GEAVET TRAINING PROGRAMME FOR CSA

CLIMATE SMART AGRICULTURE:

NIGERIA

UNIT 2.I LIVESTOCK FEED AND FEEDING MANAGEMENT

ENGLISH VERSION

GEAVET Project n° 101129027

Open Educational Resources

PART I – LEARNING MATERIAL

1. Introduction

Livestock production is a rapidly growing sector in Nigeria due to increasing household demand for animal-sourced foods to support balanced diets, its potential for job creation, and its contribution to the country's Gross Domestic Product (GDP). However, feed shortages, constrained by climate change among other factors, have consistently influenced the sustainability of the livestock production enterprise in this region. Notable consequences of climate change, such as altered environmental temperatures, irregular rainfall patterns and drought on livestock include a reduction in biomass yield of forages, increased heat stress, fluctuations in available feed types, feed quality and competition for resources with other sectors. These effects pose significant threats to growth, reproductive efficiency, health status and overall performance of animals (Nardone, 2010; Craine *et al.*, 2017; Laghari *et al*., 2024). Since feed is a key input to sustainable livestock production, and constitutes about 75% of the total cost of production in Nigeria (Ayanrinde *et al*., 2020; John *et al*., 2022 , climate-smart approaches to address feed and feeding management challenges are crucial to enhance sustainable and increased productivity, adaptation to climatic variations, ameliorate environmental footprints associated with greenhouse gas emissions, and also guarantee food and nutrition security. Therefore, this module aims to provide a practical training guide on sustainable climate-smart feed and feeding management strategies that are cost-effective and adaptable in addressing feed constraints in Nigeria's livestock production systems.

2. Climate-Smart Feed Ingredients and Livestock Feeding Management

Animal feeding and nutrition play a significant role in adjusting to climate change (Zhang *et al*., 2017). The conceptual framework of Climate-Smart Agriculture (CSA) in Nigeria is centred on transforming the agricultural sector to a resilient, productive, and sustainable system that will enhance the livelihoods of the active players (smallholder farmers) and mitigate greenhouse gas emissions (Terdoo & Adekola, 2014; NABG, 2024). Similarly, the framework for a climate-smart feed and feeding management for livestock involves: the utilisation of climate-smart feed ingredients that could optimally substitute/replace the conventional feed resources via various processing methods, and adopting the best feeding strategies to enhance resilience of livestock to climate impacts, reduce environmental pollution, greenhouse gas emissions, improve productivity, income and livelihoods.

In essence, innovative climate-smart feeding systems that increase productivity, income and livelihoods of farmers include: access of livestock to improved plane of nutrition, adherence to a good feeding regimen and well well-planned feeding schedule. In addition, access to climate-resilient forages and the use of water-efficient feeding systems during

the dry periods and heat stress will enhance the resilience and adaptation of livestock to climatic variations. Utilisation of improved feed quality to enhance efficient nutrient digestibility to reduce greenhouse gas emissions.

2.1. Approaches for Climate-smart feed and feeding of Livestock

Understanding the list of feed ingredients or feed resources that are climate-resilient is germane to the design of feed and feeding practices that could guarantee a continuous supply of feed during the period of extreme climate conditions, including:

- **Identification and production of feed resources:** These include the cultivation of feed resources such as cereals (sorghum, millet), forages (grass and legume species) and root and tuber (cassava) that are drought-tolerant and perennial in nature.

- **Utilisation and optimisation of efficiency of feed:** covers the adoption of a series of feed processing techniques, feed formulation methods, feed ingredient substitutions or replacements via the use of alternative feed sources to reduce costs without compromising feed quality, and possibly the inclusion of methane-containing feed additives (e.g tannin and saponin-containing feed source or oils) in rations. This will reduce or mitigate methane and other greenhouse gas emissions. All these will promote efficient use of nutrients for better feed conversion, reduction of wastes and optimal growth performance.

- **Feed resources management, conservation, and storage:** The adoption of effective forage defoliation and grazing methods will ensure the growth and sustainable use of pastures. These include grazing of ruminants, rotationally, on pastures, preparation of hay and silage during periods of excess forage growth to bridge the gap of feed shortage during periods of climate change extremes. Sourcing, processing (pelleting, fermentation, etc.) and adequate storage of sustainable feed ingredients such as agro-industrial by-products and crop residues/agricultural wastes will reduce competition and overdependence on cereal grains, minimise feed costs and improve livestock growth and performance.

- **Utilisation of improved feeding management:** This is the adoption of feeding practices that reduce heat stress under changing climatic conditions. Strict adherence to recommended nutrient requirements for specific age groups and production phases, appropriate ration balancing in feed formulation, feed ingredient supplementation strategies, and efficient water-use systems will reduce all forms of physiological stress that lead to

poor performance of livestock. Appropriate feed forms (total mixed ration, pellet, block, crumble, etc.), feed delivery systems (precision feeding: restricted, ad-libitum, etc.), and the use of feed troughs/containers adaptable to individual livestock species will reduce wastage.

- **Manure management & mitigation of methane emissions:** Reducing emissions that contribute to global warming as a result of improved feeding strategies will play a critical role in improved livestock productivity. Proper handling and processing of manure (via composting) as a source of organic fertilizer for pasture production will increase herbage yield and reduce the emission of methane (Wambugu *et al*., 2014).Adequate management and utilisation of droppings from poultry as a non-protein-nitrogen source in low-quality roughage feed for ruminants is capable of increasing the nitrogen demand of ruminants as well as reducing greenhouse gas emissions.

