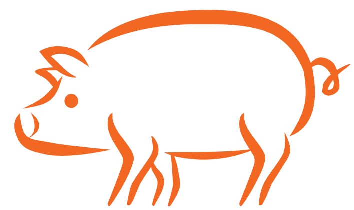
Exploring Interactions
Between Agricultural Decisions & Greenhouse Gas Emissions Using Swine Production

Part 1



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University of Arkansas, United States Department of Agriculture, and County Governments Cooperating

Acknowledgment

Special thanks to **Donna VanDevender**, high school teacher for the Arkansas School for the Deaf and Blind, for her substantial contributions toward the development of this project.

Disclaimer

The content within this activity is for educational purposes only. Every effort has been made to ensure the accuracy of the presented information, but due to the technical nature of the subject matter, some generalizations have been made.

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Introduction

This activity is an interactive lab designed to introduce students to the basic concepts of swine production in a manner that places emphasis on information comprehension. The activity delivers a generalized set of swine production information through use of a graphically assisted flashcard-style activity. Because of the general nature of the swine production information contained herein, it can be utilized as either a preparatory mechanism for the completion of Part 2 or as a stand-alone activity. The Part 2 portion of this activity is more challenging as it focuses on engaging students through critical thinking and problem solving, in addition to information comprehension. Part 2 also contains more extensive resource information and explores the subject matter in greater detail. The Part 1 activity consists of five components:

1. Resource information
2. Farm management system graphics
3. Farm flashcards
4. Lab report form
5. Farm Management Option Guide (FMOG)

(*Note: The FMOG also doubles as a Scenario Key for the completion of Part 2.)

The ***resource information*** includes a brief description of the three categories of swine management systems:

- **Feed Management**
- **Housing Management**
- **Manure Management**

The resource information also contains a brief summary of greenhouse gases and a glossary of common swine terms to aid students in grasping the concepts found within the activity. All information should be thoroughly reviewed by students in its entirety (preferably with instructor assistance) before beginning the activity.

The ***farm flashcards*** contain a brief description and graphical rendering of various swine farm components/equipment. The components/equipment discussed on the flashcards are also depicted within the swine farm illustrations of the three swine management systems. The farm graphics were included to provide students with a visual aid to depict how each individual practice/component contributes to the building of a given swine farm system.

The ***lab report form*** consists of several structured questions that are designed to provoke the student's thoughts on the considerations made while designing swine farm management systems, and the challenges of managing a swine farm. The lab report form contains blank spaces for students to list the cards that they (individually) drew from the deck and provides a brief description of their understanding of the stand-alone function and systemic role of the component/equipment featured on the cards.

The ***Farm Management Option Guide*** **(FMOG)** is a table which lists each of the swine management options and contains a brief explanation of their immediate effect on the pig and the carbon footprint of the farm. The FMOG is a tool included to assist the instructors in leading a discussion about how the implementation of different management options will influence farm management systems, financial resources and the greenhouse gas (GHG) footprint.

Instructions

To begin the Part 1 activity, students should be separated into groups consisting of four to five members. Each group should be supplied with a complete deck of flashcards, all three of the swine management system graphics and approximately two lab forms (depending on group size) for each member of the group. Students should lay out the graphics on their workstation and place the deck of cards beside it. Next, the students should take turns drawing from the deck. After each card is pulled, it should be read aloud to the other group members and visually matched with its counter-part within one of the three swine management system illustrations. The cards should be retained by the student who drew them from the deck, and the draw-read-match process should continue until the deck of flashcards is exhausted.

Once the student groups have exhausted the flashcard deck, the groups should be prompted by the instructor to engage in a brief (5-minute) group discussion about the individual functions and practical differences (i.e., cost) of each card they possess. Next, the students should retain their cards and individually complete copies of the supplied blank lab report forms. Upon completion of the lab forms, the students should participate in an instructor-guided discussion of their answers on the lab report form. Suggested topics of discussion include:

- How do the different component/equipment decisions impact the farm operations?

    1. Finances
    2. GHG emissions
    3. Management system design

The instructor will do this with the assistance of the Farm Option Guide.

➢ General Terms/Definitions

Boar – An uncastrated male swine used for breeding.

Replacement Boar – An uncastrated male swine that is intended to be used for breeding but has not yet been bred.

Sow – An adult female swine that has farrowed at least one litter.

Gilt – A young female swine, up to and including the birth of her first litter.

Breeding – The act of mating/inseminating a female pig.

Gestation – A term to describe pig pregnancy; lasting 112-114 days in length.

Farrowing – The act of giving birth; an average of 10-12 pigs is born per litter.

Litter – Pigs born to a sow during one farrowing.

Lactation/Nursing – The period when a sow provides milk to her recently farrowed pigs.

Recovery – The period during weaning when a sow is relocated from farrowing facilities to pens/stalls near the breeding area in preparation for further breeding.

Nursery Pig – Pigs from weaning to around 8-10 weeks of age.

Weaner Pig – Pigs from weaning up to about 40 pounds.

Feeder Pig – A young pig weighing between 30-90 pounds.

Growing Pig – A young pig weighing between 50-120 pounds.

Finishing Pig – Pigs 120 pounds to market weight.

Market Hog/Weight – Pigs weighing about 270-290 pounds. These pigs are sent to market, slaughtered and processed for the production of food products.

Nursing Phase – The time period between farrowing and weaning.

Weaning -- The process of ending the nursing phase by preventing young pigs access to the lactating sow.

Grow-Finish Phase – Refers to the multiple stages of production between the growing and finishing phases in which unique diets are fed to closely match nutritional content with physiological needs.

Growing Herd vs. Breeding Herd vs. Nursery

The **Growing Herd** consists of young pigs (post-weaning) which are typically between 40 and 200 pounds.

The **Breeding Herd** consists of mated females, service boars and replacement boars.

The **Nursery** is the area to which pigs are moved at weaning.

Greenhouse Gases (GHGs)

What are greenhouse gases (GHGs)?

GHGs can simplistically be described as gases that prevent heat radiated from the sunlit ground from escaping to space. GHGs warm the surface and lower atmosphere by re-emitting infrared radiation that would otherwise escape the Earth's atmosphere *(Figure 1)*. GHGs can be produced by anthropogenic activities (man-made) or occur naturally. The most common GHGs associated with swine farm activities are **methane (CH_4)**, **nitrous oxide (N_2O)** and **carbon dioxide (CO_2)** *(Table 1)*.

