KP16
Knowledge Product 16

CCARDESA
Centre for Coordination of Agricultural Research and Development for Southern Africa

DECISION TOOL:
Climate Smart Manure Management Options for Improved Soil Fertility

CLIMATE SMART AGRICULTURE
KNOWLEDGE PRODUCTS FOR EXTENSION WORKERS
Customised Information Tools for Agricultural Professionals

Audience: Local Level Extension Staff (Government, NGO/Civil Society, Private Sector)

Livestock | Decision Point | Gender | Youth | Climate Smart | Practice


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WHAT IS CLIMATE SMART AGRICULTURE (CSA)?

CSA comprises three interlinked pillars, which need to be addressed to achieve the overall goals of food security and sustainable development:

1. **Productivity:** Sustainably increase productivity and incomes from agriculture, without negative impacts on the environment.

2. **Adaptation/Resilience:** Reduce exposure of farmers to short-term risks, while building capacity to adapt and prosper in the face of shocks and longer-term stresses (resilience). Attention is given to protecting ecosystem services, maintaining productivity and our ability to adapt to climate changes.

3. **Mitigation:** Wherever and whenever possible, CSA should help to reduce and/or remove greenhouse gas (GHG) emissions. This implies that we reduce emissions for each unit of agricultural product (e.g., through decreasing use of fossil fuel, improving agricultural productivity and increasing vegetation cover).

CSA = Sustainable Agriculture + Resilience – Emissions.

How is CSA Different?

1. CSA places greater emphasis on **hazard and vulnerability assessments** and **emphasizes weather forecasting** (short term) and **climate scenario modelling** (long term) in the decision-making process for new agricultural interventions

2. CSA promotes the **scaling up of approaches** that achieve **triple wins** (increase **production**, increase **resilience** and [if possible] **mitigate GHG emissions**), while at the same time **reducing poverty** and **enhancing ecosystem services**

3. CSA promotes a systematic approach to:

   a. Identifying **best bet** opportunities for agricultural investment

   b. Contextualising **best bet** options to make them **best fit** their specific context through learning and feedback loops

   c. Ensuring the **enabling environment** is in place so that farmers (and other stakeholders) can invest in CSA practices and technologies to catalyse adoption.

Key Messages:

1. The livestock housing system determines the major manure characteristics. Immediately after excretion, nutrients may begin dissipating. Climate Smart Manure Management aims to reduce nutrient losses from manure

2. To make climate smart decisions on which climate smart manure management option best suits your farmers, you need to understand:

   a. Soil type

   b. The local climate

   c. The farming system

3. Climate smart manure management options include:

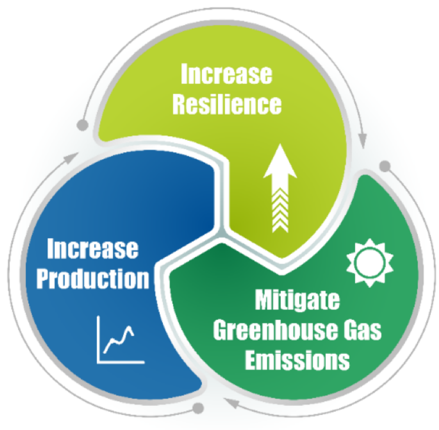
   a. Collection

   b. Storage

   c. Treatment.

Entry Points for CSA

- CSA practices and technologies
- CSA systems approaches
- Enabling environments for CSA.



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CLIMATE SMART MANURE MANAGEMENT OPTIONS

Manure management is an important CSA option because:

1. Manure is an excellent source of plant nutrients, and reduces the need for chemical fertilisers
2. A large amount of manure is required, and its nitrous oxide (N_2O) emission should make manure management a priority to reduce greenhouse gas (GHG) emissions
3. Ammonia (NH_3), arising predominantly from manure management, is considered an environmental pollutant – as opposed to GHG – but its amount, and that of N_2O emissions, depend on manure storage and management practices. NH_3 has significant effects on both human health and the natural environment, with its emission negatively affecting biodiversity – with certain species and habitats particularly susceptible to ammonia pollution
4. By contrast, methane emissions arise mainly from enteric fermentation in ruminant livestock during storage – with manure management as a secondary source.

Manure management is important to help reduce GHG creation to ensure proper disposal in an environmentally and economically friendly manner, and thus minimise GHG emission and other environmental effects.

This Decision Tool aims to help field-level extension staff make climate smart decisions on which manure management option best suits their farmers' context. This tool is not designed as a technical guide to implementation. It is designed to assist extension staff in making climate smart decisions on improvements to their farming systems with their clients/farmers. Reference to technical guides relevant to the practices and technologies outlined are included at the end of the tool. The tool focuses on some of the Best Bet Climate Smart Manure Management Options for livestock production in the Southern African Development Community (SADC) region. They are listed in no particular order and have been selected as best bet because:

- They are climate smart (see Table 1)
- They are applicable in multiple agro-ecological zones across the region
- They have high potential to mitigate GHG emissions from livestock production in the region (see Table 1).

These are Best Bet options. An understanding of the local context and farmers' priorities is required in order to make these options Best Fit to individual farmer's needs.

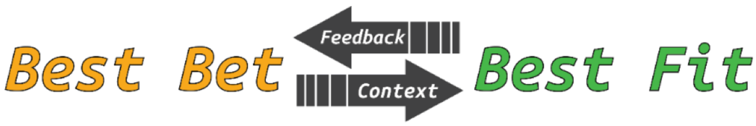


Table 1: Best Bet Climate Smart Manure Management Options for the SADC region.

Climate Smart Manure Management Option	What is it?	3 Pillars of CSA		
		Increase production	Increase resilience	Mitigate GHG emissions if possible
Collection	Methods for collecting animal manure when animals are kept in confined areas such as Kraals or sheds	Manure applied to soils improves and restores soil fertility and increases the potential crop up-take, leading to higher crop yields. May also reduce the need for supplementary synthetic fertiliser	Addition of organic matter improves physical soil conditions – particularly aggregation and pore space – which in turn leads to increased water infiltration and water-holding capacity, improved soil tilth, and decreased soil erosion. Adding organic matter also reduces the soil-eroding effects of wind and rain, and thus strengthens the soil's resilience to climate change	Integrated manure management has the potential to mitigate two powerful greenhouse gases: methane (CH) and nitrous oxide (N_2O)
Storage	Storing animal manure to ensure minimal nutrient losses and GHG emissions			
Treatment	The aim is to reduce volume exposed, improve applicability, and/or increase value	Potential to reduce energy costs through biogas production		

Integrated manure management (IMM) is the optimal, site-specific handling of livestock manure from collection, through treatment and storage, up to application to crops (and aquaculture).

