuously exploit opportunities for positive impact in society	
Negative	Projects that narrowly focusses on pasture development and not cattle production were not prioritized by producers in terms of resource allocation	Puts a strain on constraining financial, labour and other material resources.	Intervention does not directly improve food and income security
	Might introduce invasive species	Poor infrastructure to support pasture development	The project was implemented on a small proportion of the population of commercially-oriented livestock producers in Limpopo province.
The Heifer project South Africa (HPSA)			
	Ecological	*Economic*	*Social*
Positive	Promotes sustainable cattle production	Facilitates market access	Facilitates establishment of effective community management institutions
	Concerned with ecological conservation strategies	Improves household income and diversity of income	Offers training and skills development for capacity building
	Uses local breeds preferred by cattle producers	Provides livestock even to non-livestock owners, thereby, fostering societal equity	Enhances social coherence and strengthens social networks through farmer interaction
	Enhances productivity by promoting agroecology		Job creation for locals
			Provides a mix of species other than cattle, thus, improves stability of the farming system
			Promotes gender equity by empowering women
			Assists producers to lobby for government support
Negative	Seeds and animals offered are universal		No consultations on what to help to provide beneficiaries
			Promotion through small stock might not be of prime importance to low-input cattle producers

grounding for effectively rethinking the approach to developing and managing cattle development projects, and the type of policy and institutional support required.

In drawing insights from sustainability assessments a set of key indicators corresponding to the four pillars of agricultural sustainability namely; economic viability, environmental stewardship, social justice and governance were derived (Khwidzhili and Worth, 2017). Economic viability was indicated by access to markets, income opportunities and decreasing the level of risk. Environmental stewardship included, maintaining and increasing biological productivity and conservation of natural resources. Social justice indicators included food security and sovereignty, gender equality, capacity development and youth involvement. Given that all the sustainability indicators have strong links to policy, the impact of cattle development programmes would inevitably require engagement with governance mechanisms (Vanlauwe et al., 2014). As such, the impact of cattle development programmes to each of the selected indicators will be discussed along with the relevant governance implications. All the mentioned indicators, however, do not entirely identify the main areas where important contributions could be made in low-input cattle farming systems and may be contested in the broader platform.

3.1 Economic impacts of cattle development programmes

The design and implementation of the development programmes seem to be based on the preconception that the low-input cattle farming sector should be modernised and commoditised (Faku and Hebinck, 2013). The preconception reflects a lack of understanding by programme organizers on the complexity of the low-input cattle farming system which is often framed around multiple production goals (Moraine et al., 2017). In this context, cattle development programmes must first establish the priority goals of producers and then co-design programmes

with producers in line with their established goals. Overall, economic interests of low-input producers are often lost in the drive by cattle development programmes to improve their participation in formal beef value chains.

3.1.2 Access to markets

All the case studies of cattle development programmes mentioned in the current review intended to improve formal market participation by low-input producers. The Nguni cattle and ACIAR programmes successfully demonstrated that indigenous cattle breeds could be raised to formal market specifications (Thompson et al., 2010). Muchenje et al. (2008) further reported that the physicochemical meat quality attributes of Nguni cattle are comparable to, while, fatty acid composition and organoleptic quality supersedes that of exotic commercial beef breeds. These superior meat quality characteristics were recommended to be used for marketing beef from Nguni cattle to health conscious consumers (DeWaal, 2014). Ironically, save for the Limpopo-IDC Nguni cattle programme, which sort to market the Nguni-Angus F1 crossbreds as Angus beef in local retail shops, no formal arrangements were made with abattoirs to purchase cattle from the low-input sector.

In cases where producer-abattoir contractual arrangements were in place, the operational levels of the low-input cattle farming systems was not adequate to supply sufficient volumes of cattle required by the formal market (Marandure et al., 2016). Besides, the formal beef carcass classification system used in South Africa penalises the older and emaciated animals often sold by low-input cattle producers and favour young well-muscled animals (Chingala et al., 2017). Considering this, the top-down intervention by the Nguni cattle, NRMDP and ACIAR programmes to organize farmers into marketing groups to meet the volumes and quality demands of the formal market was inappropriate (Ndoro et al., 2015). Marandure et al. (2016)

reported that low-input cattle producers were not comfortable with forward contracts as they felt indebted. Besides, the programme overlooked the ability of farmers to self-organise into functional groups that can consistently match their production levels to the demand created by facilitated marketing arrangements.

Low-input cattle producers faced intense competition from established commercial farmers after the deregulation of the meat industry through the Marketing and Agriculture Act number 47 of 1996 (Meissner et al., 2013). On a global scale, van Wijk (2014) attributed the agrarian crises to globalized food and agricultural systems through liberalized agricultural markets and structural adjustment policies besides unfavourable climatic or economic conditions of low-input farmers. FAO (2003), further indicated that subsidised imports due to trade liberalization policies weakened farmers' competitiveness in their own markets, thereby, exacerbating poverty in Africa. Creating more localized food systems with short and fair distribution chains between producers and consumers are critical to reverse challenges associated with the globalized food system in this regard (Shilomboleni, 2017). Most low-input producers prefer informal cattle markets where cattle on hoof fetch higher prices than what they realize from formal markets (Marandure et al., 2016). Moreover, cattle sold on the hoof provide local buyers with the benefits of the fifth quarter products, including offals that are considered a delicacy by most rural consumers. The fifth quarter products are regarded as an extra quarter above the four quarters of the animals' dressed carcass after slaughter which contains the main cuts of both prime and processing meat (Lloyd, 2013).

Efforts to systemize the informal marketing of cattle as attempted by the NRMDP could be a beneficial intervention. However, Lubungu et al. (2012) asserts that marketing is not the primary production goal of most low-input producers who prefer essential 'flow products'

provided by cattle which include, draught power, milk, manure, a live bank, medium for traditional payments and assets of inheritance among others. Unlike 'end-products' such as, meat and hides/skins, 'flow products' generate a regular cash income or represent consistent availability of other benefits relative to the period that the animal stays on the farm (McDermott et al., 2010). Thus, selling animals, especially young stock, is not desired by low-input producers as it results in the loss of flow products (Herrero et al., 2010; McDermott et al., 2010). The preference for flow products by low-input producers is often underestimated in many cattle development programmes which are market-oriented (Wolfgang et al., 2003).

3.2.2 Decreasing the level of risk

Cattle development programmes are viewed as advancing the corporatization of Africa's agriculture through implementation of a model based on high-priced input packages that carry heavy economic risks for farmers (Shilomboleni, 2017). Khapayi and Celliers (2016) further explained the source of heavy economic risks for farmers as the persistently upward global trend of farm input costs while, farm gate prices are either constant or extremely volatile. Furthermore, low-input cattle producers reside in marginal areas with poor access to infrastructure, which increases the costs of transporting external inputs into and products out of the system (Wolfgang et al., 2003). Instead, the single focused goal of commercialization ostensibly serve the primarily interests of a few but powerful corporates and offers no valid solutions for food security challenges of the low-input cattle producers (Holt-Giménez and Altieri, 2013; Ainembabazi et al., 2018).

