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RESEARCH ARTICLE

Supporting participatory livestock feed improvement using the Feed Assessment Tool (FEAST)

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Abstract

Livestock production is central to the livelihoods of smallholder farmers in low- and middle-income countries, but livestock are often poorly fed which limits their potential for reducing poverty. Efforts to improve livestock nutrition are often driven by supply-push thinking and fail to engage meaningfully with farmers and the realities they face. The Feed Assessment Tool (FEAST) was developed as a way of involving farmers more closely in decision making on livestock feed improvement. FEAST is a participatory tool which uses focus group discussions and individual farmer interviews to develop a broad overview of the livestock farming system. FEAST has been applied in many countries in the last 10 years. Examples of intensive use come from the Accelerated Value Chain Development Project in Kenya and the Rwanda Dairy Development Project in Rwanda. In both cases the tool was used to inform feed options with strong input from farmers. Although the primary purpose of FEAST is to support improved feed strategies at farm level, the data collected through the FEAST app and published in FEAST reports are a rich information resource that can be useful for developing broader system-level understanding of livestock feed issues. FEAST data can be uploaded into a global data repository where they are available for researchers. These data are also used to generate visualizations of key feed metrics further extending the use of secondary data. FEAST is an example of a participatory tool that moves decision making in the direction of farmers, while providing insights to researchers working across farming systems. Its widespread use across many countries is an indication that it fills a gap in in the livestock feed development space. Its novelty lies in bridging the knowledge gap (both ways) between livestock researchers and small-scale livestock keepers.

Keywords Participatory tools · Livestock · Systems · Data · Smallholder · Livestock feed

1 Introduction

Seventy percent of the world's poor depend on livestock as a component of their livelihood strategy. Further, it has been estimated that one billion people worldwide rely on livestock as their main livelihood (Salmon et al. 2020). Livestock provide multiple benefits for poor people. They supply important nutrients for the household in the form of milk, meat, and eggs (Randolph et al. 2007). These commodities are also sold for cash to provide household income. As well as these tangible benefits the world's rural poor also rely on livestock for a range of indirect benefits including provision of manure, traction, and financial security (Weiler et al. 2014). In most rural communities, different types of livestock are used as a currency for transactions related to social events like agreements, dowry, sacrifices, and rewards (Ng'ang'a et al. 2018). Demand for livestock products is increasing globally, especially in low- and middle-income countries and this represents an opportunity for small-scale livestock producers to contribute to the supply response (Thornton 2010). This will require a step-change in productivity and a transformation of the smallholder livestock sector from subsistence, low-input production, toward more commercial, market-oriented production. One of the key limitations to this transformation is feed (Baltenweck et al. 2020). Smallholder livestock production is generally hampered by inadequate supplies of high-quality feed and

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current production systems are characterized by poorly fed animals which are fed opportunistically with feeds that are immediately available.

Improving the nutrition of smallholder livestock is challenging and has been the focus of much development effort over several decades. Feed is a key limiting factor and often the most expensive input in livestock production (Devendra and Sevilla 2002), representing up to 50–60% of production costs in non-industrial ruminant systems. Integrating feed and forage improvements with improved animal health and genetics has the potential to dramatically increase livestock production—by a factor of 2 or 3 (Henderson et al. 2016) albeit with higher production costs. However, attaining such yield gains has proved difficult. Conventional approaches to feed development have tended to focus on narrow technical solutions, selected in an ad hoc fashion and without sufficient consideration of wider system constraints to the adoption of new feeding technologies and practices. Furthermore, the feed interventions that have been promoted, often fail to deal with the core nutritional constraints faced by smallholder livestock. For example, many development projects have promoted the treatment of cereal crop residues with urea to increase their intake by livestock and improve their quality (Owen et al. 2012). Such interventions work well when a project is promoting them but are rarely sustained beyond the project. There are many reasons for this including cost of inputs relative to benefits, risk of poisoning, the need for specialist knowledge, and the fact that crop residues are often already in short supply. There is often a gulf between the specialist technical knowledge of livestock nutrition experts on the one hand and the practical needs and constraints of farmers on the other (Jackson 2009).

This dissonance between the solutions proposed by livestock nutrition experts and the needs of smallholder livestock keepers for practical new ways of dealing with feed shortages, was the spur for the development of a more systematic approach to the selection of appropriate feed interventions embodied in the Feed Assessment Tool (FEAST) (Duncan et al. 2012). In this paper we describe FEAST and its development as a reaction to the prevailing technology-push approach to livestock feed improvement in low- and middle-income countries. We go on to describe two case studies of FEAST application in Kenya and Rwanda, where applying FEAST with farmers was used to inform decision making at project level on feed interventions. We then provide two examples of how data collected with farmers can inform wider research inquiry, through cross country analysis, and through establishment of an open-access data platform (Fig. 1). We conclude with some reflections on the value of FEAST and similar tools, in structuring a systematic dialogue with farmers, how the application of FEAST changes perspectives of users, and how its use in multiple locations facilitates wider insights.

2 The livestock feed problem

Livestock are ubiquitous across the developing world and most smallholder farmers keep at least a few livestock (Thornton 2010). The livestock enterprise in mixed crop-livestock systems is closely integrated with crop production and indeed one of the primary reasons for keeping livestock is often to support arable production, e.g., through provision of manure and traction (Duncan et al. 2013). Ruminant livestock in smallholder systems in low- and middle-income countries tend to be fed on a mixture comprising crop residues, natural pastures, green material from marginal land such as field margins and roadsides, planted forages, agro-industrial by-products, and limited amounts of commercial concentrate feed (Lukuyu et al. 2011). Feeding is often opportunistic and makes best use of available material mixed in often sub-optimal proportions. Feed intake is often well below potential and the ratio of energy to protein varies from the optimal ratio for efficient rumen fermentation of fibrous material (van Soest 1982). Current feeding regimes are not necessarily inadvisable given the prevailing market conditions and reasons for keeping livestock, which often relate to intangible benefits, as well as obvious economic benefits related to production of meat and milk. Still there is potential for improved livestock feeding and this has been recognized as a promising means of improving smallholder livelihoods and nutrition by development projects. This has often led to promotion of various livestock feed technologies among smallholder farmers including chemical treatment of crop residues to enhance their nutritional value, new planted forage species/varieties, physical processing of roughage feeds through chopping, densifying and pelleting, and new approaches to feed preservation such as hay and silage making (Owen et al. 2012). These technologies are often promoted among small groups of farmers but examples of their spontaneous uptake at scale are relatively rare (Baltenweck et al. 2020). New thinking on livestock feed innovation has included a reframing of the livestock feed problem as one of "innovation system failure" rather than as a problem of lack of technology options. In this framework, research and technical solutions are seen as one element of a wider innovation system and more weight is placed on the need for joined up action by a range of system actors including market actors, regulatory bodies, and civil society (Ayele et al. 2012). Furthermore, the Farmer First movement has advocated for more use of participatory approaches, more engagement of farmers in development decision making, and a move to demand-driven development (Chambers and Thrupp 1994). It is against this background that FEAST was developed as an inclusive and participatory tool to enable farmer-led solutions to address livestock feed issues.

