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Strategies for strengthening feed, forage and feeding systems for a sustainable small ruminant livestock production in KSA

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*Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development
Programme (2019-2025) (UTF/SAU/051/SAU)*

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1. Introduction

Livestock is a major sub-sector of the agriculture in the Kingdom of Saudi Arabia, occupies a distinct economic, social and cultural significance, and plays important role in nutrition, food security and livelihoods of millions of small-scale farmers in Saudi Arabia. Around 150,000 – 200,000 small holder farm families depend on livestock as a source of their livelihood in KSA. Further, the growing demand for animal products creates an opportunity for the growth of this sector. SRAD (Sustainable Rural Agriculture Development Program), a flagship program jointly implemented by the Ministry of Environment, Water and Agriculture (MoEWA) and FAO, with an objective to achieve sustainable rural agricultural development and contribute to the sustainable conservation and management of natural resources in the Kingdom of Saudi Arabia, has a considerable focus on working across the livestock value chains with specific activities aimed at capacity development for better production and productivity, value addition, marketing, strengthening rural institutions, and diversification of income generation for better livelihoods.

Feeds and feeding systems under the small ruminant sector play a critical role given that feeding represents up to 80% of the variable costs of sheep and goat's production, besides greatly influencing the production efficiency of the animals. The high feeding costs of livestock in Saudi Arabia, due to the dependence on feedstuff imports has major implications in the development of livestock sector. Thus, emphasis on reviewing and contextualizing the feeds and feeding strategies for sheep and goats in Saudi Arabia will contribute to an increase in production efficiency in a sustainable and cost-effective way. This document makes an effort to outline selected strategies that could be applied under the KSA context to improve the availability of local feed and forage resources, exploring alternate ways to use non-conventional feed resources and reduce farm level feed wastage through precision feeding methods.

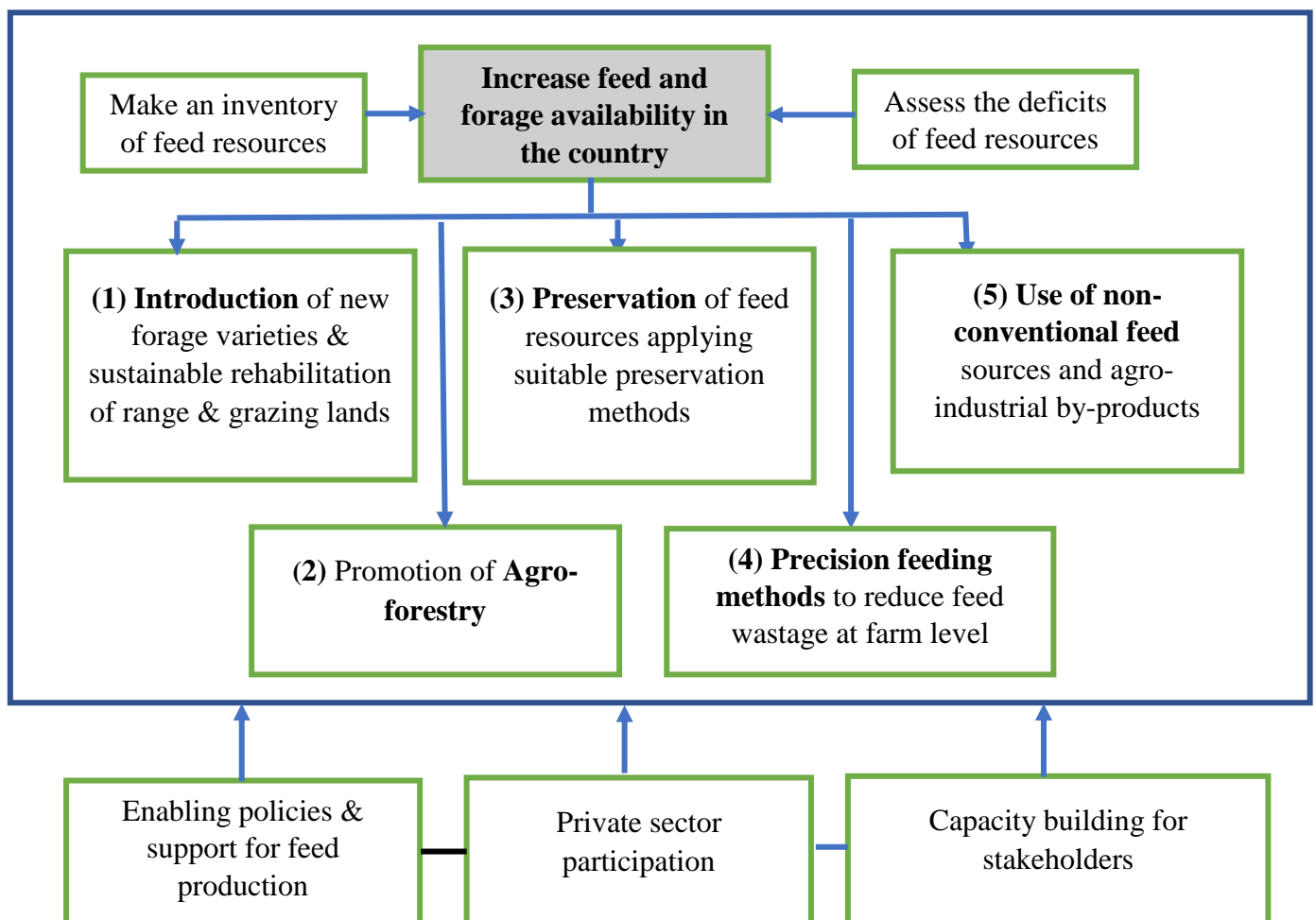
2. Steps to Improve the availability of quality feed and forage in the country

