



# GEAVET TRAINING PROGRAMME FOR CSA

## CLIMATE-SMART AND SUSTAINABLE AGRICULTURE, POST-HARVEST MANAGEMENT AND RENEWABLE ENERGY: MOZAMBIQUE

### UNIT 2.3 RENEWABLE ENERGY - SOLAR DRYERS IN POST- HARVEST PROCESSING

**ENGLISH VERSION**

GEAVET Project n° 101129027



Open Educational Resources

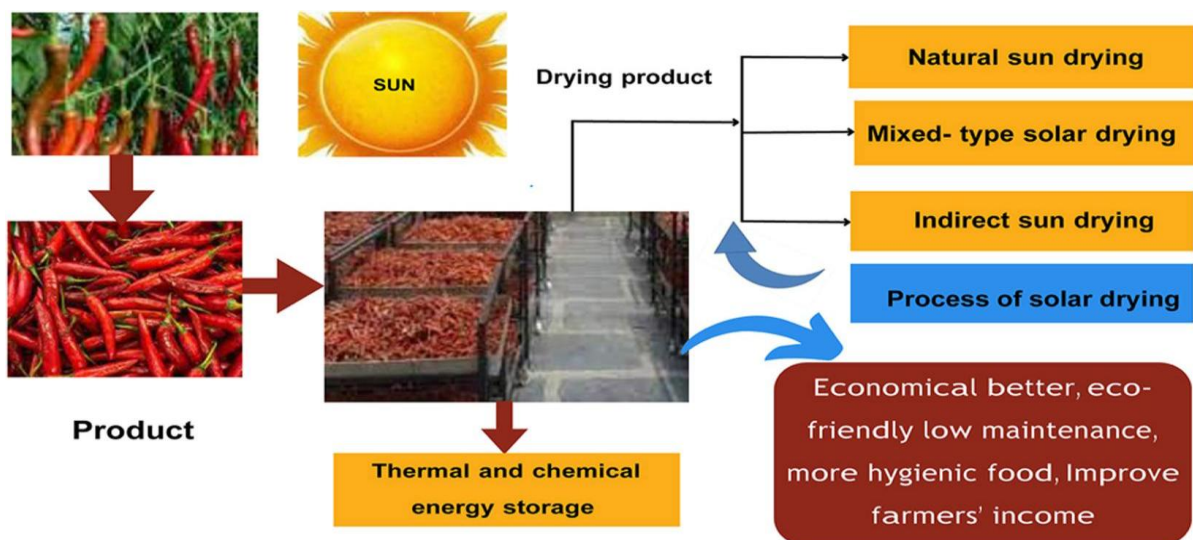


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## PART I – LEARNING MATERIAL

### 1. Introduction: Solar Energy and Post-Harvest Processing

Renewable energy, particularly solar energy, is a key driver of sustainable agriculture and climate-smart food systems, as it provides clean, low-cost power for on-farm and post-harvest operations while reducing reliance on fossil fuels and lowering greenhouse gas emissions (Garcia-Munoz et al., 2025; Udumkun et al., 2020). In post-harvest processing, solar dryers are innovative, low-cost technologies that use sunlight to remove moisture from produce, thereby extending shelf life and improving food quality. Drying is one of the oldest preservation techniques, but traditional open-air drying exposes food to dust, rain, insects, and contamination, leading to lower product quality and safety (Matavel et al., 2021; Matavel et al., 2022). Solar dryers improve hygiene, efficiency, and product value while reducing energy costs and greenhouse gas emissions (FAO, 2020; Udumkun et al., 2020).



**Figure 7. Technological development in solar dryers from 2016 to 2021 (Saini et al., 2023)**

In Mozambique and other African regions, solar dryers are increasingly used for mangoes, tomatoes, fish, cassava, and leafy vegetables—helping small farmers, fishers, and women’s groups to reduce losses and earn additional income. For example, solar tunnel dryers in Mozambique have improved the drying environment for vegetables and fruits, extending shelf life and increasing market opportunities for rural communities (UNFCCC, 2025). Implementation of solar dryers in fishing communities has also reduced drying time, contamination, and product loss compared to traditional beach drying methods (AllAfrica/GAIN, 2024).