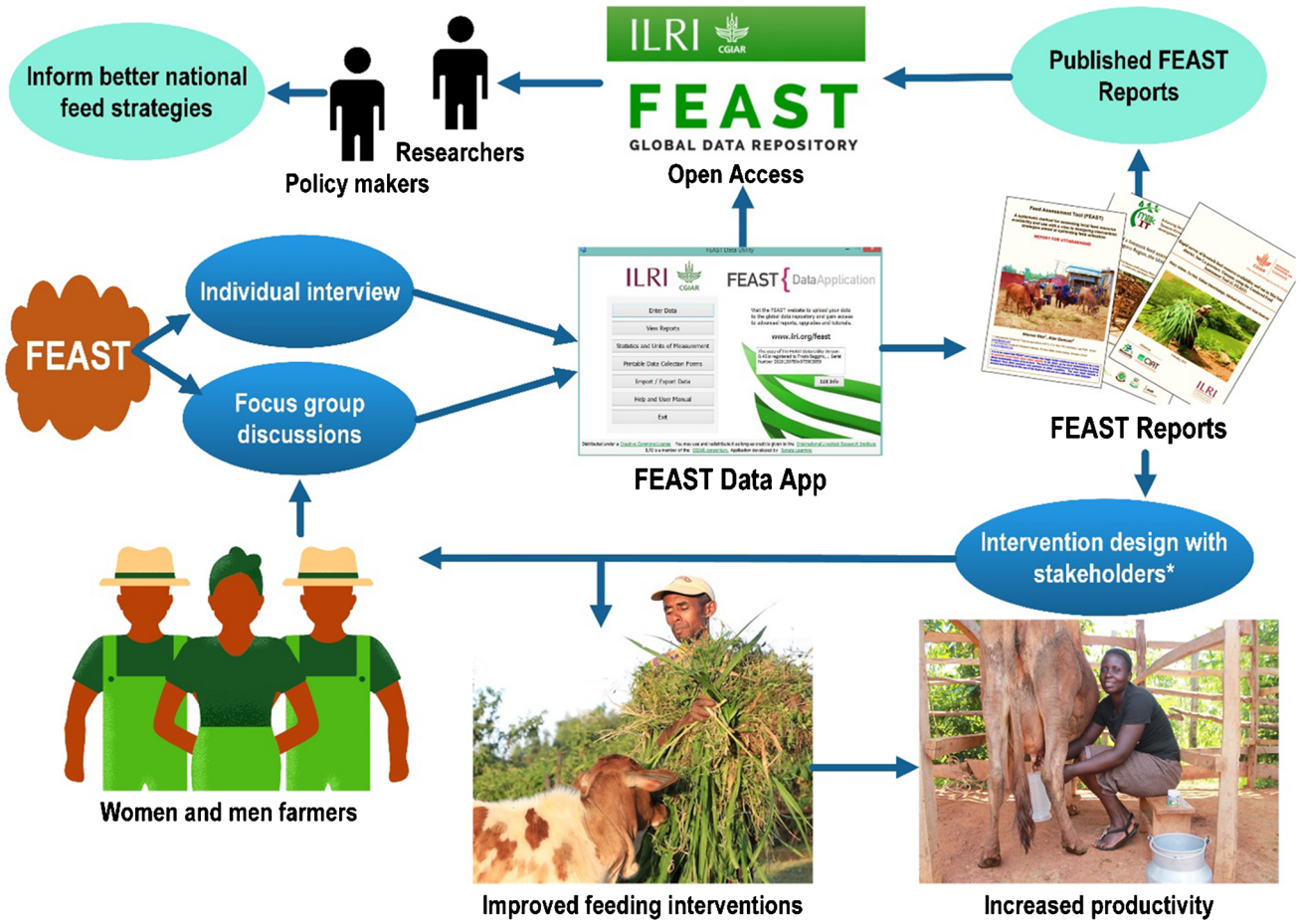

Fig. 1 Schematic showing how the FEAST family of tools starts with farmers and contributes both to improved decision making on feed options by those who work with farmers (researchers, development partners, donors, and private sector actors) while also providing system level data for researchers and policy makers.

3 Materials and methods

3.1 The Feed Assessment Tool (FEAST)

The original FEAST was a product of the Fodder Adoption Project funded by the International Fund for Agricultural Development (2006–2010). Both the Fodder Adoption Project and the Fodder Innovation Project (Department for International Development) running roughly concurrently were expressions of donor frustration at lack of progress in livestock feed development in low- and middle-income countries using conventional approaches. Both projects were influenced by the narrative of innovation systems that had its genesis in the industrialized Global North but was, at the time, influencing research for development projects in the CGIAR and the agricultural research for development community in general (Rajalahti et al. 2008; Hall et al. 2003). This move toward research aimed at understanding the institutional barriers to change in the livestock sector led to experimentation on the use of local innovation platforms to effect change, research on value chains, and research on participatory methods to catalyze innovation in livestock feed development. FEAST was an expression of this broader systems thinking. The two main elements of FEAST, the focus group discussion question guide and the household survey, arose from the International Center for Tropical Agriculture (CIAT) and the International Livestock Research Institute (ILRI) respectively. Within CIAT at the time, there was a strong tradition of using participatory technology development to guide livestock feed interventions, with particular successes in South East Asia (Horne and Stür 1999). Within ILRI, the thinking was that quantitative data collection could provide the necessary evidence for more informed decision making about livestock feed interventions. Both approaches came together at a mini-workshop in Hyderabad, India, in 2009 involving CIAT and ILRI researchers as well as Indian development partners. The framework for FEAST was developed during that meeting and has evolved steadily since then but maintaining the same basic elements.

FEAST is a systematic, participatory approach supporting design of livestock feed interventions at village/community level. It involves a structured conversation with farmers at village level to characterize the local farming system, the role of livestock in the farming system, and the way in which livestock are currently fed. This information is derived from two main elements of the tool. Firstly, a focus group discussion is held involving 10–15 men and women farmers. The objective of the focus group discussion is to reach a consensus view of participants on the following topics. (1) General Farming System Description: this includes information on local farm sizes, household sizes, labor availability, rainfall patterns, irrigation, cropping seasons and types of animals. (2) Management of Livestock Species: this identifies the main purpose of livestock in the farming system and explores how farmers feed and manage livestock. (3) Problems, Issues & Opportunities within the livestock system: this seeks farmers' views on the major problems related to livestock feed, production, and what they see as potential solutions. (4) Distribution of Wealth/Land: this defines categories of farmers by land holdings and allows selection of three farmers from each category (large, medium, and small) for individual farmer interviews. The focus group discussion also involves a discussion of key constraints and solutions to livestock production in the village/community. The focus group discussion is followed by individual farmer interviews involving nine farmers drawn from the focus group to collect additional quantitative data. Farmers selected for individual surveys generally include 3 small-scale farmers, 3 medium-scale farmers, and 3 larger scale farmers (those categories are defined during the focus group discussion). Data from the individual farmer interviews are entered into a data application which generates a series of simple graphical outputs which describe the livestock feeding system. Information from both the focus group discussion and the farmer surveys are used to develop a summary FEAST report including suggestions for intervention strategies. FEAST is strongly linked to informing on-farm feed interventions. Often projects using FEAST organize stakeholder workshops to review problems and solutions identified by farmers and design feed interventions based on farmer inputs. The core elements of FEAST and the post-FEAST process are indicated in Fig. 2.

FEAST has evolved since its early development. The original tool consisted of a focus group discussion guide, a household questionnaire, and a data template in Microsoft Excel. Over the years, the focus group discussion guide and household questionnaire were elaborated and were formally published as the FEAST tool in 2015 (International Livestock Research Institute 2015a, b). At the same time the original Excel spreadsheet was replaced by an Excel application with a user-friendly front end and driven using Visual Basic Macros. In 2015 this was replaced by a standalone data application which was designed to be resilient to changes in computer operating systems. The FEAST data app was made available for download (International Livestock Research Institute 2022) and included much improved data validation at data entry stage. In 2019 a new version of the FEAST tool (G-FEAST) was released which included a gender dimension involving collection of gender disaggregated data and employing separate male and female focus group discussions (Lukuyu et al. 2019a, b). New questions were added to help users to understand gender dimensions of decision making and labor allocation surrounding livestock feed production and use. All FEAST resources are now available through a landing page on the ILRI institutional website (International Livestock Research Institute 2022). The latest versions of the G-FEAST manual give the most comprehensive description of the tool and its implementation (Lukuyu et al. 2019a, b).