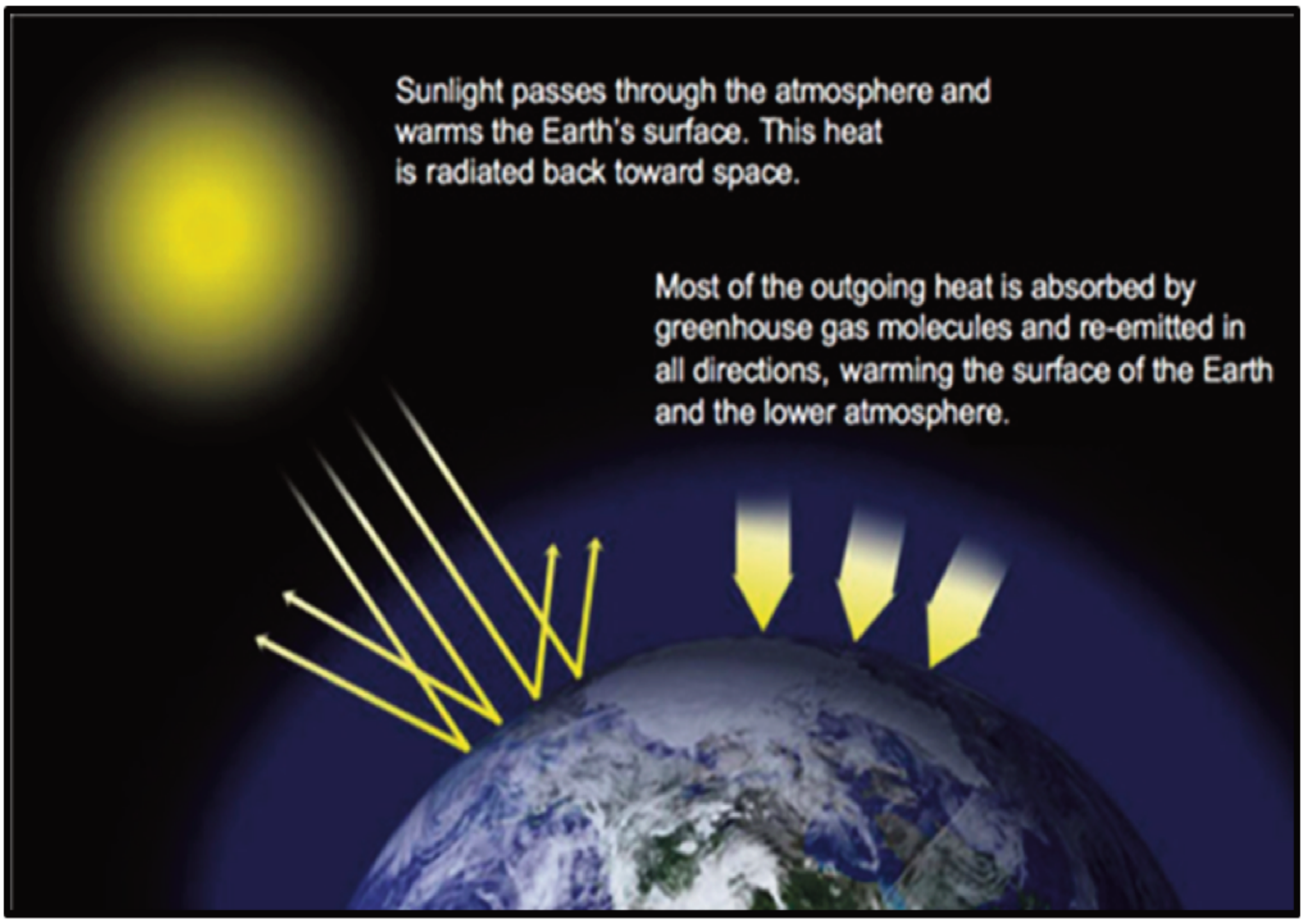


Figure 1. *(Source: NASA Earth Observatory)*

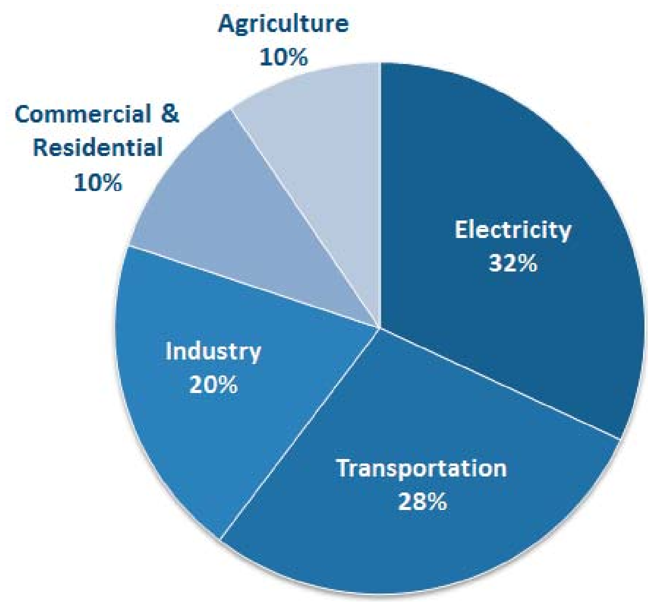
Table 1. Major GHG Emission Sources From Swine Operations

Manure storage and treatment	CH_4 and small amounts of N_2O
Land application of manure	N_2O
Enteric fermentation (feed digestion)	CH_4 and small amounts of CO_2

Sources of GHGs

Though agricultural processes produce a significant amount of GHGs, the largest source of GHGs in the U.S. is the burning of fossil fuels for electricity, heat and transportation (*Figure 2*). Greenhouse gas emissions from agriculture generally come from the cultivation of crops and livestock for food.

Figure 2.
Total U.S. Greenhouse Gas Emissions by Economic Sector in 2012



Total Emissions in 2012 =
6,526 Million Metric Tons of CO_2 Equivalent

* Land Use, Land-Use Change and Forestry in the United States is a net sink and offsets approximately 15% of these greenhouse gas emissions.

All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012.*

Overview of Swine Management Systems

Feed Management

Feed management is an important part of any swine operation. Feed influences the growth performance and overall health of the swine. Typical feedstocks include **carbohydrates, proteins, vitamins, minerals** and **some type of additive or supplement**. Feed can either be fully purchased from a commercial source or grown by the farmer. However, it is not uncommon for a farmer to grow and supply certain ingredients (corn and soybean meal) and supplement them with commercially purchased ingredients (minerals and vitamins). Sometimes additives are mixed into the feed to treat medical conditions, improve growth performance or help balance nutrients. Feed formula and portion size can also be adjusted to help compensate for changes in the pig's body condition due to growth or gestation.

- **Carbohydrates** are an essential energy source in swine feed. Carbohydrates play an important role in regulating body temperature, reproduction and are typically supplied by corn, barley and oats.

- **Proteins** are necessary for muscle and milk production and play a vital role in the building of new tissues and repair of old/torn tissues. Pigs must continually consume sufficient amounts of protein to maintain proper muscle growth and weight gain. The most common sources of proteins are soybean meal and meat/bone meal.

- **Vitamins** are organic compounds that are necessary in small amounts for normal growth, reproduction and health of animals.