2.2. Inventory of Climate-Resilient Feed Resources in Nigeria

Nigeria's livestock feed resources are numerous, potentially rich in nutrients and varied across the geographical region of the nation. They can be categorised into: forages (grasses, legumes, forbes, shrubs, aquatic weeds, etc), cereal grains, oil seeds, crop residues, agro-industrial by-products, etc. From the myriads of feed resources available in Nigeria, a vast number of them are resilient to climate variability, and if adequately processed, mixed/blended in appropriate proportions, and harnessed to bridge the gap of feed shortage in terms of quantity and quality. An inventory of climate-resilient feed resources and their utilisation by livestock owners (smallholder/commercial farmers) will promote sustainable feed systems for livestock and reduce greenhouse gas emissions. Below are some of the potential climate-smart feed resources in Nigeria.

Table 1. Common & Climate-Resilient Feed Resources in Nigeria

Category	Examples	Key Benefits	Considerations

Grasses	● Elephant grass ● Guinea grass ● Northern Gamba grass	● High biomass yield ● High energy and mineral contents ● Tolerance to drought ● Grow all year-round (e.g. elephant grass). ● Prevents soil erosion and conserves soil water. ● Relished by ruminants ● Can be conserved as hay or silage ● Can be fed as a sole diet or total mixed ration ● Adaptable to all the agroecological zones	● Supplementation with protein sources is required ● Needs reliable rainfall or irrigation
Cereal crops	● Sorghum ● Millet	● Carbohydrate content is high. ● Tolerance to heat and drought. ● Requires low rainfall. ● Adaptable to poor soil conditions. ● Regrowth potential after harvest is high. ● Good for silage production. ● Stovers are rich in fibre to provide	● Needs supplementation with nitrogen sources. ● Presence of anti-nutritional factors (tannin, saponin, etc.) may inhibit palatability

		bulk for ruminants.	and feed intake. ● Requires adequate treatment (processing) to reduce the levels of anti-nutrients.
Leguminous Fodder Trees & Shrubs	● *Gliricidia* ● *Leucaena* ● *Moringa* ● *Ficus* ● *Sesban* ● *Albizia* ● *Daniella*	● High in protein content. ● Tolerance to drought and other extremes of climatic conditions. ● Grows all year round. ● Well-adapted to all agroecological zones ● Provides shades for livestock. ● Good for live fencing (hedges) in paddocks. ● Integration in pastures enhances the supply of nitrogen into the soil. ● Reduces the reliance on N-	● Preferences for them by livestock differ. ● Recommended levels for inclusion in diets vary (may result in metabolic disorders if consumed in excess). ● Inherent astringent/anti-nutritive factors may limit palatability, intake and digestibility. ● Requires a well-planned management

		fertilisers to maintain soil fertility.	system (planting, pruning and harvesting).
Crop/agricultural Residues	● Cassava peel ● Maize stover ● Corn cob ● Groundnut haulm ● Cowpea husk ● Cowpea vines ● Sorghum stover ● Sorghum husk ● Plantain peels	● Available all year round after harvest and processing. ● Highly rich in fibre and energy to enhance digestibility and rumen activity. ● Has a longer shelf-life, if properly dried. ● Potential substitutes for dry season feeding	● Low in nutritional content (e.g. protein, minerals, etc.) ● Poorly digestible. ● Bulky to transport ● Needs processing/treatment before incorporation into diets. ● Poor digestibility limits its use in monogastrics.
Agro-industrial-by products	● Wheat offal ● Corn bran ● Cassava pulp ● Rice bran ● Palm kernel cake, ● Brewer's dried grain	● Available all year round ● High in energy content ● Has high fibre content	● Relatively lower in protein content ● Highly demanded for use in the diets of livestock species.

Alternative Feed	• Fruits and vegetable wastes • Duckweeds • Kitchen waste • Cured poultry droppings • Urea-treated sorghum stover • Urea-treated maize stover	• Available all year round • Rich in minerals and vitamins (fruits & vegetables, duckweeds) • Potential feed to reduce environmental pollution. • Reduces feed costs when used in a total mixed ration. • Good for nitrogen supplementation (poultry droppings)	• High in moisture content • Highly perishable.

A. GRASSES

Image 7. Guinea grass
(Source: Apni Kheli)

Image 8. Elephant grass
(Source: Plantvillage)

Image 9. Northern Gamba grass

Source: TRM (2025)

B. CEREAL GRAINS

Image 10. Maize plant[a]

(Source: Pixabay)

Image 11. Sorghum plant[b]

(Source: TamilNadu Agricultural University)

C. LEGUMINOUS FODDER TREES AND SHRUBS

Image 12. Gliricidia
(Source: IITA, 2024)

Image 13. Moringa plant[a]
[a] (Source: Sarvodaya Institute.org

Image 14. Leucaena[b]
(source: Weeds of Australia)

[b] (https://keyserver.lucidcentral.org/weeds/data/media/Html/leucaena_leucocephala.htm)

C. CROP/AGRICULTURAL RESIDUES

Image 15. Cassava peel

(Source: Acowas, 2025)

Image 16. Corncobs

(Source: Sisman *et al.*, 2022)