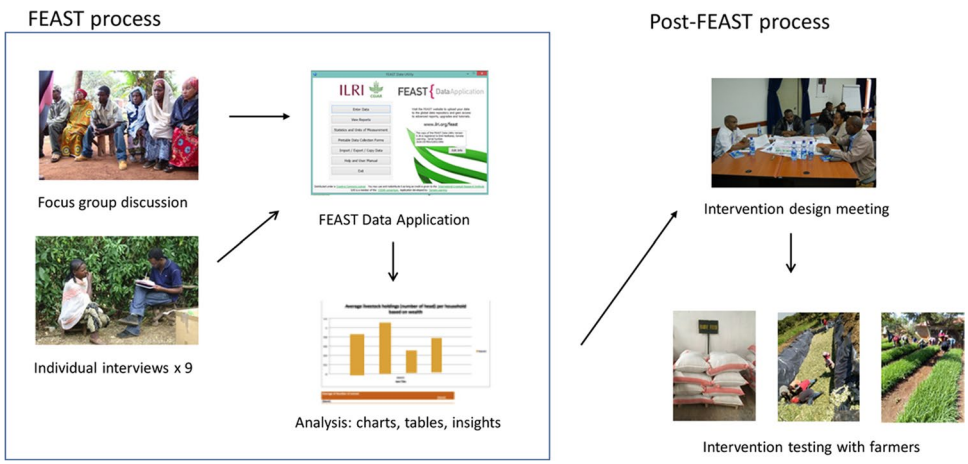

Fig. 2 Schematic illustrating the core FEAST process and how it feeds intervention design post-FEAST.

4 Results and discussion

4.1 Application of FEAST in the Kenya Accelerated Value Chain Development program

The Accelerated Value Chain Development (AVCD) program was implemented in Kenya from 2015 to 2018, by ILRI as the lead Center, International Potato Centre (CIP), and International Crops Research for Semi-Arid Tropics (ICRISAT). Activities of the program involved 21 counties in all the USAID Feed the Future Zones of Influence in Kenya. The AVCD program focused on putting research technologies into use, and in the process generating new income streams from agriculture, increasing food and nutrition security at household and community level, and transforming the agricultural landscape across 21 counties. The program concentrated on promoting "farming as a business" to catalyze the development of four key value chains. FEAST was applied in the Livestock Value Chain and the Dairy Value Chain to engage farmers in identifying promising feed solutions.

The Livestock Value Chain was focused on pastoral systems and its overall objective was to accelerate the development of livestock production, mainly small ruminants, to improve access to improved grazing areas, providing support to livestock marketing associations and private sector enterprises, and applying improved livestock management practices. It focused on 5 counties in the arid and semi-arid lands namely Isiolo, Garissa, Marsabit, Turkana, and Wajir counties (Fig. 3).

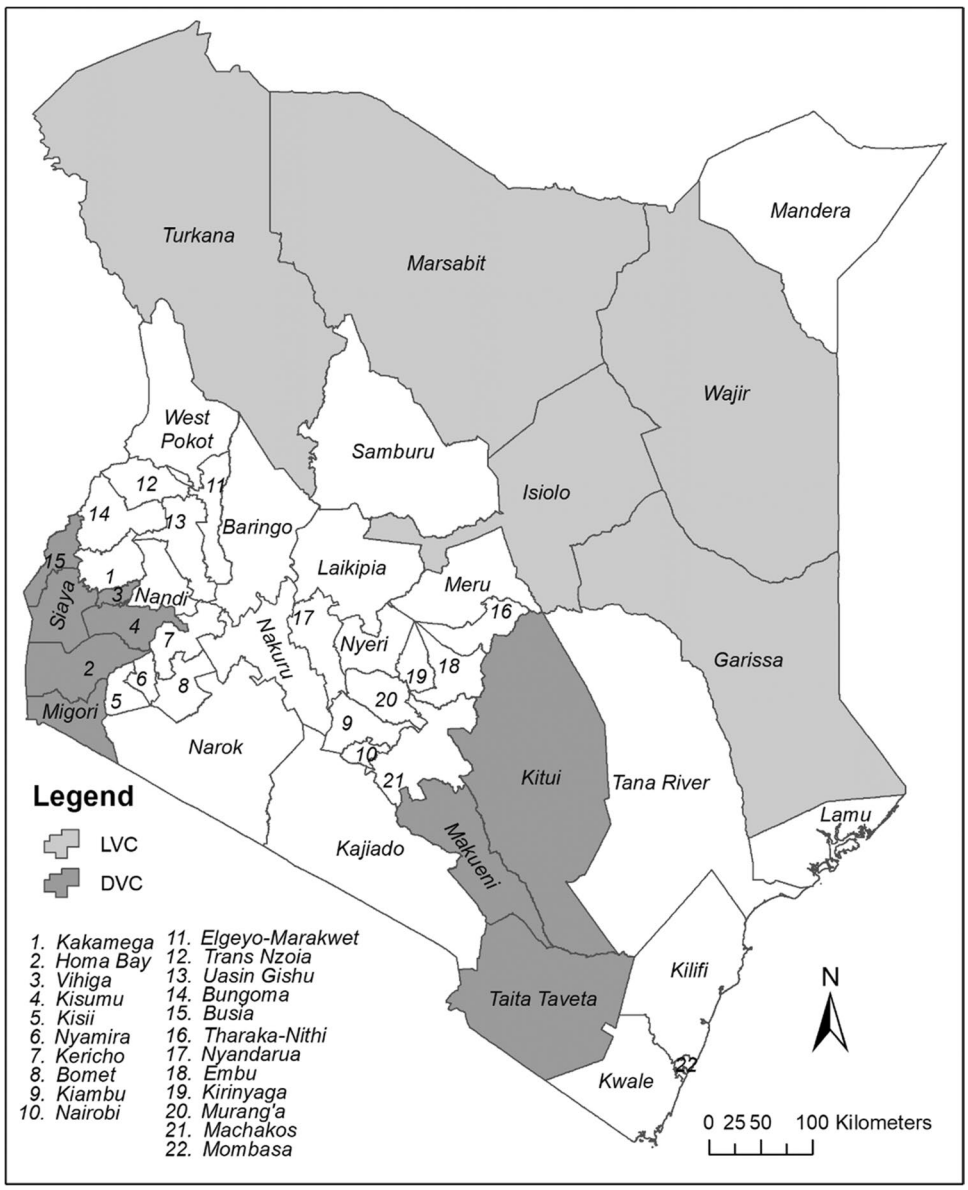

Fig. 3 Map showing locations of 14 counties where FEAST was implemented in Coastal, Eastern, North-eastern, and Western study sites in Kenya AVCD program. Sampled locations shaded.

The Dairy Value Chain component of the program aimed to contribute to improved dietary diversity, food security, and rural incomes in Kenya through enhanced milk production, productivity, and availability at household level across nine counties: Migori, Kisumu, Vihiga, Siaya, Busia, Homa Bay, Taita Taveta, Kitui, and Makueni. The focus of the Dairy Value Chain interventions was to accelerate the development of dairy farming in non-traditional dairy regions in Kenya attracting the interest of many households that had not ventured into the dairy value chain. The cattle are reared under confined, tethering/grazing, semi zero grazing, and zero grazing feeding regimes. The main sources of feed include natural pastures, planted forages, and crop residues. Animals in intensive systems are confined and fed in cattle sheds while semi-intensive system animals are sometimes put out to graze. Lack of adequate feed is a major limiting factor to dairy production (Mburu 2015).