## 2. Learning Relevance to Climate-Smart Agriculture and Renewable Energy

**Solar drying technologies** contribute significantly to **environmental, economic, and social sustainability**. From an **environmental perspective**, they rely on clean, renewable solar energy instead of firewood or fossil fuels, thereby reducing deforestation and lowering carbon dioxide emissions associated with conventional drying methods (Udomkun et al., 2020). By extending the shelf life of agricultural products, solar drying also minimizes post-harvest waste and food loss, contributing directly to Sustainable Development Goal 12 on responsible consumption and production (United Nations, 2015). **Economically**, solar dryers enable value addition through the production of dried fruits, fish, and flour-based products, which increases market value and farmers' incomes. They reduce food losses that would otherwise erode profits and create opportunities for rural entrepreneurship, particularly for women and youth engaged in small-scale processing and trade (Udomkun et al., 2020). **Socially**, solar drying improves food security and nutrition by ensuring year-round availability of preserved foods, strengthens resilience to climate change impacts on seasonal harvests, and promotes local innovation and community collaboration through shared processing and knowledge exchange (Udomkun et al., 2020).



**Figure 8. Cereal solar dryer** (Saini et al., 2023)

### 3. Key Concepts

TERM	DEFINITION
<b>Renewable Energy</b>	Energy from natural sources (solar, wind, biogas) that are continually replenished.
<b>Solar Dryer</b>	A device that uses solar heat and airflow to remove moisture from crops or fish.
<b>Post-Harvest Loss Reduction</b>	Preventing spoilage and waste of produce through improved processing and storage methods.
<b>Solar Collector</b>	The transparent cover or panel that traps and transfers solar heat to the drying chamber.
<b>Hybrid Dryer</b>	A solar dryer combined with another heat source (e.g., firewood or biogas) for cloudy weather.

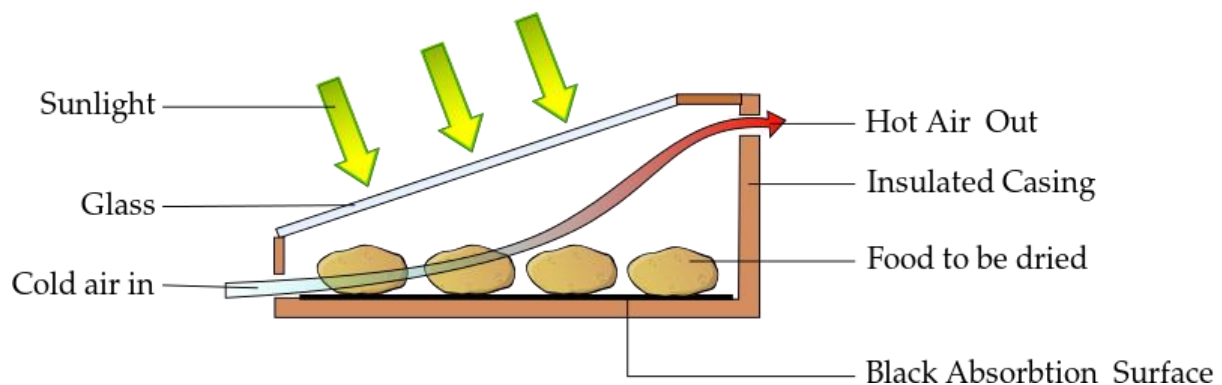
### 4. Types of Solar Dryers

Type	Description	Common Use
<b>Direct Solar Dryer</b>	Sunlight passes through a transparent cover, directly heating and drying the product.	Fruits, vegetables, spices
<b>Indirect Solar Dryer</b>	Air heated in a separate solar collector is directed into the drying chamber, preventing dust or insects.	Fish, grains, leafy vegetables
<b>Hybrid Solar Dryer</b>	Combines solar heat with an auxiliary energy source (e.g., firewood, biogas, or electricity).	Wet season drying, commercial production

#### Main Components of a Solar Dryer:

- Solar collector: Glass or clear plastic sheet to trap sunlight.
- Drying chamber: Trays or racks that hold produce.
- Absorber surface: Dark-colored material that converts sunlight into heat.
- Ventilation system: Inlet and outlet vents (or chimney) for airflow.

How to make a solar dryer: [How to make a solar dryer step by step : DIY](#)



**Figure 9. An overview of a basic solar dryer** (Rahman, 2022)

## 5. Practical Examples

### A. Drying Mango Slices (Direct Solar Dryer)

- Process: Wash, peel, and cut ripe mangoes into thin slices.
- Placement: Spread slices on mesh trays inside a direct solar dryer.
- Duration: 2–3 days under sunny weather.
- Storage: Cool and store in airtight bags or jars.
- Uses: Juice, snacks, export markets, or school nutrition programs.

**Digital Tip:** Use a solar drying monitoring app to check temperature and humidity.

### B. Drying Tilapia or Catfish (Indirect Solar Dryer)

- Preparation: Clean, split, and salt fish.
- Drying: Place on trays in an indirect solar dryer to avoid flies and dust.
- Duration: 2–4 days depending on weather.
- Outcome: Hygienic, high-quality dried fish with longer shelf life.