Image 17. Cowpea haulm

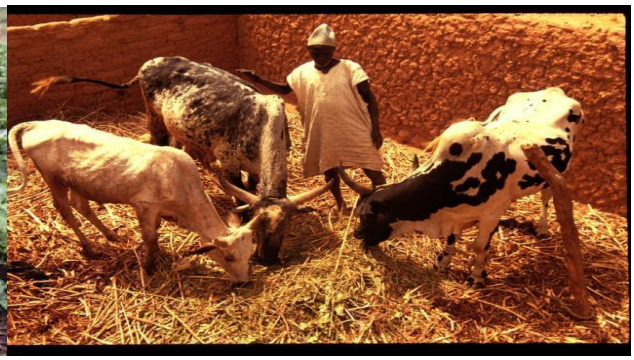

Image 18. Cattle feeding on Cowpea haulm

(Source: Feedipedia, 2025)

Images 19a & b. Groundnut haulm

(Source: Weseh *et al.*, 2017)

D. AGRO-INDUSTRIAL BY-PRODUCTS

Image 20a & b. Wheat offal

(Source: Afrimash)

Image 21. Corn/maize bran

(Source: KBAF, 2018)

F. ALTERNATIVE FEED

Image 22. Fruits and vegetable wastes

(Source: Yemisi Odusanya, The Guardian, Nigeria, 2017; Business Post, Nigeria, 2018)

Image 23. Unripe Plantain peels
(NatureNews 2024)

Image 24. Watermelon waste
(Source: Financial Nigeria, 2017)

2.3. Identifying and Evaluating Feed Quality

The quality of feed offered to livestock significantly influences the overall performance of animals in terms of intake, growth, reproduction, milk yield, and health status. A farmer should possess the basic skills and knowledge required to evaluate feed quality. Feed quality can be determined by feed evaluation, which is the assessment of the nutritional value of individual feed ingredients and complete diets.

Feed quality evaluation can be through physical/sensory parameters such as colour, weight, smell, texture, particle size, moisture content and levels of contamination. In addition, chemical analysis reports of the feed ingredients and feed mix (complete feed) after the diet has been compounded will also provide information about the quality of the feed (dry matter, protein, energy, carbohydrate, minerals and vitamins) to meet the nutritional requirements of the specific class of livestock species. Therefore, the quality of livestock feed can be evaluated based on nutrient composition, digestibility, freshness and storage, and sources of feed ingredients.

A quality feed for monogastric (poultry and pigs) should have a moisture content of less than 10%, acceptable energy and protein contents, a pleasant aroma/smell that will enhance palatability and an acceptable particle size for increased intake. It should be friable, free of mould or contamination and not rancid.

Similarly, forages (grasses or legumes) for ruminants must have a high leaves-to-stem ratio, required quantity of nitrogen or crude protein, minerals and fibre (principally, neutral detergent fibre and acid detergent fibre) levels that meet higher

amounts could result in acidosis. In the same vein, forages should be free from contamination with soil. Grasses of younger age are of relatively high quality, and when fed to ruminants, they reduce the emission of methane gas (Himanshu et al., 2018; Cole et al., 2020).

2.4. Evaluation of the quality of poultry feed in Nigeria

Over 85 million of the Nigerian population are actively involved in poultry production, where the majority of them are small to medium-scale farmers (PAN 2017; FAO, 2019; LiveGAPs Factsheet, 2020). The performance, profitability and sustainability of the poultry industry largely depend on the quality of feed, a major input in poultry production. Generally, most farmers rely on commercially produced feeds from different companies, whose quality or standards vary based on several factors. In Nigeria, quality assessments of poultry feed must adhere to the criteria established by the Standards Organisation of Nigeria (SON) and the National Agency for Food and Drug Administration and Control (NAFDAC). Compliance with the regulations is monitored by the Nigerian Institute of Animal Science (NIAS), which mandates the registration and auditing of all feed business premises. Nevertheless, farmers must be able to identify and evaluate the quality of feeds that are commercially produced or compounded by themselves. Laboratory analysis (proximate composition and microbiological) will reveal the levels of nutrients and contamination, while visual or sensory assessments should indicate the following, as indicated in Table 2. Watch the videos on proximate composition analysis (https://www.youtube.com/watch?v=_RnlPwx9uhw), feed quality check (https://www.youtube.com/watch?v=LdnW6jw0h0o) and how to conduct feed testing (https://www.youtube.com/watch?v=rP_nOx4OHFU).

Table 2. Visual and Sensory Indicators of Feed Quality (Poultry feed)

Indicator	Good Quality Sign	Poor Quality Sign
Colour	Uniform and typical for the feed type (e.g. golden for corn-based feeds, brown for wheat/sorghum-based feeds).	Unusual discolouration, dark patches, or a bleached appearance

Texture	Free-flowing. Consistent particle size Uniform appearance. Pellets should be durable and not excessively broken. Mash or crumble should not be excessively fine	Excessive dustiness, abnormal crumble size and clumping.
Foreign objects	Free from any extraneous materials (metals or other adulterants).	Presence of unwanted grains, dirt, stones, metal pieces, or wood.
Insects/Mould	No visible signs of insect infestation or mould growth.	Visible live or dead insects, larvae, webbing, or any signs of white, green, or black mould growth.
Moisture	Dry appearance and feel.	Dampness (indicates high moisture content that encourages mould growth).
Smell/odour	Characteristic pleasant smell of grains, oils and micronutrients	Rancid, sour and pungent odour.

