Food and Agriculture Organization of the United Nations

Module 6: Climate-smart livestock fodder bank

Climate-smart Farmer Field School curriculum

with the financial support of

UNDP

GREEN CLIMATE FUND

Module 6: Climate-smart livestock fodder bank

Climate-smart Farmer Field School curriculum

Authors
Jam Muhammad Khalid
Rania Wajdi Ibrahim
Nicholas Molyneux
Rand Alamoush

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
AMMAN, 2024

Required citation:

Khalid, J.M., Ibrahim, R.W., Molyneux, N. and Alamoush, R. 2024. *Module 6: Climate-smart livestock fodder bank – Climate-smart Farmer Field School curriculum.* Amman, FAO. https://doi.org/10.4060/cd2755en

ISBN 978-92-5-139196-9

Contents

Acknowledgements

We extend our sincere gratitude to everyone who contributed to the development of the climate-smart Farmer Field School (CS-FFS) curriculum package. This curriculum serves facilitators and farmers within the "Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector (BRCCJ)" project, implemented by the Food and Agriculture Organization of the United Nations (FAO).

This training material involves Module 6: climate-smart livestock fodder bank aims to guide CS-FFS facilitators, master trainers, and farmers in enhancing climate resilience across livestock production system for sustainable food production and livelihood. We envision this document as a vital resource to foster climate-smart practices, ultimately supporting the overarching goals of the CS-FFS initiative within Jordan's agriculture sector.

Special thanks are due to Nabil Assaf (FAO Representative to Jordan), Mohamed AlHamdi (Lead Technical Officer), Maysoon AlZoubi (Project Manager), Nicholas Molyneux (Chief Technical Advisor), and Rania Wajdi Ibrahim (Agronomist and Climate Adaptation Specialist-Component-2 Lead) for their unwavering guidance, support, and appreciation throughout this process.

We deeply appreciate Jam Muhammad Khalid (International Consultant) and Rand Alamoush (National Consultant) for their invaluable contributions. Jam Khalid's expertise has been instrumental in shaping the conceptualization and design of the course material, aligning it with international best practices in climate change adaptation and water-saving agriculture. Rand Alamoush's local knowledge and understanding of training needs were key in tailoring the material to address the specific challenges faced by farmers and FFS facilitators in the project's target areas.

We extend thanks to the technical team and representatives from the ministry of agriculture (MOA), including but not limited to Eng. Baker Albalawneh, Eng. Khalid Alheesa, Eng. Worood Al Abbadi, Eng. Mustafa Al Autoom, and Eng. Talal Joudeh, for their insightful feedback, ensuring the course content's relevance and effectiveness.

This field school curriculum training material would not have been possible without the generous support of CS-FFS facilitators, practitioners, and farmers across Jordan, especially those in the governorates of Main, Tafileh, Madaba, and Karak. Your contributions in shaping the climate-smart approaches outlined in this document are deeply valued.

Finally, we acknowledge the communication and ICT team for their graphic design contributions, as well as the logistics and operations team for their support throughout the missions of the international and national teams.

Abbreviations

AESA	agroecosystem analysis
BRCCJ	Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector
CSA	climate-smart agriculture
CS-LFB	climate-smart livestock fodder bank
CS-FFS	climate-smart Farmer Field School
FAO	Food and Agriculture Organization of the United Nations
ICT	information and communication technology
IEC	information, education and communication
MEAL	monitoring, evaluation, accountability and learning
TOFs	training of facilitators
TOTs	training of trainers

Introduction of the module

Climate-smart livestock fodder bank

In recent years, climate change has emerged as a significant challenge for agricultural practices worldwide, affecting livestock production and food security. Jordan, situated in a semi-arid region faces challenges exacerbated by climate change, including water scarcity, land degradation, and extreme weather events. Climate-related hazards such as extreme temperatures, droughts, flash floods, storms, and landslides affect Jordan severely, while climate change increases their frequency and intensity yearly.

These challenges have prompted the need for innovative and sustainable agricultural practices that can mitigate the impacts of climate change while ensuring food security and livelihoods for farmers. The climate-smart livestock fodder bank (CS-LFB) is a promising solution that addresses these challenges by promoting sustainable livestock feed management while enhancing climate resilience in agriculture. This learning module, developed under the “Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector (BRCCJ)” project, aims to introduce Jordanian farmers to the concept of CS-LFB and equip them with the knowledge and skills needed to establish and manage their own fodder banks effectively.

Research indicates that the establishment of fodder banks can significantly benefit livestock production systems in arid and semi-arid regions. By growing a diverse range of drought-resistant forage crops, fodder banks provide a reliable and nutritious source of feed for livestock, reducing dependency on costly external feed sources. Moreover, fodder banks contribute to soil health and water conservation through enhanced vegetation cover and reduced soil erosion, thus promoting sustainable land management practices.

Several studies have highlighted the potential of fodder banks to improve livestock productivity and resilience to climate variability. For example, a study demonstrated that the integration of fodder banks into smallholder livestock systems in similar agroecological contexts led to increased milk yields and improved body condition scores in livestock (Demeke & Tadesse, 2017) and similarly, research found that the establishment of fodder banks improved livestock productivity and resilience to drought in semi-arid regions (Fenta *et al*.,2019), resulting in enhanced food security and livelihoods for farmers.

The adoption of CS-LFB can also contribute to climate change mitigation efforts by sequestering carbon through increased vegetation cover and reduced soil degradation. This aligns with Jordan’s commitments to climate action under the Paris agreement and supports national efforts to enhance climate resilience in the agricultural sector.