A key constraint to milk production in AVCD project sites was inadequate feed availability especially in the dry season. The first step was to identify the most suitable feed options using FEAST. The FEAST implementation process involved a series of steps as follows:

I. Training of facilitators in use of FEAST and the process of engaging with local communities

A total of 61 FEAST facilitators were trained from all project sites. Participants learned about the various components of FEAST including the participatory data collection process through focused group discussions, individual farmer survey, data entry into the FEAST app, the reporting format, and how to move from FEAST reports to successful livestock feed interventions.

II. Conducting FEAST and producing simple FEAST reports summarizing livestock feed issues in target sites

After the training, FEAST was implemented in 45 project sites by technical teams.

III. Identification of livestock feed interventions for promotion by the AVCD project

In the Dairy Value Chain, following application of FEAST in project sites, several feed interventions were identified in a workshop held in November 2016. The workshop brought together the FEAST implementing teams that comprised local county government livestock production staff in all target sites, Village-based Advisors with Farm Input Promotions Africa Ltd (FIPS-Africa), and some cooperative management officials. The main objectives of the workshop were to review FEAST reports and synthesize problems/constraints, and solutions proposed by farmers, and technical interventions suggested by the FEAST. These findings were used as a starting point of discussions to determine which priority interventions made sense for each project site. Selected interventions from this workshop were tested with farmers. In the Dairy Value Chain, the AVCD program worked with Farm Input Promotions Africa Ltd (FIPS-Africa) to promote a portfolio of technologies and methods ("options") through Village-based Advisors who help their neighbors increase productivity on their farms. Village-based Advisors worked with farmers to promote new forages, introducing small scale machines for harvesting and chopping feeds and building capacity of farmers to use the new technologies.

In the livestock value chain, FEAST assessments identified feed/fodder scarcity especially seasonal feed scarcity as the key issue in the project sites. It generally concluded that without improvement in the availability of feed, interventions in markets and marketing, livestock health, and herd management would be futile. FEAST findings suggested a set of technologies and innovations that could improve productivity, for example (a) fodder cultivation; (b) intercropping of legumes and grasses for production of high-quality forage; (c) milling and blending of legumes and grasses to produce high quality fodder; and (d) preservation of excess fodder through ensiling could be promoted.

Interventions emerging from application of FEAST in AVCD can be summarized as follows:

I. Introduction of new forage varieties: To overcome inadequate feed quantity and quality in dry seasons, and knowledge gaps in feed and forage production, management, and use in Western and Nyanza regions, new Brachiaria grass varieties including *Brachiaria decumbens* cv. Basilisk, *B. brizantha* cv. MG4, *B. brizantha* cv. Piatã, and *B. brizantha* cv. Xaraés were promoted. They are best suited for semi-arid, sub-humid, and humid project areas. The AVCD project supported individuals, groups, or cooperatives to produce and supply splits/cuttings of Brachiaria grass to farmers including commercialization of Brachiaria grass and building capacity of farmers on improved forages through a Training of Trainers approach. In Eastern and Coastal areas, rangeland grass species including *Andropogon appendiculatus*, *Cenchrus ciliaris*, and *Panicum maximum* were promoted. The program worked with farmer cluster leaders to establish bulking plots that became the source of planting materials for farmers. Through these community bulking plots, farmers accessed clean planting materials including Napier grass, Desmodium spp., and Brachiaria grass splits, at affordable price within their localities.
II. Building capacity of farmers and other value chain actors: Knowledge gaps in feed and forage production, management, and use was identified as a major

constraint to dairy production through conversations with farmers during the FEAST process. The AVCD program supported dairy cooperatives to implement a private sector-led extension program dubbed the Dairy Farmer Assistant model. The extensionists (Dairy Farmer Assistants) took a leading role in offering technologies to the farmers and providing technical backstopping.

III. On-farm feed ration formulation using local feed resources: Lack of skills in diet formulation was identified through FEAST as a key challenge to the better use of locally abundant crop residues, e.g., sugarcane tops, maize stovers, and rice straws. The project trained Dairy Farmer Assistants on diet formulation and supported them to give hands-on training to farmers on how to formulate and mix feeds on farms. The project developed an open online self-learning module where Dairy Farmer Assistants and other extension service providers could go for refresher training on dairy farming.

IV. Mechanized harvesting and chopping of feed and forages: Through dialogue with farmers during application of FEAST, harvesting of forages was identified as a tedious and time-consuming task that deterred most farmers from adopting practices of feed processing to improve feed use. AVCD worked with dairy cooperatives to promote the use of mechanized harvesting of forage using brush cutters and feed choppers. The machines helped to alleviate demand on labor and create employment for local youth. The cooperative supported youth to purchase brush cutters and feed choppers and then to provide harvesting/chopping services to other members of the cooperative at a fee.

The findings from FEAST were used to develop feed plans for dairy cooperatives in the Dairy Value Chain areas (Lukuyu et al. 2021). Feed plans were developed to guide dairy cooperatives in feed resourcing to support farmers to meet nutrition requirements of their herds throughout the year. Dairy Farmer Assistants were involved in the feed planning process. The AVCD project achieved notable progress in feed development supported using FEAST, particularly in the Dairy Value Chain (International Livestock Research Institute 2017). A total of 12,392 hectares was planted with Brachiaria grass against a target of 6836 hectares (Maina et al. 2020). As well as forage Brachiaria establishment, farmers were trained on fodder conservation including simple baling technologies. For example, three community-based organizations produced a surplus of 1900 bales of Brachiaria grass, which they sold at Kshs 300 per bale, thus earning a total of Kshs 570,000. Some large-scale farmers were supported to establish large forage fields and linked to dairy cooperatives for sale. The project established 240 nurseries and trained 2521 farmers on multiplying planting material for Napier grass, Brachiaria, Calliandra, and Desmodium fodder crops. Some farmers took up the business of producing and selling seedlings to other farmers. These changes illustrate the way in which FEAST moved feed development activities beyond simple feed technology promotion toward organizational innovations such as forage and seed marketing as well as capacity development activities which were identified as key barriers to feed development through FEAST exercises.

4.2 Application of FEAST in the Rwanda Dairy Development Project (RDDP)

In Rwanda FEAST was applied in the Rwanda Dairy Development Project (RDDP), a project of the Government of Rwanda supported by the International Fund for Agricultural Development (IFAD). The rationale for RDDP was based on the strong potential for smallholder dairy development and the potential benefits for smallholder producers. In response the Government of Rwanda set a goal of doubling milk production from 2010 to 2030 (International Fund for Agricultural Development 2016). RDDP initiated different feed resource development interventions being implemented through Livestock Farmer Field Schools and forage seed multiplication initiatives under its project. The project identified lack of feed resources as a major blockage to achieving the goal of doubling milk production. As a result, RDDP contracted ILRI in 2019 to work with Rwanda Agriculture and Animal Resources Development Board and University of Rwanda to offer technical assistance on feed development, including diagnosis of livestock feed constraints using the FEAST methodology. The outputs from FEAST were expected to provide both quantitative and qualitative information on overall feed availability, its quality and seasonal variation, which would then be used to design intervention strategies. Activities were conducted using a blend of virtual and face-to-face engagement, against the backdrop of the COVID pandemic.