- **Minerals** play a support role for many biological functions, such as fortifying the pig's structural components (bones and teeth). Minerals also support healthy cell development and function, and are involved in the functions of enzymes.

- **Feed additives** are ingredients that provide no nutritional value, yet may enhance production and profitability. Feed additives are regulated by the U.S. Food and Drug Administration (FDA), and their use is overseen by strict guidelines. There are many classes of food additives including **antibiotics**, **anthelmintics** and **enzymes**.

- **Antibiotics** are compounds extracted from living organisms (bacteria and molds) that can inhibit the growth of microorganisms. Antibiotics can be useful in the treatment of bacterial infections and, in low doses, can be used to prevent bacterial infections altogether.

- **Anthelmintics** are compounds that are used to expel parasitic worms from the body. The specific anthelmintic administered varies with the type of parasitic worm.

- **Enzymes** are microorganisms which play an essential role in the pig's feed digestion. Enzymes stimulate the pig's digestive system and aid in breaking down feed components. Enzymes can also be used to release minerals (i.e., phytase releases phosphorous) that are bound in unusable forms, therefore making them available to be used by the pig.

Housing Management

Proper housing accommodations are a critical component of a successful swine operation. For this exercise, there are two main types of housing setups: grow-finish (2-phase) and nursery-grow-finish (3-phase). In a grow-finish operation, swine are brought into the facility after weaning and grown until they reach the market weight. Nursery-grow-finish operations breed and farrow piglets, then grow them to market weight. Regardless of the type of operation, certain components will be present on any swine farm including **lighting**, **ventilation fans**, **insulation** and **a heating fuel source**. Because of the general nature of these components, there are a range of different efficiencies and model options to choose from when selecting them. The farmer's selection depends on factors such as financial resources, existing infrastructure and GHG emission preferences.

Lighting source decisions provide an opportunity for farmers to conserve energy, financial resources and reduce the farm's GHG footprint. Also, inadequate lighting in a barn presents a safety hazard for workers due to lowered visibility. Lighting also can have major implications for both the animal's health and welfare.

- **Light-emitting diodes (LEDs)** use semiconductive diodes instead of traditional filament to generate light. A semiconductor is a material with the ability to conduct electrical current. In the case of LEDs, the conductive material is typically aluminum-gallium-arsenide (AlGaAs). LEDs only lose about 5% of their energy to heat production. Because such a high percentage (95%) of the electrical input is going directly to generating light, they can cut electricity demands considerably.

- **Halogen light** bulbs emit light through conduction of electricity through a semiconductive tungsten filament. Halogen bulbs loose about 90% of their energy to heat production. Because such a low percentage (10%) of the electrical input is going directly to generating light, halogen bulbs waste a lot of electricity.

Ventilation fans provide the proper air exchange within the barns. Air exchange (replacing stale air with fresh air) is essential to indoor control of temperature, moisture levels and odor.

Insulation material slows down the conduction of heat through walls, ceilings and floors. Insulation is rated by "R-value," which is a measure of thermal resistance. The higher the insulation's R-value, the better its ability to slow down heat flow.

Heating energy source choices are among the most important decisions producers make. Energy source decisions have a lasting effect on the practical functionality, finances and greenhouse gas emissions associated with swine operations. Two common energy sources for heating barns in Arkansas are natural gas and propane. Both propane and natural gas are fossil fuels.

- **Propane** (C_3H_8) is a hydrocarbon that is produced as a by-product from both the processing of natural gas and the refining of crude oil. Propane naturally occurs in a gaseous state; however, it can be changed to a liquid state as liquefied petroleum gas (LPG) when pressurized within a container.

- **Natural gas** is a combustible mixture of hydrocarbon gases. The primary component of natural gas is methane (CH_4), but it also contains ethane (C_2H_6), butane (C_4H_{10}), carbon dioxide (CO_2) and propane (C_3H_8). Natural gas is colorless, odorless and tasteless. The chemical mercaptan is added to the gas prior to distribution. Mercaptan has a distinct rotten-egg smell and is added to aid in leak detection.

Manure Management

Proper manure management is also an important part of a successful swine operation. The flow of manure on a swine operation depends on the design of the manure management system. The manure management system is the way in which the farm handles, treats, stores, transfers and utilizes manure and is dependent on the farmer's land availability, financial resources, GHG emission philosophy and manure utilization preferences. Accordingly, there are many different components and equipment options available for swine farmers to implement in order to accommodate their resource availability and achieve production goals.

Six Basic Functions of Swine Manure Management

1. **Production** is the amount and nature of the manure generated.

2. **Collection** refers to the capture of manure from the point of origin. The most common manure collection process in Arkansas is the practice of raising swine on **slatted floors** over manure storage pits.

3. **Transfer** refers to the movement of manure throughout the management system. It includes the transfer of manure from the collection point to the storage facility, to the treatment facility and to the utilization site.