Water scarcity, climatic conditions and low availability of fodder production, leading to growing dependency on imported forages are some of the main problems faced by farmers of KSA. Additionally, there is no comprehensive data is available on the availability of forages in different regions, availability of crop and food industry by products such as date palm wastes, agro-industrial by-products, fruit industry wastes, and quality of these feed in terms of its nutritive value; deficits in terms of dry matter, energy and crude protein; and, linking to the soil profile that can inform on the availability of different soil nutrients that gets enriched into the feed, etc., Therefore the first step to address the fodder and feed deficit is to undertake a systematic analysis of the fodder availability and its gaps in different regions of the country. This will provide options to plan for the feed and forage production in a more systematic and sustainable way. An action plan towards improving feed production in the country requires:

- Data on KSA' feed and fodder production, availability, seasonal variations and gaps – this provides critical information for country' animal feed planning.

- Work through a strategy of addressing the sustainable access to feed and fodder sources applying value chain approaches and by promoting private sector investments in feed and fodder production
- Sustainably rehabilitate the natural resource base such as the rangelands and establish community-based management systems of these resources
- Keep appropriate policy instruments that favours feed production in the country

Some of the ways to address the challenges of animal feed availability in the country are: (1) Introduction of new fodder plants (new to KSA) adapted to the arid regions (2) Promotion of integrated systems such as agro -forestry (3) Preservation of available feed sources using appropriate methods suitable for KSA (4) precision feeding methods to reduce feed wastage (5) use of non-conventional feed sources that comes out of crop production and food processing industries. To overcome these challenges a comprehensive framework is being proposed.



2.1. Inventory of Feed resources & assessment of the feed deficits

The following framework could be used to assess the feed and fodder resources and related Green House Gas (GHG) emissions in the country as provided by Makkar (2018).

- Procedures and methodologies to assess crop residues, agro-industrial by-products, cultivated fodders, oilseed cakes and permanent crops; and to calculate metabolizable energy (ME) and crude protein (CP) requirements of different animal species, which are required for the establishment of a national feed inventory and calculation of a national feed balance
- A tool to capture data on competitive uses of various feed resources and agro-industry by products, which facilitates a better understanding of uses of various biomasses and conversion of a potential feed inventory to an actual one;
- A template for the characterization of feeding systems, which is required to make feed strategies more efficient and to generate the national greenhouse gases (GHG) inventory
- A template for recording herd structure of small and large ruminants, which is needed to calculate animal feed requirements and GHG emissions from the livestock sector.

Tools such as FEAST (Feed Assessment Tool) - [Feed Assessment Tool \(FEAST\) | International Livestock Research Institute \(ilri.org\), www.ilri.org/feast](http://www.ilri.org/feast), a tool developed by ILRI (International Livestock Research Institute) could assist in working through the process of assessing the local feed resources availability and its use. This is a simple, structured and systematic way of identifying option to improve feed supply for farmers in the country. Orienting the MoEWA staff across the different regions of the KSA to use the tool in assessing the feed availability and its use will assist in planning a systematic feed and forage production planning.

2.2. Introduction of new forage species & sustainable rehabilitation of rangelands

KSA need to invest in research and development activities that aims to scout and introduce forage species that have been successfully used in other countries with similar agro-eco systems. Some of the examples are: Spineless cactus (*Opuntia ficus indica*), *Cenchrus ciliaris*, *C. setigerus*, *Lasiurus scindicus* and *Panicum species*. These species have been well adopted as fodder species for cultivation as well as grazing land rehabilitation in arid regions of countries in Asia and Africa. Of late spineless cactus is gaining prominence as a choice of fodder for arid regions, catering to the feed requirements of small ruminant production system. Spineless cactus has the capacity to produce good biomass throughout year using minimum water. Spineless cactus is a multipurpose plant, drought tolerant, easy to establish, a potential plant for rangeland and pastureland management, helps in soil and water conservation, and additionally a source of a variety of agri-foods. Cactus dry matter (DM) yield varies between 20 tons/ year/ha to 200 tons, depending on the water availability. Being rich in water (90%), it is an option to provide water for animals in dry areas. The cultivated cactus can be harvested at 1 year of age and the biomass yield is around 15-20 kg per plant in single harvest. The yield will increase in subsequent years (30 kg in 20 months). Cactus could be included up to 25-40% of the feed ration dry matter in Total Mixed Rations (TMR). Due to high water content, animals can survive for long time without water where water is a constraint in dry areas. Similarly, efforts are needed to scout and introduce drought resistant