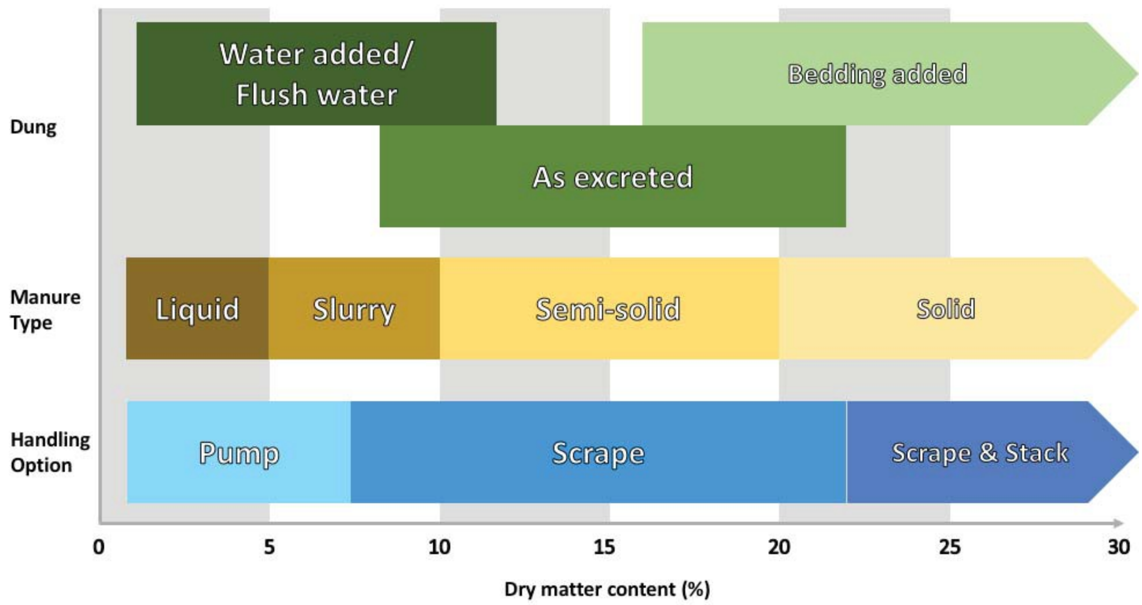
Key facts to remember:

- The livestock housing system determines the major manure characteristics
- Immediately after excretion, nutrients may begin dissipating.

The aim of IMM is to prevent nutrient losses in the manure chain to the greatest extent practically possible.

Initially, dung and urine are the substances excreted by the animals. As soon as **dung** is mixed with other substances like urine, water, or bedding materials, it is called **manure.** Based on the dry matter content, there are several types of manure. These are detailed in Figure 1.

Figure 1: Main manure types according to dry matter content.



Source: after Wageningen UR: Manure Management in the sub-tropics – Training Manual for Extension Workers

WHICH CLIMATE SMART MANURE MANAGEMENT PRACTICES ARE BEST SUITED FOR YOUR FARMER(S)?

Manure is applied as a **soil amendment (See KP06 – Climate Smart Soil Amendment Options)**. To make climate smart decisions on manure management and have the best possible quality of manure to apply, it is necessary to understand:

- The soil type (texture, slope, organic matter content, etc.)
- The local climate (rainfall timing, duration and intensity, and temperatures/sunshine)
- The current farming system.

A deep understanding of the **context** will help you to develop **Best Fit** rather than just **Best Bet** options to improve **manure management** on the farm.

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KNOW YOUR SOIL

Most farms in the SADC region will benefit from the **addition of organic matter**.

Understanding the current characteristics of the soil will help you in making decisions on when, where, and how much manure might be required to maintain and improve soil fertility.

Key questions:

- What is the soil texture (clay/silt/sand)?
- What is the soil structure – does it hold together well when placed in water?
- How much organic matter is in the soil?
- What method of tillage is used (if any)?
- What is the slope?
- What soil amendments are currently applied, if any?
  - Are these applied everywhere or just in some parts?
- Are there many trees in and/or around the fields?
- Are crops cultivated?
  - What crops and where?
  - Does livestock graze on the cropland?

Figure 2 and Figure 3 illustrate some of the characteristics of healthy and unhealthy topsoil. Figure 2 shows earthworms in a clump of topsoil – a good indicator of soil biological activity, but almost completely absent from tilled soils. Figure 3 shows small clods from a ploughed field (right) and virgin land (left) after being carefully dropped into water. The lighter coloured clods from the ploughed field disintegrate, while the clods from the virgin soil stay intact.

UNDERSTAND THE CLIMATE

The next step is to understand the local context in terms of rainfall and sunshine as these factors can have a dramatic effect on the quality of manure produced, as well as on the length of time it may need to be stored before use:

- When is rain expected to fall?
- What is the intensity of the rainfall events throughout the season?
- When are sunny and/or dry periods?

Work with your farmers to build a seasonal calendar that depicts incidences of rainfall and dry periods. If reliable data is not available locally, work with your farmers to collect rainfall data – especially documenting dates on which it rained, duration and intensity. Over time, you can build up a picture of the trends locally. This information can be used to inform multiple climate smart decisions on the farm, not just in relation to manure management.

Figure 2: A healthy topsoil showing abundant earthworm activity.

Source: Patrick Wall, CIMMYT

Figure 3: A field-test of aggregate stability.