Images 25. Poultry feed forms of different colours and textures

(Source: Alibaba.com; Poultry Hub Australia; Afrimash)

2.5. Climate-Smart Ration Formulation for Livestock

In Nigeria, formulation of climate-smart rations for all classes of livestock involves the use of locally available climate-resilient feed ingredients to meet the specific nutritional requirements, reduce greenhouse gas emissions, while maintaining overall animal performance and health, especially during periods of climate change, such as excessively higher temperatures that lead to heat stress conditions. The approach involves the substitution or replacement of feed ingredients which potentially have a higher environmental impact on animals with locally available ingredients that reduce heat stress, based on proportions or ratios of inclusions, using simple feed formulation tools such as; feed formulation software- Excel sheet (https://www.youtube.com/watch?v=9wDjb0mzqis) or the Simple Pearson Square method (Giving Hope Feed Formulation Guide). Incorporation of feed additives will also enhance the efficiency of feed utilisation, climate resilience and performance. The key strategies to formulating a climate-resilient ration centre on the proportions/ratios of each ingredient used in a diet, depending on the weight, age, reproductive phase, production purpose of the livestock and seasons. The use of a nutrient master plan and the results of nutrient compositions of ingredients will play a significant role in obtaining a balanced diet to meet the specific nutrient requirements. Watch the video on preparation and mixing of broiler feed (https://www.youtube.com/watch?v=8o_B0EwJ9Pg)

An example of a typical climate-smart ration (broiler finisher) formulated based on the use of locally available by-products and incorporation of additives to build

resilience against climate change associated with fluctuations in the supply of major ingredients and their prices is highlighted in Table 3.

Table 3. Climate-resilience Broiler Feed (Finisher)

Ingredient	Quantity (kg)	Rationale for Climate-Smart Choice
Sorghum grain (low-tannin variety)	40 kg	More drought-resistant than maize, and is an energy source.
Cassava peels (fermented/dried)	10 kg	Drought-tolerant, Low-cost, energy source, and replaces a portion of maize
Palm kernel cake (local)	15 kg	Abundant agro-industrial by-product with good protein/fat content.
Groundnut cake	15 kg	Alternative protein sources to reduce over-dependence on soya bean meal.
Black soldier fly larvae meal.	5 kg	Novel, locally produced, protein and fat sources
Fish meal (local source)	5 kg	High-quality protein, sustainable options to import.
Limestone/oyster shells	4 kg	Essential minerals for bone.
Bone meal	2 kg	Local source of calcium and phosphorus to replace the industrial and expensive Dicalcium phosphate (DCP)

Vegetable oil (e.g. palm oil)	2.5 kg	High energy density source, often locally produced.
Salt (iodised)	0.5 kg	Sodium/chloride requirement.
Vitamin & mineral premix	0.5 kg	Essential micronutrients.
Crystalline Amino Acids	0.4 kg	Allows for lower total protein without compromising growth.
Enzymes (phytase or xylanase)	0.1 kg	Improves nutrient digestibility and reduces phosphorus excretion.
Vitamin C and Folic Acid	Traces	Reduces heat stress during hot periods.
Total	**100 kg**	

Formulation of climate-smart rations for sheep, goat and cattle utilises a high percentage of agro-industrial residues and the inclusion of feed additives to improve digestibility and reduce enteric methane emissions. A typical example is a Total Mixed Ration (TMR) of roughages and concentrates presented in Table 4. It is a maintenance ration, though proportions of each ingredient can be varied to meet the specific needs of the animal. Detailed Nutrient Compositions for locally available feed ingredients in Nigeria can be found in the National Listing of Approved Feed Ingredients for Feedmills in Nigeria.Watch videos on how to mix goat feed (https://www.youtube.com/watch?v=12P0Puxhfvw) or ruminant feed (https://www.youtube.com/watch?v=87HFjb1YuNk).

Table 4. Total Mixed Ration for ruminant

Ingredient Type	Specific Ingredient	Proportion (%)	Weight (kg)

Roughage (Fibre source)	Maize stover or Corn cobs (chopped/ground)	60%	60 kg
Energy Source	Maize or Sorghum grains	10%	10 kg
Protein Source	Groundnut cake, Soybean meal or poultry droppings (dried)	15%	15 kg
Energy/Laxative	Rice bran, Corn bran or Wheat offal	10%	10 kg
Methane Inhibitor/Binder	Duckweed/Molasses	2%	2 kg
Minerals/Vitamins	Bone Meal or Di-calcium Phosphate (DCP)	1.5%	1.5 kg
Additives	Salt and Vitamin/Mineral Premix	1.5%	1.5 kg
Total		**100%**	**100 kg**

2.6. Improving low-quality roughages via urea treatment for climate-resilient rations for ruminants

Crop residues, such as maize stover, sorghum stover, rice husk, and corn cobs, are classified as low-quality roughages for feeding ruminants. They are abundant in larger quantities after harvesting and processing. However, they are low in nitrogen/protein content and high in fibre. Processing (chopping and crushing/grinding) and treatment with urea fertiliser improve their nutritional values, digestibility, and feed intake. These crop residues have been successfully incorporated into a climate-smart feed system to address feed challenges associated with ruminant production during the dry season, when green grasses are grossly inadequate. Urea-treated cobs can be used to formulate a balanced ration for sheep where the treated corn cobs constitute 10-40% of the total mixed ration (Maikeke et al. 2024). Urea-treated maize cob could also be fed as a basal diet alongside a concentrate mixture to sheep (Negewo et al., 2018). Note that Urea-treated corn cobs can be used to formulate a concentrate mix for small ruminants where the treated corn cobs constitute 40% of the total mixed ration, in which the concentrate mixture contained 7.2% coconut meal, 18.0% rice bran, 12.0% soybean meal, 14.4% ground maize grain, 6.0% molasses, 0.6% urea, 0.9% salt, and 0.9% mineral supplement (Yulistiani et al., 2021). Watch the enrichment of dry fodder (low-quality roughages) with urea (https://www.youtube.com/watch?v=9PpPon0ZM_U).