cereal and legume forage varieties developed, and available for propagation in different parts of the world. Associating with organizations like ICARDA and other dry land agriculture research organizations might help to attain this objective. Some of the potential forage crops that could be considered for KSA agro-eco system.



Cenhrus ciliaris (buffel grass) (photo source: tropicalforages.info)



Cenchrus setigerus (bird wood grass) (photo source: tropicalforages.info)



Panicum species (photo source: tropicalforages.info)



Lasiurus scindicus (photo source: cazrienvs.nic.in)



Stylosanthes hemata (legume) for dry regions; *Stylosanthes* on roadside plantation



Stylosanthes hemata under irrigation system ; *Stylosanthes hemata* under agro-forestry



Macroptilium atropurpureum (Siratro – legume considered for dry regions)

(Photo source: tropicalforages.info)



Cactus as a source of forage for livestock

2.3. Promotion of agro-forestry

Farmers in the hot arid zone grow arable crops in association with tree species. In fact, such integration of arable crops with trees in the farming systems is a unique, combined, protective-productive system that works on the principles of ecology, productivity, economics, and sustainability. These systems are now generally referred to as agroforestry. An integrated tree forage-based livestock production system is considered a low-input technology. The systems use multipurpose leguminous trees and shrubs in marginal areas and wastelands in an agroforestry system for forage and livestock production in the small holder farming system. The technology has potential for improving soil properties, farm income and agro-ecology in farms through cultivation of multipurpose leguminous forage trees on fallow lands. Because most trees are drought resistant, they are still able to provide fuel, fodder, fruit and other products, when the crops fail, as frequent droughts are a common phenomenon. Thus, trees have a very important place in the life of people in the arid zone, as they are directly related to the livelihood of inhabitants, and also provide the important service of climate moderation in an inhospitable environment.

Agroforestry is generally practiced with the intention of developing a more efficient and sustainable form of land use that can improve farm productivity and the welfare of the rural community. The forest resources are under enormous pressure to meet requirements for wood, food, fuel and fodder, the ultimate answer is promotion of agroforestry outside the

forests by the introduction of agroforestry practices in which trees can be grown for food, fodder, wood and fuelwood, e.g., along field boundaries and on unutilized and underutilized corners of farms, fallow lands, uncultivable fallow lands, etc. The tree component of agroforestry systems can greatly contribute to the restoration of shattered domestic rural economies, becoming a prized capital asset for resource-poor farmers, compensating for seasonal shortages, providing recurrent flows of food, fuel, fodder and other useful materials for rural industries, and conserving soil, water and human energy.

The agroforestry system can provide valuable source of high quality, protein-rich forage for subsistence, and commercial production of livestock, able to supply foliage during dry periods when herbaceous species are not productive, being deep rooted, they are drought tolerant and thus are important components of adaptation strategies to climate change, and living fences, around homesteads and fields. Tree species that are adapted for arid and semi-arid conditions such as *Acacia* species, *Calliandra* species, *Gliricidia sepium*, *Leucaena leucocephala*, *Sesbania* species, *Moringa* species, etc., could be considered as tree species suitable for promotion under agro-forestry under the KSA production environments. Agro forestry models such as silvopasture system, and alley cropping could be some of the options that could be considered under agro-forestry system with an objective to improve forage availability.

Promotion of agro-forestry within the context of sustainable livestock production, will be one of the opt approaches to reduce fodder deficits. Various agro-forestry models appropriate for arid regions are available across the world. Agro-forestry models such as pearl millet-Ziziphus- Prosopis cineraria- Lasiurus scindicus- cluster bean, etc., could be explored for promotion under agro-forestry. Linkages with organizations like World Agro-forestry (ICRAF) might assist in selecting needed technologies and models suited for KSA' agro-climate. Another method is to explore promotion of silvopasture based agro-forestry models.

Silvopasture is the integration of trees and grazing livestock operations on the same land. These systems are intensively managed for both forest products and forage, providing both short- and long-term income sources. Silvopasture systems are created by introducing forage into a tree plantation or by introducing trees into a pasture and following rotational grazing or harvesting the forage and feeding the animals. Efforts are needed to identify compatible species under the silvopasture system that could be promoted in KSA. Well-managed silvopasture employ agronomic principals, typically including introduced or native pasture grasses, fertilization and nitrogen-fixing legumes, and rotational grazing systems that employ short grazing periods that maximize vegetative plant growth and harvest.