In the context of the BRCCJ project, this learning module seeks to empower Jordanian farmers with the knowledge and skills needed to implement CS-LFB as a climate-smart agricultural practice which uses water efficient techniques that help

Jordanian farmers facing water challenges. By promoting sustainable livestock feed management and enhancing climate resilience, the CS-LFB approach offers a promising pathway towards achieving food security, livelihood improvement, and environmental sustainability in Jordan's agriculture sector.

Through a Farmer Field School approach, this learning module will engage farmers in hands-on learning experiences, field demonstrations, and knowledge sharing sessions to facilitate the adoption and adaptation of CS-LFB to local conditions. By building capacity and fostering community participation, the BRCCJ project aims to catalyse positive change in Jordan's agricultural sector and contribute to the country's sustainable development goals.

Learning objectives

This module is a comprehensive resource supporting both training of facilitators (ToF) and the delivery of Farmer Field School (FFS) sessions on climate-smart livestock fodder bank. It provides detailed lesson plans, background information, and practical tools for training extension staff in the ToF context. When directly used in FFS sessions, it offers a structured curriculum to guide farmers in adopting CS-LFB practices.

This module, designed as a guiding tool, will help achieve the following learning objectives of the Farmer Field School approach on CS-LFB for farmers in Jordan:

1. Gain practical knowledge and skills in hydroponic azolla production, specifically tailored for poultry and small animal feed supplementation, including its nutritional value and integration into existing farming systems.

2. Develop the ability to assess the suitability of different fodder bank practices based on local agroecological conditions and resource availability, considering factors such as soil quality, water availability, and climate variability.

3. Apply participatory learning-by-doing approaches and discovery learning principles in the establishment and management of climate-smart livestock fodder banks, fostering active engagement, experimentation, and knowledge sharing among smallholder farmers in Jordan.

Water-smart technologies

Integrated climate-smart livestock fodder bank systems offer a promising solution by incorporating water-smart technologies that maximize the use of limited water resources while enhancing fodder production for livestock. This module introduces several water-smart technologies integral to the establishment and management of integrated fodder bank systems:

1- Cocoons

2- Azolla Hydroponic Cultivation

1. Cocoons

Cocoons are a groundbreaking, biodegradable planting technology designed to transform tree establishment, especially in arid and degraded landscapes. This innovative solution consists of a doughnut-shaped structure, often made from recycled cardboard that surrounds a young sapling. At its core lies a water reservoir that steadily seeps moisture through wicking fabric into the surrounding soil. This targeted, slow-release hydration system mimics optimal conditions for seedling development. Additionally, the cocoon acts as a mini greenhouse, shielding the young tree from harsh weather and minimizing evaporation, thus significantly increasing survival rates. As an added benefit, cocoons are biodegradable, leaving no harmful residue behind.

Source: Mallee Conservation. 2024. *Revegetation in dry times - Cocoon planters.* [Cited 20 September 2021]. *https://www.malleeconservation.com.au/blog/revegetation-in-dry-times*

For arid regions like Jordan, where water scarcity is a major obstacle to reforestation, cocoons offer a sustainable and water-efficient solution. By replicating the nurturing microenvironment found under a nurse plant in nature, cocoons enable young trees to thrive even in challenging conditions. As Jordan faces desertification and seeks to restore its landscapes, cocoons technology emerges as a powerful tool for successful reforestation and ecological revitalization.

The benefits of cocoons extend far beyond reforestation alone. This versatile technology holds promise for various environmental and agricultural projects where water resources are limited. Cocoons can facilitate land rehabilitation efforts like revegetating mining sites, contribute to urban greening initiatives, and even support crop cultivation in water-stressed areas. Moreover, cocoons act as a protective barrier, safeguarding young saplings from extreme temperatures, arid soils, and harmful pests.

The strength of cocoons lies in their ability to create a self-sustaining microenvironment that supports a young tree throughout its vulnerable early stages. The biodegradable cocoon holds a water reservoir, providing gradual moisture release over several months and drastically reducing the need for frequent irrigation. It also shields the young plant from extreme temperatures, wind, and excess sun. Meanwhile, as the cocoon decomposes, it adds nutrients to the soil. This combined effect of steady hydration, protection, and nourishment gives seedlings the best chance to establish robust root systems and become self-sufficient.

Cocoons vs. traditional methods: Water savings and success

Cocoons offer significant advantages over traditional tree planting methods (flood irrigation either manually or with the support of drip lines), especially regarding water conservation and survival rates. Without the cocoon's protective water reservoir, traditional methods expose seedlings to environmental stresses and require frequent irrigation, which isn't always sustainable in dry areas. Cocoons drastically cut water needs and significantly boost survival rates. This efficiency makes Cocoons a valuable tool for successful, long-term restoration and reforestation projects.

Cocoons are a promising agroforestry technique for optimizing water use efficiency in fodder tree cultivation. Especially in arid environments, cocoons can create the ideal conditions for young trees, leading to higher survival rates and reduced water needs when establishing fodder sources. Research underscores the potential of Cocoons as a water-smart technology for sustainable livestock fodder production in arid regions.

Cocoons benefits

- Delivers water directly to the root zone, minimizing waste compared to traditional irrigation methods.
- The slow-release reservoir extends the time intervals between watering.
- The consistent moisture encourages the tree to develop strong, deep roots.
- Dramatically increased tree survival rates especially in arid and degraded areas, leading to successful reforestation and restoration projects.
- Up to 90 percent reduction in irrigation needs compared to traditional methods (Land Life, 2024).

- The cocoon buffers against harsh heat and cold, improving young tree resilience.
- The cocoon acts as a physical barrier, helping the sapling outcompete weeds for resources.
- The cocoon breaks down naturally, leaving no waste footprint.
- Successful tree establishment can contribute to restoring degraded land and increasing soil carbon storage.