**Sustainability Tip:** Replace wood smoking with solar drying to reduce deforestation and smoke pollution.

### C. Drying Cassava Chips (Hybrid Dryer)

- Process: Peel, slice, and soak cassava to remove toxins.
- Drying: Use hybrid dryer (solar + auxiliary heat) for faster drying even in cloudy weather.
- Result: Dry chips milled into cassava flour for extended storage and local market sale.

**Integration Example:** Combine solar drying with solar-powered milling for a complete renewable post-harvest system.

## 6. Benefits of Solar Dryers

**Solar dryers** offer multiple **advantages** across **environmental, economic, and social dimensions**. **Environmentally**, they utilize renewable solar energy, significantly reducing greenhouse gas emissions and minimizing dependence on firewood, thereby helping to prevent deforestation. **Economically**, solar dryers have low operational and maintenance costs and enable value addition to agricultural produce, creating opportunities for entrepreneurship and increased income. **Socially**, they improve food safety and quality, reduce post-harvest losses, and contribute to employment generation, particularly for youth and women.

In addition to these benefits, solar dryers provide faster and cleaner drying compared to traditional open-air methods. The drying products are protected from contamination by dust, insects, animals, and unexpected rainfall. Solar dryers are adaptable to different crops and climatic conditions and can be used in various locations. They can also be constructed using locally available materials such as wood, bamboo, and plastic sheets, making them affordable and accessible for rural and small-scale users.

## 7. Integration with Sustainable Systems

Sector	Application
Farming Systems	Dry surplus fruits, vegetables, or grains to reduce waste.
Fisheries	Dry fish hygienically for market or storage.
Entrepreneurship	Produce packaged dried goods for sale (e.g., dried mango, cassava flour, fish snacks).
Climate Adaptation	Reduces dependence on fossil fuels and preserves harvests during erratic weather.

## 8. Challenges and Solutions

One of the main challenges in drying processes is inconsistent sunlight, which can be addressed by using hybrid dryers or carefully scheduling drying activities on sunny days. Poor airflow or uneven drying is another common issue, and this can be improved by ensuring proper ventilation and regularly rotating trays during the drying process. The initial cost of construction may also pose a barrier, but this can be reduced by using recycled local materials and promoting community-based dryer projects. In addition, limited technical knowledge can hinder effective use of drying technologies; therefore, providing TVET training, demonstration kits, and farmer field schools is essential. Finally, the lack of proper storage after drying can compromise

product quality, so training on appropriate packaging and storage methods is necessary to maintain the dried products' quality.

## 9. References/Sources

AllAfrica/GAIN. (2024, November 25). *Solar dryers transform Mozambique's fisheries*. <https://allafrica.com/stories/202411250096.html>

FAO. (2020). *Labour-saving technologies and practices: Solar drying equipment*. Food and Agriculture Organization of the United Nations. <https://www.fao.org/family-farming/detail/en/c/1619208/>

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United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. <https://sdgs.un.org/2030agenda>

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## PART 2 – CURRICULUM

### Learning Objectives:

KNOWLEDGE	SKILLS	ATTITUDES
<p><i>Students will know to:</i></p> <ul style="list-style-type: none"> <li>● Explain principles of solar drying and renewable energy.</li> <li>● Identify types and components of solar dryers.</li> <li>● Recognize the role of solar energy in post-harvest sustainability.</li> </ul>	<p><i>Student will be able to:</i></p> <ul style="list-style-type: none"> <li>● Construct and operate a simple solar dryer.</li> <li>● Apply solar drying techniques to crops or fish.</li> <li>● Measure and record drying time, temperature, and quality.</li> </ul>	<p><i>Student will develop the following mindset:</i></p> <ul style="list-style-type: none"> <li>● Responsibility toward clean energy and environmental protection.</li> <li>● Appreciation for innovation and circular economy thinking.</li> <li>● Willingness to share knowledge and promote renewable technologies.</li> </ul>
<p><b>TRANSVERSAL SKILLS INTEGRATED:</b></p> <ul style="list-style-type: none"> <li>● <b>Critical Thinking:</b> Select appropriate dryer type for different products and weather.</li> <li>● <b>Collaboration:</b> Work in groups to design and construct solar dryers.</li> <li>● <b>Problem Solving:</b> Troubleshoot uneven drying or airflow challenges.</li> </ul>		
<p><b>DIGITAL SKILLS INTEGRATED:</b></p> <ul style="list-style-type: none"> <li>● <b>ICT for Renewable Energy:</b> Use solar radiation apps to plan drying sessions.</li> <li>● <b>Data Collection:</b> Record and analyze drying data with mobile tools or spreadsheets.</li> <li>● <b>Online Learning:</b> Access video tutorials or design plans via mobile internet.</li> </ul>		
<p><b>GREEN SKILLS INTEGRATED:</b></p> <ul style="list-style-type: none"> <li>● <b>Sustainable Energy Use:</b> Reduce firewood and fossil fuel dependence.</li> <li>● <b>Circular Economy:</b> Use waste heat or integrate solar drying into value chains.</li> <li>● <b>Climate Adaptation:</b> Enhance food preservation under changing weather conditions.</li> </ul>		