The animals given by the Nguni cattle programme and the HPSA offered a form of credit facility to recipient low-input cattle producers, the majority of whom do not have collateral to access loans through the formal systems (Otieno, 2012). A lack of clearly stated penalties to

loan defaulters might, however, discourage the low-input producers from repaying the loans even if they could afford to. The loans may be considered as gifts by producers which may encourage reluctance to repay for horizontal expansion to new recipients (Sirohi, 2010). According to Faku and Hebinck (2013) in many African societies, including South Africa, it is considered a bad cultural habit to turn down a gift of cattle. Thus, low-input producers still accept cattle even if they might not prefer the breed or have the capital to repay them. Nevertheless, low-input producers seem to prefer diverse cattle breeds with large adaptive and production differences which compromises resilience against shocks in extreme climate, low management levels or volatile markets (Theunissen et al., 2013). Theunissen et al. (2013) predicts that indigenous and theirs non-descript crossbreeds will gain more importance in the region as the effects of climate change become more pronounced owing to their adaptation to the local environment.

3.1.3 Income opportunities

Marandure et al. (2016) reported higher cattle market offtake rates leading to increased household income since the inception of the NRMDP. A final report of the BPP also revealed positive economic impacts where the programme increased revenue to the recipient commercially-oriented farmers by an average of R16 000 (US$ 1 212.12) per producer per year (Burrow et al., 2008). It is estimated that the BPP programme increased profits to the subset of farmer teams that measured gross margins by an average of about R7 500 (US$568.18) per producer per year (Burrow et al., 2008). This income was largely generated from 'flow products' of cattle, for example, through milk sales, draught power hire, manure for fertiliser and energy (McDermott et al., 2010). However, low-input cattle producers prefer varied income sources to add to the diversity of income and to improve resilience at the household level (Shah et al., 2013). In this regard, only the HPSA promoted diversity of household income

sources by facilitating income generation from crops, handicrafts, trade, wage labour and/or remittances (Shiferaw et al., 2014). Besides meeting household needs, such as paying for health care and education, improved household income aid investment in other agricultural enterprises and towards environmental stewardship (Shah et al., 2013).

3.2 Environmental impacts of cattle development programmes

From an environmental perspective, it is recommended that cattle development programmes should prioritize sustainable use of local resources (Broom et al., 2013). The cattle development programmes mentioned in the current review showed that reliance on externally sourced resources often present problems. For example, the Angus bulls introduced in the Limpopo-IDC Nguni programme failed to survive under commercially-oriented farmer's socio-environmental conditions and the legume species introduced by the ACIAR were unsuited to the local climatic and edaphic conditions.

3.2.1 Maintaining and increasing biological productivity

3.2.1.1 Soil productivity

The foundation of environmental sustainability that is capable of supporting optimum cattle productivity encompasses maintenance and improvement of soil quality (Rosa and Sobral, 2008). According to Rosa & Sobral (2008) environmental degradation often arise from prolonged exploitation of land-use systems without consideration of soil conservation and or improvement. A good soil system provides a satisfactory environment for sustainable rangeland productivity, which supports optimum livestock productivity (Thorne and Tanner, 2002; Rosa García et al., 2012) and consequently increase farmers revenue. None of the programmes reviewed in the current article had direct goals related to actively improving soil productivity, although, the ACIAR legume programme may have soil improvement intention

through biological nitrogen fixation (Mapiye et al., 2006). This is not unusual given the fact raised by Shilomboleni (2017) that low-input cattle producers shun interventions with no direct income or food security benefit. Fertile soils should have a capacity to recycle vital nutrients and to maintain a diversity of organisms that minimize disease and parasite outbreaks (Shilomboleni, 2017). It is essential for cattle development programmes to incorporate soil productivity along with other intended objectives. Continual improvements are necessary as removal of cattle from the system through sales and/or mortality export nutrients from soils, and these have to be replaced to avoid soil degradation (Conant et al., 2017), which in turn reduces vegetation biomass and quality (Holt-Giménez and Altieri, 2013).

3.2.1.2 Vegetation productivity

The interventions of the ACIAR programme including rangeland restoration, reinforcement and management as well as requirements for rangeland management plans by the Nguni cattle programme had potential to improve forage biomass and quality for cattle. The cost of reinforcing, restoring or establishing the necessary infrastructure for rangeland development is often well beyond the limited financial resources of most low-input cattle producers (Stür et al., 2013). Reluctance to invest in rangeland improvement by low-input producers could also indicate a tragedy of the commons where unequal individual benefits from such public goods discourages collective development interests (Hardin, 1968). A combination of poor climatic and edaphic conditions coupled with heavy encroachment by bush mopane, Vachellia and Acacia species also disqualified the introduction of viable populations of forage legumes on most recipient farms (MacLeod et al., 2008).

Cattle producers may view rangeland improvement initiatives as straining their already constrained labour, capital and other agronomic inputs resources that are often prioritized for

food and cash crop production (Amary, 2016). This is particularly true given the fact that rangeland management plans are often linked to specified conservative stocking rates which might be viewed by low-input cattle producers as potentially limiting their stock numbers (Gayatri, 2016). Recent studies suggest that communal rangelands have adapted to overgrazing overtime, in such cases, it is important to recalibrate their carrying capacity (Faku and Hebinck, 2013). The HPSA goal of enhancing rangeland management by adopting agroecology can be emulated in future cattle development programmes (Holt-Giménez and Altieri, 2013). According to Lovell et al. (2010), agroecology replicates the model of traditional agriculture to improve the productivity of ecological landscapes, by optimizing practices, such as nutrient cycling and forage diversity using low-input technologies. The principles of agroecology were proven successful in meeting the food security needs of low-input farmers living in marginal environments in Africa, Asia and Latin America (Holt-Giménez and Altieri, 2013). Improved rangeland production consequently improve cattle productivity (Chaudhry, 2008).

3.2.1.3 Cattle productivity

The Nguni cattle programme and the HPSA provided the essential raw materials for production in the form of interest-free cattle loans. All the case studies of cattle development programmes mentioned perceived the low-input cattle farming system as archaic and unproductive system, needing to be replaced by modern, intensive, market-oriented system (Segnon et al., 2015). For example, the reliance of the NRMDP intervention on custom feeding of cattle using externally sourced commercial feed and veterinary inputs. Such costs are beyond the majority of low-input producers, thus are not economically sustainable. In addition, the animals that were not in the CFCs were subjected to suboptimal growth largely due to inadequate nutrition and poor veterinary care (Tedeschi et al., 2015). The use of diverse breeds also provides raw materials to exploit heterosis and opportunities to maximize high productivity and profitability (Tada et

al., 2013). Generally, indigenous breeds such as, the Nguni are small framed but they are adapted to local disease and parasites, have low feed requirements, are fertile and maintain high productivity under extreme climatic conditions, which suit the low management levels of most low-input farmers (Nyamushamba et al., 2017). Exotic breeds, on the other hand have large frames but fail to thrive under low-input farmers' management due to their need of a high plain of nutrition, veterinary drugs and low tolerance to heat stress. Crossbreeding, is therefore, recommended to combine the hardy characteristics of indigenous cattle with high growth traits of the exotic breeds.