Cocoons theory

Reservoir

The central component of the cocoon is a reservoir designed to be filled with water (usually around 15–20 litres depending on the size). This stored water provides a steady supply to the young tree.

Wicking system

The cocoon has fabric tabs or wicks extending outwards from the reservoir. These wicks contact the surrounding soil.

Capillary action and evaporation reduction

Through capillary action, the wicks slowly draw water from the reservoir and release it into the soil near the tree's roots. This provides consistent moisture without overwatering.

The cocoon acts as a cover over the soil, reducing evaporation and keeping the moisture in the soil for longer periods.

See also FAO. 2024. *Climate-smart Farmer Field School catalogue – Cocoons.* FAO, Jordan. [Cited on 10 October 2024] *https://openknowledge.fao.org/handle/20.500.14283/cd2297m*

Installation methodology

Essentials for CS-FFS learning plots

Table 1 FFS learning requirements for cocoons technology

Item	Responsibility/share		Remarks
	BRCCJ project	Host farmer	
Shovel or digging tool	-	X	For creating planting holes
Cocoons	X	-	
Saplings	X	-	Approved variety
Water		X	For initial watering of the cocoon
Mulch (optional)	X	-	To help retain moisture around the base of the plant
Gloves	X	-	To protect your hands
Safety glasses	X	-	To protect your eyes from dirt and debris

Source: Authors' own elaboration.

Site selection

- Choose an area with appropriate sunlight and soil drainage for your chosen tree species. Avoid areas with excessive slopes or standing water.
- Evaluate soil type, drainage, and sunlight availability.

Hole preparation

- Mark the locations of each cocoon planting hole based on your chosen spacing and orientation.
- Dig a hole slightly larger than the cocoon. The depth should be sufficient to accommodate the cocoon's reservoir and the tree's root ball.

Cocoon placement

- Remove the outer packaging of the cocoon.

Tree planting

- Place the cocoon in the hole, ensuring the wick system (the tabs /strips of absorbent material extending outwards) is in contact with the soil.
- Gently place the sapling in the center of the cocoon.
- Backfill the hole around the cocoon and the tree, ensuring the root ball is fully covered.
- Tap the soil lightly to remove air pockets.

Watering

- Fill the cocoon's reservoir with water according to the manufacturer's instructions (usually about 15–20 litres).

Mulching (optional)

- The water will gradually seep into the soil through the wicks, providing moisture to the young tree.
- Apply a layer of mulch around the base of the tree to further suppress weeds and conserve moisture.

Precautions

- Handle cocoons with care by avoiding tearing or damaging the material.
- Use the cocoon size recommended for your specific tree species.
- Plant at the appropriate time and consult with local experts on the best planting season for your area.

Safety measures

- Use gloves and safety glasses when digging and handling materials.
- Avoid working in extreme heat or during storms.
- Use tools correctly to prevent accidents.

Important notes

- Always follow the manufacturer's specific instructions for your cocoon product.
- Monitor the cocoons and saplings regularly. Ensure they're not damaged, and the water reservoir is maintained as needed during the first year of establishment.
- The cocoon will biodegrade over time. Once the tree is established it won't require removal.

Suitable fodder plants

Table 2 Suitable fodder plants for BRCCJ project area

Fodder tree	Madaba	Tafileh	Ma'an	Karak
Acacia species: Like *Acacia saligna*, *Acacia tortilis*) are drought-resistant trees providing nutritious pods and leaves that goats and sheep love.	■	■	■	■
Siris tree (Albizia lebbeck): Tolerant of drought conditions, this tree provides nutritious leaves and pods that are beneficial for small ruminants.			■	■
Almond (*Prunus dulcis*): Almond trees produce nuts that can be consumed by both humans and animals. The leaves and twigs are also nutritious for browsing animals.	■			
Carob (*Ceratonia siliqua*): Carob trees produce sweet pods that are high in protein and can be consumed by goats and sheep.	■	■		
Eucalyptus (*Eucalyptus* spp.): Some species of eucalyptus trees, such as *Eucalyptus camaldulensis*, can provide forage for livestock during dry periods. However, caution should be taken as eucalyptus leaves contain compounds that can be toxic in large quantities.	■	■	■	■
Faidherbia albida: *Acacia albida* in old classification, also known as the white acacia, this tree is native to the region and provides nutritious leaves and pods for animals.		■		
Ficus (*Ficus* spp.): Certain species of fig trees, such as *Ficus carica*, can provide edible leaves and fruits for small ruminants.	■			■
Jujube (*Ziziphus jujuba*): Jujube trees produce sweet, nutritious fruits that are enjoyed by both humans and animals. The leaves can also be browsed by goats and sheep.	■			
Leucaena (*Leucaena leucocephala*): Leucaena is a fast-growing leguminous tree that provides high-protein leaves and pods. It can tolerate drought conditions and poor soil.	■	■	■	■

Fodder tree	Madaba	Tafileh	Ma'an	Karak
Moringa oleifera: Also known as the Drumstick Tree, Moringa is a fast-growing tree that thrives in arid climates. Its leaves are highly nutritious and can serve as fodder for small animals.			■	■
Mulberry *(Morus alba*): While primarily known for its leaves, which are a favorite of silkworms, mulberry trees also produce fruit that is relished by goats and sheep.	■			■
Olive (*Olea europaea*): Olive trees are well-suited to the Mediterranean climate of Jordan and provide both fruits and leaves that can be grazed by goats and sheep.	■			
Prickly pear cactus (*Opuntia* spp.): Though not a tree, prickly pear cactus is a valuable fodder plant for goats and sheep in arid regions like Jordan. It's drought-tolerant and provides both food and water.				■
Prosopis species: Prosopis trees, such as *Prosopis juliflora* (Mesquite), are well-suited for arid environments and provide nutritious fodder for small ruminants. However, they can be invasive in some areas, so proper management is necessary.		■	■	■
Tamarisk (*Tamarix* spp.): Tamarisk trees are hardy and can tolerate saline soils, making them suitable for arid regions like Madaba. They provide nutritious leaves and twigs for browsing animals.	■	■	■	■

Source: Authors' own elaboration.

