Farm as an Enterprise situated in an Ecosystem System Description

Abstract

The system-of-interest for this System Description is the Farm as an Enterprise situated in an Ecosystem.

This system description identifies the system elements of a farm using the Enterprise model. This focuses on the following:

- Organizations
- Capabilities (including People)
- Technology.

PDF: System Description: Enterprise as a System of Systems (SoS), Version 0.20, 25-November-2024

In addition, the system description also focuses on the farm human activity habitats and habitat types (land types) that the farm uses to produce food. Each habitat type can support use by the following types of organisms in their habitats:

- Crop Habitats
- Animal Habitats
- Human Habitats

PDF:: System Description: Ecological System (Ecosystem), Version 0.4, 06-November-2023

The dynamics of this type of system are addressed through the various processes used to manage the farm human activity habitat types and the mix of habitats for specific species. These dynamics can highlight the differences between the following types of farming.

- Industrial Farming
- Organic / Re-generative Farming
- Vertical Farming

The farm as a system supports Goal 2 of the United Nations Sustainable Development Goal in the areas of improved nutrition and sustainable agriculture.

PDF: System Descriptions: Farm as an Enterprise situated in an Ecosystem, Version 0.5, 08-January-2024 (Prototype Draft)

Author and Version

Bruce McNaughton, Version 0.5, 08-January-2024 (Prototype Draft)

Contents

Revision History

V0.5 08-January-2024 improved soil component.
V0.4 06-November-2023 Problem / Solution topics and open initial review.
V0.3 02-November-2023 Various updates and view models.
V0.2 27-October-2023 Revise ecosystem connection; Add initial problems and solutions.
V0.1 14-January-2023 Inclusion of Correspondences
V0.0 21-December-2022, Initial Draft

Introduction: Farm as an Enterprise situated in an Ecosystem

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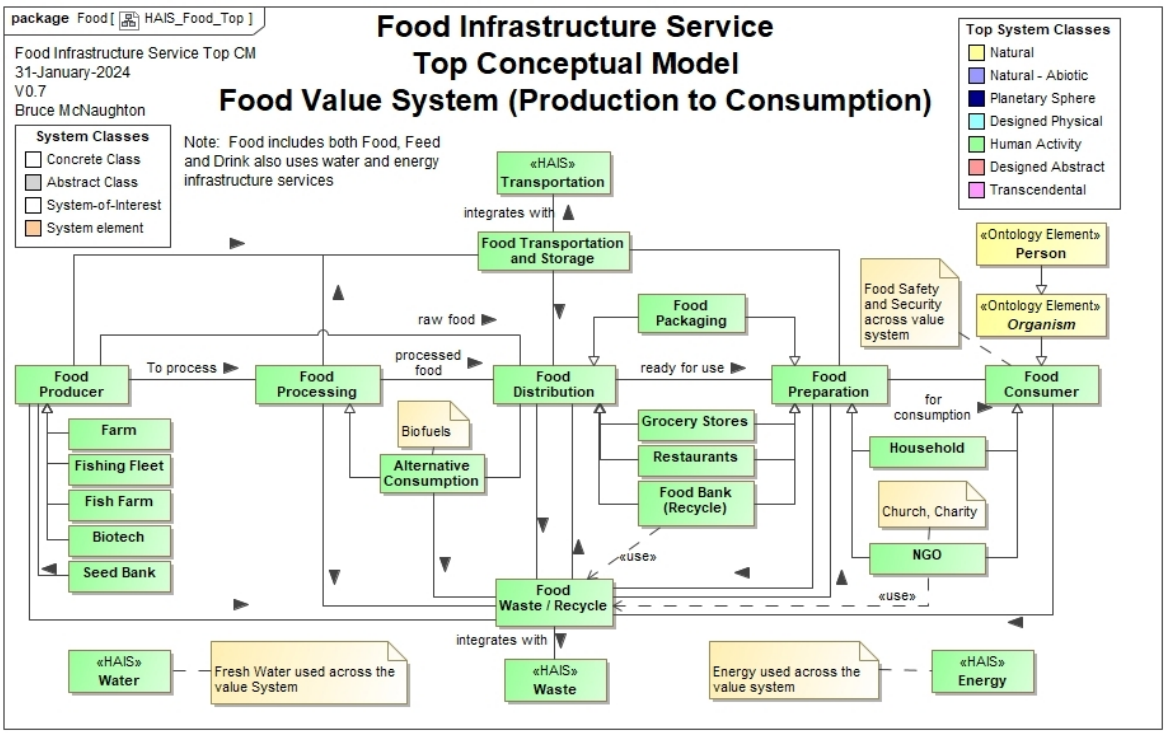
This Food Infrastructure Service provides the context for the Farm as an Enterprise situated in an Ecosystem. The Food Infrastructure Service shows the full life cycle from production to consumption of food items



The farm is shown as a key element of the Food Production process. The entire set of organizations in the Food Value System (including the Farm) may be part of a wider Food Safety management system initiative using ISO 22000 (See FSSC 22000).