FEAST assessments in RDDP sites in Rwanda involved a series of steps similar to those used in Kenya AVCD:

I. Training of FEAST Lead trainers

A FEAST training workshop of Lead trainers for FEAST was held in January 2019 in Kigali, Rwanda, involving participants from Rwanda Agriculture and Animal Resources Development Board, University of Rwanda (UR), and from the Ministry of Agriculture and Animal Resources. They included mainly government officers with livestock knowledge who facilitated the implementation of FEAST and subsequent feed interventions in selected RDDP project areas in Rwanda.

II. Conducting FEAST and producing simple FEAST reports summarizing livestock feed issues in target sites

Following training, six target sites were selected for FEAST implementation. Teams of facilitators collected data on local feed resource availability and use using FEAST and produced FEAST reports as well accompanying datasets for each site. FEAST was implemented in Nyagatare, Gicumbi, Musanze, Rubavu, Nyanza, and Rutsiro (Fig. 4). FEAST reports presented an overview of the livestock feeding system in each site and provided some preliminary ideas for feed interventions based on the information collected with farmers.

III. Identifying and designing feed interventions

A workshop to identify and design livestock feed interventions was held in May 2019 in Kigali, Rwanda, including trained FEAST facilitators from Rwanda Agriculture and Animal Resources Development Board, University of Rwanda and Ministry of Agriculture and Animal Resources. The workshop focused on agreeing "best bet" feed interventions based on FEAST findings and developing plans for implementation of livestock feed interventions in different sites. This exercise was preceded by a field trip to some of the RDDP sites. Several feed-related interventions were implemented across the different project sites. Some of the interventions were husbandry interventions that were supported by livestock nutrition interventions.

The FEAST process and associated training supported implementation of a number of interventions including:

I. Zero-grazing as a dairy production system was promoted coupled with distribution of improved breeds to improve household nutrition and income status through increased milk production. Cowsheds, water tanks, and animal feed stores were also established on farms across project sites. These measures were designed to improve cattle housing conditions and drinking water provision. Seasonal feed shortages were identified as a serious constraint and forage storage facilities were promoted. These interventions were supported through matching grants whereby farmers constructed stands for the water tanks and RDDP supplied the tanks to the farmers free of charge. RDDP also offered support to the farmers for construction of cowsheds and feed stores in the form of matching grants.
II. Forage seed multiplication plots for forage seed production were established in the Livestock Farmer Field Schools. Lead trainers gave training on various agronomic practices for improved forage production. Lead trainers were trained by ILRI to support the farmers. After the training and demonstration, forage seeds were distributed to farmers and to collective

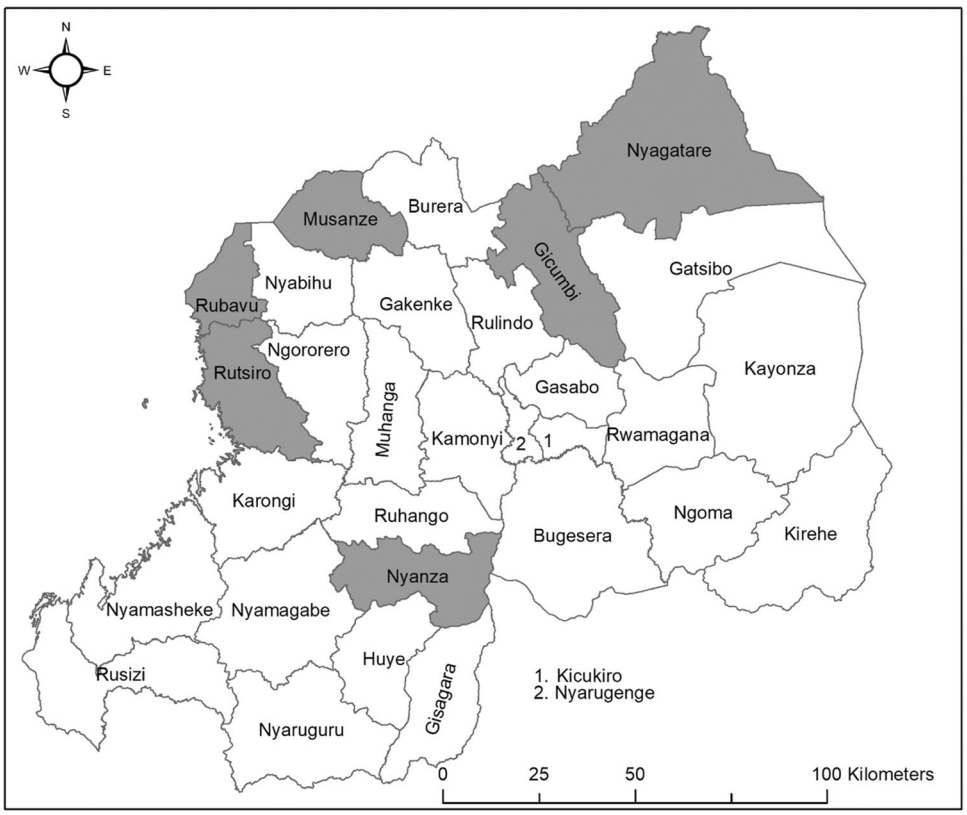

Fig. 4 Map showing locations of 6 districts where FEAST was implemented in the Rwanda Dairy Development project. Sampled locations in gray.

farms for forage production. Various forage varieties that were adapted to the agro-ecological conditions in each of the sites were promoted. Additional forage varieties were also being grown by the farmers.

III. Crop residue feeding practices to make more efficient use of crop residues for dairy feeding were also promoted in the Livestock Farmer Field Schools. Training was given on optimal mixtures of the locally available crop residues and forages to enhance productivity.

IV. Forage conservation including hay making was also promoted. Farmers belonging to the different Livestock Farmer Field Schools were taught how to make dry hay. Additionally, every Livestock Farmer Field School was given at least one fodder chopper by RDDP to facilitate the process of forage conservation

Embedding of FEAST in a large development project such as RDDP presented opportunities but also challenges. RDDP provided an excellent framework within which to implement FEAST. There was a ready-made set of sites and well-established Farmer Field Schools, which meant that farmers were already part of an organizational structure and local relationships were well established. Furthermore, there were funds for implementation of interventions. The embedding in RDDP also presented some challenges. There was considerable existing momentum in RDDP before FEAST was implemented. There was a need to show implementation progress, which meant that intervention selection sometimes went ahead of the FEAST process. Furthermore, although the funds for roll-out of interventions such as forage storage facilities were useful, the use of project funds did raise questions about the sustainability of some of the more capital-intensive interventions, and whether the innovations would persist post-project.

4.3 Evidence of impact

In general, in both AVCD Kenya and RDDP Rwanda, although FEAST was only a small component of two very large projects, it was appreciated by project managers and farmers in helping to introduce a participatory, farmer-centered approach to feed intervention selection and design. Use of FEAST ensured that farmers were consulted about feed issues and their views on what the main livestock production constraints were. In many cases, these included feed constraints but not exclusively. Interventions emerging from FEAST conversations were often broader than simply improving feed options, and this also helped to ensure success.

In Rwanda, we conducted a light evaluation of the extent to which farmers felt that FEAST had led to better outcomes than business as usual. Farmer perceptions regarding sustainability and impact of feed interventions indicated that farmers appreciated the various feed interventions emerging from FEAST implementation in the six RDDP sites, but for different reasons. For example, results indicated that one key benefit of feed interventions was that forage introductions saved labor, especially for women, which could be diverted to other economic and social activities. Results also showed that FEAST application had broader benefits beyond simple improvement of feed supply and quality; the interventions also improved social cohesion at study sites (Ahumuza et al. 2021).