Agroforestry models (photo source: <https://agritech.tnau.ac.in/forestry/agroforestry>)

2.4. Preservation of feed forage resources through appropriate technologies

Forage conservation / preservation serves one fundamental function – to ensure adequate nutrition of animals also in seasons without or with limited plant growth. Nowhere in the world fresh forage is available throughout the year at constant volume and quality. The alternation is more typical between seasons with and without vegetation, between summer and winter, or between wet and dry seasons. Animal production, on the contrary, is a continuous process that requires a constant supply of feed in quantity and quality. Animals do have requirements for maintenance, and only feed intake exceeding this will lead in performance. Each day, on which the genetically and physiologically determined performance potential is not fully used due to insufficient nutrition, will ultimately result in losses in productivity. Thus, forage conservation resolves the discrepancy between continuity in feed demand and discontinuity in vegetation. It therefore ensures the supply of feed based on demand throughout the year. Moreover, only the conservation of forages enables the fixation of optimal quality which would otherwise change during the course of vegetation. This makes it possible to fully exploit the performance potential of animals throughout the year. Therefore, we must conclude that forage conservation and storage is an essential issue.

Forage crops are preserved either by hay making (field drying) or by ensiling as silage. Hay is preserved because of its low water content which restricts detrimental microbial activity. Hay making is restricted to thin stemmed crops which can dry quickly and uniformly, and to areas without rainfall during the harvesting season. Silage is usually achieved when green fodders are surplus and plenty to meet the demands of good quality fodder during lean feed seasons or scarce periods of the year. The thorns in some plant species may be rendered weak through ensiling and weed seeds die off in the silo.

Hay making is a suitable method to preserve these fodders and grasses. Leguminous plants, which are a major source of protein, can also be conserved in this way for feeding at a later stage. The low moisture content of hay considerably reduces costs and efforts involved in transportation and handling. Its flavours can be preserved well, especially if the drying process takes little time. The basic principle of silage making is to convert the sugars in the ensiled fodder into lactic acid, this reduces the pH of the silage to about 4.0 or lower, depending on the type of process. In this way, the biological activities

responsible for spoilage are inhibited. To attain this, the early establishment and maintenance of an oxygen free, i.e., anaerobic, micro-environment is essential.

2.5. Small scale forage conservation methods adapted for KSA smallholder farms

The mixed irrigated farming systems of KSA, where forage production is being practiced, it will be better to design an appropriate mixed cropping system with cereal forages (sorghum, maize, oats, barley, millet) and leguminous crops (pea, beans), and harvest them at appropriate stages, and make efforts to preserve them (the surplus forage) for future use. Typical forage preservation methods as followed in developed countries are limiting factors in KSA due to its technology intensiveness, large size mechanized operations, etc.,

Within the context of KSA' small holder system appropriate silage making technologies should be established by transferring the technologies meant for small scale farmers in other parts of the world. One such example is silage making in bags. In this process, cut green mass is stored in sacks (of different sizes) made from polythene. The filled material is pressed removing the air and thereby preventing decomposition once the bag has been filled and shut. The feed can be stored in this way, without losing the nutritive quality, for up to a year. This allows farmers to maintain feed levels throughout the year. This has several advantages such as: Plastics silage bags are an economical alternative to traditional silage storage systems, such as pits and silos; it is an effective way for preserving feed with minimum nutrient loss.; allows farmers to store silage anywhere they need it; the silage is completely sealed in the bag, means that all the acid is retained in the silage, unlike that in pit silage when it seeps out through the bottom of the pit as effluent; ensiling in a bag avoids the hard work of having to remove silage, as it has to be from a pit, when it has to be dug out every day; because the whole bag is fed out to the animal, it means the rest of the silage which is in the other bags is not exposed to air at removal and is therefore unspoiled; much of the silage in pits has been found to be spoiled due to poor sealing and exposure to air every day when the silage is removed for feeding; the bag is easily stored and easily portable so that any member of the family can carry it to the feed trough.



Small scale silage making in polythene bags (Photo source: USAID)



Small scale pit silage making (photo source: FAO)



Small scale hay making (photo source : FAO)

2.6. Precision feeding methods to reduce feed wastage




Precision animal nutrition is one of the effective utilizations of available feed resources with an objective to maximize the animals' response to nutrients. This technology appears to be an ideal approach to improve the productivity of animals in developing countries in view of inadequate feed resources. Precision feeding targets providing the animal with the feed that precisely meet its nutritional requirements for optimum productive efficiency to produce better quality animal products and to contribute cleaner environment and thereby ensure profitability. Further, it reduces the enteric emission of methane, excretion of nitrogen (ammonia), phosphorus and other compounds into the environment. Several tools could contribute to this process. Some of them are: balancing the feed that precisely meet the nutrient requirements at various stages of production, inclusion of feed additives that assist in better nutrient utilization in the body and phased feeding systems.