Source: Christian Thierfelder, CIMMYT

THE CURRENT FARMING SYSTEM

Farming systems are varied and complex across the Southern African region. A farmer may only have one specific type of livestock as their sole source of income, or they may have several types of livestock, as well as crops, and each part of the system may impact on another. Most smallholders will have a diverse farm system in which livestock play a key role. To make climate smart decisions on manure management options, we need to understand current management practices for each type of livestock in the farming system, including the following:

- **Farming system:**
  - When are the main cropping and grazing seasons?
  - What crops are grown?
  - What are these used for?
  - Rotational grazing? How do the livestock graze?

  Developing a detailed agricultural calendar is a smart way to understand changes throughout the year

- **Livestock holdings:**
  - Types and numbers (the age, and sex should be recorded)
  - Why is each type of livestock kept?

- **Livestock housing:**
  - What are the housing structures, if any?
  - What bedding is used, if any?
  - What are the housing times – are they day/night, and/or seasonal changes?
  - Are animals all housed together, or are they separated by age, gender and/or species?
  - Are feeding troughs provided?
  - Where is manure collected, if at all, and how?
  - How often is manure collected, and what is it used for?
  - Are different livestock treated differently?

- **Animal manure:**
  - Is this currently used on the farm?
  - How much?
  - For what is it used?
  - How is it collected and stored?
  - Is it treated?

- **Watering points:**
  - Where are the watering points?
  - Is there sufficient water throughout the year?

- **Crops grown on farm:**
  - What are the main crops grown by the farmer on his or her land?
  - What are the nutrient requirements?
  - What is the growing cycle of each crop grown?
  - What are the nutrient requirements?
  - What is the typical yield?
  - What is done with crop residues?

- **Livestock feeding:**
  - Is livestock stall-fed, tethered, grazed openly, or a combination of these?
  - How does this change over the year and seasons?
  - Where do animals graze (if they do), and for how long?
  - What plants, residues, crops and/or trees do animals feed on?
  - How do feeding habits change throughout the year?

- **Cultivated fodder:**
  - What are the main types of fodder crops planted on the farm, specifically as forage material for livestock grazing (including trees)?
  - How much land is used for each crop?

- **Collected fodder:**
  - Does the farmer collect any fodder material?
  - If so, what is it, and how much does this source of feed contribute to the diet of their animals (as a percentage)?

- **Purchased supplementary feed:**
  - What feeds does the farmer purchase, if any?
  - How does this change throughout the year (or from season to season)?
  - How much does this cost?

- **Processed fodder:**
  - Is any of the fodder processed (e.g., chopped or baled, or processed into silage or hay)?

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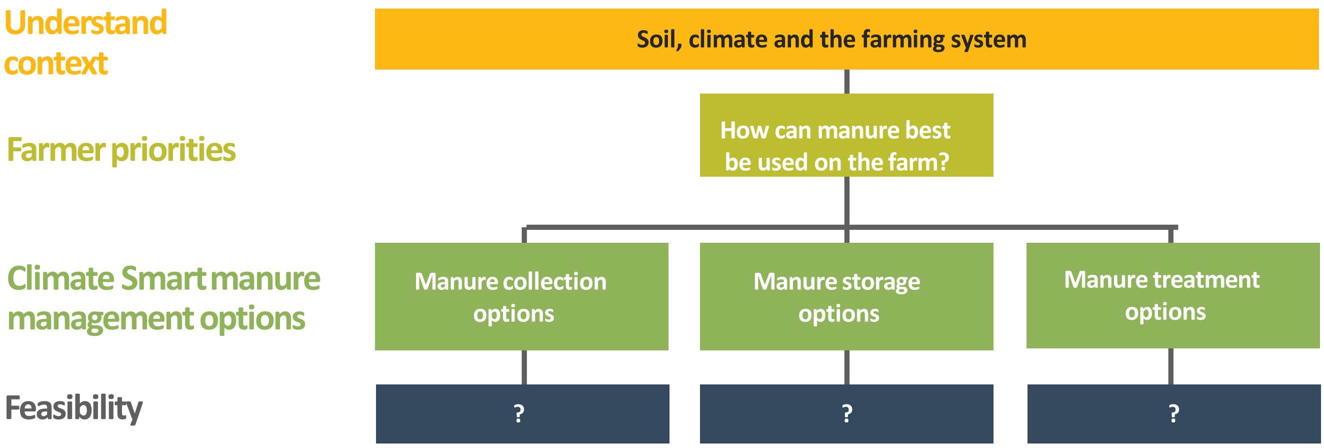
- **Grazing:**
  - Do the animals spend any time grazing?
  - If so, how much does this source of feed contribute to the diet of the animals (as a percentage)?
- **Sources of household income:**
  - What are the main contributions to household income?
  - How much does the income from livestock contribute to total household income?
- **Use of livestock within the farming system:**
  - Why does the farmer keep each type of livestock?
    - » For his or her own consumption, or sale (meat, dairy or another product)?
    - » As a coping strategy (for sale in lean periods or during household shocks)?
    - » As a status symbol?
    - » As draught animals?
    - » For transportation?
    - » As a source of manure for crops and/or fuel?
    - » For a combination of reasons?
- **Labour:**
  - Who performs each animal husbandry task (men, women and/or children)?
  - How much time is spent on each task?
  - Do any tasks require hired labour and if so, how much does this cost?
- **Seasonality:**
  - Do labour requirements and their availability change throughout the year (for men, women and/or children)?
  - Do animals move from one area to another throughout the year?
- **Sources of credit:**
  - Is credit equally accessible to all farmers (men, women, youth and other subgroups)?
  - What are the repayment conditions?
- **Access to agricultural inputs:**
  - Is access equal for men, women, youth and other sub groups?
  - What limits a farmer's access?
- **Land ownership:**
  - Is land community owned, or individually owned, or both?
  - Where is community land, and where is individually-owned land? A resource map may be useful here.
  - Where is water sourced, and who has access to this water?
  - Is land owned by men or women, or both?
    - » Are men's and women's access equal?
    - » Are there some groups who have more access than others?
    - » What limits access to land?
- **Are there any agricultural projects in the target area:**
  - Who and what are these projects targeting?
  - Can projects be leveraged to help support climate smart manure management or vice versa?

The **Decision Point** below outlines how an understanding of the context and an assessment of farmer priorities can lead to climate smart decisions on manure management options.