Preparation and treatment processes:

- Crush/ground dry corncob to a desirable particle size to pass through a 2-5 mm sieve.
- Dissolve 5 kg of urea fertilizer-in 50 litres of water (50% moisture level) to treat 100 kg of dry corncobs.
- Spray the urea solution uniformly onto the cobs and mix thoroughly.
- Ensilage the treated cobs in an airtight plastic bag or a sealed pit, for a minimum of three weeks to increase the crude protein content and allow ammonia to break down the fibre to improve digestibility and intake.
- Open the ensiled material to aerate (air-dry) the treated cobs for 1-2 days to evaporate the excess ammonia gas before feeding the animals.

2.7. Feeding practices to reduce feed wastage

Good quality feed and proper feeding practices improve livestock productivity. Depending on the species of livestock and systems of production, feeding

practices vary from grazing/browsing on natural pastures to supplementation with different feed resources (concentrates, formulated feeds, kitchen waste and conserved forages) of higher nutritional value. However, facilities to enhance feed consumption, improve feed utilisation efficiency, and reduce waste are essential to guarantee profitability and sustainability.

Basic principles and methods of reducing feed wastage include:

- Provide well-designed species-specific feed/water troughs.
- Maintain a right feed/water trough suitable for the height of the animal.
- Practice controlled (restricted or ad libitum) or precision feeding (feed according to quantity required per day/age/body weight)
- Adopt feed delivery methods/present feed forms adaptable to specific species of livestock (e.g. use of pellet, crumble, Mash or block feed types).
- Cut forages (e.g. grasses) to desirable length sizes.
- Adopt a good feeding regimen and a well-planned feeding schedule.
- Group animals and feed according to age groups/size.
- Monitoring of daily/weekly feed consumption.

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PART 2 - CURRICULUM

Learning Objectives

KNOWLEDGE	SKILLS	ATTITUDES
Students should be able to: ● Describe climate-smart feed practices for livestock. ● Explain approaches for climate-smart feed and feeding of livestock ● Identify the available climate-resilient feed resources. ● Explain how to formulate climate-resilient rations. ● Evaluate feed quality ● Describe feeding practices to reduce feed wastage.	*Students should be able to:* ● Produce climate-smart feed resources ● Assess the quality of feed ingredients and compounded rations. ● Demonstrate and prepare quality livestock feed. ● Implement climate-smart ration for poultry and small ruminants. ● Demonstrate improvement in the low-quality for inclusion in the total mixed ration. ● Apply and monitor feed wastage minimisation.	*Students should be able to:* ● Demonstrate commitment to learning ● Show commitment to reducing waste ● Appreciate the role of feed and feed management in reducing methane emissions. ● Advocate for climate-smart feeding practices. ● Demonstrate teamwork and collaboration during group monitoring and problem-solving tasks. ● Exhibit responsibility and environmental sensitivity in climate-smart feeding practices for livestock. ● Value-informed feeding decisions for subsequent improvement.
TRANSVERSAL SKILLS INTEGRATED: **Problem-solving and critical thinking** ● Assessing, identifying and developing innovative solutions to challenges of livestock feeding. **Communication and interpersonal relationships** ● Disseminating knowledge, innovations and new ideas effectively to farmers on		

feed management.

Collaboration and teamwork

- Working harmoniously within and outside professional groups as a team to resolve feed-related matters for livestock.

Interpretation of feed analytical results

- Evaluating, calculating and interpreting the results of feed analyses for informed decisions on feed formulation and preparation of quality feed for the categories of livestock.

Adaptability and Flexibility

- Adjusting to recent advances in the utilisation of non-conventional feed resources as replacements for the highly expensive conventional feed resources, considering the nutritional needs/requirements of classes of livestock.
- Adapting animals to available feed resources as dictated by seasons or weather patterns.

Continuous training and learning

- Staying up-to-date on feed and feeding management strategies and attending capacity-building meetings/workshops.

DIGITAL SKILLS INTEGRATED:

- Proficiency in using software to input data on feed intake, weight gain and overall performance of livestock.
- Literacy in applying software to formulate balanced feed and interpreting the outcomes of the overall impact of compounded diets on livestock.
- Understanding precision feeding methods and automated feeding strategies to minimise feed wastage and improve feed intake for increased livestock productivity.
- Proficiency in using e-communication tools (social media platforms/apps: Facebook, TikTok, WhatsApp, Instagram, Telegram, etc.) to interact with farmers.

GREEN SKILLS INTEGRATED:

Sustainable feed production

- Understanding sustainable feed production systems that guarantee the continuous availability of feed resources for livestock

Sustainable environmental protection

- Knowledge of diverse livestock feed resources/ingredients/additives that are eco-friendly, enhance efficient nutrient utilisation, improve performance, are cost-effective and mitigate greenhouse gas emissions.