3.2.2 Conservation of natural resources

3.2.2.1 Conservation of indigenous forage genetic resources

By encouraging good grazing management the programmes reviewed in the current study, serve for the NRMDP, promoted conservation of forage genetic resources. This is essential given the fact that low-input cattle producers often fail to balance ideal management of resources with optimum cattle production per unit agricultural area (Goswami et al., 2017). Many aspects of rangeland resources such as, quality and quantity (Metzger et al. 2005; Bernués et al. 2011), species and community biodiversity (Snyman and Fouché, 1993), vegetation dynamics, shrub invasion (Rosa García et al., 2012), are also modified by grazing livestock (Rook & Tallowin 2003). Therefore, inventories of rangeland resources should precede any extensive cattle developmental program as a matter of principle. LaCanne and Lundgren, (2018) explained that most rangeland biodiversity is lost through land degradation because of a combination of deforestation and overgrazing. Even the NRMDP indirectly contributed to forage resource conservation by removing cattle from rangelands thereby, reducing grazing pressure. However, interventions by the ACIAR programme might be viewed as anti-conservation as it introduces alien species to rangelands which might lead to loss of

indigenous biodiversity as they become outcompeted. Questions may also be raised on the approach by the HPSA that involved distributing the same seed and animal genotypes across different agro-ecological areas.

3.2.2.2 Conservation of indigenous cattle genetic resources

The organizers of the ACIAR and the Nguni cattle programme presented the Nguni as an environmentally friendly, sturdy and easy-to-handle breed that should be kept pure to maintain its unique organic beef attributes and develop a niche market locally and internationally (Bester et al., 2003). The adaptation of the Nguni breed to marginal environments characterised by vegetation of low nutritive value, extreme climatic conditions, high prevalence of diseases and parasites and low management regimes is indeed beneficial to low-input cattle producers (Tada et al., 2013). However, most local feedlot operators dislike the Nguni breed because of its small frame, low growth rates and carcass yield (Chingala et al., 2017).

Faku and Hebinck (2013) also reported that most low-input cattle producers, having been accustomed to non-descript crossbreeds for over 60 years, have grown to appreciate and value some of their qualities, such as, larger frame sizes and carcass yield compared to Nguni cattle (Faku and Hebinck, 2013). This is confirmed by numerous studies that reported non-descript crossbreeds as the most common breed kept by low-input cattle producers in South Africa (Scholtz et al., 2008; Mapiye et al., 2009a; Nowers et al., 2013). Over the time the non-descript crossbreds also developed relative adaptation to the local climate, diseases and parasites, marginal feed resources and management regimes of low-input cattle producers compared to pure exotic breeds (Faku and Hebinck, 2013). Nonetheless, Nyamushamba et al. 2017 expressed the importance of conserving the indigenous cattle genetic material, including the Nguni, as raw materials for crossbreeding.

3.3 Social impacts of cattle development programmes

The social values of cattle are clearly not prioritized in the market-based interventions by most cattle development programmes. Social challenges that characterize low-input cattle farmers including, food insecurity, gender disparity, low intergenerational succession rates and lack of sustainable cattle farming knowledge among others are complex and would require a holistic systems approach to understand them (Ayantunde et al., 2011). Kruska et al. (2003) mentioned that improved targeting and dissemination of interventions with positive impacts on cattle farming requires a thorough understanding of the overall system and the environment in which the low-input farmers operate.

3.3.1 Food security and sovereignty

In general, all the cattle development programmes under review either directly or indirectly sought to enhance household food security by providing animals or improving their production and marketing (McDermott et al., 2010). In reality, household food insecurity remain prevalent in low-input farming systems (Jacobs, 2012), indicating inadequacy of narrow market-led focus of most cattle development programmes. Such interventions were dismissed by Otte et al. (2005) as having failed to adequately feed the world in a sustainable manner. Save for the HPSA where the poorest households were identified through recommendations from the community leadership, other programmes discriminated against non-cattle owners and those with small herds who are more food and income insecure.

The Nguni cattle programme and the HPSA have the potential to contribute towards food sovereignty through provision of animals to farmers. Food sovereignty was defined by Holt-Giménez and Altieri (2013) as right of people to healthy and culturally appropriate food produced through ecologically sustainable methods, and their right to define their own food

and agricultural systems. The food sovereignty model endeavours to put those who produce, distribute and consume food at the heart of the food system, rather than the demands of markets and corporations (Holt-Giménez and Altieri, 2013). In light of this, development programmes which promoted the raising of indigenous cattle breeds using local resources were implemented within the prescripts of the food sovereignty model. However, none of the programmes followed the other food sovereignty principle that farmers should grow food for self-sufficiency purposes and be embedded in locally-based markets as opposed to national and global value chains (Shilomboleni, 2017). The state should be a prime guarantor of food security and sovereignty as it can enforce the legal nature of various entitlements to promote the social and economic conditions necessary to secure individuals' access to food and ensure fair and stable food prices (Letty and Alcock, 2013). In South Africa, the mechanisms by which agricultural policies are expected to alleviate poverty and enhance food security are not inherently clear (Jacobs, 2012).

3.3.2 Gender equality

Only the HPSA clearly stated the goal of providing cattle and other means of production to women so as to elevate their social status (Achandi et al., 2018). According to Kristjanson et al., (2010), elevated social status often translates to access or even authority over a broader base of community resources. The elevated status gives women the necessary leverage to lobby for support from government and other organizations in parallel with their male counterparts (Njuki et al., 2011). Shah et al. (2013) expressed that women are better at allocating scarce resources and sharing knowledge about production than men. Overall, resources (i.e., food and income) under the control of women are more likely to be used to improve family welfare as women spend up to 90% of their income on their families (Hausmann et al., 2011). Such qualities are essential in improving food security and strengthening social networks that are

responsible for horizontal knowledge transfer within and between communities (Kristjanson et al., 2010).

With the exception of HPSA, the focus of the rest of the cited development programmes on cattle, is likely to discriminate against women who are often left in charge of smaller livestock species such as poultry and small ruminants, while men delegate themselves to cattle and other larger livestock (Njuki et al., 2011; Myeki et al., 2014). In fact, some cultures prohibit women from owning cattle, limiting the potential for gender equity in low-input cattle farming systems (Njuki et al., 2011). This is despite the fact that women are often left in charge of households by their husbands when the latter seek off-farm employment (Meijer et al., 2015; Njuki et al., 2011). Overall, HPSA involved community leadership in identifying the poorest households in need of assistance, which could have significantly contributed towards reduction of societal inequalities. Other development programmes were discriminating against cattle ownership and this may have fuelled societal inequities.

3.3.3 Youth involvement

The focus of the HPSA on training local young people as communal animal health workers created a nucleus of custodians of information within communities which is essential given the inefficient extension services in low-input farming areas (Mwacharo et al., 2009). Unfortunately, none of the other programmes under current review actively targeted the youths. The youth have a critical role of providing progressive management strategies which are essential for the sustainability of low-input cattle farming systems. Youths involvement in development programmes stimulates their interests in cattle farming, helping to counter the long-term challenge of lack of intergenerational succession which seriously threatens sustainability of low-input cattle farming systems (Dapaah et al., 2001; Nakano et al., 2018).

Thus, youth involvement in cattle production is an important indicator of the continuing existence of the system in future (Nqeno et al., 2011). As with women, capacity building of young people essentially guarantees wider horizontal knowledge transfer as they have wider communication networks.