2. Azolla hydroponic fodder production

Azolla, also known as duckweed, is a free-floating aquatic fern characterized by its small, flat, compact green mass that floats on the water's surface. Belonging to the family *Azollaceae*, azolla species are found worldwide, with common species like *Azolla pinnata* prevalent in regions like India. Known for its rapid growth rate, azolla doubles its biomass every three days under optimal conditions, making it a highly productive feed supplement for livestock, poultry, and fish. Rich in protein and nutrients, azolla is considered a super plant due to its ability to produce high-quality protein in significant quantities compared to traditional feed sources like lucerne and hybrid napier grass. Its ease of cultivation, fast growth, and versatility in various agricultural applications make azolla an attractive option for sustainable livestock feed production and environmental management.

Azolla is a small, fast-growing floating fern. It's exceptionally high in protein (25–35 percent), contains essential vitamins, minerals, and amino acids, making it an

excellent fodder supplement. Azolla thrives in freshwater environments and doubles its biomass within days, making it an efficient, sustainable source of feed.

Azolla hydroponic farming presents a water-smart alternative for producing nutrient-rich feed for livestock, particularly poultry and small animals. Azolla thrives in nutrient-rich water and can be cultivated hydroponically, minimizing water usage compared to traditional soil-based cultivation methods. Furthermore, azolla's ability to fix atmospheric nitrogen enhances its nutritional value while reducing the dependency on external inputs such as synthetic fertilizers.

Installation methodology

1. **Pond or tank setup**

- Choose a well-lit area with partial shade to prevent overheating. Direct, all-day sun can harm azolla.
- Size – begin with a surface area of up to 2–3 square metres. This provides enough azolla for supplementing feed for a small flock of poultry or a few livestock animals.
- Depth – shallow is key. A depth of 20–30 cm is ideal for optimal azolla growth and ease of harvesting.
- Shape – flexible, rectangular, circular, or even an irregularly shaped pond will work as long as it holds water, rectangular shape is preferred.
- Drainage – a drainage facility should be considered for cleaning or partial water changes.

2. **Required materials**

As shown in below table.

Table 3 Required material for azolla production

Item	**Responsibility/share**		**Remarks**
	BRCCJ	Farmer	
Wooden box	X	-	Pond box made of wood (20–30 cm in depth), size of (1 m in width and 3 m in length).
Concrete blocks (length 40 cm, height 25 cm, width 15 cm)	X	-	Different way to create the pond other than the wooden box, a rectangular border of concrete blocks can be used as a pond. Pond size: (1 m in width and 3 m in length).
Pond liner 30–45 mil thick food grade (5 metre square) 500 microns is used usually in Jordan	X	-	

Item	Responsibility/share		Remarks
	BRCCJ	Farmer	
Mesh netting	X	-	
Shad cloth	-	X	
Small fountain or aerator	-	X	
Azolla plants (seed or fresh azolla)	X	-	
Pond preparation labour cost	X	-	
Water	-	X	
Fertilizer/ processed fermented animal manure	X	X	Fertilizer for azolla cultivation, usually is preferred from chicken origin.
Agricultural green net	X	-	1 metre by 4 metre in size. Used to provide shade for azolla cultivation pond especially in hot weathers.
Greenhouse nylon cover sheets			Important in cold seasons (winter) to retain temperature higher for the azolla pond.

Source: Authors' own elaboration.

- Lining
    - Pond liner with 30–45 mm thick food grade plastic sheet is highly durable and widely available.
    - Clay – if locally available and suitable, well-compacted clay can create a watertight seal.
    - Concrete – provides a long-lasting solution but requires more construction effort and cost.
- Structure/support
    - Earthen – dig a shallow depression and use the excavated soil to form slightly raised berms around the pond.
    - Bricks or stones – used to define the perimeter of the pond and support the liner.
    - Mesh netting (optional) – to deter birds and reduce excessive leaf debris.
    - Shade cloth – may be necessary during the hottest times of year to prevent azolla from overheating.

- Small fountain or aerator (optional) – if the pond is large, this can help oxygenate the water and reduce stagnation.

3. **Water preparation**

- Use clean freshwater from a well, rainwater collection, or a municipal source if available.
- Azolla requires phosphorus for optimal growth. Add a small amount of superphosphate fertilizer (follow package directions). Consider adding a small amount of aged cow dung to provide additional nutrients.

4. **Azolla introduction**

- Source healthy azolla from a local supplier, agricultural extension service, or potentially from a natural pond.
- Gently spread a generous amount of azolla across the surface of your pond or tank. It will quickly form a dense mat, don't fill the pond fully as azolla will reproduce increasing its surface within a short period.

5. **Management**

- Monitor for excessive direct sunlight. Provide additional shade netting if needed.
- Collect a portion of the azolla daily (roughly 10–20 percent) for feeding your livestock. The azolla will rapidly regrow.
- Replenish evaporated water to maintain a consistent level. Avoid stagnant water – a slight overflow can help.
- Consult local agricultural extension services for azolla strains best suited to your region and specific livestock needs.
- Begin with a manageable system and scale up as you gain experience and understand the feeding needs of your livestock.

6. **Feeding livestock**

- Azolla can be fed fresh or dried in the sun.
- Mix azolla with other fodder for a balanced diet. Avoid using it as the sole source of nutrition, especially for sheep.