2.6.1. Balancing the rations

Feed costs are the major cost of animal production, and making the most efficient use of feeds is of prime importance in determining profits. Rations must be properly balanced for sheep and goats. Ration balancing is another management tool the efficient producer can use to maximize profits. A ration is the amount of feed an animal receives in a 24-hour period. A balanced ration is the amount of feed that will supply the proper amount and proportions of nutrients needed for an animal to perform a specific purpose such as growth, maintenance, lactation or gestation. Farmers feed their animals based on their traditional knowledge and information passed through generations with crop residues, locally available one or two feed

ingredients like brans, oil-cakes, grains etc. and seasonally available green fodders. In most of the cases, the quantity of feed/fodder offered to animals is either more or less than the requirements. This leads to an imbalance of protein, energy and minerals in their ration. Animals on such imbalanced ration produce sub-optimally, cost of production is higher and it affects the health and fertility of animals. Therefore, it is necessary to develop and implement a system of feeding of balanced ration to small ruminants that can bring desirable results. To balance a ration, producers need to know the nutrient requirements of the small ruminants, nutrient content of feedstuffs being considered for the ration, and the mathematical calculations necessary to determine the amount of each feedstuff needed to meet the requirement.

Computer programs now available can really speed up the process of balancing a ration and few of them are available commercially. However, they have been developed using the livestock production system variables (such as feed and fodder resources and its nutritive values, prices, etc.) of those countries where it was developed, and their utility under the KSA context need to be validated. The other options could be to develop its own system of a ration balancing digital tool for use by the farmer. Two important prerequisites needed to implement a ration balancing program is to make an inventory of the available feed resources of KSA, assess its nutritive value and tabulate them for use in the ration balancing program. For an immediate use of the program, the nutritive values of common feed materials as published by National Research Council (NRC), USA could be used. Equally important is to establish a small ruminant nutrient requirement table for KSA sheep and goat population, that defines specific nutrient requirement at specific stage of production, for a specific breed of sheep and goats. This again requires a research component that the MoEWA and KSA' Animal Science Faculties should consider.

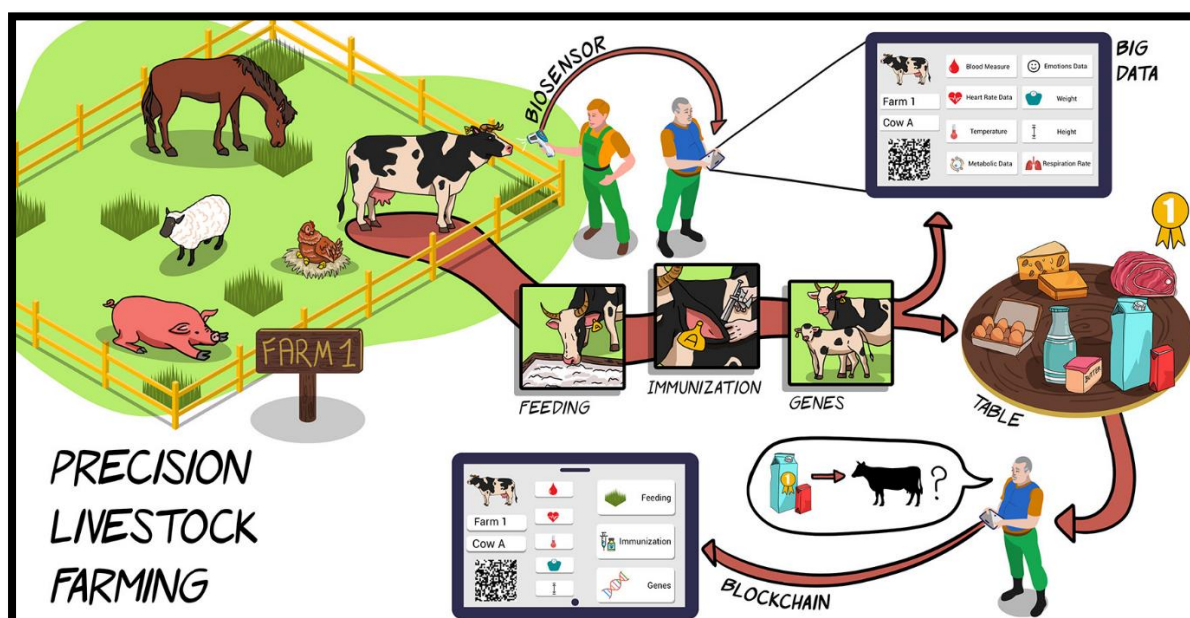
Balance a Diet for: Ewe, Late Gestation Twin Lambs 154 lbs/70 kg									
			DM Fed Lbs	As Fed Lbs	TDN Lbs	CP Lbs	Ca g	P g	
		Requirements	4.20		2.8	0.47	7.60	5.60	
<input type="button" value="Edit Amt"/>	<input type="button" value="Remove"/>	Barley grain	0.89	1.0	0.8	0.12	0.20	1.54	
<input type="button" value="Edit Amt"/>	<input type="button" value="Remove"/>	Jeff's Orchardgrass hay	3.56	4.0	2.2	0.62	22.65	6.47	
		% of Required	105.95		104.5	157.36	300.75	143.04	
		Total in Diet	4.45	5.0	2.9	0.74	22.86	8.01	
			DM Fed Lbs	As Fed Lbs	TDN Lbs	CP Lbs	Ca g	P g	