Climate-Smart Feed and Feeding Management

- Identifying and promoting the cultivation of drought-tolerant forage resources adaptable to specific agro ecology.
- Using the preservation techniques that are suitable to improve the shelf-life of feed resources/ingredients.
- Adapting feeding management practices to prevailing or changing weather patterns.

Implementation plan of pedagogical activities (Scheme of work / Session plan)

Duration: 3 hours 25 min				
Target: VET learners, Diploma certificate holders/trainees, smallholder farmers, and agricultural advisors (gender-balanced; mixed experience)				
No.	**Duration**	**Training Methods / Activity**	**What the trainers do**	**What the participants do**
1.	45 min	Problem-Based Learning (PBL): "Feed Shortage Constraints in Dry Season"	● Introduce feed shortage constraints; guide learners to identify locally available non-conventional and conventional feed resources. ● Provide laboratory analysis of feed ingredients for observation. ● Propose feed options for dry seasons (e.g. crop residue-based feed) for ruminants.	● Work in groups to share experiences on feeding-related issues, ask questions, and develop solutions to address livestock feed constraints. ● Observe the feed samples displayed.
2.	45 min	Hands-on Demonstration Training	● Make available forage samples (grasses and	● Participate actively in the activities and ask

			legumes) of different ages and discuss the mixing ratios of grasses and legumes for feeding of ruminants (sheep and goats). ● Provide samples of common crop residues and agro-industrial by-products that could be used as replacements/substitutes for conventional feed ingredients in ruminant feeding strategies. ● Demonstrate: urea treatment of low-quality roughages, Preparation of total mixed ration, assessment of feed quality (ingredients/formulated feed), and Display facilities to reduce feed wastages.	questions, and train others.
3.	50 min	Mini-Enterprise Challenge: "Feed Bank Startup"	● Explain the cost-benefit model of crop residue-	● List the raw materials (local), identify the nutrient composition

			based concentrate/Total mixed ration (TMR) business; guide learners to write a business proposal and highlight the tips for success.	(via nutrient analysis reports) and share experiences with others.
4.	45 min	Digital Simulation & Data Exercise (FeedCalc Practice)	● Presents videos on feed formulation, guides learners on data entry.	● Watch and Input data on feed composition and interpret results.
5.	25 min	Collaborative Reflection Forum	● Summarise course contents. ● Encourage active participation and engagement ● Use open-ended questions to stimulate discussion.	● Share real-life experiences/challenges ● Participate in group discussions ● Reflect and provide constructive feedback on peers' experiences ● Identify best practices ● Reflect and discuss on Improving their problem-solving skills

Materials (What trainers need to have prepared):

- Samples of feed ingredients (both conventional and non-conventional),
- Feed ingredients nutrient analysis.
- Corn cobs, maize stover, urea, mixing tools, plastic container, Nylon sheet
- Android devices with FeedCalc, FAO e-Feed, GEA_VET LMS, and WhatsApp group set-up
- Short video clips of the preparation of TMR and enriching low-quality roughages/crop residues.

PART 3 – ACTIVITY GUIDE

DESCRIPTION OF ACTIVITIES

1." Solutions to Feed Shortage Constraints" – Problem-Based Learning Activity

Feed shortage constraints have consistently influenced the profitability and sustainability of the livestock production enterprise. Climate change, such as excessively high environmental temperatures, irregular rainfall patterns and drought, reduces biomass yield and quality of natural and cultivated pastures. Trainees/Learners are exposed to a field situation where smallholder ruminant (sheep and goat) farmers cannot adequately feed their animals during the extreme dry season period due to inadequate green fodder (grasses). The trainer asked trainees about the possible options of making feed available to the animals, and introduced the locally available feed resources (arrays of crop residues and tree legumes that could be used to manage the feed crisis. After much deliberation and discussions within the groups on which of the available feed resources to use, trainees were briefed about the feeding values of the suggested feed resources, using the results of feed composition analysis and nutrient requirements of the specific class or ruminant. Thereafter, trainees were guided on the processing and treatment of low-quality roughages (corn cob/maize stover) with urea fertiliser for subsequent inclusion in the total mixed ration for feeding to increase the feed intake, protein content, digestibility and growth performance of the animals. Adoption of this climate-smart feed addresses feed and feeding management challenges, mitigates environmental footprints associated with greenhouse gas emissions, and also promotes food and nutrition security.

1. Aim of the activity: To assess feed shortage challenges associated with climate change and proffer climate-resilient feed options.

2. Duration: 45 min

3. Material required:

- Samples of feedstuffs (corn cobs, maize stover, Urea fertilizer)
- A weighing scale water
- Sprinkler
- Plastic bags or plastic drums
- Shovels
- Grinder
- A nylon sheet
- Short videos

4. Step-by-step instruction of the task/practical exercise/case study:

- **Present the Case Study:** A mixed crop–livestock farming community in Northern Nigeria experienced recurring dry-season feed shortages, leading to weight loss and low productivity in cattle and small ruminants. To address this challenge, farmers adopted practical feed solutions using crop residues, supported by extension officers and TVET trainees. Corncobs were collected from the field after harvesting and the removal of the grains. Corn cobs were processed to improve their feeding value. Corn cobs were ground to a smaller particle size and treated with urea fertiliser to enhance the nitrogen content and digestibility before being stored for dry-season use. Farmers were trained to mix the urea-treated corncobs, with other locally available feed ingredients to have a balanced ration.
- **Preparation and treatment of Urea-treated corn cobs**:
    - Crush/grind dry corncob to a desirable particle size to pass through a 2-5 mm sieve.
    - Dissolve 5 kg of urea fertiliser in 50 litres of water (50% moisture level) to treat 100 kg of dry corncobs.
    - Spray the urea solution uniformly onto the cobs and mix thoroughly.
    - Ensilage the treated cobs in an airtight plastic bag or a sealed pit, for a minimum of three weeks to increase the crude protein content and allow ammonia to break down the fibre to improve digestibility and intake.
    - Open the ensiled material to aerate (air-dry) the treated cobs for 1-2 days to evaporate the excess ammonia gas before feeding the animals.