Important considerations for Jordan

- Hot summers may require more shade and frequent water replenishment. Experiment for optimal conditions in your area.
- If water salinity is a concern, monitor carefully. Consider periodic partial water changes.
- Azolla's dense growth can attract mosquitoes. Employ a fine mesh cover or introduce small fish that eat mosquito larvae.

Additional benefits

- Azolla helps absorb excess nutrients, improving water quality.
- Harvested azolla biomass can be composted or used directly as a high-quality fertilizer.

See also FAO. 2024. *Climate-smart Farmer Field School catalogue – Azolla hydroponic*. FAO, Jordan. [Cited on 10 October 2024] *https://openknowledge.fao.org/handle/20.500.14283/CD2664EN*

Learning lessons

This chapter presents key lessons for CS-FFS training sessions, covering general and technical topics, as well as essential activities. These lessons will support participatory learning exercises focused on selected CSA technologies, crops, and farming systems. While the lessons thematic areas outlined here don't reflect the exact session order (for CS-FFS as well as TOFs/TOTs), they provide a customizable foundation for specific sessions using the curriculum development form given in the climate-smart Farmer Field School curriculum part-5 – data governance.

Lesson 1 – Farmer's organization and community development

- Introduction of project.
- Field visit of the selected CS-FSS Site and discovery learning.
- Farmer organization development.
- Team building and norms setting.

Lesson 2 – Introduction to climate-smart livestock fodder bank systems

- Concept of climate-smart agriculture.
- Understanding with CSA practices and technologies.
- Understanding climate-smart livestock fodder bank system.
- Integrated fodder production lay out designing.

Lesson 3 – Site assessment and adaptation

- Field-based assessment of soil quality, water availability, and climatic conditions.
- Determine the most suitable fodder bank CSA practices for specific farm sites and identify potential adaptations.
- Most suitable fodders of the area.
- Livestock vaccinations.

Lesson 4 – Agroforestry techniques using cocoons for fodder trees

- Science by farmers basics - setting experimentations
- Hands-on demonstration of cocoon installation and planting techniques,
- Practical sessions in the field for planting fodder trees and monitoring their growth progress.

Lesson 5 – Hydroponic azolla production for poultry and small animals

- Practical demonstration of hydroponic azolla production systems, including setup, maintenance, and harvesting procedures,

- Hands-on training in integrating azolla into poultry and small animal diets.
- Occupational safety, health, and hygiene

Lesson 6 – Agroecosystem analysis and decision making

- Practical training in monitoring key indicators of selected CSA technologies for fodder bank performance, such as fodder yield, water use efficiency, soil health, and livestock productivity,
- Learning analytical skills on ecosystem-based data collection and analysis exercises to assess the impact of implemented practices.
- Poultry enterprise development

Lesson 7 – Integration with livestock management practices

- On-farm demonstrations and practical sessions on integrating fodder bank practices with:
    - livestock management,
    - including feed formulation,
    - feeding schedules, and
    - monitoring livestock biosafety, health, and performance.

Lesson 8 – Planning for sustainable fodder bank management

- Participatory planning exercises to develop long-term management plans for climate-smart integrated fodder banks:
    - up-scaling learnings,
    - integrated fodder crop management strategies,
    - water management plans, and
    - pest and disease management strategies.

Lesson 9 – Participatory learning, knowledge sharing and networking

- Field day for knowledge sharing facilitated by farmers and experts, focusing on sharing experiences, lessons learned, and best practices in climate-smart integrated fodder bank management.
- Farmers linkages and networking.
- Graduation and certificate award celebrations.

Learning layout for science by farmer

The participatory learning comprises two basic components. First are the CSA technology /practice plots and second is the agroecosystem analysis (AESA) of the learning plots. The CS-FFS group will select any suitable technology, or crop or system for AESA practices to learn the observational and analytical skills as prime objective of the field school approach.

A. CSA plots layout – experimentations

Different CS-FFS may has different set of packages based on the project provisions; however, each CS-FFS group may have up to 2–3 primary technology packages for learning. More selection depends upon farmers share and budget provision in the project.