We also collected informal feedback from the FEAST technical team in Rwanda. One researcher/lecturer from the University of Rwanda indicated: "(Through FEAST), problems were identified as well as possible solutions. Some of the solutions required capital to be solved. For example, in Nyagatare District farmers have a challenge of water scarcity and solution was to harvest rainwater and build dams where water can be stored. Feed harvesting was also identified, to solve the issue of feed scarcity". Feed harvesting in this context was shorthand for forage establishment, pasture improvement and management, harvesting, forage conservation and utilization (Nshokeyinka et al. 2019). According to an RDDP field officer, one of the benefits of FEAST was as a catalyst for farmer mobilization: "Regarding the implementation and adoption of FEAST, it was used in farmers' mobilization especially in advising them on dairy feeding. FEAST at farm level allowed us to start to advise farmers on feed formulation based on available feeds".

Further evidence of the usefulness of applying FEAST comes from an IFAD supervision mission report which evaluated the entire RDDP project. The report highlights the effectiveness of FEAST in identifying the key feed issues in each target site. It further acknowledges close alignment between the feed solutions emerging from FEAST and the interventions being pursued by the wider project. Finally, it commits to the use of FEAST recommendations in the future phase of the RDDP project (IFAD 2020).

In Kenya, use of FEAST led to various changes in the way to the project was implemented and the types of feed interventions that were pursued. Many of the changes related to improving communications among key stakeholders and fostering better collaboration. The starting point for change was therefore institutional rather than technical although technical changes did then follow. For example, dairy cooperatives realized that they could use FEAST to develop feed plans for their members. Farmers developed insights into alternative locally available feed resources which they could use to diversify diets for their livestock. Feed plans at cooperative level led to cooperatives signing contracts with input suppliers for supply of hay and concentrate feeds based on estimates from feed plans (Lukuyu et al. 2021).

FEAST also allowed knowledge gaps to be identified and training activities to be developed. Extension officers

used FEAST reports to identify livestock topics that had knowledge gaps and developed training activities on proper feeding of dairy cattle to increase productivity (International Livestock Research Institute 2017). Some of the extension staff also went on to use the FEAST tool on other projects.

Finally, the FEAST process enabled better interactions among stakeholders—farmers, dairy farmers assistants, government extension staff, non-governmental partners—that boosted ownership of the FEAST process and more importantly the emerging feed interventions.

4.4 Secondary use of FEAST data to generate system level understanding

The data collected through the FEAST app and published in FEAST reports are a rich information resource that can be used as a secondary data source for developing broader system-level understanding of livestock feed issues.

I. Cross country analysis of FEAST reports to understand key constraints in smallholder agriculture

The core purpose of FEAST is to support better livestock feed intervention strategies at community level through more engagement with farmers in the feed intervention selection process. However, a by-product of applying FEAST in many locations is the accumulation of lots of standardized information on livestock feeding systems across many locations. In many cases this information is documented and published in the form of FEAST reports, which provide a knowledge resource for further synthesis. Such synthesis can provide broad-scale information on feed constraints, feeding practices and general understanding of the livestock system https://cgspace.cgiar.org/handle/10568/16490. In a recent exercise, published FEAST reports were used to conduct an analysis of farmer perceptions on the main limiting factors to improved livestock productivity across multiple locations (Duncan 2021). Around 80 FEAST reports have been published reporting findings from around 150 focus groups, across 14 countries, and involving close to 3000 farmers (Fig. 5). Part of the FEAST process is a ranking exercise with farmers where they are asked to identify the main constraints to livestock production in their location. A ranking exercise is used to develop a prioritized list of constraints. Textual analysis was then used to assign each listed constraint to one of nine constraint categories. These were weighted by their position in the ranked list to come up with an importance score for each issue. The scores were allocated to ranks as follows: Rank 1 = 5, Rank 2 =4, Rank 3 = 3, Rank 4 = 2, Rank 5 = 1. Results of this exercise yielded insights on the relative importance of production constraints according to farmers (Fig. 5). Feeding and health issues featured strongly among perceived constraints among farmers. Infrastructure, knowledge, and breeding constraints were also important. More detail, including on issues contributing to each constraint, can be found in the original source (Duncan 2021).

II. Development of Global Data Repository for FEAST

As demonstrated above, results from individual reports provide much-needed insights into key constraints in smallholder livestock enterprises. However, it is time consuming to conduct such analyses. This means that location or time specific results are not adequately generalized into regional trends. To overcome this gap in generalizability, a global

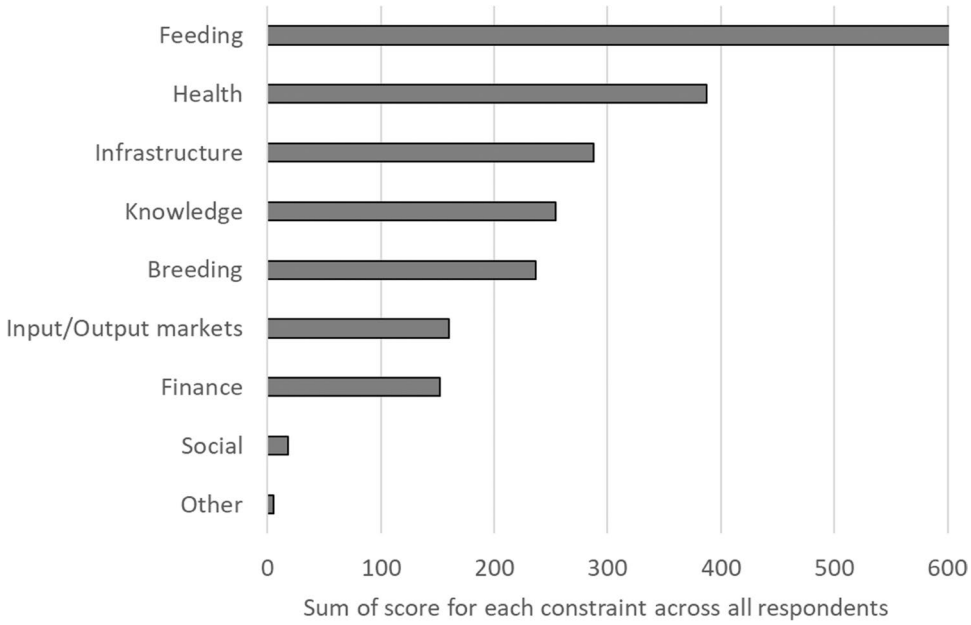

Fig. 5 Assessment of the most important constraints in livestock management (number of mentions of key constraints to livestock productivity across 149 focus group discussions involving 2796 farmers in 14 countries).

FEAST data repository has been developed and is used to aggregate data for further analysis and quick access to visualizations (Alemu et al. 2021).

The global FEAST data repository facilitates system level understanding at project, village, and regional levels (Fig. 1). The repository is continually growing with current data spanning 170 sites across 12 countries in tropical latitudes (Fig. 6). Responses from focus group discussions and individual interviews are aggregated, providing a multi-regional resource on: farm system constraints, livestock holdings, feed availability, purchased feed, fodder cultivation, crop cultivation, decision making, labor, income and co-operative membership. Results are processed and made available as open data and publication-ready visualizations. Further visualizations were developed in collaboration with www.livestockdata.org (Livestock Data for Decisions 2020). Secondary analysis of these results can provide evidence for decision making on sector development priorities for development projects or national livestock master plans. Informed decision making will become increasingly important as demand for livestock products increases and feed resources become increasingly scarce.