DECISION POINT



BEST BET CLIMATE SMART MANURE MANAGEMENT OPTIONS FOR ADDRESSING GHG EMISSIONS

There are three stages in manure management. The aim is to minimise nutrient losses at each stage. This will reduce GHG emissions, and also ensure that the maximum benefit is obtained from adding manure to the soil as an organic soil amendment by ensuring optimal time application for crop use and minimizing the risk of loss through gaseous emissions, leaching or run-off. The three stages are applicable across the SADC region. Combinations of these options will give optimum results. While these are best bet options, they are not universally applicable. CSA is context specific and each of these options will need to be tested under local conditions and adapted to make it **Best Fit** the local context.

Before assessing feasibility of the climate smart manure management options, each option should be discussed in detail with your farmers.

MANURE COLLECTION

Higher nutrient intake means more nutrients in the animals' dung and urine. Urine contains mineral nitrogen and potassium. The livestock housing system determines the major manure characteristics.

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Table 2 outlines the different animal housing systems in the region, and the corresponding attributes of manure from each. Dry, solid, farmyard, slurry and liquid manure are manure types that can be found throughout different livestock systems. As soon as dung is mixed with other substances like urine, water or bedding materials, it is called manure. Whether dung gets mixed with other substances highly depends on the housing system.

Table 2: Relationship between livestock housing system and manure type, with indications of the suitability of different manure types for different treatments and applications.

Housing system	Collection & additions	Manure type	Most suitable for:
For cattle:			
Free range + kraal	Most urine is lost	Dry dung	Fertilisation
Zero-grazing, dung removal	Urine can be collected	Wet dung	Digestion, fertilisation
Zero-grazing, daily flushing	Dung + urine + water	Liquid manure	Digestion, irrigation, fish farming
Zero-grazing, scraping	Dung + urine	Slurry	Digestion, fertilisation
Zero-grazing, bedding floor	Dung + some urine + bedding	Farmyard manure	Composting, fertilisation
Zero-grazing, slatted floor	Dung + urine	Slurry	Digestion, fertilisation
For pigs:			
Slatted floor (wooden pens)	Urine can be collected	Wet dung	Digestion, fertilisation
Slatted floor, slurry storage	Dung + urine	Slurry	Digestion, fertilisation
Solid floor, daily flushing	Dung + urine + water	Liquid manure	Digestion, irrigation, fish farming
Solid floor with bedding	Dung + some urine + bedding	Farmyard manure	Composting, fertilisation
For poultry:			
Free range with night pen	Dry manure	Dry manure	Fertilisation
Layers in cages	Wet manure if fresh	Wet manure	Fertilisation
For all livestock:			
Deep litter	Dung + urine + much bedding	Farmyard manure	Composting, fertilisation

Source: FAO, Manure management in the (sub) Tropics

Dung and urine of confined animals can be readily collected. In kraal systems; animals have some confinement, which allows collection of dung, but:

- As the animals are often kept on bare soil, urine cannot be collected
- The dung is subject to higher nitrogen losses.

Flooring facilitates collection of both dung and urine.

Manure stored in roofed houses is less exposed to nitrogen losses through volatilisation. Roofing also prevents run-off and leaching losses of minerals due to rain.

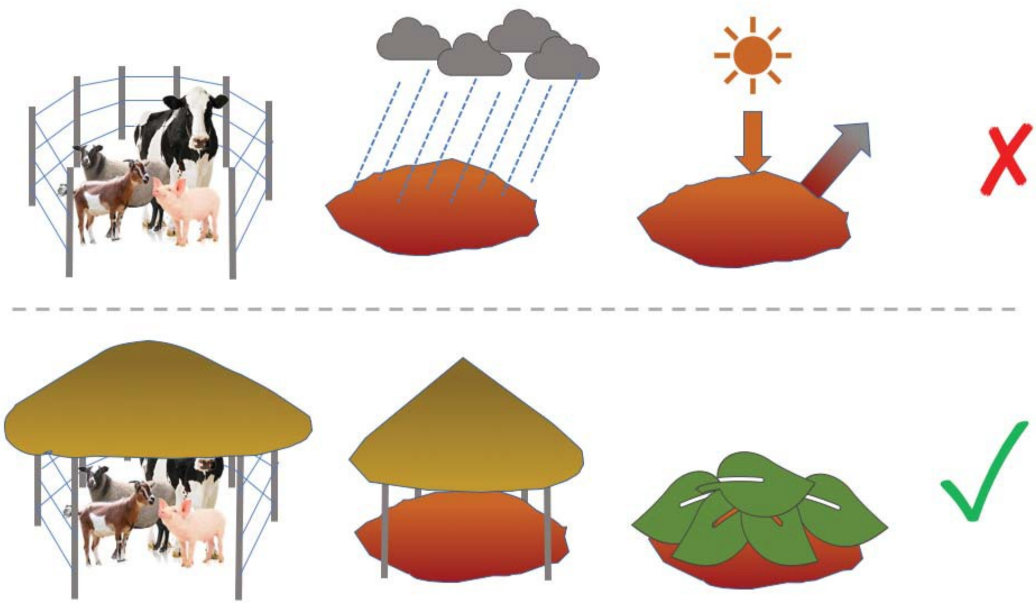
Manure nutrient content depends on what is collected together with the manure: bedding material, feed leftovers, flushing water, feathers and soil, for example, will affect the nutrient content. Figure 4 illustrates the do's and don'ts of manure collection and storage.

Collecting urine with the dung to form slurry is the easiest way, but often not very feasible for smallholder farms.

Bedding materials absorb urine and contain residual plant food (see Figure 4). This adds to the overall nutrient value of compost. To prevent urine discharge with bedding, consider the following activities:

- **Chop or shred** the materials (e.g., dried rice straw and/or stubbles, grass clippings, uneaten green feeds) so that they are easier to spread and will decompose faster. Coffee hulls and sawdust can also be used.
- Spread a 15 cm layer of **litter bedding** over the floor space. Allow manure and urine to **accumulate**.
- After 3–4 days, the bedding materials will have been fully soaked with urine. **Mix them to incorporate the manure**. Remove the mixture and put it in a pit or a pile, fully covered, to conserve the nutrients.
    - The compost is ready for use in one-and-a-half months or less.
- **Provide fresh bedding** materials and repeat the previous steps.