3.3.4 Capacity building and knowledge transfer opportunities

There were clear capacity building benefits provided for low-input producers by all the cattle development programmes case studies. The interactions during training presented opportunities for developing functional social networks and fostering unity among low-input cattle producers (Segnon et al., 2015). Nakano et al. (2018) mentioned the importance of training programmes to be coordinated to ensure they communicate the same message and provide win-win benefits to both low-input cattle producers and programme organisers. Continuous improvement cycles instigated by the ACIAR programme is essential in building know-how on consistent monitoring and adjustment strategies for their production practices. The implementation of the HPSA, including its training protocol, is based on the principles of agroecology and this advances the operationalization of sustainability through more rationale and efficient use of local resources to improve cattle production (HPSA, 2008). The basis of the HPSA training could be adopted in designing future cattle development programmes.

4. Designing, implementing and exiting strategies for sustainable cattle development programmes

All cattle development programmes prefer their technologies to be implemented longer after their active engagement with various communities. As such, it is essential for cattle development programme organizers to consider a sustainability-based holistic systems approach when developing their design, implementation and exit strategies. A two-phase

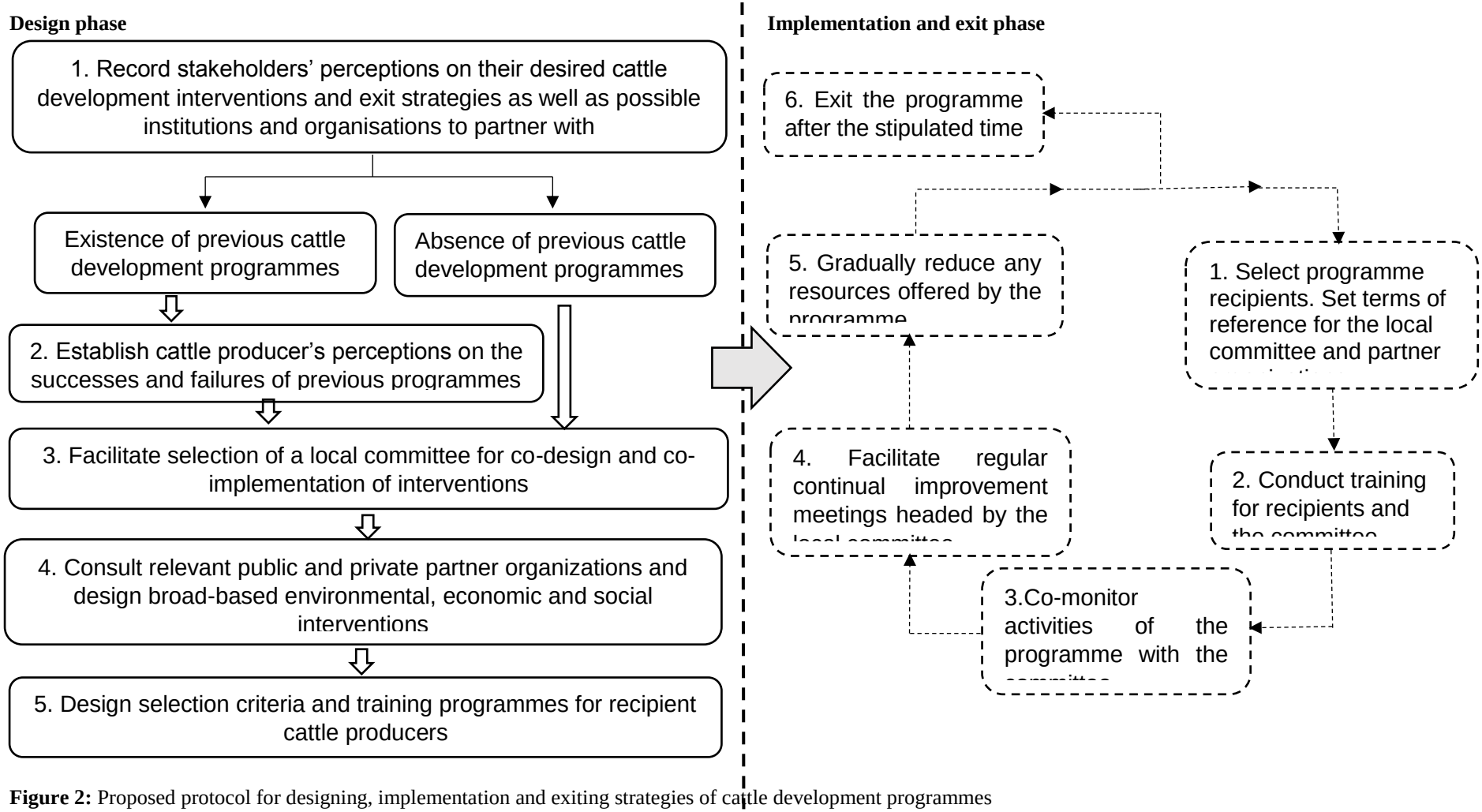

Figure 2: Proposed protocol for designing, implementation and exiting strategies of cattle development programmes

protocol is proposed for use in low-input cattle development programmes consisting of a design and implementation phase with the exit phase running in parallel with the later as presented in Figure 2.

4.1 Design phase

The cattle development programmes under the current review reflected limited understanding of the complexity surrounding low-input farming systems. In that regard, it is crucial to conduct extensive consultations with local stakeholders, including, cattle producers, community leaders, local extension officers, local government officials and other researchers in the area. Stakeholders' perceptions on the challenges and opportunities of the low-input cattle production system provides the basic understanding of the system required for designing more appropriate interventions (Kruska et al., 2003). Stakeholders should take a leading role in suggesting strategies for new broad-based interventions that cover the environmental, economic and social aspects of low-input cattle production as well as, a desired implementing and exit strategies for the programmes (Mascarenhas et al., 2015). In the same regard, stakeholders can also be requested to suggest the selection criteria for recipients as well as, relevant organizations, groups or departments that can be approached for partnerships in the new endeavours. This critical step is often not considered in most development programmes, including those under review. The programmes fail to acknowledge that low-input cattle producers have loads of inherent valuable knowledge and experiences spanning hundreds of years that they can share (Kruska et al., 2003). This provides useful input towards designing of relevant and sustainable interventions. In contrast, cattle development programmes draw their knowledge from a mixture of scientific, idealistic and even romantic views developed within a fixed time frame (Kruska et al., 2003).

We propose the selection of a committee comprised of local producers, leadership, public and private enterprises that will assist with co-designing and co-administration of the actual intervention strategies with the organisers. The committee will also form part of the transitioning phase that will eventually assume total responsibility of activities upon exiting of the programme after its implementation period (Rogers and Macías, 2004). Early consideration of exit strategies is critical as some positive technological interventions are often lost after respective cattle development programmes withdraw their support at the end of their implementation period (Gardner et al., 2005). According to Davis and Sankar (2006) transition and exit strategies are best co-developed with farmers and local stakeholders to ensure a sustained source of resources, technical and managerial capacity, and sustained motivation of beneficiaries and service providers after the project ends.

Coates et al. (2016) identified three approaches to exit strategies namely; phase-down, phase-over and phase-out. Phase-down refers to gradual reduction of programme inputs offered to recipient communities. Phase-over refers to the transfer of programme activities to another entity such as a local committee, a research institution, a branch of local, regional or national government, or other local or international funding organizations (Rogers and Macías, 2004). This phase also includes capacity building of recipient farmers who will eventually assume responsibility of activities (Coates et al., 2016). For best sustainability prospects community members can be left with the responsibility of programme activities which can be regularly monitored by a selected institution. Phase-out refers to abrupt removal of programme inputs or activities without any arrangements for their further use. This is common in self-sustaining programmes whose resources requirements change once their objectives are achieved (Gardner et al., 2005). Finally, the components required as well as the contents of training material can be organized in preparation for implementation of the programme.