5 Conclusion

5.1 Potential and limitations of FEAST and other participatory digital tools

Participatory tools continue to be prominent in agricultural research. Four decades after Chambers and others kicked off the Farmer First Revolution (Chambers et al. 1983), the use of participatory approaches is now well embedded in agricultural research. More recently, advances in information and communication technology have spawned a plethora of digital tools and methodologies to support research and decision making in the smallholder agricultural sector in low- and middle-income countries (Vásquez-Bermúdez et al. 2019) and increasing donor interest in information and communication technologies for agriculture (World Development Report 2021). FEAST is one such tool. Others include AKT5 (Walker and Sinclair 1998), RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Schut et al. 2015), iCow (Marwa et al. 2020) and AgroDuos (Steinke and van Etten 2017). Participatory digital tools do not always live up to their promise however (Heeks 2002). Their use has stimulated criticism on several fronts. Participatory tools involving focus groups and surveys are time consuming and require considerable expertise to implement properly (Steinke and van Etten 2017). They can also play into existing power imbalances and give the illusion of empowering farmers and increasing their agency, while in reality they perpetuate existing power structures, and serve researchers' interests more than the intended communities' (Barnaud and van Paassen 2013; McCampbell et al. 2021).

Some tools are simple systematic question guides and require no technical infrastructure to support them. Others are more data driven and have associated software applications at their core. Decision support systems relying on software can be problematic since they require regular maintenance and updates and the software is often a "black box"

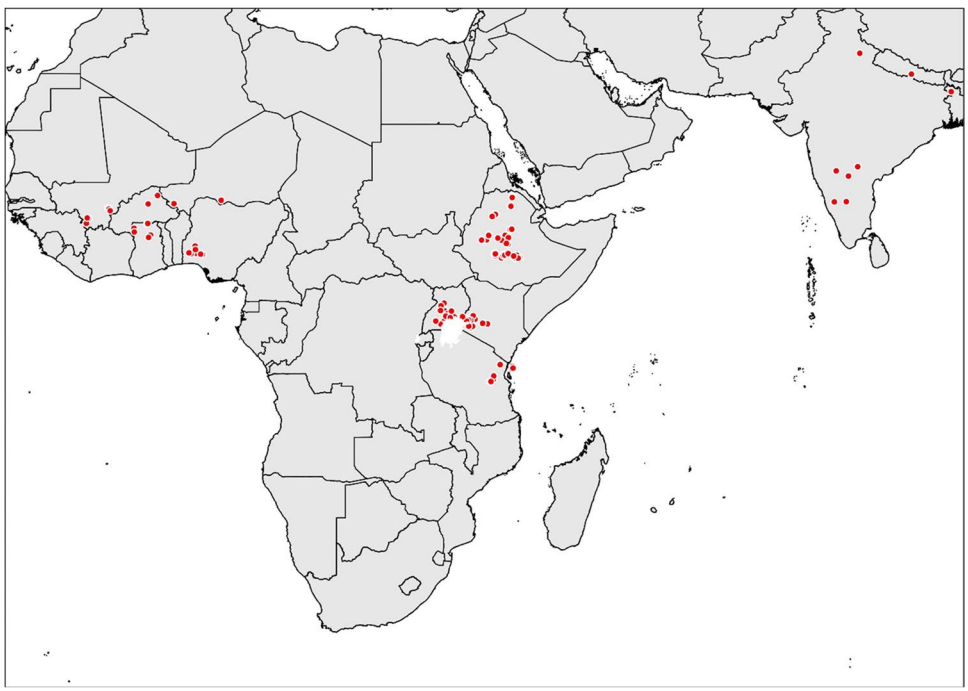

Fig. 6 Geographical distribution of publicly available FEAST reports.

which hides algorithms from users. The decision support emerging from such systems can look credible but can tend to over-ride common sense decision making.

Despite these shortcomings, tools such as FEAST do have several positives. FEAST provides a mechanism to support pro-poor agency (as conceptualized in Marshall et al. (2018)). FEAST provides a systematic approach to describe the livestock systems with feed as the targeted problem domain. FEAST intentionally crosses the knowledge systems of (a) the rural communities and (b) scientific communities. This means that implementation potentially affects the participants, the surrounding rural communities, and the researchers themselves. For instance, even though the number of farmers directly involved is relatively small, the learning and choice of interventions does spill over to other farmers partly through farmer-to-farmer exchange but also through new insights among researchers. In the AVCD project in Kenya, the number of farmers benefiting from improved feed options far exceeded those involved in FEAST exercises. Indeed, one of our learnings has been about the effect of applying FEAST on the researchers involved. In our experience, use of FEAST channels researchers into having meaningful conversations with farmers about the constraints they face and the lived realities of farming life. This can generate more realism among researchers about which interventions are likely to work and can break down the "cognitive dissonance" so often embedded in the mindset of researchers whereby *their* technical solutions are always the best thing for farmers to adopt (Jackson 2009). This change of mindset is difficult to quantify but has large potential impacts on actors whose aim is to support farmers, leading them toward a more farmer-centered approach.

Researchers are often looking for tools such as FEAST to deliver "silver bullet" solutions that will transform livestock production. FEAST does not deliver such blueprints but needs to be seen as a conversation starter and facilitator of positive change. When speaking of ICT solutions more generally, de Brauw and Bulte (2021) assert that this facilitation role is most effective when the information is relevant to decision makers and that those decision makers have the power and incentives to act. This means that it is the process of applying FEAST as much as the information that is generated from its use that has the potential to foster improved intervention strategies.

Finally, FEAST was originally designed as a way of increasing farmer involvement in livestock feed intervention design. A by-product of its use across multiple global locations is the rich information resource that has built up over the course of its use. In common with other agricultural development digital tools, the data landscape behind the tool has much potential to help researchers understand agricultural constraints at system level, thereby enhancing decision making among policy makers as well as at grassroots level.

Authors' contributions AJD conceived the paper and led the writing. BL wrote the Kenya case study and Gilbert Mutoni wrote the Rwanda case study. Simon Fraval wrote material on the FEAST Global Data Repository and improved other parts of the paper. Zelalem Lema helped with writing and conceptualization.

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Data availability FEAST data are available for public use at www.feastdata.org. Many FEAST reports can be found on CGSpace and a link to all reports is to be found at www.ilri.org/feast.

Code availability Not applicable

Declarations

Ethics approval Use of FEAST in AVCD and RDDP was approved through ILRI's Institutional Research Ethics Committee

Consent to participate Informed consent was given by FEAST participants in AVCD and RDDP.

Consent for publication Informed consent given by FEAST participants in AVCD and RDDP included statements about results being published in the public domain but without possibility of identification of individual respondents.

Conflict of interest The authors declare no competing interests.

References

Ahumuza R, Mutoni G, Ouma E, Lukuyu B, Nshokeyinka J, Duncan A (2021) Feed interventions under the Rwanda Dairy Development Project–farmer perceptions regarding sustainability and impact. ILRI Research Report 99. ILRI, Nairobi. https://hdl.handle.net/10568/117679