Example of ration balancing calculator (Photo source: Maryland Small ruminant page)

2.6.2. Application of analytics in precision animal nutrition

The pressure on food systems to produce food sustainably under the given circumstance of population growth, climate change scenario and pressure on the natural resources is tremendous. Sustainable livestock production is a critical point in food production, as significant portion of the projected increases in global food demand is anticipated to come from livestock. This could be achieved through optimizing the different aspects of animal production, i.e., genetics, nutrition, animal health and farm management. Optimization of these resource use requires improving the farm decision making processes by the farmers. In many circumstances it is a complex process and the farmer is burdened. One of the possible solutions to assist the farmers in decision making process is precision farming technologies. Precision crop agriculture technologies such as global positioning system guided equipment, robotic harvesting, automated agrochemical application, etc., are being widely adopted in large scale industrial production. Similarly, in livestock sector system like robotic milking system, rumen sensors, activity monitors exist, but not expanded on a wider scale.

On farm sensors, data generation on important farm and animal performance, use of data analytics such as linear modelling and machine learning in interpreting these data has great potential in the management of precision animal nutrition. Precision nutrition systems such as optimizing rumen fermentation, detection of metabolic diseases, response based nutrient requirement recommendation and automated feeding systems can have high impact on sustainable livestock production and profitability. Combination of appropriate animal ID system (e.g., RFID based), IoT based sensors and data analytics could be one of the ways to take this further and follow economic feeding systems. This is highly pertinent to country like KSA, which depends heavily for imported feed and fodder sources. The precision systems also could help in reducing the GHG emissions from livestock sector.



Digital Livestock Farming (photo source: <https://doi.org/10.1016/j.sbsr.2021.100408>)

2.7. Use of Non-Conventional Feed Resources (NCFR)

Non-Conventional Feed Resources (NCFR) refers to feeds which have not been used traditionally or commercially for livestock feeding. Traditional feeds include those feed which is of crop origin while NCFR includes feed from perennial crops, animal and industrial origin. e.g., Oil palm by-products, cotton stalk, sesame stalk, date palm kernels, etc., Inadequate supply and low levels of feeding due to a severe lack of feedstuffs are the main reasons for poor levels of animal production. There is a significant disparity between animal nutrients demand and supply. It is preferable to build up sufficient and alternative feed resources. However, there are several reasons for their limited use, including their low nutritional value and difficulties in handling and usage for long periods of time. Crop residues, agro-industrial by-products, browsing foliage, and other NCFRs will become increasingly significant as feed sources in the future as human and livestock populations expand. Many of the NCFR are currently designated as wastes, which is an inaccurate description. They are wastes to the extent that they have not been shown to have an economic value through utilization and conversion by animals into valuable products for human benefit.

Recycling, reprocessing and utilization of all or a portion of the wastes offer the possibility of alleviating the existing limited feed resources. Recycling of agricultural wastes and their utilization as alternative energy sources for ruminant feeding is important for economic and environmental reasons. Regarding the sheep and goat production industry in Saudi Arabia, diets based on barley grain, wheat bran and legume could have these ingredients partially replaced by dates as an energy source. Similarly, the non-useable crop residues like sesame stalk have the potential to be used as a feed after applying appropriate physical or chemical treatment methods to convert poorly digestible nutrients.

2.7.1. Use of date palm waste as feed

The Kingdom of Saudi Arabia is a major producing country, accounting for 14.4%, or 1.078 million tons, of the world production and with nearly 25 million of date palm trees across more than 400 varieties. There are significant quantities of by-products from the date industry that has limited or no value as human food. As reported, in Saudi Arabia, about 20% of the total date production is unsuitable for human consumption and wasted. Some of the low-quality dates, the discarded dates or the processing plant, the old dates of the previous year and date pits available in considerable amount to be used as feedstuff for animals. The availability of date pits increases in proportion to the expansion of the date confectionary market. The pits weigh about 10 to 15% of the fruit, and thus the estimated amount produced of this by-product is going to be about 25,000 to 40,000 tonnes yearly.