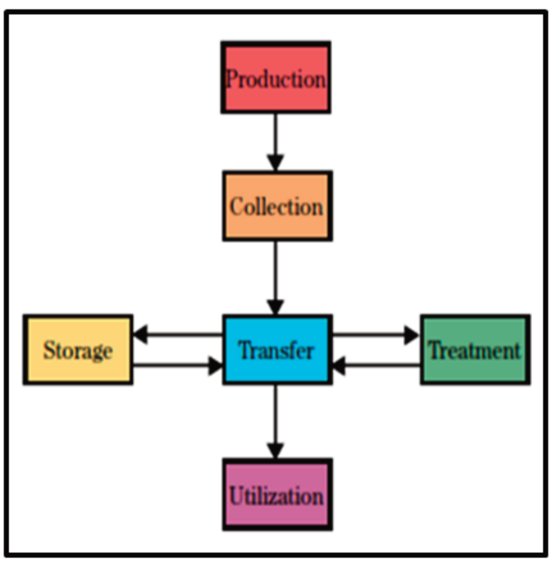
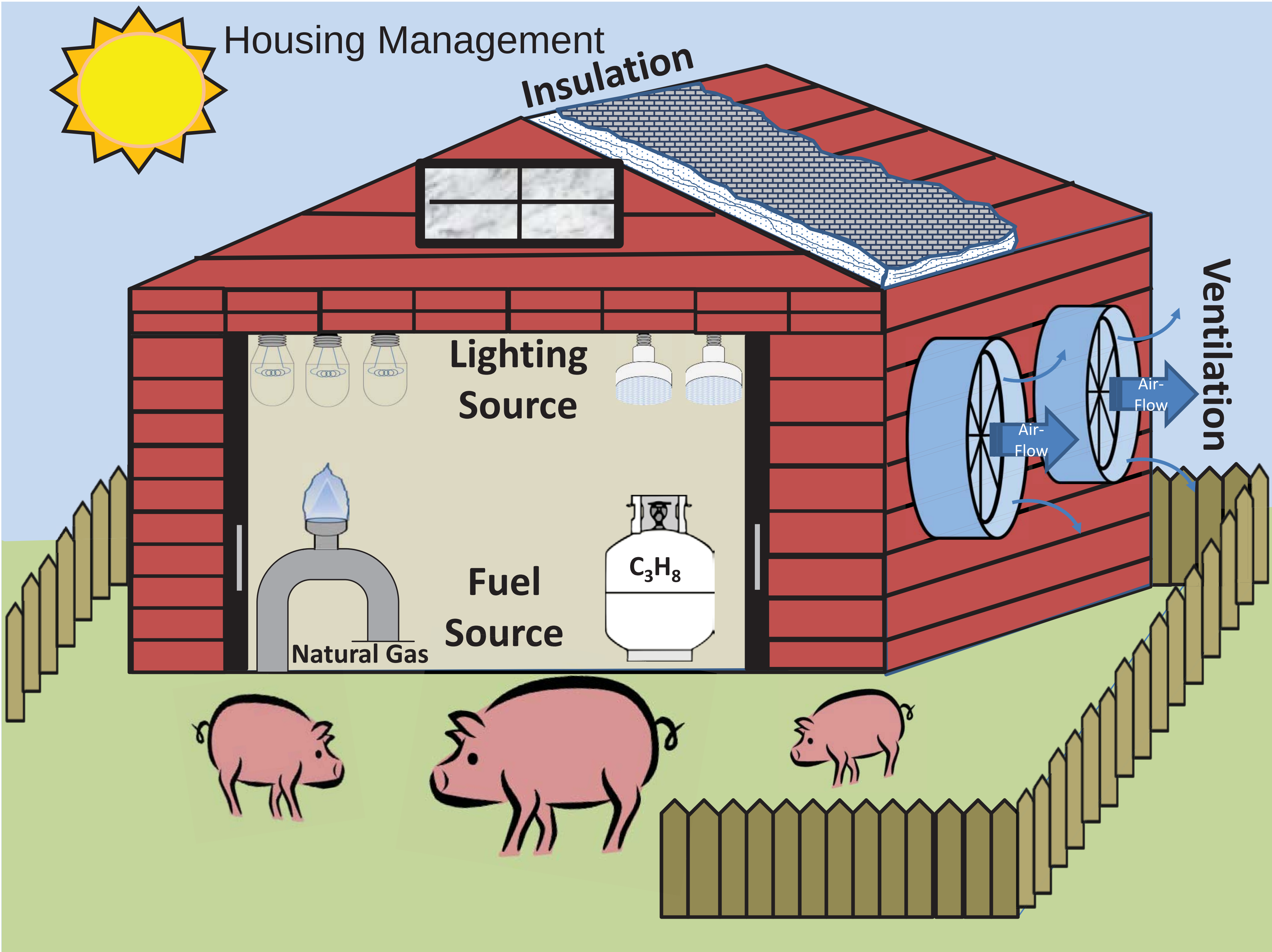


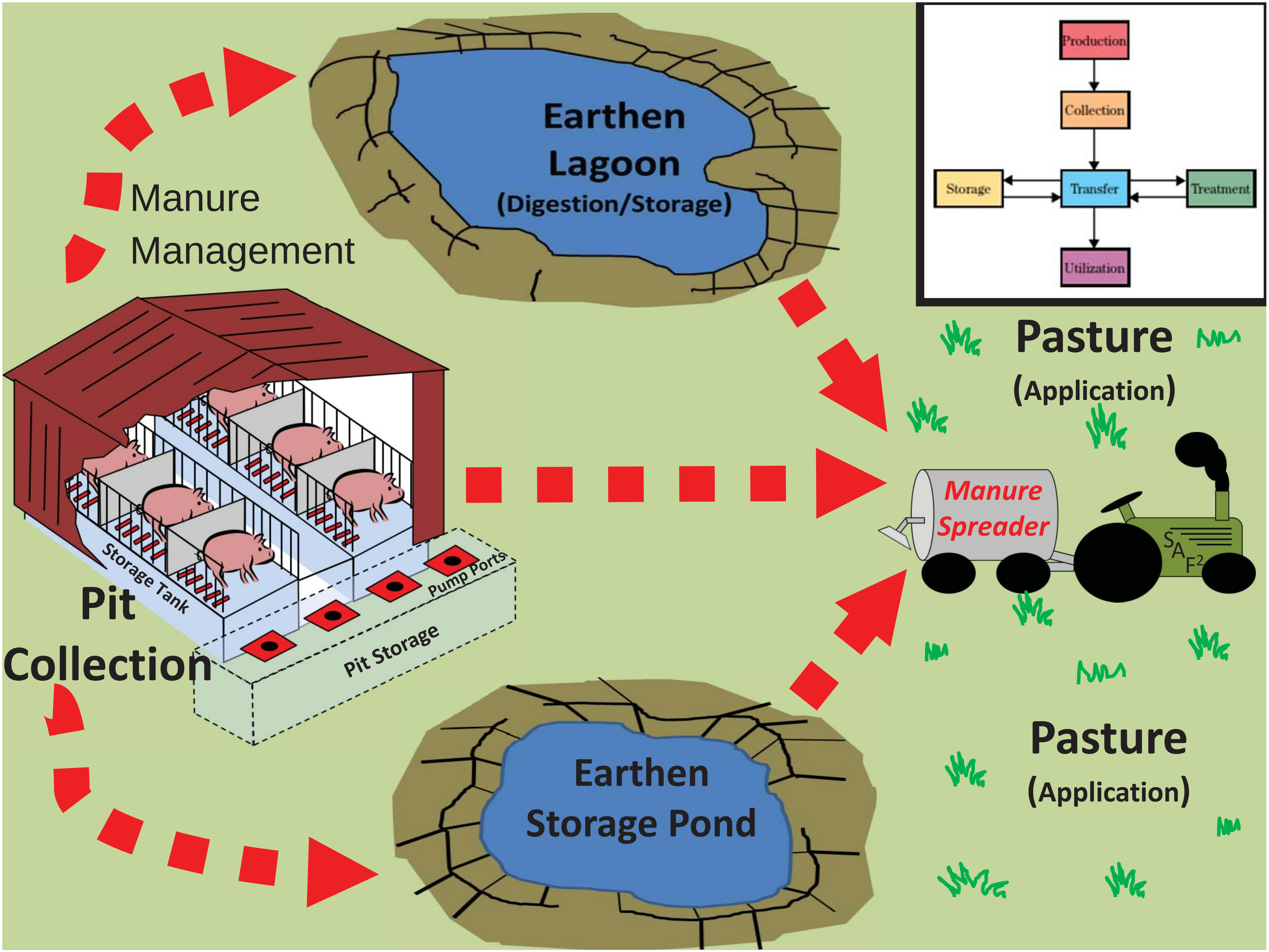
Figure 3.
(Source: USDA-NRCS Agricultural Waste Management Handbook)