## Implementation plan of pedagogical activities - Scheme of work

Duration: 2,5 - 3 hours				
Target: TVET learners, farmers, fishers, and agro-processors				
No. of Activity	Duration	Training Methods / Activity	What the trainers do	What the participants do
1.	50 min	Interactive lecture + video + Q&A	<ul style="list-style-type: none"> <li>● Explain solar energy principles and show examples of dryers in Africa.</li> </ul>	<ul style="list-style-type: none"> <li>● Listen</li> <li>● Discuss</li> <li>● Take short quiz.</li> </ul>
2.	120 min	Group planning + design session + practical demo	<ul style="list-style-type: none"> <li>● Guide groups to plan and sketch dryer design using local materials</li> <li>● Supervise construction (and drying test when possible)</li> </ul>	<ul style="list-style-type: none"> <li>● Collaborate</li> <li>● Calculate dimensions</li> <li>● Select dryer type.</li> <li>● Build a model dryer and record drying data (when possible)</li> </ul>
<b>Materials (What trainers need to have prepared):</b> <ul style="list-style-type: none"> <li>● Flip-charts</li> <li>● Projector</li> <li>● Transparent sheets</li> <li>● Wood</li> <li>● Mesh trays</li> <li>● Nails</li> <li>● Thermometer</li> <li>● Solar radiation app</li> </ul>				

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|--|
| <ul style="list-style-type: none"><li>● Markers.</li></ul> |
| <b>Other notes:</b>  |

## **PART 3 – ACTIVITY GUIDE**

### **DESCRIPTION OF THE ACTIVITIES**

#### **1. Understanding Solar Energy and Drying Principles**

The trainer introduces learners to renewable energy concepts and the principles of solar drying through an interactive lecture and a short video demonstration (e.g. “Solar dryer | solar drying | Solar dryer for fruits & vegetables | solar dryer in renewable energy” - <https://www.youtube.com/watch?v=t-Hz2nsg-bk&t=14s>). Learners identify different types of solar dryers, explore their advantages and limitations, and discuss how solar drying supports sustainable food preservation in local communities as well as how to easily build a solar dryer.

- 1. Aim of the activity:** Build foundational understanding of solar drying and its benefits.
- 2. Duration:** 50 min
- 3. Material required:**
  - Projector
  - Flip-chart
  - Markers
  - Short quiz (Mentimeter or paper)
- 4. Step-by-step instruction of the task/practical exercise/case study:**
  - Define renewable energy and solar drying (10 min)
    - Trainer Presentation (5 min):
      - Define renewable energy and discuss examples (solar, wind, hydro, biomass).
      - Introduce solar drying as a renewable energy application used to preserve food, feed, and other agricultural products.
      - Explain the basic principle: converting solar radiation into heat energy to remove moisture safely and efficiently.
    - Learner Brainstorm (5 min):

- Ask learners: “What products in your community are dried using sunlight?”
  - Record responses on the flip-chart (e.g., maize, cassava, fish, fruits, herbs).
  - Discuss traditional open-air drying vs. improved solar dryer methods.
- Show video and discuss local applications (20 min)
  - Video Viewing (10 min):
    - Play the video
    - Encourage learners to note down:
      - Types of dryers shown (direct, indirect, hybrid).
      - Benefits of solar dryers (hygiene, faster drying, quality retention).
      - Any examples of rural or small-scale applications.
  - Group Discussion (10 min): Divide learners into small groups (4–6 members). Discussion prompts:
    - What were the main types of solar dryers shown?
    - How do solar dryers improve product quality compared to open sun drying?
    - What local materials could be used to build simple solar dryers?