The main energetic by-products are cull dates, date pits, press cakes and mixed date pits and fibre, from date processing, which could be used to feed animals. Other by-products derived from date cultivation, such as leaves, and floral stems supporting date regimes may be useful in animal feeding. The implications on growth, milk production and quality, carcass quality, meat attributes, animal health and economics in response to dietary treatments where discarded dates were included to replace conventional energetic feedstuffs (i.e., barley), has been object of study by researchers in the Middle East with emphasis in Saudi Arabia. There are convincing studies to demonstrate that inclusion of date palm wastes in the animal feed at certain levels did not alter the growth rate and meat quality. For example, one research shows that diets supplemented with up to 20% of discarded dates could be used efficiently in feeding Najdi lambs without adverse effects on growth (daily weight gain).

In depth research and development efforts are needed to find suitable method to treat and convert different date palm wastes into feed. For example, the date palm seeds could be converted into feed using several methods, such as soaking, grinding, alkali chemical treatment (9.6% NaOH), biological treatments like use of fungi or cultivation of mushroom on seed bed to soften the hard fibrous contents,

etc., The proven models available in other countries could be scouted and applied directly in this process.

2.7.2. Ozone treatment of crop residues (Sorghum stover) to improve digestibility and palatability

The problem with crop residues is that the plants are harvested at a time when cell wall content and lignification are at a maximum in plant tissue. Although these residues are high in the structural carbohydrates, cellulose and hemicellulose, these carbohydrates are bound in an undefined complex with lignin which severely limits their accessibility to rumen bacteria, and thus their value to the ruminant. However, crop residues may be subjected to chemical agents capable of disrupting the lignocellulose complex and be substantially improved in nutritive value. Ozonation is a chemical treatment which is known to effectively disrupt the lignocellulose complex. Ozone will selectively oxidize lignin, and works most efficiently on those materials which are most highly lignified. Several thousand tons of sorghum and sesame stover are produced in the KSA. Sorghum stover is relatively low in nutritive value, and is often grazed or returned to the soil. However, stover may be harvested and effectively used as an alternative roughage source. Stover was found to contain adequate digestible energy to be used as a maintenance feed for ruminants, although the low protein content of stover would necessitate protein supplementation for adequate performance. The ability of ozone to degrade plant lignin and structural carbohydrates has been well established. The reaction of ozone with lignin has attracted considerable attention, particularly with its potential use in the industrial bleaching of chemical and mechanical pulps. However, the potent delignifying capability of ozone also makes it an effective agent for upgrading the nutritive value of low-quality roughages. Such technologies have been developed in some countries (e.g., by Indian Institute of Technology, Mumbai, India) on a pilot basis which could be tried in KSA on a trial basis for converting hard fibrous feed like sorghum and sesame stalks into feed materials. With appropriate inclusion levels, and by adding other protein, vitamin and mineral supplements, it could be converted into a complete feed for the small ruminants.

2.7.3. Other technologies for the efficient utilization of NCFR

Other technologies like urea treatment of wheat and paddy straw, making feed blocks with NCFR, ensiling of fruit pulps that comes out of fruit processing industries, shrub mixed feed blocks, etc., Ammonia gas, or ammonia produced by anaerobic digestion of urea, weakens fibre and disrupts the complex between lignin and other digestible components in fibrous feedstuffs including straws. The benefits of this strategy on nutritive value of straw and animal performance have been thoroughly proven in the literature. Ammonia treatment improves animal production by increasing crude protein content, consumption, and digestion of treated straws. The ensiling process for fruit pulp can be used to safely store these by-products alone or in combination with other (molasses, wheat bran, etc.) for lengthy periods of time. For example, olive cake silage are based on its aroma, colour, pH, and lack of mould. Olive cake silage are used to replace part of the barley hay and straw fed to lactating ewes and does without affecting their performance.

Feed block technology is a good technique to make use of unconventional resources. This technology allows extension workers and farmers to determine which ingredients to include in the feed block and how to use it as a supplement in times of drought and other adversity. Furthermore, the blocks can be made when the cost of the components is cheap and kept for later use. These cost-effective supplements are a solidified mixture of agro-industrial by-products (such as olive cake, tomato pulp, grape waste, molasses, etc.), urea, minerals, and vitamins. Protein is the most critical nutrient for improving animal performance by promoting efficient roughage fermentation in the rumen. Ruminants cannot be given browse foliage that contains more non-nutritive elements as a sole diet. However, it can be combined

with other feedstuffs to provide a nutritionally balanced diet and to reduce the impact of non-nutritive elements. It could be combined with the feed block making technology.