View: System Name and Class

Name: Farm as an Enterprise situated in an Ecosystem

Based on: Enterprise (SoS) situated in Ecosystem

See the correspondences section for the specific extensions of the Enterprise and Ecosystem conceptual models for the farm.

PDF: System Description: Enterprise as a System of Systems (SoS), Version 0.20, 25-November-2024

PDF:: System Description: Ecological System (Ecosystem), Version 0.4, 06-November-2023

Note: This system description uses a set of classes that are derived from the Enterprise SoS conceptual model and the Ecosystem Conceptual Model. These are:

- Farm as an Enterprise
- Farm Household as an Organization
- Farm Organization as an Organization
- Farm Capability as a Capability
- Farm Human Activity Habitat as Human Activity Habitat.

The above classes will be used in this System Description. (NOTE: These could be modelled as stereotypes or other approaches or tools. These will be evaluated later).

See the Correspondence section to see the specific mapping for each of the classes from the enterprise and the ecosystem.

The Household is also a human activity system and has the following system description. Household elements are also included in the Farm correspondence..

PDF: System Description: Household as a System, Version 0.0, 11-July-2022

This document integrates terms from the Enterprise and the Ecosystem. Note: see the Enterprise and Ecosystem System Descriptions for the full termonology for each type of system.

The following are key terms used in this System Description for the Farm as an Enterprise situated in an Ecosystem:

- Agriculture: encompasses crop and livestock production, aquaculture, fisheries, and forestry for food and non-food products.
- Horticulture: is the cultivation of plants in gardens or greenhouses, as opposed to the field-scale production of crops characteristic of agriculture. It includes the cultivation of fruits, vegetables, nuts, seeds, herbs, sprouts, mushrooms, algae, flowers, seaweeds and non-food crops such as grass and ornamental trees and plants.
- Green Manure: is a crop specifically cultivated to be incorporated into the soil while still green.
- Cover Crop: are plants that are planted to cover the soil rather than for the purpose of being harvested. Cover crops manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem—an ecological system managed and shaped by humans. Cover crops can increase microbial activity in the soil, which has a positive effect on nitrogen availability, nitrogen uptake in target crops, and crop yields.
- Compost: is a mixture of ingredients used as plant fertilizer and to improve soil's physical, chemical, and biological properties. It is commonly prepared by decomposing plant and food waste, recycling organic materials, and manure. The resulting mixture is rich in plant nutrients and beneficial organisms, such as bacteria, protozoa, nematodes, and fungi.
- Soil Terminology and Nutrients
- Food Safety and Traceability
- Food Loss and Waste: is food that is not eaten. The causes of food waste or loss are numerous and occur throughout the food system, during production, processing, distribution, retail and food service sales, and consumption. Overall, about one-third of the world's food is thrown away.
- Agricultural Pollution: refers to biotic and abiotic byproducts of farming practices that result in contamination or degradation of the environment and surrounding ecosystems, and/or cause injury to humans and their economic interests. The pollution may come from a variety of sources, ranging from point source water pollution (from a single discharge point) to more diffuse, landscape-level causes, also known as non-point source pollution and air pollution.

Soil Terminology

Key terms for Soil in Ecosystems and for the Food Infrastructure Service (The Farm).

Soil: Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Earth's body of soil, called the pedosphere, has four important functions:

- as a medium for plant growth
- as a means of water storage, supply and purification
- as a modifier of Earth's atmosphere
- as a habitat for organisms

All of these functions, in their turn, modify the soil and its properties.

Soil can be seen as a type of Ecosystem at a microbiological level.

Soil Science: is the study of soil as a natural resource on the surface of the Earth including soil formation, classification and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of soils.

Pedosphere: Soil occupies the pedosphere, one of Earth's spheres that the geosciences use to organize the Earth conceptually. This is the conceptual perspective of pedology and edaphology, the two main branches of soil science. Pedology is the study of soil in its natural setting. Edaphology is the study of soil in relation to soil-dependent uses. Both branches apply a combination of soil physics, soil chemistry, and soil biology.