In view of the limited coordination between different cattle development programmes (Sirohi and Chauhan, 2010) which compromises continuity, the protocol proposes the establishment of a management database which will inform on successes, failures and lessons learnt during implementation of various programmes. The database can be maintained by local the institutions involved in the project. The primary purpose of the database will be to integrate activities of various cattle development interventions to encourage coherent adoption of technologies. At the same time, a more coordinated delivery of interventions will address the current challenges where conflicting interests of various programmes might confuse the recipients (Makkar and Ankers, 2014). The management database could also save as a monitoring and evaluation tool for the cattle development programmes.

4.2 Implementation phase

Implementation of programme activities should be informed by what stakeholders suggest in the design phase of the proposed framework. This includes selection of recipient low-input farmers using stakeholders' recommendations mentioned in the design phase. This is opposed to the top-down approach of unilaterally developing a criteria for selecting recipients as practiced by most cattle development programmes (Faku and Hebinck, 2013) including those under the current review. Of the programmes under the current review, only the HPSA selected recipients at the recommendation of local community leadership, as such, appropriate beneficiaries were identified.

Another important sustainability aspect which is considered by all the cattle development programmes under the current review is capacity building. The training material of the different cattle development programmes can, however, be synchronized, possibly through the proposed

management database, to allow consistent knowledge delivery and skills development (Fraser et al., 2006). Farmer training forms the second step of the implementation phase of the proposed protocol (Figure 2). It is also important to emulate the continual improvement strategy of the ACIAR programme where cattle producers meet once every 60 to 90 days for programme introspection and effecting changes where necessary (Fisher and Hohnen, 2012). This step is important to ensure that programme activities constantly align to prevailing conditions in recipient communities. The process also helps to instil the skills of continually improving activities to adapt to developing circumstances. Finally, preparations can be made for horizontal expansion of the programme before the implementation cycle is repeated again by selecting new recipients.

Overall, the concept of sustainability is often not considered during performance monitoring and evaluation of cattle development programmes (Searcy et al., 2014). In fact, to the authors' knowledge, there is no existing framework designed to incorporate sustainability in the performance measurement of cattle development programmes in the low-input farming sector. Sustainability evaluation ensures that the performance of cattle development programmes essentially transcends beyond economic gains to include environmental and social benefits in line with the multi-faceted challenges and pluralistic production goals of low-input farmers (Olde et al., 2016). A holistic systems approach is, therefore, required to ensure that the performance of cattle development programmes is evaluated in the context of sustainability to address the diverse challenges and pluralistic production goals of low-input farmers (Searcy et al., 2014).

5. A holistic systems approach to sustainability evaluation of cattle development programmes: Application potential in low-input farming areas

A holistic systems approach can be used to facilitate the development of sustainability evaluation and monitoring framework for cattle development programs in low input farming areas (Searcy et al., 2014). The framework can help organizations involved in cattle development programmes to measure progress towards their goals. In the process, the organizations will develop understanding of the current situation, the key issues that should be addressed, and the options available (Chakravarti, 2018). However, there are many challenges associated with the design, implementation, and evolution of a robust sustainability evaluation and monitoring framework (Bockstaller et al., 2015). The challenges include developing linkages between the measures, integrating the measures with existing internal initiatives, and accounting for non- financial issues in the system. This is worsened by the fact that performance measurement system must always be context- specific (de Olde et al., 2018).

A holistic systems approach can help stakeholders to address many of the challenges inherent in the design, implementation, and evolution of a sustainability evaluation and monitoring framework (Searcy et al., 2014). In particular, a holistic systems approach is useful in developing the process of creating a sustainability evaluation and monitoring framework (Sala et al., 2015). However, a holistic system approach do not absolutely guarantee the successful design, implementation, and evolution of an appropriate sustainability evaluation framework in all cases but, can provide the needed direction and serve as tests of validity throughout the process (Searcy et al., 2014). It can also provide insight into how organizations involved in cattle development projects can develop a sustainability evaluation and monitoring framework tailored to their unique needs.

6. Conclusions

Overall, the market-led interventions by both the local and international cattle development programmes narrowly focused and inadequately addressed a wide array of environmental, economic, social, technical and institutional challenges faced by low-input cattle producers in South Africa. The current review demonstrated that a holistic systems approach provides both the structure and flexibility required to guide the design, implementation, and evolution of sustainable cattle development programs in the low-input farming areas in South Africa. The review also indicates the usefulness of a holistic systems approach in developing the process, structure and content of a sustainability evaluation and monitoring framework.

Reference:

Achandi, E.L., Mujawamariya, G., Agboh-Noameshie, A.R., Gebremariam, S., Rahalivavololona, N., Rodenburg, J., 2018. Women's access to agricultural technologies in rice production and processing hubs: A comparative analysis of Ethiopia, Madagascar and Tanzania. J Rural Stud 60, 188–198. doi:10.1016/j.jrurstud.2018.03.011

Ainembabazi, J.H., Abdoulaye, T., Feleke, S., Alene, A., Dontsop-Nguezet, P.M., Ndayisaba, P.C., Hicintuka, C., Mapatano, S., Manyong, V., 2018. Who benefits from which agricultural research-for-development technologies? Evidence from farm household poverty analysis in Central Africa. World Dev 108, 28–46. doi:10.1016/j.worlddev.2018.03.013

Amary, N.., 2016. Assessing the quality of forage of for livestock in a semi-arid pastoral system in South Africa. University of the Western Cape, South Africa.

Astier, M., García-Barrios, L., 2012. Assessing the sustainability of small farmer natural resource management systems. A critical analysis of the MESMIS program. Ecol Soc 17, 25. doi:10.5751/ES-04910-170325

Ayantunde, A.A., de Leeuw, J., Turner, M.D., Said, M., 2011. Challenges of assessing the sustainability of (agro)-pastoral systems. Livest Sci 139, 30–43. doi:10.1016/j.livsci.2011.03.019

Baumgartner, S.A., Treydte, A.C., Grant, C.C., van Rooyen, J., 2015. Can diverse herbivore communities increase landscape heterogeneity? Comparing wild and domestic herbivore assemblages in a South African savanna. Perspect Plant Ecol Evol Syst 17, 34–43. doi:10.1016/j.ppees.2014.11.002

Bernués, A., Ruiz, R., Olaizola, A., Villalba, D., Casasús, I., 2011. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. Livest Sci 139, 44–57. doi:10.1016/j.livsci.2011.03.018

Bester, J., Matjuda, L.., Rust, J.M., Fourie, H.J., 2003. The Nguni: A case study, in: The Concept of Community Ownership and Mobilization: Experiences from Community-Based Natural Resources Management. p. 184.

Blignaut, J., 2015. Sustainable farming as a viable option for enhanced food and nutritional security and a sustainable productive resource base 1–112.

Bockstaller, C., Feschet, P., Angevin, F., 2015. Issues in evaluating sustainability of farming systems with indicators. Ocl 22, D102. doi:10.1051/ocl/2014052

Broom, D.M., Galindo, F. a, Murgueitio, E., 2013. Sustainable, efficient livestock production with high biodiversity and good welfare for animals. Proc R Soc B Biol Sci 280, 20132025–20132025. doi:10.1098/rspb.2013.2025

Burrow, H., 2015. ACIAR Project LPS / 2005 / 128 - High quality markets and value chains for small-scale and emerging beef cattle farmers in South Africa. Pretoria.