Figure 4: Covering manure prevents nitrogen loss trough leaching, run-off and volatilisation.



Source: FAO, Manure management in the (sub) Tropics

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This simple method comes close to the principles of a **deep-litter system** (see Figure 5). These are systems where layers of bedding material are repeatedly spread on older layers as they get soiled. This system is most common in poultry farms, though it is also used for pigs, cattle and small ruminants. The manure usually breaks down gradually and composts sooner or later. Deep-litter management involves the following:

- Providing **proper aeration** of the litter:
  - In poultry systems, the chickens will take care of turning much of the litter, but it must be monitored and areas that are missed or become caked should be turned
- **Providing proper ventilation:** Cross-ventilation and open eaves are ideal. Ensure no drafts exist, particularly over roosts. Excess moisture and ammonia gases must have a means of escape
- **Ensuring a correct moisture balance:** Moisture is essential to the process. Droppings consist of 60%–70% water, making it more likely that the litter will become too wet, rather than too dry
  - Wet litter is a recipe for sick chickens. Prevent any water spills from drinkers, and add litter when necessary to prevent matting
- **Animal health** is improved using 'all-in, all-out' management, where the manure is also removed from the house after every production round.

Figure 5: Finishing beef cattle on a deep litter system.

Source: FAO, Manure management in the (sub) Tropics

MANURE STORAGE

Manure storage is necessary to bridge the gap between the moment of excretion and the optimal moment of application on cropland. This is the period in which nutrients are very susceptible to losses into the environment. Proper manure storage plays a key role in preventing environmental pollution, and other nuisances like odour and flies.

The amount of nitrogen in the manure tends to decrease over time, because ammonia (NH_3), nitrogen (N_2) or nitrous oxide (N_2O) are emitted, or because soluble nitrogen is leached by rainwater. The phosphorous pentoxide (P_2O_5) and potassium oxide (K_2O) can also be lost through leaching from rainfall, further reducing the usefulness of the manure.

Proper storage preserves crop nutrients until the time of application. The following features are recommended:

- Storage roofing prevents runoff of nutrients into the soil and water
- Storage flooring prevents leaching of nutrients into the soil and water
- Airtight storage coverings prevent nutrients from volatilisating into the air.

Climate smart options for manure storage include:

- **Covered compost pits**
  - These can be sealed by compacting the soil floor, or by lining with plastic sheeting, mud plaster or concrete, thus limiting gas emissions to the environment
  - Sunlight should be excluded as much as possible
- **Sheds with raised, slatted floors** (used primarily for goats)
  - Dung and urine collect underneath the slatted floor
  - Floors are usually of compacted earth, and urine can leach away. This can be improved by:
    - »Sealing the floor so urine cannot soak away
    - »Mixing in some straw to soak up urine
    - »Ensuring no sunlight reaches the manure
    - »Ensuring the roof has enough of an overhang to keep any rainwater away from the dung and manure

- Alternatively, the manure can be collected regularly and transferred to a pit or other prepared storage area
  - »This requires more labour

- **Kraals**
  - These enclosures are often used as in-situ fertilisation of arable land by moving the kraal regularly
  - Soil fertility of a larger area is partially concentrated on the arable land, thus improving the nutrient levels – especially nitrogen concentrated on the arable land, thus enabling crop production in resource-poor situations
  - Losses through leaching will be slightly higher than during normal grazing, with the increased nitrogen and potassium levels

- **Dry lot storage**
  - If urine is not collected and bedding is sparsely used, losses of nitrogen and potassium will be high as most urine is lost. Nutrients in faeces will also be partially lost. Urine collection will minimise potassium losses, but nitrogen losses will often remain high as volatilisation will increase – though this is dependent on climatic conditions, storage time, and storage method.
  - Using bedding, with sufficient absorption capacity to capture urine, might reduce nitrogen losses by around 15% (the loss by mass of nitrogen per hectare)

- **Liquid manures and slurry**
  - Slurry originates when dung and urine are stored together indoors under the floor, or transferred to an outdoor silo or pit
  - The floor may be solid with regular scraping, or slatted – in which case the excretions immediately drop into the storage. In dairy, often flushing water from an adjacent milking parlour is also added
  - Except for broilers, this is the main system in intensive livestock systems
  - Slurry becomes liquid manure when water is added, and dry matter goes below 5%. When no water is added, and dry matter stays within the range of 5%–10%, it is still slurry
  - Volatilisation losses are dependent on the level of ventilation, depth of storage and storage time, but often range between 5% and 35% of the total nitrogen excreted
  - Emissions of methane can be reduced by anaerobic digestion of the fresh slurry in a closed silo.

Biogas

Another method of storage is a biogas digester. Production of biogas through anaerobic digestion of organic material, e.g., manure, is a relatively simple technology. It can be implemented at industrial, village and farm household scales. The gas can either be used directly as a heat source for cooking or lighting, or indirectly by powering a generator to produce electricity. One cubic metre of biogas contains the equivalent of 6 kWh of calorific energy – equivalent to approximately: 1 litre diesel, 2 kWh electricity, 4 kg firewood, or 6 kg paddy straw. One crossbred cow or two local breed cows may be enough to generate enough biogas for a single household.

Biogas produces less carbon dioxide than fossil fuel, and therefore its production and use contributes to the mitigation of greenhouse gases.

Figure 6 gives an overview of where biogas production is recommended, and which type of digester can be used with different types of manure. To successfully operate an anaerobic digester, it needs a constant in-flow of feedstock (manure) and, depending on the dry matter content of the feedstock, water. Both should be continuously available. This might cause continuity problems in 'all-in–all-out' livestock systems, where barns are left empty for a period to control animal diseases and pests. Also, the available quantity of manure from cattle is not constant when cattle are grazing during the growing season and are only kept in confinement during limited periods of time, e.g., dry periods or extremely wet periods.