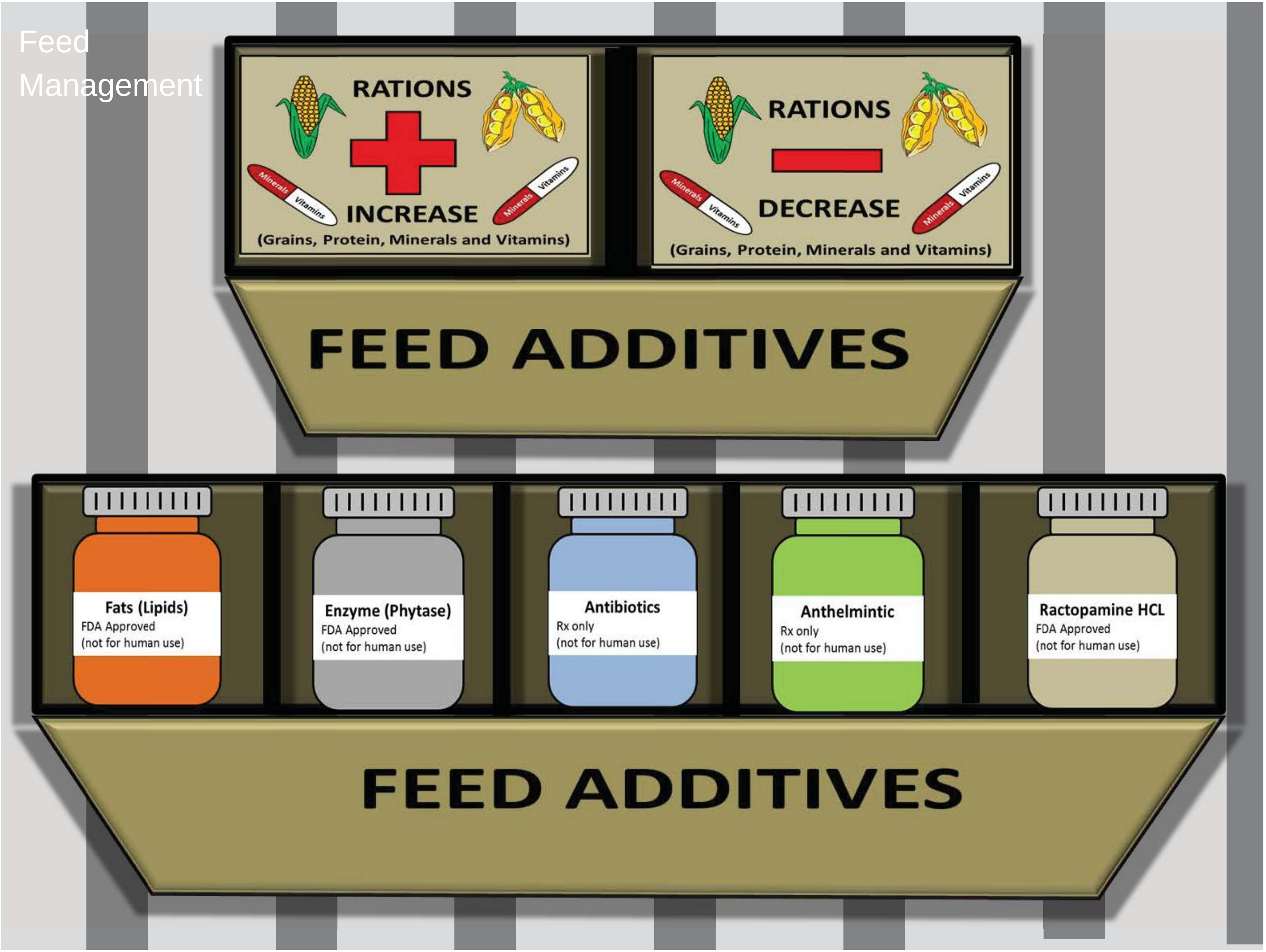
4. **Storage** is the temporary containment of manure. The storage facility is the tool that gives the manager control over the timing and scheduling of system functions. The manure storage period is ideally determined by the utilization schedule. Swine manure is commonly stored in **earthen storage ponds**.

5. **Treatment** is the function designed to reduce the pollution potential or modify the physical/chemical characteristics of the manure. Manure treatment consists of physical, biological and chemical processes. Swine manure is commonly treated in an **anaerobic lagoon**.

6. **Utilization** includes the use and recycling of manure products. Manure may be used as a source of energy, organic matter or plant nutrients. Manure can be converted to an energy source through the **anaerobic digestion** process. Because manure is rich in plant-available nutrients, it is a valuable fertilizer for crops and forages. When utilized as a fertilizer, manure is typically **land applied** with a spreading device. The application can take place at the farm that produced the manure, or it can be **transported off-site** where it is utilized as a fertilizer at another far location.


Housing Management
Insulation
Lighting Source
Fuel Source
Natural Gas
C_3H_8
Ventilation
Air-Flow
Air-Flow


Earthen
Lagoon
(Digestion/Storage)
Production
Collection
Storage
Transfer
Treatment
Utilization
Manure
Management
Pasture
(Application)
Manure
Spreader
SAF2
Storage Tank
Pump Ports
Pit Storage
Pit
Collection
Earthen
Storage Pond
Pasture
(Application)

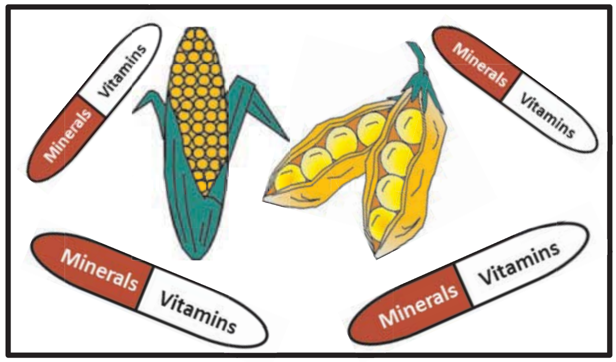

Feed
Management
RATIONS
INCREASE
(Grains, Protein, Minerals and Vitamins)
RATIONS
DECREASE
(Grains, Protein, Minerals and Vitamins)
Minerals
Vitamins
FEED ADDITIVES
Fats (Lipids)
FDA Approved
(not for human use)
Enzyme (Phytase)
FDA Approved
(not for human use)
Antibiotics
Rx only
(not for human use)
Anthelmintic
Rx only
(not for human use)
Ractopamine HCL
FDA Approved
(not for human use)
FEED ADDITIVES