3. Capacity building in Animal Nutrition for the stakeholders

All stakeholders involved in nutrition implementation plan will have a baseline training on sheep and goat production according to their specific requirements and needed level of practical understanding. This will include assessing the quality of feedstuffs, balancing rations, assessing nutritional level of the animals, management practices to optimize performance, flock or trip age structure management, feed storage and delivery, annual planning of feeding requirements, common diseases related to productivity, principles of reproduction related to nutritional status and, best management practices. Other topics for training need to be developed in response to the identified needs and demands from the stakeholders and/or novel husbandry and market challenges

4. Policies on Animal Nutrition

KSA at present does not have any well-defined policies in respect of animal nutrition and animal feed. It will be appropriate for the MoEWA to define policy instruments that has been formulated to realize a vision of a developed animal feeds industry that contributes significantly to improved animal production and productivity. The policy should focus on promoting participation of the private, providing a conducive environment for good manufacturing practice and quality control, promoting and stimulating a competitive animal feeds industry, providing a conducive fiscal and regulatory basis for the growth of the industry and putting in place suitable institutional framework and infrastructure for delivery of support services. The animal nutrition policy should aim at stimulating increased feed production, ensuring quality animal feeds on the market, reducing production costs and building capacity among private and public sector for the development of the animal feeds industry, simultaneously taking into account decentralisation, private sector participation, gender considerations and protection of the environment.

Other areas of policy that are equally important for the livestock production are: strengthening of research, availing credit to the industry, and encouraging increased production of raw materials for feeds production, transfer of appropriate technologies, encouraging formation of farmers and manufacturers associations, developing rural infrastructure to increase access to raw materials, ensure animal feeds quality, formulation of standards, rules and regulations to govern the industry and creation of institutional and legal framework to enforce these provisions. It is preferable to spell out clearly the implementation of an effective animal nutrition policies and animal nutrition improvement program in the country through a designated technical, advisory and regulatory committee.

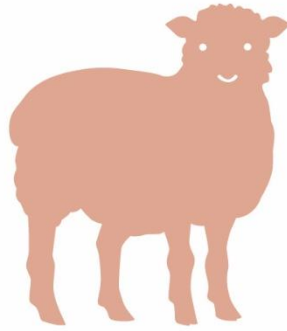
5. Private Sector Engagement

KSA have a long history of stimulating private sector growth in many of the economic spheres of the country. The same logic could be applied to stimulate growth in the animal feed and fodder industry in the country. Some of the approaches could be: facilitate the private sector to improve commercial feed and fodder production through various incentives,

capacity development, as well as harmonize policies at regional and country level; encourage to participate in the investment opportunities in feed and fodder value chain using available loan facilities from financial institutions to promote investment in the sector; private sector should be encouraged to invest in infrastructure that supports fodder/seed production, value addition, storage and marketing; strengthen certification of feeds and fodder seeds to mitigate quality issues, improve confidence and enhance trade; and, strengthen research to promote fodder production for commercial purposes and utilization of non-conventional feed resources (e.g., date palm waste) through conversion on a large commercial scale.

References:

1. Aljumaah R.S., Alshaikh M.A., Alyemni A.H., Ayadi M., Sayadi S. Chentouf M. , López-Francos A. , Bengoumi M. , Gabiña D. , 2014, Technical and socio- economic characterization of small ruminants production systems in Saudi Arabia: results from a survey to stockbreeders, <http://om.ciheam.org/article.php?IDPDF=00007668>
2. BAIF Development Research Foundation, Booklet on Cactus an Emerging Fodder Crop of Arid and Semi-Arid India, August, 2017.
3. D V Reddy, N Krishna, 2009, Precision animal nutrition: A tool for economic and eco-friendly animal production in ruminants, *Livestock Research for Rural Development* 21 (3) 2009
4. Douglas M Liebe, Robin R White, 2019, Analytics in sustainable precision animal nutrition, <https://doi.org/10.1093/af/vfz003>
5. De Waal, H.O 2015, Spineless cactus pear as livestock feed in South Africa. In: Development of cactus pear agro-industry for the Sub-Saharan Africa Region. Proceedings of International Workshop. 27-28 January 2015. University of Free State, Bloemfontein, South Africa. Pp 30-39. *Cactusnet Newsletter*, 14.
6. FAO and IGAD. 2019. East Africa Animal Feed Action Plan. Rome.
7. H.Makkar, L. Gizachew, A. Tolera, A. Salis. Feed Inventory and feed balance of Ethiopia and way forward. 2019. https://www.researchgate.net/publication/341453445_Feed_Inventory_and_feed_balance_of_Ethiopia_and_way_forward
8. Suresh Neethirajan, Bas Kemp. Digital Livestock Farming. Sensing and Bio-Sensing Research 32 (2021) 100408. <https://doi.org/10.1016/j.sbsr.2021.100408>
9. Yuri Montanholi, 2020, PRODUCTION, FEEDS AND FEEDING STRATEGIES FOR SHEEP AND GOATS FARMING TECHNICAL NOTE FOR TRAINING AND EXTENSION IN SAUDI ARABIA, FAO technical report under SRAD project



برنامج التعاون الفني بين وزارة البيئة والمياه والزراعة ومنظمة الأغذية
والزراعة للأمم المتحدة، الرياض، المملكة العربية السعودية
ص.ب.: 558 الرياض 11421
بريد إلكتروني: FAO-SA@fao.org