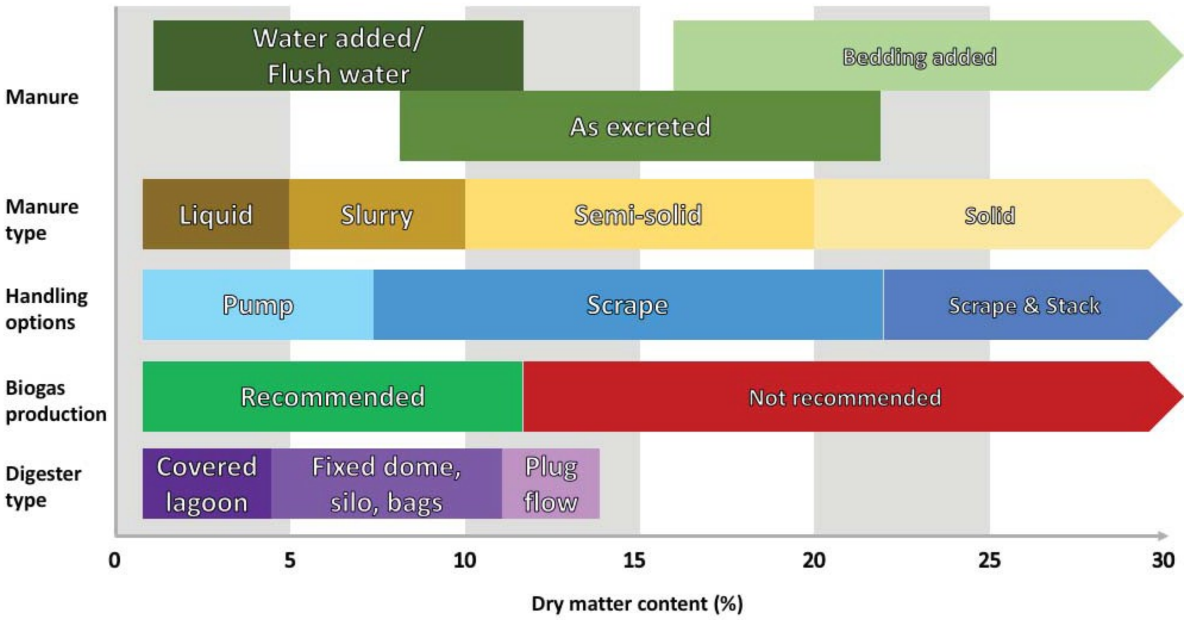
Economics of biomass:

- Biogas is a substitute for fossil fuel and biomass fuel
- A bio-digester needs to be fed with fresh manure every day of the year
- Digestion of manure does not change the nutrient content of manure; bio-slurry is still a valuable fertiliser.

There are several types of bio-digesters available:

- Covered lagoons and silos are more suited to larger-scale production
- Fixed domes, bags and plug flow digesters are more suited to small-scale production.

Figure 6: Schematic overview of manure characteristics towards anaerobic digester decision making.



Source: FAO, Manure management in the (sub) Tropics

MANURE TREATMENT

The characteristics of manure can be changed before, during, or after storage. The type of treatment will be dictated by what the farmer wants to achieve. Table 3 details the types of treatments required, according to the objective of manure treatment.

Table 3: Some potential reasons for treating manure.

Objective	Outcome	Treatments
Reduce volume	Easier handling, less storage capacity needed, and less transport costs	Dehydrating Physical separating
Improve applicability	Easier handling and more possibilities for specific application	Additions Physical separating Composting
Increase value	High-concentrated fertilisers	Refining

Source: FAO,2015

Dehydration: The process of removing water from slurry. This can be done in several ways:

- Air drying
  - A large space with a waterproof floor is required
  - Rain needs to be kept off, so a roof may be required
  - In air drying, practically all mineral nitrogen is lost
  - The final product, a thin crust of manure is suitable for bagging and selling
- Active drying
  - Using fans to speed up the drying process
  - Used in large-scale chicken/egg production
- Kraal drying
  - Using a hand rotavator to mix the top layer of soil with the manure every few days
  - This aerates the dung/urine and the soil, helping it to dry
  - The manure can then be removed for storage or application
  - May be suitable for some small/medium scale producers.

Physical Separation: A mechanical treatment, mostly applied to slurries to squeeze out moisture and separate manure into a liquid and a solid fraction. Separation does not affect the chemical composition, but it does affect the nutrient content of both fractions. The following are some considerations you should consider when employing physical separation:

- Since the mineral nitrogen content is higher in urine and the P_2O_5 (phosphorus pentoxide) content is higher in dung, after separation the liquid fraction contains more nitrogen and the solid fraction will contain more P_2O_5
- On farms with limited fertiliser resources, this method opens the possibility to use the liquid fraction on crops with a relatively high nitrogen demand (e.g., maize) and to use the solid fraction on soils with relatively low P_2O_5 levels
- Diluted with water, the liquid fraction can be used to irrigate crops
- The undiluted liquid fraction is also suitable as fertiliser in fish farming
- The solid fraction, being a stackable product, is easy to store and to transport (e.g., for sale).

Additions: Aim to make the manure product more suitable to handle. Anaerobic digesters produce biogas and bio-slurry. The bio-slurry is often difficult to handle because it is very liquid, and crops may be far away and/or difficult to reach.

Adding bedding materials, like straw or dry crop residues to the bio-slurry to capture a lot of the moisture, eventually produces a stackable and therefore easier-to-handle product. It will also have an increased organic matter content.

This is a kind of pre-stage for composting.

Refining: This is a high-tech solution to harvest nutrients (minerals or compounds) from organic manure. The harvested materials can either be used for fertilization or for further bio-chemical processing. This is an industrial treatment, and it is not suitable for smallholder farmers.

Composting

This can be used for turning on-farm organic waste materials into a valuable soil amendment and fertiliser resource. Composting is suitable in all farm situations, large or small, and with solid and liquid manure types.

Composting is the natural process of fermentation, or decomposition, of organic matter by microorganisms under aerobic conditions. Compost is a rich source of organic matter. Soil organic matter plays a key role in sustaining soil quality, and hence in sustainable agricultural production. In addition to being a source of crop nutrients, it improves the physiochemical and biological properties of the soil (e.g., water-holding capacity and erosion resistance).