Groups summarize key points on flip-chart paper. The trainer facilitates the discussion and clarifies any technical terms such as moisture content, airflow, etc. The trainer also links concepts to learners’ local realities (for example: fruit drying inland or fish drying in coastal areas).
- Summarize and conduct quick quiz (10 min)
  - Trainer Summary (5 min): Review key takeaways on the board or flip chart:
    - Solar energy as a clean, renewable power source.
    - Principles of heat transfer and air circulation in dryers.
    - Main types of solar dryers (direct, indirect, hybrid).
    - Benefits for food safety, quality, and environmental protection.
  - Quick Quiz (5 min): Conduct a short quiz to check understanding (using Mentimeter, Google Forms, or paper-based questions). Example questions:
    - What is one main advantage of using solar dryers?
    - Name one type of solar dryer.
    - What is the purpose of the solar collector?
    - Why is solar drying considered sustainable?
- Reflection on local challenges (10 min)

- Group Reflection (7 min): Ask learners to think about challenges in implementing solar dryers locally, such as:
  - Cost and material availability.
  - Weather variability.
  - Lack of technical knowledge or maintenance skills.
 Each group proposes at least one solution or local adaptation (e.g., using recycled materials, community cooperatives).
- Trainer Wrap-Up (3 min):
  - Summarize reflections, highlighting the importance of innovation and local adaptation.
  - Encourage learners to consider how solar drying could support income generation, food security, and sustainability.

**References/Sources/Further materials:**

<https://www.youtube.com/watch?v=t-Hz2nsg-bk&t=14s>

## 2. Design and Build a Simple Solar Dryer

Learners work collaboratively in small groups to design and construct a small-scale solar dryer (either *direct* or *indirect type*) using locally available materials such as wood, transparent plastic, and mesh trays. They document the materials, costs, and dimensions, and then test the dryer using local agricultural produce (fruits, vegetables, fish, or leafy greens). This hands-on activity promotes innovation, teamwork, and understanding of renewable energy applications for food preservation.

1. **Aim of the activity:** Develop technical and collaborative skills in renewable energy innovation
2. **Duration:** 2 hours
3. **Material required:**
  - Wood frame
  - Transparent plastic
  - Mesh trays
  - Black paint
  - Thermometer
  - Nails
  - Measuring tape.
4. **Step-by-step instruction of the task/practical exercise/case study:**
  - Introduce task and show sample designs (15 min)

- Trainer Introduction (7 min):
  - Explain the objective: to design and build a simple, low-cost solar dryer using available materials.
  - Discuss key design principles: airflow, temperature control, protection from contamination, and use of solar heat efficiently.
- Show Sample Designs (8 min):
  - Use images, posters, or video snippets of FAO or local dryer models (such as “How to Build a Solar Dryer: Sustainable Food Drying at Home Beginners Guide” - <https://www.youtube.com/watch?v=ckN5aMwXVg8>)
  - Point out components (collector, drying chamber, vents, trays).
  - Encourage learners to think about adaptations using local materials (e.g., bamboo frame, recycled plastic, mosquito netting).
- Group construction using local materials (90 min): Learners form small groups (4–6 members) and begin designing and building their dryers.
  - Group Tasks: Design Phase (15 min):
    - Sketch a simple plan on flip-chart paper, including dimensions, tray arrangement, and air inlets/outlets.
    - List materials and estimate costs.
  - Construction Phase (75 min):
    - Build the dryer frame using wood or sticks.
    - Attach transparent plastic as the solar collector/cover.
    - Install mesh trays inside for placing the produce.
    - Paint the inside black (if possible) to enhance heat absorption.
    - Create ventilation openings to allow hot air to circulate and moisture to escape.
  - Testing (optional, within available time):
    - Place small amounts of local produce inside the dryer.
    - Measure the internal temperature with a thermometer after a few minutes.
    - Record results and observations (temperature, drying rate, appearance).

Trainer’s Role: Move between groups offering guidance and ensuring safety in tool use; provide tips for improving airflow, sealing edges, and ensuring stability; encourage resourcefulness – using recycled or low-cost materials.

- Presentation and peer review (15 min).

- Each group presents their dryer design and prototype (3–4 minutes per group). Presentation points:
  - Type of dryer (direct or indirect).
  - Materials used and total estimated cost.
  - Key dimensions and airflow design.
  - Observations from testing (if conducted).
- Peer Review (5–7 min): Other groups provide constructive feedback on:
  - Practicality and durability.
  - Cost-effectiveness and local suitability.
  - Innovation and environmental considerations.
- Trainer Wrap-Up (3 min):
  - Highlight effective design features.
  - Reinforce the link between renewable energy innovation and sustainable food preservation.
  - Encourage learners to refine and scale up their designs for community use.

**References/Sources/Further materials:**

<https://www.youtube.com/watch?v=ckN5aMWXVg8>