Chakravarti, A.., 2018. Cattle Development Problems and Programs in India : A Regional Analysis. GeoJournal 10, 21–45.

Chaudhry, A.S., 2008. Forage based animal production systems and sustainability, an invited

keynote. Rev Bras Zootec 37, 78–84. doi:10.1590/S1516-35982008001300010

Chingala, G., Raffrenato, E., Dzama, K., Hoffman, L.C., Mapiye, C., 2017. Towards a regional beef carcass classification system for Southern Africa. S Afr J Anim Sci 47, 408–423.

Coates, J., Kegode, E., Galante, T., Blau, A., 2016. Sustaining Development: Results from a Study of Sustainability and Exit Strategies among Development Food Assistance Projects– Kenya Country Study of the.

Conant, R.T., Cerri, C.E.P., Osborne, B.B., Paustian, K., 2017. Grassland management impacts on soil carbon stocks: a new synthesis. Ecol Appl 27, 662–668. doi:10.1002/eap.1473

Conmark, 2013. Giving Development a Face (Eastern Cape Red Meat Project). ConMark Trust, South Africa.

Cousins, B., 2008. What Is a "Smallholder" (No. 16).

Dahal, S., 2011. Sustainability in Pasture-based Livestock Production System : A Review. Sustainability.

Davis, N., Sankar, M., 2006. A Practice Review of UNESCO ' s Exit and Transition Strategies. Strategies.

de Olde, E.M., Sautier, M., Whitehead, J., 2018. Comprehensiveness or implementation: Challenges in translating farm-level sustainability assessments into action for sustainable development. Ecol Indic 85, 1107–1112. doi:10.1016/j.ecolind.2017.11.058

Dean, S., 2017. Nguni development project pays off for Limpopo. Farmer's Wkly.

DeWaal, H.O., 2014. Overview of the Northern Cape IDC Nguni Cattle Development Project and the Free State IDC Nguni Cattle Development Project.

Faku, N., Hebinck, P., 2013. Cattle and rural development in the Eastern Cape, South Africa: the Nguni project revisited,. Hebinck, P B Cousins (eds), 'In Shad Policy Everyday

Pract South Africa's L Agrar Reform', Johannesbg Wits Univ Press 281–295.

Fakudze, B.., 2015. An economic evaluation of the National Red Meat Development Programme in the Eastern Cape Province, South Africa. University of Pretoria.

Fisher, H., Hohnen, L., 2012. ACIAR's activities in Africa: a review. Canberra.

Food and Agriculture Organization of the United Nations (FAO), 2003. Global Livestock and Poverty Mapping Meeting. A living from Livest.

Fraser, E.D.G., Dougill, A.J., Mabee, W.E., Reed, M., McAlpine, P., 2006. Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. J Environ Manage 78, 114–27. doi:10.1016/j.jenvman.2005.04.009

Gardner, A., Greenblott, K., Joubert, E., 2005. What we know about exit strategies : Practical guidance for developing exit strategies in the field. Security 1–29.

Gayatri, S., 2016. Aspects of Sustainability of Smallholder Beef Cattle Farming in Semarang Regency , Central Java Province , Indonesia Aspects of Sustainability of Smallholder Beef Cattle Farming in Semarang Regency , Central Java Province , Indonesia.

Gerber, P.., Steifield, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., Tempio, G., 2013. Tackling climate change through livestock - A global assesssment of emmissions and mitigation opportunities, Food and Agriculture Organization of the United Nations (FAO), Rome. doi:10.1016/j.anifeedsci.2011.04.074

Goswami, R., Saha, S., Dasgupta, P., 2017. Sustainability assessment of smallholder farms in developing countries. Agroecol Sustain Food Syst 3565, 21683565.2017.1290730. doi:10.1080/21683565.2017.1290730

Graeub, B.E., Chappell, M.J., Wittman, H., Ledermann, S., Kerr, R.B., Gemmill-Herren, B., 2016. The State of Family Farms in the World. World Dev 87, 1–15. doi:10.1016/j.worlddev.2015.05.012

Hardin, G., 1968. The Tragedy of the Commons. Science (80-) 162, 1243–1248. doi:10.1126/science.162.3859.1243

Harrison, D., Hai, R., Dang, T.H., Israel, K., Maw Maw, T., 2001. Current constraints and R&D opportunities for sustainable livestock production systems for the resource poor in Ganyesa and Kudumane districts in the North West Province of South Africa (No. 94), Towards communal land-use systems.

Hausmann, R., Tyson, L.D., Zahidi, S., 2011. The global gender gap report. Geneva.

Heather, B., Strydom, P., Nengovhela, B.N., Madzivhandila, P., Motiang, D., Griffith, G., Clark, R., 2008. Developing Profitable Beef Business Systems for Previously Disadvantaged Farmers in South Africa, ACIAR Final Report. Canberra.

Herrero, M., Havlík, P., McIntire, J., Palazzo, A., Valin, H., 2014. African Livestock Futures: Realising the potential of livestock for food security, poverty reduction and the environment in Sub-Saharan Africa. Geneva, Switzerland.

Herrero, M., Thornton, P.K., Gerber, P., Reid, R.S., 2009. Livestock, livelihoods and the environment: understanding the trade-offs. Curr Opin Environ Sustain 1, 111–120. doi:10.1016/j.cosust.2009.10.003

Herrero, M., Thornton, P.K., Notenbaert, a M., Wood, S., Msangi, S., Freeman, H. a, Bossio, D., Dixon, J., Peters, M., van de Steeg, J., Lynam, J., Parthasarathy Rao, P., Macmillan, S., Gerard, B., McDermott, J., Seré, C., Rosegrant, M., 2010. Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science 327, 822–5. doi:10.1126/science.1183725

Holt-Giménez, E., Altieri, M.A., 2013. Agroecology, food sovereignty, and the new green revolution. Agroecol Sustain Food Syst 37, 90–102. doi:10.1080/10440046.2012.716388

HPSA, 2008. Heifer Internation Southern Africa [WWW Document]. URL

http://www.hpsa.org.za/about-hpsa (accessed 1.20.18).

Jacobs, P., n.d. Household food access in rural South Africa : Lessons for emerging food security policy, in: International Scientific Symposium on Food and Nutrition Security Information. Rome.

Khapayi, M., Celliers, P.., 2016. Factors limiting and preventing emerging farmers to progress to commercial agricultural farmning in the King Williams town area of the Eastern Cape Province, South Africa. S.Afr.J.Agric.Ext 44, 25–41.