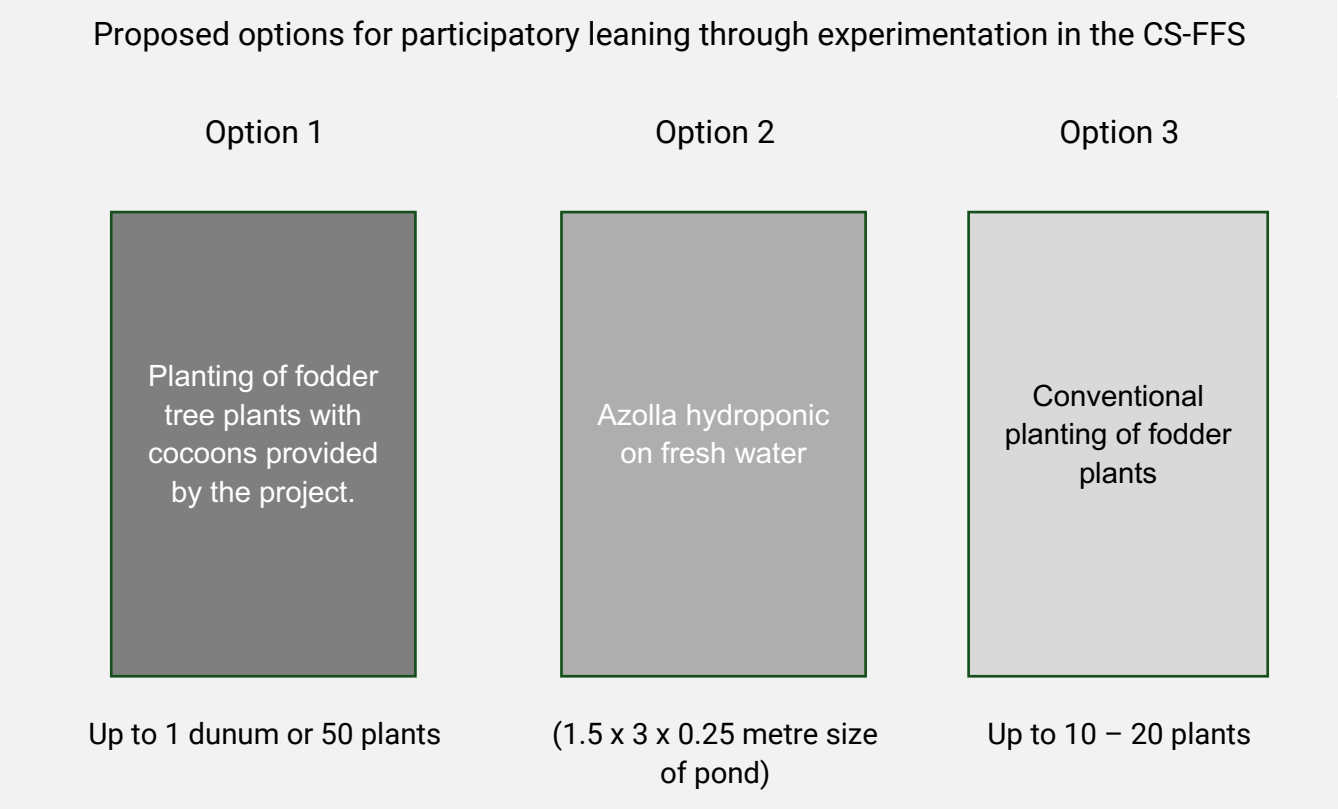

Figure 1 CS-FFS learning experiments options

Source: Authors' own elaboration.

B. Agroecosystem analysis parameters

Following different systems can be selected for learning under the AESA model.

1. Azolla hydroponic
2. Cocoons technology

Keeping in mind the limited available slot for learning session under the field school program, it will be more practical to choose up to one CSA technology with its production system for learning agroecosystem analysis. Following key parameters would be selected for data observation, analysis, interpretation, and decision making.

Table 4 Agro-ecosystem analysis parameters

Parameters	**Primary CSA technology**	
	Azolla hydroponic	**Cocoons technology**
Crop /farming	Azolla hydroponic	Fodder trees / shrubs transplantation
Livestock	Small animals	Small animals
Water use	Quantity used (volume, frequency)	Irrigation quantity (volume, frequency)
Water quality	pH, salinity, presence of contaminants	pH, salinity, presence of contaminants
Plant/ crop growth	Azolla growth rate, coverage, color	Tree growth rate, leaf health, signs of nutrient deficiency
Pests scouting	Identification of pest insects, diseases & weeds	Identification of pest insects, diseases & weeds
Predator insects scouting	Identification of beneficial insects	Identification of beneficial insects
Soil scouting	-	Soil moisture, texture, /compaction
Animal health	Animal weight gain, feed conversion, signs of disease, vaccination	Animal weight gain, feed conversion, signs of disease, vaccination

Source: Authors' own elaboration.

Additional considerations

Table 5 Additional parameters for consideration for FFS

Parameters		**Use of CS-FFS tools**
Economic analysis	Include simple economic parameters like input costs and yield/production to help farmers evaluate profitability in context.	Use CS-FFS data book and farmer diary
Comparison to traditional methods	Encourage a side-by-side comparison with existing practices. This will help farmers visualize the differences and benefits.	Use CS-FFS data book and farmer diary; AESA and experimentations
Adaptation of technologies	Discuss possible adaptations and variations of the CSA techniques for specific farmer needs and contexts.	Adaptation plan development
Farmer-Led decision-making	The CS-FFS process should emphasize farmer-driven analysis and decision-making based on their observations of the agroecosystem.	Adopt proper AESA

Source: Authors' own elaboration.

The parameters within these tables serve as a guide. You might adjust or add more parameters depending on the specific CSA technology, local context, and the farmers' areas of interest.

Additional considerations

- **Tools:** Use CS-FFS data books and farmer diaries to track observations over time.
- **Economics:** Calculate simple input costs (water, treatments, labour) vs. output (fodder yield/sales) to assess profitability of the CSA system.
- **Compare & Contrast:** Maintain a section in your data book for how these observations differ from traditional fodder system in your area.
- **Adaptations:** Discuss with farmers how these CSA methods could be modified to suit their specific needs and resources.
- **Farmer-Led Decisions:** The goal of AESA is to empower farmers! Encourage them to analyse what they observe and make informed choices for their own orchards.

The parameters within these table serve as a guide. You might adjust or add more parameters depending on the specific CSA technology, local context, and the farmers' areas of interest.

Implementation calendars

Calendar guiding crops or tree cultivation, technology, and practice implementation under the CS-FFS

A. CS-FFS implementation calendar

Module:	Climate-smart livestock fodder bank
Time duration:	Round the year–12 months
Start month:	September–March
Graduation month:	August–February
Regular sessions No.:	10 (or can be adjusted with prior approval)
Follow-up meetings/visits:	up to 5 (or can be adjusted with prior approval)

Table 6 CS-FFS implementation calendar

CS-FFS starts in autumn			**Autumn**			**Winter**			**Spring**			**Summer**		
		Months	S	O	N	D	J	F	M	A	M	J	J	A
CS-FFS starts in spring			**Spring**			**Summer**			**Autumn**			**Winter**		
		Months	M	A	M	J	J	A	S	O	N	D	J	F
Steps		**Output**												
1	Ground working and promotion	• Preparation of curricula. • Meetings with community. • Procurement of CS-FFS inputs & learning material.												
2	Identification of participants	• Need assessment and mapping.												
3	Group formation and organization	• Farmers registration completed.												