Farm Flashcards

Base-Mix System

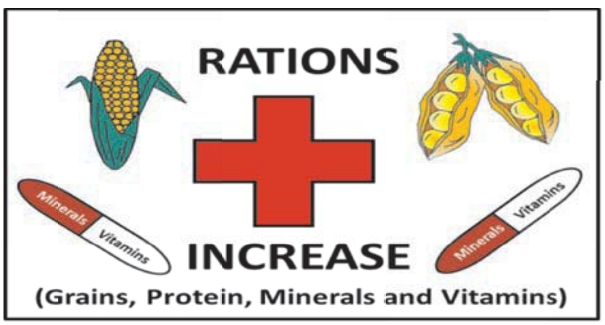
Description: Pre-mixed vitamins and minerals are purchased and added to farmer supplied grains and soybean meal (protein source). This system works well for farmers whom have access to bulk soybean meal/grain supplies and need dietary flexibility.
Effect on GHG: Reduced GHG footprint through lowered feed transportation emissions
Effect on $: Reduced expenses through lowered feed transport costs

Complete Diet System



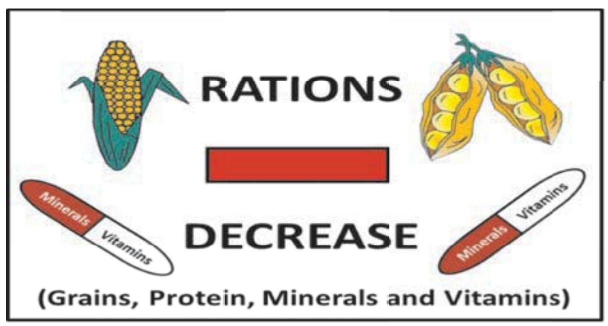
Description: Commercially mixed diets are purchased from a manufacturer and delivered in bulk. This system works well for operations without access to bulk grain/ soybean meal supplies. Specialty feeds, such as gestation diets are best served by this feed system.
Effect on GHG: Increased GHG footprint through higher feed transportation emissions
Effect on $: Increased expenses through higher feed transport costs.

Feed Additive



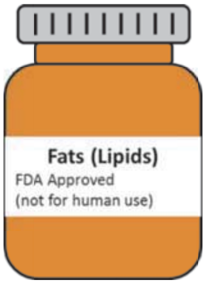
Description: Increase the rations for a given swine type by an amount recommended by the dietary consultant.
Effect on GHG:
If changed due to body condition; reduced GHG output through improved feed efficiency.
If changed due to thermal stress; increased GHG footprint due to lowered feed efficiency.
Effect on $:
If changed due to body condition; decreased expenses through higher efficiency.
If changed due to thermal stress; increased expenses due to poor growth performance and feed efficiency

Feed Additive



Description: Decrease the rations for a given swine type by an amount recommended by the dietary consultant.
Effect on GHG:
If changed due to body condition; reduced GHG output through improved feed efficiency.
If changed due to thermal stress; increased GHG footprint due to lowered feed efficiency.
Effect on $:
If changed due to body condition; decreased expenses through higher efficiency.
If changed due to thermal stress; increased expenses due to poor growth performance and feed efficiency

Feed Additive



Description: Fats are used when caloric requirements need to be increased due to changes in the pig's environmental or body condition.

Effect on GHG:

If fed due to body condition; reduced GHG output through improved feed efficiency.

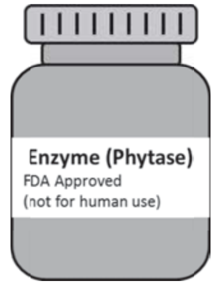
If fed due to thermal stress; increased GHG footprint due to lowered feed efficiency.

Effect on $:

If fed due to body condition; decreased expenditures through higher efficiency.

If fed due to thermal stress; increased expenditures due to poor growth performance and feed efficiency.

Feed Additive



Description: Enzymes stimulate the pig's digestive system and help breakdown feed. Enzymes also release minerals within the feed (i.e. Phytase releases Phosphorous) that are bound in unusable forms, making them available to be used by the pig instead of excreted in manure.

Effect on GHG:

If manure is land applied; reduced GHG footprint through improved nutrient balance.

If manure is transported off site; no local effect

Effect on $:

If manure is land applied; decreased expenses through improved nutrient management.

If manure is transported off site; no local effect

Feed Additive

Description: Antibiotics are medical compounds made from bacteria and mold extracts, and are used to inhibit the growth of harmful microorganisms that cause sickness.

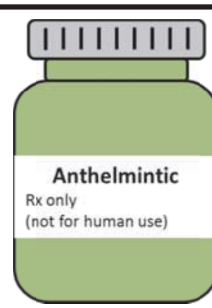
Effect on GHG:

If antibiotics are administered; reduced GHG footprint through improved feed efficiency and growth performance.

Effect on $:

If antibiotics are administered; decreased expenses through improved feed efficiency and growth performance.

Feed Additive



Description: Anthelmintics are medical compounds that are administered to expel parasitic worms from the body.

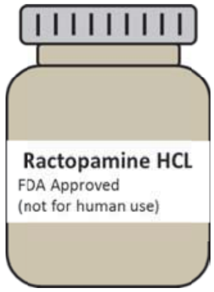
Effect on GHG:

If anthelmintics are administered; reduced GHG footprint through improved feed efficiency and growth performance.

Effect on $:

If anthelmintics are administered; decreased expenses through improved feed efficiency and growth performance.

Feed Additive

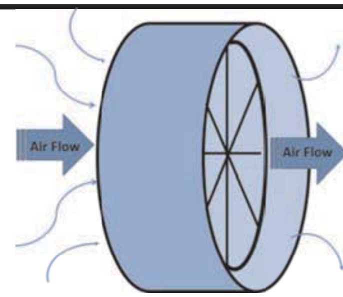


Description: Ractopamine is a beta-antagonistic feed additive used to simultaneously decrease fat depositions and increase lean tissue (muscle). It is added to feed at very specific amounts to meet federal guidelines.

Effect on GHG:
If Ractopamine is administered; reduced GHG footprint through improved feed efficiency and growth performance.

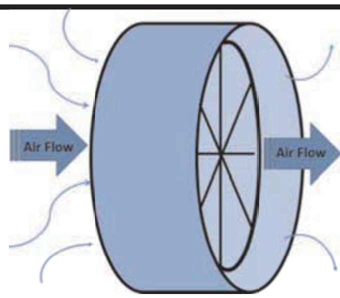
Effect on $:
If Ractopamine is administered; decreased expenses through improved feed efficiency and decreased time to market weight.

Tunnel Ventilation (25 cfm/W)



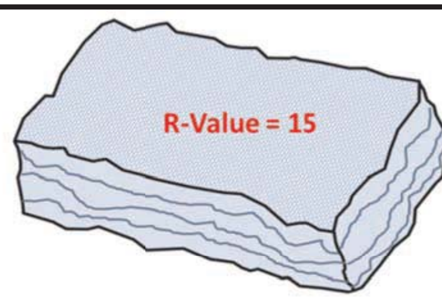
Description: Barn ventilation fans help regulate and maintain air exchange within the barn (i.e. replacing stale air with fresh air). Fan performance is measured by the fans efficiency (i.e. the amount of electricity required to power the fan [expressed in watts] in relationship to the volume of air moved by the fan[expressed in cubic feet per minute]). High efficiency fans move more air per watt.
Effect on GHG: Decreased GHG footprint through energy efficient ventilation.
Effect on $: Despite a higher upfront cost, energy efficient fans have a low long-term cost due to money saved from lowered energy consumption.