Collecting the composting materials, setting up the heap, regular watering and repeated turning of the heap – when not mechanised, make composting a very labour-intensive activity. It is important to understand who will provide the labour for compost making, and when this work needs to be done, so that the compost is ready for application when needed.

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The microorganisms in the compost pile need carbon (C) and nitrogen (N) in the proper proportions for their growth and activity. A few materials, such as cattle manure mixed with bedding, soybean shells, and legume hay, have C/N ratios close to the ideal range. Materials high in N are animal manures and vegetable waste; while those high in C are maize stalks, sawdust and hay. If too much green material is included, the heap will become rotten and much of the N will be lost as gas. If too little green material is used, then the decomposition process will be too slow and tough materials, weed seeds and pathogens will not be broken down, or only after an extended period.

Slurry is an excellent material for increasing the rate at which refuse, crop waste, garbage, etc., are composted. It also provides moisture to the compostable biomass.

Regularly turning the compost inside–out ensures a good oxygen supply, and it ensures a good composting process of all the mixed layers. The main disadvantage is the high loss of mineral-N through the volatilisation of ammonia (NH_3) and nitrous oxide (N_2O) emissions.

Characteristics of mature compost:

- Coarse materials become finer over time until a fine, loamy material is produced
- The different materials are no longer recognisable
- The material has a slight 'earthy' and inoffensive smell
- Temperature drops and the compost is cool
- Compost is dry.

There are different methods of composting. The two most common are:

1. **Heap or pile method**, suitable for large-scale processing and for small-scale operations in areas with higher rainfall
2. **Pit method**, suitable for small-scale processing in areas with low rainfall and a long dry season, and for composting of liquid manures.

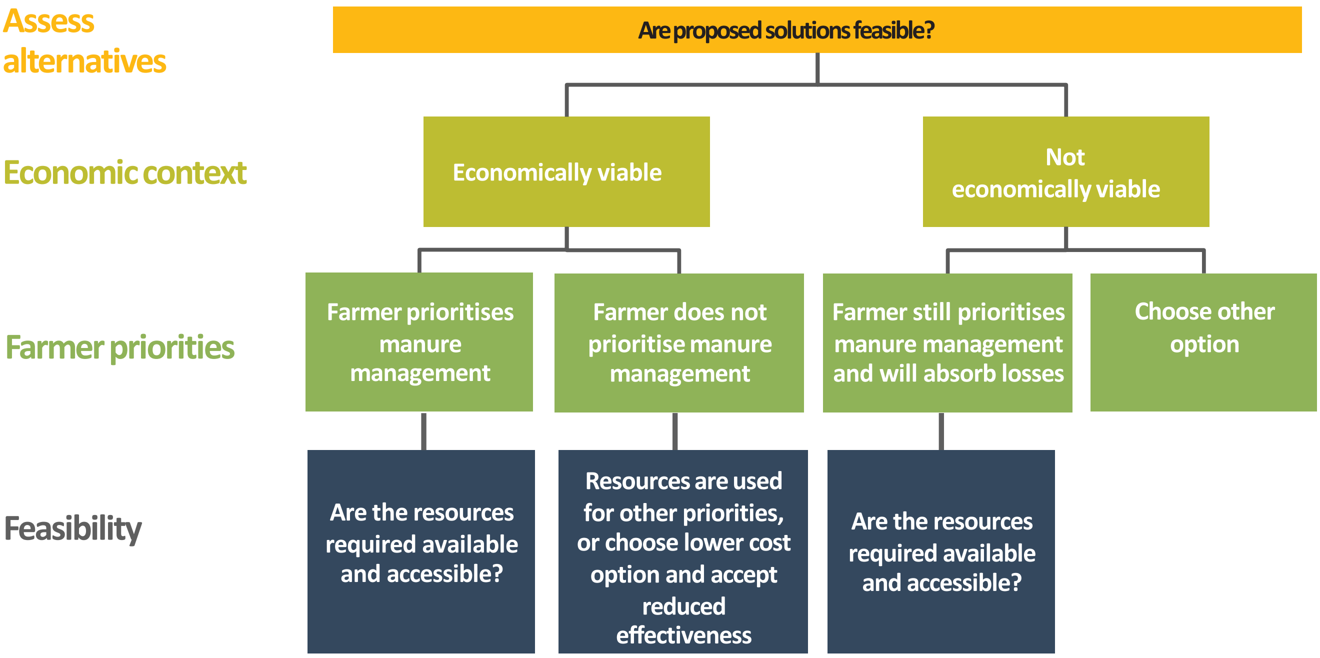
Mature compost should be kept covered to protect it from rain and sun. If the compost is kept for too long before use, it will lose some nutrients and may also become a breeding place for unwanted insects. You can produce a regular supply of compost by digging three pits (or piling three heaps) side-by-side. Every 2 to 3 weeks, turn the compost from one pit into the next one, and start a new compost pile with fresh vegetation in the empty pit.

Source: www.omafra.gov.on.ca

FEASIBILITY

The **Decision Point** below outlines a decision tree that can be used to help make decisions on whether climate smart manure management options identified and selected are actually feasible in the individual farmer's context.

DECISION POINT



Economic viability

Will the costs of the climate smart manure management option result in increased returns for the farmer, or are they unsustainable? In some cases, the farmer may lose out in the short term (high initial costs) but may benefit in the longer term. For example, building or renovating a shed so that dung and urine can be collected and stored properly can have high initial costs, but the returns on increased crop production and soil fertility in the long term may outweigh the initial costs.

Labour is a key factor that must be assessed in terms of economic viability. Farmers rarely account for the cost of their own and family labour, but will consider wage labour costs. Understanding who is responsible for key livestock management tasks and how improvements in manure management might affect their roles, is critical in assessing if there are opportunity costs associated with the option proposed. Extra labour may be required to regularly collect manure or turn compost. The following questions can be discussed with the farmer:

- Who will do this work? Men, women and/or children?
- What would they be doing if they are not doing this task?
  - Will children miss school?
  - Will women still be able to do their other tasks?
  - Is paid labour available and what are the costs?