CS-FFS starts in autumn Months			Autumn			Winter			Spring			Summer		
			S	O	N	D	J	F	M	A	M	J	J	A
CS-FFS starts in spring Months			Spring			Summer			Autumn			Winter		
			M	A	M	J	J	A	S	O	N	D	J	F
		• Farmers organization formed.												
4	Identify participatory learning site	• Host farmers identified. Resolution form signed by host farmer.												
5	Planning of CS-FFS learning CSA technology and crops	• CSA technology /practice identified and agreed with farmers. • farming system identified.												
6	Establishment of participatory learning sites	• CSA technology including cocoons and azolla hydroponic for fodder production implemented. • Fodder trees plants are transplanted, and fodder crops alfalfa & lucerne are sown.												
8	Regular CS-FFS meetings	Training sessions on critical stages of selected CSA technologies, fodder crops and tress as well as poultry birds and small animals' production technology/ practice (agreed with farmers).												

CS-FFS starts in autumn Months			Autumn			Winter			Spring			Summer		
			S	O	N	D	J	F	M	A	M	J	J	A
CS-FFS starts in spring **Months**			**Spring**			**Summer**			**Autumn**			**Winter**		
			M	A	M	J	J	A	S	O	N	D	J	F
9	Agroecosystem analysis (AESA) of learning plots	• Farmers are trained on agroecosystem parameters. • Farmers are able to observe crop and farm ecosystem.												
10	Farm agribusiness and enterprises	• Farmers are trained on business and enterprise. • Farmers are record keeping regularly. • Farmers can do economic analysis.												
11	Harvest of learning plots	• Sessions on harvest and post-harvest conducted. • Farmers conducted cost benefit analysis.												
12	Post-harvest learning for CS-FFS produce	• CSA practices on value chains are considered.												
13	Planning and preparation for value addition (optional)	• Farmers are trained on post-harvest CSA practices including feed mixing.												
14	Field day celebrations	• Neighbour farmers visited CS-FFS learning sites.												
15	Participatory evaluation	• CS-FFS data record maintained in data books.												

CS-FFS starts in autumn Months			Autumn			Winter			Spring			Summer		
			S	O	N	D	J	F	M	A	M	J	J	A
CS-FFS starts in spring **Months**			**Spring**			**Summer**			**Autumn**			**Winter**		
			M	A	M	J	J	A	S	O	N	D	J	F
		• MEAL team conducted pro-post evaluation and learning assessments.												
16	FFS alumni network (optional)	CS-FFS organization is networked with CS-FFS clusters, networks locally, regionally, nationally, and globally (where possible).												
17	Graduation	• CS-FFS graduation criteria assessed. • Successful farmers awarded certificates.												
18	Post CS-FFS	• Post CS-FFS planning conducted. • Action plan implemented												

Source: Authors' own elaboration.

B. CS-FFS tentative sessions schedule

The development of CS-FFS tentative sessions schedule for the Module-6 climate-smart livestock fodder bank can be customized by using the curriculum development form given in Part 5 – data governance and considering the relevant tools provided in the CS-FFS learning package during the training of facilitators or trainers (TOF/TOT) course.

Section A

Module-6 Climate-smart livestock fodder bank

Section B

Part 1 – CSA practices compendium
Part 2 – CSA practices catalogue
Part 3 – One curriculum
Part 4 – Standards operating procedures
Part 5 – Data recording and governance
Part 6 – Digital support

Section C

Two years CS-FFS implementation work plan

Box 1 CS-FFS session schedule form

#.	Sessions Title	Main field learning activities	Group dynamic	Special topic	Learning skills	Date of session	Time duration (hours)	Facilitator
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Source: Authors' own elaboration.

Remember

- Tailor the technologies and specific activities to the exact region and farmers' needs.
- Be prepared to adjust the schedule based on weather, crop development, and farmers' questions.
- Adjust agroecosystem analysis activity in regularly to ensure analytical skills learning.
- Sessions should be farmer-led as much as possible, with facilitators guiding the learning.

C. Fodder trees calendar

This calendar provides a general guideline for planting these species in different regions of Jordan, but local variations and specific conditions should also be considered for optimal planting times.

Table 7: Fodder trees calendar for targeted governorates

Plant Name	**Karak**	**Tafileh**	**Madaba**	**Jordan Valley**	**Notes**
Acacia species (*Acacia saligna, Acacia tortilis*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Autumn	Drought-tolerant, good for all regions
Siris tree *(Albizia lebbeck*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Tolerates drought
Almond (*Prunus dulcis*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	
Carob (*Ceratonia siliqua*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Sweet, high-protein pods
Faidherbia albida or *Acacia* albida (as old classification)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Nutritious leaves and pods
Ficus (*Ficus* spp.)	Late winter/early spring	Late winter/early spring	Late winter/early spring	Late winter/ early spring	Edible leaves & fruits (species-specific)
Jujube (*Ziziphus jujuba*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Sweet, nutritious fruits
Leucaena (*Leucaena leucocephala*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Fast-growing, high protein

Plant Name	Karak	Tafileh	Madaba	Jordan Valley	Notes
Moringa *(Moringa oleifera)*	Late spring/ early summer	Late spring/ early summer	Late spring/ early summer	Late spring/ early summer	Highly nutritious leaves
Mulberry (*Morus alba*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Fruit & leaves for browsing
Olive (*Olea europaea*)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Fruits & leaves for grazing
Prickly Pear (*Opuntia* spp)	Late spring/ early summer	Late spring/ early summer	Late spring/ early summer	Late spring/ early summer	Drought-tolerant, food/water source
Prosopis Species	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Nutritious fodder, manage invasiveness
Tamarisk (*Tamarix* spp.)	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Late autumn/ early winter	Tolerates saline soils

Source: Authors' own elaboration.