References/Sources/Further materials:

Negewo, T., Melaku, S., Asmare, B. and Tolera, A. (2018). Performance of Arsi-Bale sheep fed urea-treated maize cob as basal diet and supplemented with graded levels of concentrate mixture. *Tropical Animal Health and Production*, 50: 1209–1217. https://doi.org/10.1007/s11250-018-1544-4.

Yulistiani, D., Puastut, W. and Wina, E. (2021). Response of sheep fed urea-treated corncob and supplemented with cassava leaf meal. *South African Journal of Animal Science* 51(6): 689-699. https://doi.org/10.4314/sajas.v51i6.2

2. Hands-on Demonstration Training on Mixing Ratios of Grasses and Legumes for Feeding Small Ruminants

In Nigeria, small ruminants' productivity in the dry season declines due to scarcity of feed, both in quantity and quality. The trainer presents a scenario of exploring climate-resilient grasses and tree legumes as feed. The trainer asks the trainee to list the available climate-resilient grasses and tree legumes for feeding small ruminants, and state the

appropriate age to harvest forages for feeding. The trainer suggested Napier grass, Northern Gamba grass and legumes (e.g. tree legumes/shrubs: Leucaena, Gliricidia) as potential forages for feeding, and highlighted the nutrient composition of identified forages. In addition, trainees were advised to cut forages for feeding when their nutrient content is at optimum, preferably at 8-10 weeks old, depending on forage types. Thereafter, the trainer in collaboration with the learners, demonstrated the preparation of grass-legume ration for feeding, and taking into consideration their mixing ratios, in a cut-and-carry system of feeding small ruminants. Additionally, the trainer provides a list of common crop residues and agro-industrial products that could be used as climate-resilient feed for ruminants. Identified crop residues as well as agro-industrial by-products were used to prepare feed options (total mixed ration and urea-treated maize stover) for feeding small ruminants in the dry season.

1. Aim of the activity: To demonstrate the mixing ratios of grass-legume mixtures, preparation of urea-treated molasses maize stover and total mixed ration of crop residues-based as climate-resilient feed options.

2. Duration: 45 min

3. Materials required:

- Maize stover
- Urea fertilizer
- Molasses
- Water
- Plastic drums
- Elephant grass
- *Leucaena* leaves
- *Gliricidia* leaves
- Nylon sheets
- Weighing scale
- Sprinkler, etc.

4. Step-by-step instructions of the task/practical exercise/case study:

➢ **Preparation of grass and legumes for feeding small ruminants**

- Harvest the grasses (Napier/Elephant grass and legumes (e.g. *Leucaena*, *Gliricidia*) at the right stage of maturity, when the nutrient content is at optimum.
- Chop the grasses to a size of 3-5cm using a forage chopper.
- Wilt the grasses or legumes under a shade for 24 hours.

- Mix the grasses and legumes in the following ratios: (60-70% grasses and 30-40% legumes).
- Serve the chopped and wilted forage mixtures to the animals in an appropriate quantity via the feeding troughs.

Maize stover is a residue of the maize plant after harvesting from the field. Although very low in protein, they are important crop residues that are often grazed by ruminants immediately after maize grains are harvested. Urea treatment reportedly improves the nitrogen content and breaks down lignin for increased digestibility. The addition of molasses to the urea-treated maize stover will improve the taste/palatability and subsequently feed intake.

➢ **Preparation of urea-treated molasses maize stover**

- Collect maize stovers from the field immediately after harvesting maize grains and cobs
- Chop to moderate sizes of 5-8cm
- Dissolve 4-5kg of urea in 50 litres of water, and blend thoroughly until the urea crystals disappear from the solution.
- Add 10kg of molasses to the urea solution and mix thoroughly.
- Sprinkle urea-molasses solution uniformly on 100kg of maize stover
- Store urea-treated molasses maize stover in a container or in a concrete-lined pit, and cover with plastic film or nylon sheet to make it air tight.
- Allow to ensile for 3-4 weeks.
- Open the treated maize stover, collect the quantity required and aerate for a day before feeding to animals.

➢ **Preparation of a total mixed ration of crop residue-based**

- Collect cowpea husk from the field after harvesting and processing of pulses.
- Collect palm kernel sludge and soybean hull from the palm kernel and soya bean oil processing mills.
- Harvest *Gliricidia sepium* leaves at the right maturity stage and air-dry in the shade.
- Crush the dried cowpea husk to a moderate particle size.
- Mix all the feed ingredients according to the following proportions: 30% Palm kernel sludge, 12% soya bean hull, 53% cowpea husk, 4.5% Gliricidia leaves and 0.5% salt.