Khwidzhili, R.H., Worth, S.H., 2017. Evaluation of policies promoting sustainable agriculture in South Africa. South African J Agric Ext 45, 73–85. doi:10.17159/2413-3221/2017/v45n2a443

Kristjanson, P., Waters-bayer, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., Grace, D., Macmillan, S., 2010. Livestock and Women ' s Livelihoods : A Review of the Recent Evidence, ILRI. Nairobi. doi:10.1023/A:1006447915074

Kruska, R.L., Reid, R.S., Thornton, P.K., Henninger, N., Kristjanson, P.M., 2003. Mapping livestock-oriented agricultural production systems for the developing world. Agric Syst 77, 39–63. doi:10.1016/S0308-521X(02)00085-9

LaCanne, C.E., Lundgren, J.G., 2018. Regenerative agriculture: merging farming and natural resource conservation profitably. PeerJ 6, e4428. doi:10.7717/peerj.4428

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., Ryan, M., Uthes, S., 2016. Measurement of sustainability in agriculture : a review of indicators three sustainability pillars. Stud Agric Econ 118, 123–130. doi:10.7896/j.1624

Letty, B., Alcock, R., 2013. Crop–livestock interactions: implications for policy-makers and for farmers. African J Range Forage Sci 30, 45–50. doi:10.2989/10220119.2013.776633

Lloyd, P., 2013. Growing profit in the 'fifth quarter.' Farmer's Wkly.

Lovell, S.T., DeSantis, S., Nathan, C.A., Olson, M.B., Ernesto Méndez, V., Kominami, H.C.,

Erickson, D.L., Morris, K.S., Morris, W.B., 2010. Integrating agroecology and landscape multifunctionality in Vermont: An evolving framework to evaluate the design of agroecosystems. Agric Syst 103, 327–341. doi:10.1016/j.agsy.2010.03.003

Lubungu, M., Chapoto, A., Tembo, G., 2012. Smallholder Farmers Participation in Livestock Markets : The Case of Zambian Farmers by Indaba Agricultural Policy Research Institute (IAPRI) Smallholder Farmers Participation in Livestock Markets : The Case of Zambian Farmers.

MacLeod, N., McDonald, C., van Oudtshoorn, F., 2008. Challenges for emerging livestock farmers in Limpopo province, South Africa. African J Range Forage Sci 25, 71–77. doi:10.2989/AJRFS.2008.25.2.5.484

Makkar, H.P.S., Ankers, P., 2014. Towards sustainable animal diets: A survey-based study. Anim Feed Sci Technol 198, 309–322. doi:10.1016/j.anifeedsci.2014.09.018

Mapiye, C., Chimonyo, M., Dzama, K., Raats, J.G., Mapekula, M., 2009. Opportunities for improving Nguni cattle production in the smallholder farming systems of South Africa. Livest Sci 124, 196–204. doi:10.1016/j.livsci.2009.01.013

Mapiye, C., Chimonyo, M., Muchenje, V., Dzama, K., Marufu, M.C., Raats, J.G., 2007. Potential for value-addition of Nguni cattle products in the communal areas of South Africa: a review. African J Agric Res 2, 488–495.

Mapiye, C., Mupangwa, J.F., Mugabe, P.H., Chikumba, N., Poshiwa, X., Foti, R., 2006. A review of forage legume research for rangeland improvement in Zimbabwe. Trop Grasslands 40, 145–149.

Mapiye, O., Makombe, G., Mapiye, C., Dzama, K., 2018. Limitations and prospects of improving beef cattle production in the emerging sector: A case of Limpopo Province, South Africa. Trop Anim Health Prod. doi:DOI: 10.1007/s11250-018-1632-5

Marandure, T., Mapiye, C., Makombe, G., Nengovhela, B., Strydom, P., Muchenje, V.,

Dzama, K., 2016. Determinants and opportunities for commercial marketing of beef cattle raised on communally owned natural pastures in South Africa. African J Range Forage Sci 33, 199–206. doi:10.2989/10220119.2016.1235617

Mascarenhas, A., Nunes, L.M., Ramos, T.B., 2015. Selection of sustainability indicators for planning: Combining stakeholders' participation and data reduction techniques. J Clean Prod 92, 295–307. doi:10.1016/j.jclepro.2015.01.005

McDermott, J.J., Staal, S.J., Freeman, H.A., Herrero, M., Van de Steeg, J.A., 2010. Sustaining intensification of smallholder livestock systems in the tropics. Livest Sci 130, 95–109. doi:10.1016/j.livsci.2010.02.014

Meijer, S.S., Catacutan, D., Ajayi, O.C., Sileshi, G.W., 2015. The role of knowledge , attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub- Saharan Africa. Int J Agric Sustain 13, 40–54. doi:10.1080/14735903.2014.912493

Meissner, H.H., Scholtz, M.M., Engelbrecht, F.A., 2013. Sustainability of the South African livestock sector towards 2050 part 2: Challenges, changes and required implementations. South African J Anim Sci 43, 298–319. doi:10.4314/sajas.v43i3.6

Metzger, K.L., Coughenour, M.B., Reich, R.M., Boone, R.B., 2005. Effects of seasonal grazing on plant species diversity and vegetation structure in a semi-arid ecosystem. J Arid Environ 61, 147–160. doi:10.1016/j.jaridenv.2004.07.019

Mkhabela, T., 2013. Linking farmers with markets in rural South Africa: Rural development and poverty alleviation through supply chain management, National Agricultural Marketing Council. Pretoria.

Moraine, M., Duru, M., Therond, O., 2017. A social-ecological framework for analyzing and designing integrated crop–livestock systems from farm to territory levels. Renew Agric Food Syst 32, 43–56. doi:10.1017/S1742170515000526

Muchenje, V., Dzama, K., Chimonyo, M., Strydom, P.E., Hugo, A., Raats, J.G., 2008. Sensory evaluation and its relationship to physical meat quality attributes of beef from Nguni and Bonsmara steers raised on natural pasture. Animal 2, 1700–1706. doi:10.1017/S1751731108002802

Mwacharo, J.M., Ojango, J.M.K., Baltenweck, I., Wright, I., Staal, S., Rege, J.E.O., Okeyo, A.M., 2009. Livestock Productivity Constraints and Opportunities for Investment in Science and Technology, BMGF-ILRI Project on Livestock Knowledge Generation.

Myeki, L., Mmbengwa, V., Ngqangweni, S., 2014. Assessing the use of communal feedlot in empowering women farmers : A case of Mount Frere cattle. Int J Sustain Dev 07, 11–18.

Nakano, Y., Tsusaka, T., Aida, T., Pede, V., 2018. Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. World Dev 105, 336–351. doi:https://doi.org/10.1016/j.worlddev.2017.12.013

NAMC, 2013. National Red Meat Development Programme: 3rd Beef Cattle Farming Report.

Ndoro, J.T., Mudhara, M., Chimonyo, M., 2015. Farmers' choice of cattle marketing channels under transaction cost in rural South Africa: a multinomial logit model. African J Range Forage Sci 32, 243–252. doi:10.2989/10220119.2014.959056

Netshipale, A.J., Oosting, S.J., Raidimi, E.N., Mashiloane, M.L., de Boer, I.J.M., 2017. Land reform in South Africa: Beneficiary participation and impact on land use in the Waterberg District. NJAS - Wageningen J Life Sci 83, 57–66. doi:10.1016/j.njas.2017.07.003

Njuki, J., Poole, J., Johnson, N., Baltenweck, I., Pali, P., Mburu, S., 2011. Gender , Livestock and Livelihood Indicators. Nairobi.

Nowers, C.B., Nobumba, L.M., Welgemoed, J., 2013. Reproduction and production potential of communal cattle on sourveld in the Eastern Cape Province , South Africa. Appl Anim

Husb Rural Dev 6, 48–54.