Tunnel Ventilation (12 cfm/W)



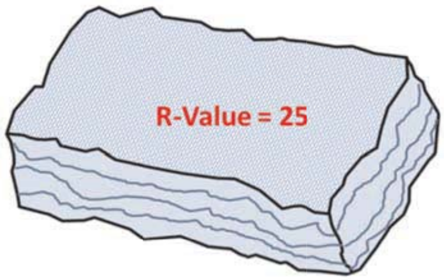
Description: Barn ventilation fans help regulate and maintain air exchange within the barn (i.e. replacing stale air with fresh air). Fan performance is measured by the fans efficiency (i.e. the amount of electricity required to power the fan [expressed in watts] in relationship to the volume of air moved by the fan[expressed in cubic feet per minute]). Low efficiency fans move less air per watt.
Effect on GHG: Increased GHG footprint through energy inefficient ventilation.
Effect on $: Despite a lower upfront cost, energy inefficient fans have a high long-term cost due to money spent from increased energy consumption.

Barn Insulation Material



Description: Barn insulation material is installed within the barn to help regulate the barn's internal temperature. The efficiency rating of the insulation material is expressed as the "R-value". The Higher the R-value, the more efficient the insulation material (i.e. the better it keeps the outside temperatures from effecting the temperature inside the barn). Conversely, the lower the R-value the less efficient the insulation material.
Effect on GHG: Increased GHG footprint through energy inefficient insulation.
Effect on $: Despite a lower upfront cost, energy inefficient insulation can have a high long-term cost due excessive heating and cooling needs.

Barn Insulation Material



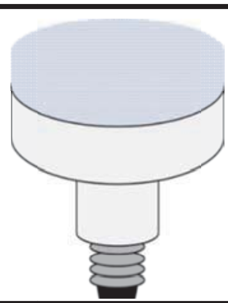
Description: Barn insulation material is installed within the barn's walls to help regulate the barn's internal temperature. The efficiency rating of the insulation material is expressed as the "R-value". The Higher the R-value, more efficient the insulation material (i.e. the better it keeps the outside temperatures from effecting the temperature inside the barn). Conversely, the lower the R-value the less efficient the insulation material.
Effect on GHG: Decreased GHG footprint through energy efficient insulation.
Effect on $: Despite a higher upfront cost, energy efficient insulation can have a lower long-term cost due moderate heating and cooling needs.

Halogen Lighting

Description: Halogen lights are tungsten filament based light bulbs. Halogen bulbs use gas infused envelopes to extend the bulbs temperature range and lifetime. Much of the energy input is lost to heat production instead of being used for lighting.

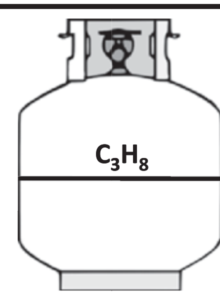
Effect on GHG: Decreased GHG footprint through energy inefficient lighting.
Effect on $: Despite a low upfront cost, energy inefficient lighting will have a high long-term cost due to excessive energy consumption.

LED Lighting



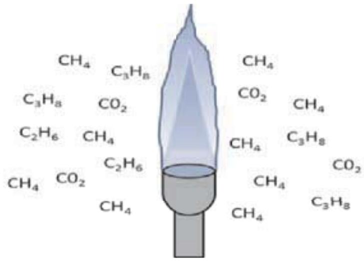
Description: Light Emitting Diode (LED) lights are filament free light sources that utilize aluminum-gallium-arsenide (AlGaAs) as electrical conductive material. LEDs are highly energy efficient light sources because they do not lose much of the input energy to heat emission.
Effect on GHG: Decreased GHG footprint through energy efficient insulation.
Effect on $: Despite a higher upfront cost, energy efficient lighting will have a lower long-term cost due conservative energy consumption.

Propane Fuel Source



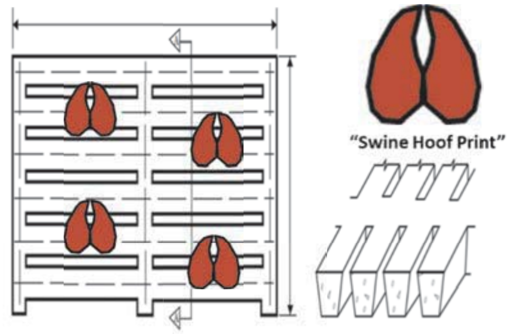
Description: Propane (C_3H_8) is a hydrocarbon that is produced as a by-product from both the processing of natural gas and the refining of crude oil.
Effect on GHG: The Environmental Protection Agency (EPA) classifies propane as non-toxic, as it causes no harm to air, soil and water resources if released into the atmosphere before combustion and contains only minimal toxin levels if emitted post-combustion. Propane is considered to be clean burning alternative to coal generated energy and for the purposes of this exercise a GHG footprint is not assessed.
Effect on $: Propane is a commodity, prices and associated costs are set and driven by local and global trade markets.

Natural Gas Fuel Source



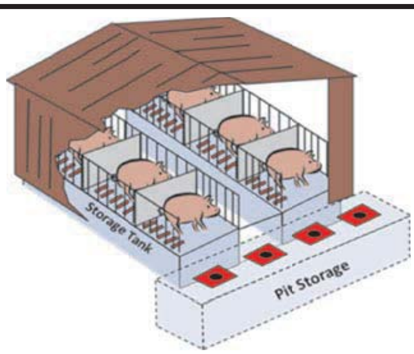
Description: Natural gas is a combustible mixture of hydrocarbon gasses. The primary component of natural gas is methane (CH_4), but it also contains ethane (C_2H_6), butane(C_4H_{10}), carbon dioxide (CO_2) and propane(C_3H_8).
Effect on GHG: According to the Environmental Protection Agency (EPA), natural gas is classified as a greenhouse gas only when it is discharged directly into the atmosphere before combustion. However, natural gas is considered to be a clean burning alternative to coal generated energy and for the purposes of this exercise a GHG points are not assessed.
Effect on $: Natural gas is a commodity, prices and associated costs are driven by local and global trade markets.