Important Notes:

- Some plants may be vulnerable to frost even if listed as late autumn/ early winter. Consider local frost patterns.
- Even within these areas, there could be microclimates. Always factor in elevation and very specific local conditions.
- Especially in arid Ma'an, these calendars don't address irrigation and water conservation strategies. Adapt as needed.

D. Livestock vaccination calendar

Vaccination of livestock plays a crucial role in the agricultural sector of Jordan, a country where livestock farming significantly contributes to the rural economy. Ensuring the health of these animals through vaccination not only protects them from common infectious diseases but also safeguards public health by preventing the transmission of zoonotic diseases to humans. Moreover, healthy livestock are essential for food security and nutrition, as they are a primary source of protein. Vaccination also has economic benefits, as it reduces the need for treatments and minimizes livestock mortality rates, thereby enhancing productivity and profitability for farmers. In Jordan, where climatic conditions can be harsh and resources limited, vaccination is a proactive measure that helps maintain the resilience of livestock populations against outbreaks that could devastate herds and livelihoods.

Facts about livestock vaccination

- Vaccines expose animals to safe versions or components of pathogens, priming their immune systems to fight off a real infection.
- Vaccines help animals create antibodies, proteins that specifically target and neutralize pathogens.
- Vaccinating a high percentage of a herd protects even unvaccinated individuals by making disease spread less likely.
- Many vaccines require repeat doses (boosters) to maintain long-lasting immunity.
- Vaccination schedules are designed to maximize protection, especially for young animals.

Important considerations

- Always consult a vet for the correct vaccines, dosages, and timing for your animals.
- Vaccination needs vary for goats vs. sheep, and for different regions based on disease risks.
- Only vaccinate healthy animals.
- Follow vaccine storage instructions for effectiveness.

See following documents for livestock vaccination calendars for backyard poultry (FAO, 2024a) and small animals (FAO, 2024b):

E. Information, education and communication materials for farmers

Information, education and communication (IEC) materials play a vital role in disseminating knowledge and promoting the adoption of improved agricultural practices, including climate-smart agriculture (CSA) technologies. Here's why these materials matter:

- IEC materials like posters, pamphlets, farmer's diary and catalogues present complex information in a simplified, visually appealing, and easy-to-understand format. This makes information accessible to farmers with varying levels of literacy and technical backgrounds.
- Well-designed IEC materials cater to the specific needs and challenges of farmers in the CS-FFS area. They address local concerns, highlight the benefits of CSA practices, and use relatable language and visuals.
- IEC materials serve as a consistent reference point for farmers, reinforcing the lessons learned during Farmer Field School sessions. They help farmers remember key concepts, best practices, and important steps, even after the training has ended.
- IEC materials can be distributed beyond the Farmer Field School participants. This helps promote CSA technologies within the broader community, potentially leading to widespread adoption and increased impact.

The following IEC material should be produced for farmers of the CS-FFS area for broader adoption and implementation of CSA technologies.

1- Livestock vaccination schedule poster /pamphlets published in the CSA catalogues developed for backyard poultry (FAO, 2024a) and backyard small animals (FAO, 2024b) designed for Jordanian FFS farmers.

2- CSA catalogues developed for cocoons (FAO, 2024c) and azolla hydroponic (FAO, 2024d).

References

Demeke, T. and Tadesse A.. 2017. *The impact of establishing forage banks on milk yield and body condition score of dairy cattle in Lemo and Kersa Districts of Ethiopia.* Livestock Research for Rural Development 29.3.

FAO. 2024a. *Climate-smart Farmer Field School catalogue – Backyard poultry.* FAO, Jordan.

FAO. 2024b. *Climate-smart Farmer Field School catalogue – Backyard small animals.* FAO, Jordan.

FAO. 2024c. *Climate-smart Farmer Field School catalogue – Cocoons.* FAO, Jordan. [Cited 8 October 2024] *https://openknowledge.fao.org/handle/20.500.14283/cd2297m*

FAO. 2024d. *Climate-smart Farmer Field School catalogue – Azolla hydroponic*. FAO, Jordan. [Cited 8 October 2024] *https://openknowledge.fao.org/handle/20.500.14283/CD2664EN*

Fenta, K., Assefa, A., & Molla, A. 2019. *Evaluation of the performance of planted forage species in relation to natural pastures in arid and semi-arid rangelands of Eastern Ethiopia. Ethiopian Journal of Agricultural Sciences*, *29*(3), 103-121.

Land Life. 2024. *Innovations – Cocoons.* [Cited 14 May 2024]. *https://landlifecompany.com/innovation*

Mallee Conservation. 2024. *Revegetation in dry times - Cocoon planters.* [Cited 20 September 2021]. *https://www.malleeconservation.com.au/blog/revegetation-in-dry-times*

Project

Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector

Partners

Ministry of Agriculture, Jordan

Ministry of Environment, Jordan

Ministry of Water and Irrigation, Jordan

United Nations Development Programme

Funded by

Green Climate Fund

Geographic coverage

Ma’an, Tafileh, Karak and Madaba Governorates

Contact

FAO Representation, Jordan

Al-Sha'b Street

FAO-JO@fao.org

Food and Agriculture Organization of the United Nations

Amman, Jordan

ISBN 978-92-5-139196-9

9 789251 391969

CD2755EN/1/10.24