References/Sources/Further materials:

Abera, F., Urge, M. and Animut, G. (2018). Feeding Value of Maize Stover Treated with Urea or Urea Molasses for Hararghe Highland Sheep. *The Open Agriculture Journal*, 12, 84-94.Addah, W. and Ayantunde, A. 2021. Manual on conservation and utilisation of crop residues as livestock feed. Published by the International Institute of Tropical Agriculture. Produced by the University for Development Studies and the International Livestock Research Institute.

Omotoso, S. O., Ajayi, F. T., Boladuro, B. A. and Emerue, P. C. (2021). A mixed ration of crop residues: effects on rumen fermentation characteristics and blood indices of West African dwarf sheep. *Nigerian Journal of Animal Production*, 48(6):348-362. https://doi.org/10.51791/njap.v48i6.3323.

3. Mini-Enterprise Challenge: "Feed Bank Startup for Crop Residues-Based Concentrate or Total Mixed Ration

The trainer exposes the learners to the benefits of having a feed backup for their livestock, the cost implications and profits if they are interested in establishing a mini feed bank. Learners were advised to consider the following: availability of raw materials based on nutritional values (e.g. crop residues, by-products of grains and legumes, etc.), Processing/production processes (collection, grinding, pelletising, packaging, branding, etc.), target products (concentrates for small ruminants/ monogastrics, etc.), target market (small-scale livestock farmers, feed vendors, etc.), sales and advisory services (marketing strategy) and income streams as keys to feed bank business. The trainer highlighted the estimated startup costs with respect to the prevailing local prices of items required for production activities.

1. Aim of the activity: To develop a business plan for a mini livestock feed bank of crop residues-based concentrate or Total Mixed Ration.

2. Duration: 50 minutes

3. Materials required:

- Business plan templates
- Case studies of successful feed banks
- Financial projection tools
- Feed production and cost worksheets
- Market situation guides

4. Step-by-step instructions of the task/practical exercise/case study:

- Identify the crop residues and other essential ingredients that are in abundance and readily available.
- Decide on production capacity and scalability.

- Collect and process the crop residues into desirable forms (pellets, crumble or feed block).
- Package (bagging) and brand the products.
- Market the products (with emphasis on nutritional values and cost benefits).
- Conduct market research on the products and adjust product formulations.
- Maintain the quality of the products and focus on customer satisfaction.

4. Digital Simulation on Feed Formulation

The trainer presents a case of a livestock farmer in southwestern Nigeria who wants to formulate feed for sheep and goats. The farmer needed an expert's advice on the ingredients, nutrient composition and how to develop high-quality feed that meets the nutrient requirements of the animals using a feed formulation software. The trainer provided the trainee with a list of ingredients available within the locality. Data on the nutrient composition of ingredients and the nutrient requirements for the livestock were made available.

1. Aim of the activity: To demonstrate the formulation of feed for livestock using feed formulation software.

2. Duration: 45 min

3. Materials required:

- Feed formulation guides
- Worksheets
- Nutrient composition of ingredients and their prices
- Sample feed formulation scenarios
- Video clips on Feed formulation Simplified- (https://www.youtube.com/watch?v=amWvGX_E75A)
- Video on Least Cost Feed Formulation (by WinFeed) (https://www.youtube.com/watch?v=M1PHulzyUR4)

4. Step-by-step instructions of the task/practical exercise/case study:

- Identify the type of livestock (ruminants-sheep, goats or poultry)
- State the purpose of production (i.e. product desired)
- List the available feed ingredients and their prices
- Gather data on the nutrient composition of the available feed ingredients
- Set up the feed formulation software/tool and input the nutrient composition of the ingredients.
- Input the nutrient requirements for the livestock (e.g., energy, protein, calcium, phosphorus).

- ➢ Formulate a feed that meets the nutrient requirements of the livestock.
- ➢ Analyse the results of the formulated feed composition.
- ➢ Calculate the cost of the formulated feed.

References/Sources/Further materials:

FAO, (2016). FAO Ration tool for dairy cows - FAO: Outil de rationnement pour vaches laitières - FAO: Herramienta de racionamiento para vacas lecheras. FAO, Rome, Italy

5. Collaborative Reflection Forum

The trainer requested that all the trainees reflect on what was taught, share their real-life experiences, challenges and successes, and in doing this, respect for individual opinions and constructive feedback was mentioned as the ground rules of the forum. The trainers engaged the trainees through open-ended questions to harvest the lessons learnt from the training exercise in order to stimulate discussion within the various groups of trainees, while major takeaways and actionable points from the discussions were highlighted and summarized.

1. Aims of the activity: To facilitate a collaborative reflection forum for TVET trainees/farmers to share experiences, challenges, and best practices in livestock feed and feeding management.

2. Duration: 25 minutes

3. Materials:

- Whiteboards
- Note taking materials
- Case studies in feed formulation challenges

4. Step-by-step instructions of the task/practical exercise/case study:

- ➢ Collaborative Reflection Forum on Livestock feed and feeding Management.
    - ○ Welcome all the participants and define the purpose of the forum
    - ○ Get the trainee engaged in an activity to encourage participation
    - ○ Trainees present case studies on lessons taught, with focus on successes, and failures.
    - ○ Trainees discuss case studies in small groups with emphasis on major challenges, best practices, and areas for improvement.
    - ○ Reflection and sharing of major takeaways
    - ○ Develop actionable plans for trainees to apply to learnings in their own contexts.

References/Sources/Further materials:

Not required