These are known as opportunity costs, and must be factored in.

Where livestock is being managed in intensive systems, such as dairy cows with cut and carry fodder and/or silage, it may be possible to forecast the potential costs associated with changes to more climate smart practices. This should be done by:

- Developing a cashflow forecast for the year
- Including labour requirements in the forecast
- Testing the assumptions in the forecast, e.g.:
- Will money, labour be available when it is needed?

Throughout the year, the farmer should be supported to collect accurate data on:

- Inputs
- Rainfall – duration and intensity
- Costs
- Labour (who and how much)
- Management practices (e.g., digging of pits, collecting compost, infrastructure investment, turning compost) and timing
- Productivity (yield increases)
- Revenue generated (if compost and/or manure are sold).

The data collected can be used to develop **gross margins**. Due to the complexity of crop production systems, it may be difficult to attribute any increases in production to manure management. Comparing different plots that either have or have not been treated with manure and/or compost (with different types and rates) will enable farmers to take decisions on different manure management practices, so they are the **'best fit'** to their local context.

Accurate economic forecasting and analysis is not always easy, as there are various factors that need to be considered. This is especially the case in more complicated farming systems where livestock are a part of agropastoral systems, and there are other external factors to consider. Discussing issues with your farmers can help identify major factors that might help you decide on economic viability at this stage. Collecting accurate data on costs incurred, production attained and externalities such as climatic conditions and/or pest/disease outbreaks throughout the year, and reflecting on these, will help you and your farmers make much more informed decisions in the following season.

Farmers' priorities

Climate smart manure management is likely to be a higher priority in smallholder farming systems, where manure and/or compost can be used for the following applications:

- Improve crop (or fishery) production
- Increase income through sale.

Where farmers use inorganic fertiliser on their farm, it is highly advisable to also apply organic manure and/or compost to make fertilization more efficient overall. Improved methods for collecting, storing, and treating (esp. composting) animal dung and urine generally have low financial costs, but may require extra labour.

Feasibility

Finally, you need to work with your farmers to assess if the preferred options are feasible in terms of accessibility and availability:

- Are the required inputs (including labour) available?
  - Where can they be sourced?
  - Will they need to be sourced regularly or once off?
  - Is credit available and affordable?
- If available, are the required inputs accessible?
  - Will the farmer be able to access the required resources?
  - Are they close by?
  - Will she/he be able to transport them?
  - Do men and women have equal access to inputs (including credit)?
- Are markets available and accessible for the sale of compost and/or manure?
  - Are these markets equally accessible to men and women?
  - How will the products be transported to market (if they need to be)?

TO SUMMARISE

STEP 1: Understand the context

- Soil type/local climate
- What is the farming system?
- How are livestock currently managed?

STEP 2: Select 'Best Fit' options

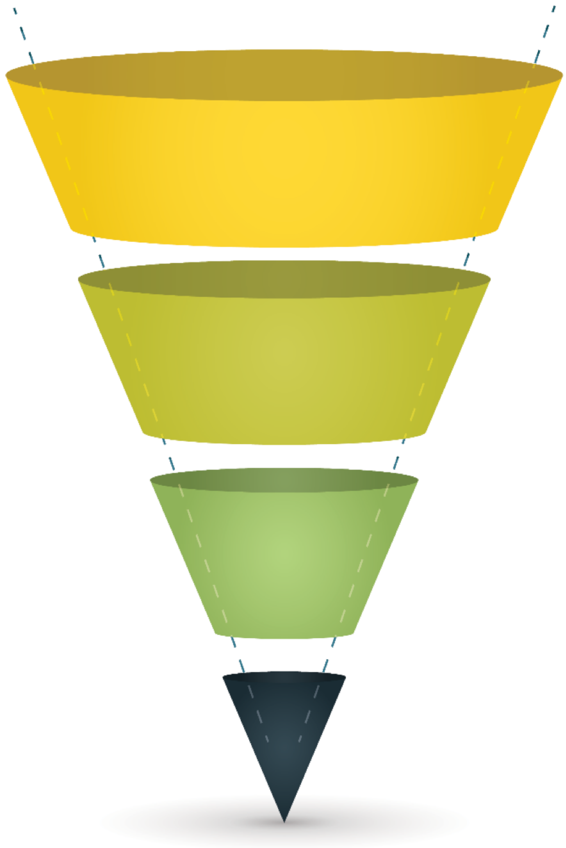
- Manure collection options
- Manure storage options
- Manure treatment options

STEP 3: Assess feasibility

- Assess economic viability
- Cross-check with farmer priorities
- Are other options available?

STEP 4: Test and improve

- Try different options
- Collect data and reflect on possible improvements.



WHERE CAN I FIND MORE INFORMATION?

The following resources, which were used as reference for the development of this Knowledge Product, provide valuable additional reading on this subject. Please also refer to the CCARDESA website (www.ccardesa.org), the full series of Knowledge Products, and associated Technical Briefs.

- **The CCARDESA Knowledge Hub – See KP 6 Climate Smart Soil Amendments.www.ccardesa.org**
- **Access Agriculture** – Videos on compost making, biogas and sheep/goat housing
  - Very useful to show to farmers, and available in multiple languages. Sign-up for free to gain access to downloadable technical guides. A good resource to return to on any topic
- **Food and Agriculture Organisation of the United Nations (FAO)** – Manure Management in the (Sub-)Tropics: Training Manual for Extension Workers, Report 919 Wageningen UR Livestock Research Rome/ Wageningen, October 2015
  - A very practical resource for extension staff
- **FAO** – Climate Smart Agriculture: Building Resilience to Climate Change – Section IV; A Qualitative Evaluation of CSA Options in Mixed Crop-Livestock Systems in Developing Countries
  - Good background information. Not a technical guide
- **FAO** – On Farm Composting Methods; Land and Water Discussion Paper 2
  - A detailed guide on how to make different types of compost. Chapter 2 is especially relevant to smallholders
- **Institute for Sustainable Development (ISD)** – How to Make and Use Compost
- **Shamba Shape-Up**
  - Various videos and leaflets available. May take some time to find the ones you are looking for, but well worth the effort.

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