Alemu M, Mungai K, Fraval S (2021) Feed assessment tool (FEAST) data repository - PHP code anddatabase structure for website

version 2.0.0. Source code. Nairobi, Kenya: ILRI. https://hdl.handle.net/10568/111320
Ayele S, Duncan A, Larbi A, Khanh TT (2012) Enhancing innovation in livestock value chains through networks: lessons from fodder innovation case studies in developing countries. Sci Public Policy 39:333–346. https://doi.org/10.1093/scipol/scs022
Baltenweck I, Cherney D, Duncan A et al (2020) A scoping review of feed interventions and livelihoods of small-scale livestock keepers. Nat Plants 6:1242–1249. https://doi.org/10.1038/s41477-020-00786-w
Barnaud C, van Paassen A (2013) Equity, power games, and legitimacy: dilemmas of participatory natural resource management. Ecol Soc 18:art21. https://doi.org/10.5751/ES-05459-180221
Chambers R, Thrupp LA (1994) Farmer first: farmer innovation and agricultural research. Karthala Editions
de Brauw A, Bulte E (2021) Silver bullets? In: African farmers, value chains and agricultural development. Palgrave Macmillan, pp 155–188
Devendra C, Sevilla CC (2002) Availability and use of feed resources in crop–animal systems in Asia. Agric Syst 71(1–2):59–73
Duncan AJ (2021) What are the main limits to livestock production in the tropics – according to farmers? In: International grasslands and rangelands conference. https://hdl.handle.net/10568/119671
Duncan AJ, York L, Lukuyu B et al (2012) FEAST: Feed Assessment Tool Questionnaire for Facilitators (Version 5.3). Addis Ababa
Duncan AJ, Tarawali SA, Thorne PJ et al (2013) Integrated crop-livestock systems – a key to sustainable intensification in Africa. Trop Grassl Forrajes Trop 1:202. https://doi.org/10.17138/TGFT(1)202-206
Hall A, Rasheed Sulaiman V, Clark N, Yoganand B (2003) From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. InAgricultural Systems, Elsevier. 78(2):213–241. https://doi.org/10.1016/S0308-521X(03)00127-6
Heeks R (2002) Information systems and developing countries: failure, success, and local improvisations. Inf Soc 18:101–112. https://doi.org/10.1080/01972240290075039
Henderson B, Godde C, Medina-Hidalgo D et al (2016) Closing system-wide yield gaps to increase food production and mitigate GHGs among mixed crop–livestock smallholders in Sub-Saharan Africa. Agric Syst 143:106–113
Horne PM, Stür WW (1999) Developing forage technologies with smallholder farmers. ACIAR Monograph 62
International Fund for Agricultural Development (2016) Rwanda Dairy Development Project - Detailed Design Report. Rome
International Fund for Agricultural Development (2020) Rwanda Dairy Development Project Supervision Report. Mission Dates: 18-29 May 2020. Report number 5440-RW. Rome
International Livestock Research Institute (2015a) Feed assessment tool (FEAST) individual farmer interview questionnaire. Addis Ababa. https://hdl.handle.net/10568/65966
International Livestock Research Institute (2015b) Feed assessment tool (FEAST) focus group discussion guide. Addis Ababa. https://hdl.handle.net/10568/100243
International Livestock Research Institute (2017) Accelerated Value Chain Development Program (AVCD): 2016/17 Annual Progress Report. ILRI, Nairobi. https://hdl.handle.net/10568/101924. Accessed 18 Nov 2022
International Livestock Research Institute (2022) FEAST landing page. https://www.ilri.org/feast. Accessed 5 Oct 2022
Jackson MG (2009) Community learning for empowerment. In: Proceedings of a Workshop on Community Learning held at Almora 22-23 May 2009
Livestock Data for Decisions (2020) FEAST: What livestock eat in low- and middle-income countries. In: https://livestockdata.org/data-object/feast-what-livestock-eat-low-and-middle-income-countries
Lukuyu B, Franzel S, Ongadi PM, Duncan AJ (2011) Livestock feed resources: current production and management practices in central and northern rift valley provinces of Kenya. Livestock Research for Rural Development 23
Lukuyu B, Eerdewijk AV, Kinati W, et al (2019a) Gendered feed assessment tool (G-FEAST) individual farmer interview questionnaire. Addis Ababa. https://hdl.handle.net/10568/100244
Lukuyu B, Eerdewijk AV, Kinati W, et al (2019b) Gendered feed assessment tool (G-FEAST) focus group discussion guide. Addis Ababa. https://hdl.handle.net/10568/100243
Lukuyu B, Rao EJO, Githinji J (2021) Feed the future accelerated value chain development (AVCD) program: feed plans for producer organizations in Nyanza region, Kenya: implementation of feed plans through producer organizations to improve productivity. ILRI, Nairobi https://hdl.handle.net/10568/114309
Maina KW, Ritho CN, Lukuyu BA, Rao EJO (2020) Socio-economic determinants and impact of adopting climate-smart Brachiaria grass among dairy farmers in Eastern and Western regions of Kenya. Heliyon 6:e04335. https://doi.org/10.1016/j.heliyon.2020.e04335
Marshall F, Dolley J, Priya R (2018) Transdisciplinary research as transformative space making for sustainability: enhancing propoor transformative agency in periurban contexts. Ecol Soc 23:8. https://doi.org/10.5751/ES-10249-230308
Marwa ME, Mburu J, Oburu REJ et al (2020) Impact of ICT based extension services on dairy production and household welfare: the case of iCow service in Kenya. J Agric Sci 12:1–12. https://doi.org/10.5539/jas.v12n3p141
Mburu LM (2015) Effect of seasonality of feed resources on dairy cattle production in coastal lowlands of Kenya. http://erepository.uonbi.ac.ke/handle/11295/90790
McCampbell M, Schumann C, Klerkx L (2021) Good intentions in complex realities: challenges for designing responsibly in digital agriculture in low-income countries. Sociol Ruralis. https://doi.org/10.1111/soru.12359
Ng'ang'a SK, Ritho C, Herrero M, Fraval S (2018) Household-oriented benefits largely outweigh commercial benefits derived from cattle in Mabalane District, Mozambique. Rangel J 40:565–576. https://doi.org/10.1071/RJ17115
Nshokeyinka J, Manishimwe A, Kagwa E, Maurice R, Niyiragira V, Lukuyu BA (2019) Characterization of livestock production systems and identifying potential feed interventions for increasing dairy productivity in Nyagatare district, eastern Rwanda. ILRI report accessed at https://hdl.handle.net/10568/111262
Owen E, Smith T, Makkar H (2012) Successes and failures with animal nutrition practices and technologies in developing countries: a synthesis of an FAO e-conference. Anim Feed Sci Technol 174:211–226
Rajalahti R, Janssen W, Pehu E (2008) Agricultural innovation systems: from diagnostics toward operational practices. Washington, DC: Agriculture & Rural Development Department, World Bank
Randolph TF, Schelling E, Grace D et al (2007) Role of livestock in human nutrition and health for poverty reduction in developing countries. J Anim Sci 85:2788–2800
Salmon GR, MacLeod M, Claxton JR et al (2020) Exploring the landscape of livestock 'Facts.' Glob Food Sec 25:100329. https://doi.org/10.1016/j.gfs.2019.100329
Schut M, Klerkx L, Rodenburg J et al (2015) RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part I). A diagnostic tool for integrated analysis of complex problems and innovation capacity. Agric Syst 132:1–11. https://doi.org/10.1016/j.agsy.2014.08.009
Steinke J, van Etten J (2017) Gamification of farmer-participatory priority setting in plant breeding: Design and validation of

"AgroDuos." J Crop Improv 31:356–378. https://doi.org/10.1080/15427528.2017.1303801

Thornton PK (2010) Livestock production: recent trends, future prospects. Philos Trans R Soc b: Biol Sci 365:2853–2867. https://doi.org/10.1098/rstb.2010.0134

van Soest PJ (1982) Nutritional ecology of the ruminant. Cornell University Press, Corvallis

Vásquez-Bermúdez M, Hidalgo J, Crespo-León K, Cadena-Iturralde J (2019) Citizen science in agriculture through ICTs. A systematic review. In: Advances in intelligent systems and computing, pp 111–121

Walker DH, Sinclair FL (1998) Acquiring qualitative knowledge about complex agroecosystems. Part 2: formal representation. Agric Syst 56:365–386. https://doi.org/10.1016/S0308-521X(97)00049-8

Weiler V, Udo HMJ, Viets T et al (2014) Handling multi-functionality of livestock in a life cycle assessment: the case of smallholder dairying in Kenya. Curr Opin Environ Sustain 8:29–38

World Bank (2021) World development report. Data for better lives