Nqeno, N., Chimonyo, M., Mapiye, C., 2011. Farmers' perceptions of the causes of low reproductive performance in cows kept under low-input communal production systems in South Africa. Trop Anim Health Prod 43, 315–321. doi:10.1007/s11250-010-9691-2

Nyamushamba, G., Mapiye, C., Tada, O., Halimani, T., Muchenje, V., 2017. Conservation of Indigenous Cattle Genetic Resources in Southern Africa's Smallholder Areas: Turning Threats into Opportunities. Asian Austral J Anim 00, 1–19. doi:10.5713/ajas.16.0024

Nyhodo, B., Mmbengwa, V.M., Balarane, A., Ngetu, X., 2014. Formulating the least cost feeding strategy of a custom feeding programme: A linear programming approach. Int J Sustain Dev 07, 85–92.

Ogunkoya, F.T., 2014. Socio-economic factors that affect livestock numbers: A case study of smallholder cattle and sheep farmers in the Free State Province of South Africa. University of South Africa.

Olde, E.M. De, Oudshoorn, F.W., Sørensen, C.A.G., Bokkers, E.A.M., Boer, I.J.M. De, 2016. Assessing sustainability at farm-level : Lessons learned from a comparison of tools in practice. Ecol Indic 66, 391–404. doi:10.1016/j.ecolind.2016.01.047

Oosting, S.J., Udo, H.M.J., Viets, T.C., 2014. Development of livestock production in the tropics: farm and farmers' perspectives. Animal 8, 1–11. doi:10.1017/S1751731114000548

Otieno, D.J., 2012. Market and non-market factors influencing farmers' adoption of improved beef cattle in arid and semi-arid areas of Kenya. J Agric Sci 5, 32–43. doi:10.5539/jas.v5n1p32

Otte, M., Costales, A., Upton, M., 2005. Smallholder livestock keepers in the era of globalization, in: Livestock–Crop Systems to Meet the Challenges of Globalisation. p. 18.

Rogers, B.L., Macías, K.E., 2004. Program Graduation and Exit Strategies: A Focus on Title II Food Aid Development Programs. Technical Note No. 9. Nairobi.

Rook, A.J., Tallowin, J.R.B., 2003. Grazing and pasture management for biodiversity benefit. Anim Res 52, 181–189. doi:10.1051/animres:2003014

Rosa, D. De, Sobral, R., 2008. Soil Quality and Methods for its Assessment. Soil Sci 167–200. doi:10.1007/978-1-4020-6778-5_9

Rosa García, R., Celaya, R., García, U., Osoro, K., 2012. Goat grazing, its interactions with other herbivores and biodiversity conservation issues. Small Rumin Res 107, 49–64. doi:10.1016/j.smallrumres.2012.03.021

Sala, S., Ciuffo, B., Nijkamp, P., 2015. A systemic framework for sustainability assessment. Ecol Econ 119, 314–325. doi:10.1016/j.ecolecon.2015.09.015

Scholtz, M.M., Bester, J., Mamabolo, J.M., Ramsay, K.A., 2008. Results of the national cattle survey undertaken in South Africa , with emphasis on beef. Appl Anim Husb Rural Dev 2008, 1, 1–9.

Searcy, C., Karapetrovic, S., McCartney, D., 2014. Application of a systems approachto sustainable development performance measurement. Int J Product Perform Manag 57, 82–197. doi:http://dx.doi.org/10.1108/MRR-09-2015-0216

Segnon, A.C., Achigan-dako, E.G., Gaoue, O.G., Ahanchédé, A., 2015. Farmer's Knowledge and Perception of Diversified Farming Systems in Sub-Humid and Semi-Arid Areas in Benin. Sustain 7, 6573–6592. doi:10.3390/su7066573

Shah, K.U., Dulal, H.B., Johnson, C., Baptiste, A., 2013. Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. Geoforum 47, 125–137. doi:10.1016/j.geoforum.2013.04.004

Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M., Menkir, A., 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan

Africa: Technological, institutional and policy options. Weather Clim Extrem 3, 67–79. doi:10.1016/j.wace.2014.04.004

Shilomboleni, H., 2017. A sustainability assessment framework for the African green revolution and food sovereignty models in southern Africa. Cogent Food Agric 41, 1–17. doi:10.1080/23311932.2017.1328150

Sirohi, S., Chauhan, A.., 2010. Current scenario of livestock development and potential interventions for livelihood improvement : Case of Jharkhand, India.

Snyman, H.A., Fouché, H.J., 1993. Estimating seasonal herbage production of a semi- arid grassland based on veld condition, rainfall, and evapotranspiration. African J Range Forage Sci 10, 21–24. doi:10.1080/10220119.1993.9638316

Stür, W., Khanh, T.T., Duncan, A., 2013. Transformation of smallholder beef cattle production in Vietnam. Int J Agric Sustain 11, 363–381. doi:10.1080/14735903.2013.779074

Tada, O., Muchenje, V., Dzama, K., 2013. Preferential traits for breeding Nguni cattle in low-input in-situ conservation production systems. Springerplus 2, 1–7. doi:10.1186/2193-1801-2-195

Tada, O., Muchenje, V., Dzama, K., 2012. Monetary value, current roles, marketing options, and farmer concerns of communal Nguni cattle in the Eastern Cape Province, South Africa. African J Bus Manag 6, 11304–11311. doi:10.5897/AJBM12.564

Tedeschi, L.O., Muir, J.P., Riley, D.G., Fox, D.G., 2015. The role of ruminant animals in sustainable livestock intensification programs. Int J Sustain Dev World Ecol 4509, 1–14. doi:10.1080/13504509.2015.1075441

Tembo, G., Tembo, A., Goma, F., Kapekele, E., Sambo, J., 2014. Livelihood Activities and the Role of Livestock in Smallholder Farming Communities of Southern Zambia. Open J Soc Sci 2, 299–307.

Tendeshi, L.., Nicholson, C.F., Rich, E., 2011. Using System Dynamics modelling approach to develop management tools for animal production with emphasis on small ruminants. Small Rumin Res 98.

Theunissen, A., Scholtz, M.M., Neser, F.W.C., 2013. An overview of crossbreeding in beef cattle with reference to the Southern African situation. Appl Anim Husb Rural Dev 6, 18–21.

Thompson, J., Polkinghorne, R., Gee, A., Motiang, D., Strydom, P., Mashau, M., Ng'ambi, J., DeKock, R., Heather, B., 2010. Beef palatability in the Republic of South Africa: implications for niche-marketing strategies. Canberra.

van Wijk, M.T., 2014. From global economic modelling to household level analyses of food security and sustainability: How big is the gap and can we bridge it? Food Policy 49, 378–388. doi:10.1016/j.foodpol.2014.10.003

Vanlauwe, B., Coyne, D., Gockowski, J., Hauser, S., Huising, J., Masso, C., Nziguheba, G., Schut, M., Van Asten, P., 2014. Sustainable intensification and the African smallholder farmer. Curr Opin Environ Sustain 8, 15–22. doi:10.1016/j.cosust.2014.06.001

Whitbread, A., Pengelly, B., 2004. Tropical legumes for sustainable farming systems in southern Africa and Australia, in: ACIAR Proceedings No. 115. ACIAR, Canberra, p. 180.

Winter, B., 2011. Beef production in crop–livestock systems: simple approaches for complex problems (No. 145). Canberra.

Wolfgang, B., von Lossau, A., Feldmann, A., 2003. The concept of community ownership and mobilization: Experiences from Community-Based Natural Resources Management, in: Community-Based Management of Animal and Genetic Resources. p. 121.