Slatted Floors Collection



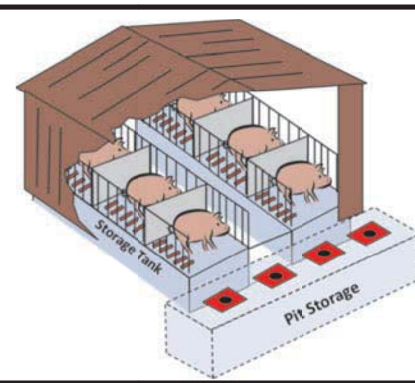
Description: Manure is transferred into pits located below stalls through slats in flooring via action of pig's hoofs. The captured manure is then transported to treatment or storage by flushing the alleys with water several times a day.
Effect on GHG: There is a small GHG footprint generated from volatization that occurs during the manures residence time. There is also a small carbon footprint associated with operating the pump that flushes the manure into storage pits.
Effect on $: There is a marginal expense associated with clean-out, maintenance of the flooring and flush pump operation.

Shallow Pit Storage



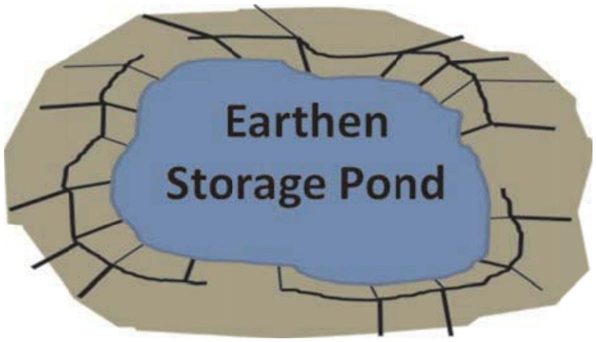
Description: Liquid manure storage option that collects flushed manure for temporary (2-10 days) storage prior to treatment, long-term storage or utilization.
Effect on GHG: There is a small GHG footprint generated from volatization that occurs during the manures residence time. There is also a small carbon footprint associated with operating the pump that transfers the manure to subsequent storage, treatment or use.
Effect on $: There is a marginal expense associated with clean-out, maintenance of the shallow pit and pump operation.

Deep Pit Storage



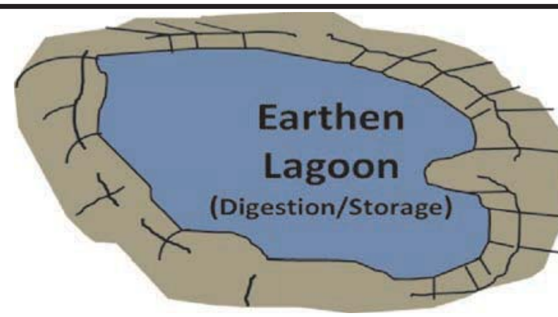
Description: Liquid manure storage option that collects manure through slatted flooring for temporary (up-to 180 days) storage prior to treatment, long-term storage or utilization.
Effect on GHG: There is a small GHG footprint generated from volatization that occurs during the manures residence time. There is also a small carbon footprint associated with operating the pump that transfers the manure to subsequent storage, treatment, or use.
Effect on $: There is a moderate expense associated with clean-out, maintenance of deep pit storage.

Earthen Storage Pond



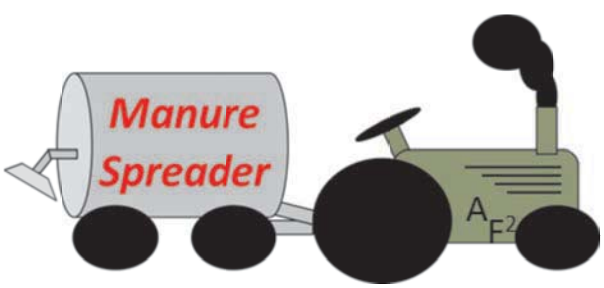
Description: Earthen storage ponds are liquid manure storages which use concrete/clay lined ponds for long-term storage. Manure can be treated before entering the pond, or treated/ utilized after residing in the pond for a given period of time.
Effect on GHG: There is a small GHG carbon footprint generated from volatization that occurs during the manures residence time
Effect on $: Earthen storage is very economical, and is generally the least expensive long-term storage. There is a marginal expense associated with pond clean-out, maintenance and materials.

Earthen Lagoon



Description: Earthen lagoons are anaerobic waste treatments that utilizes microbes to produce Methane(CH_4) from the Carbon and Hydrogen in manure. Earthen clay liners are typical; If covers are installed to capture gas and/or reduce odor, they are usually a plastic fabric material.
Effect on GHG: If methane is captured; the GHG footprint is reduced through carbon sequestration. **If methane is not captured ;** there is a moderate GHG footprint generated from CH_4 emission.
Effect on $: Earthen lagoons are the least expensive digestion option. There is a marginal expense associated with pond clean-out, maintenance and materials. Any captured CH_4 can be used to offset energy costs

Field Application

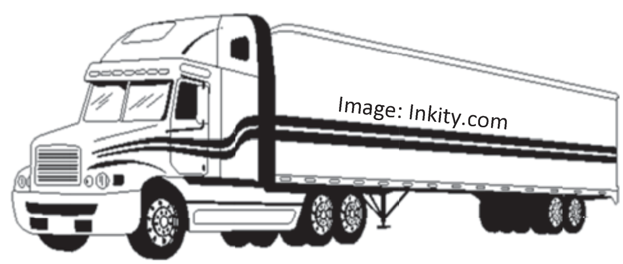


Description: Manure is applied to land at rates and times that meets the nutrient needs of crop (s) to be grown. Solids are applied using manure spreaders. Liquid and slurry manures are usually applied using tank wagons, or irrigation.

Effect on GHG: Generally, there is a marginal GHG footprint associated with land applications due to the variable levels of volatization that occur after manure application.

Effect on $:Overall, land application of manure saves money through reducing the need to purchase commercial fertilizers.

Off-farm Transport

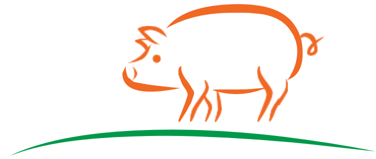


Description: Manure is transported for off-site utilization. The manure may be applied as fertilizer on another farm or utilized as an energy source at an energy conversion facility.
Effect on GHG: There is a marginal GHG footprint associated with the loading and transport of manure for off-site usage.
Effect on $: Generally there is a variable amount of money made by the farmer from the transport of manure for off-site usage. However, there can also be a variable loss of funds. This depends on several factors including; the sale price of the manure and the distance the manure is transported.

Name ______________________________

Date ______________________________

Lab Report Form



Trial 1:

Flashcard selected _________________________

To which management system does this card belong?

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What is the function of this card’s component/equipment?

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What is component/equipment’s role in its management system?

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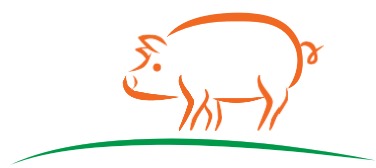
Trial 2:



Flashcard selected _________________________

To which management system does this card belong?

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What is the function of this card’s component/equipment?

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What is component/equipment’s role in its management system?

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