Soil Classification: deals with the systematic categorization of soils based on distinguishing characteristics as well as criteria that dictate choices in use.

- USDA Soil Taxonomy
- World Reference Base for Soil Resources

Soil Formation: also known as pedogenesis, is the process of soil genesis as regulated by the effects of place, environment, and history. Biogeochemical processes act to both create and destroy order (anisotropy) within soils. These alterations lead to the development of layers, termed soil horizons, distinguished by differences in color, structure, texture, and chemistry. These features occur in patterns of soil type distribution, forming in response to differences in soil forming factors.

Soil Fertility: refers to the ability of soil to sustain agricultural plant growth, i.e. to provide plant habitat and result in sustained and consistent yields of high quality.[3] It also refers to the soil's ability to supply plant / crop nutrients in the right quantities and qualities over a sustained period of time. A fertile soil has the following properties:[4]

- The ability to supply essential plant nutrients and water in adequate amounts and proportions for plant growth and reproduction; and
- The absence of toxic substances which may inhibit plant growth e.g Fe2+ which leads to nutrient toxicity.

Soil retrogression and degradation: are two regressive evolution processes associated with the loss of equilibrium of a stable soil. Retrogression is primarily due to soil erosion and corresponds to a phenomenon where succession reverts the land to its natural physical state. Degradation is an evolution, different from natural evolution, related to the local climate and vegetation.

Respiration (Soil): Soil respiration refers to the production of carbon dioxide when soil organisms respire. This includes respiration of plant roots, the rhizosphere, microbes and fauna.

Soil respiration is a key ecosystem process that releases carbon from the soil in the form of CO2. CO2 is acquired by plants from the atmosphere and converted into organic compounds in the process of photosynthesis.

Microorganism: A microorganism, or microbe,[a] is an organism of microscopic size, which may exist in its single-celled form or as a colony of cells.

Detritus: In biology, detritus (/dɪˈtraɪtəs/) is dead particulate organic material, as distinguished from dissolved organic material. Detritus typically includes the bodies or fragments of bodies of dead organisms, and fecal material. Detritus typically hosts communities of microorganisms that colonize and decompose (i.e. remineralize) it.

Feces, Fecal Matter, Faeces: are the solid or semi-solid remains of food that was not digested in the small intestine, and has been broken down by bacteria in the large intestine.[1][2] Feces contain a relatively small amount of metabolic waste products such as bacterially altered bilirubin, and dead epithelial cells from the lining of the gut.[1]

Fungus: A fungus (plural: fungi[2] or funguses[3]) is any member of the group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. (Fungi).

Humus: humus is the dark organic matter that forms in soil when dead plant and animal matter (including aerobic compost) breaks down further, specifically through the action of anaerobic organisms. Humus has many nutrients that improve the health of soil, nitrogen being the most important.

Nutrient Cycle

Nutrients are a necessary part of soil and result from the decomposition process or other biogeochemical processes (see *).

Types of Nutrients

Nutrient (primary)

- Nitrogen *
- Phosphorous *
- Potassium

MicroNutrient

- Boron
- Chloride
- Copper
- Iron
- Magnesium
- Molybdenum
- Zinc

Beneficial

- Aluminium
- Cobalt
- Iodine
- Nickel
- Selenium
- Sodium

Biogeochemical Cycle Terminology

Key terms for Biogeochemical Cycles in Ecosystems.

Biogeochemistry: Biogeochemistry is the scientific discipline that involves the study of the chemical, physical, geological, and biological processes and reactions that govern the composition of the natural environment (including the biosphere, the cryosphere, the hydrosphere, the pedosphere, the atmosphere, and the lithosphere). In particular, biogeochemistry is the study of biogeochemical cycles, the cycles of chemical elements such as carbon and nitrogen, and their interactions with and incorporation into living things transported through earth scale biological systems in space and time..

Biogeochemical Cycle: A biogeochemical cycle is the pathway by which a chemical substance cycles (is turned over or moves through) the biotic and the abiotic compartments of Earth. The biotic compartment is the biosphere and the abiotic compartments are the atmosphere, hydrosphere and lithosphere. There are biogeochemical cycles for chemical elements, such as for calcium, carbon, hydrogen, mercury, nitrogen, oxygen, phosphorus, selenium, iron and sulfur, as well as molecular cycles, such as for water and silica.

Biogeochemical Cycles are considered part of the behaviour of an ecosystem or the planetary processes. These biogeochemical cycles are interdependent where one cycle changing can influence the other cycles. For example, The water cycle changing due to temperature change can cause other cycles to change (e.g. extreme weather events).

Note: The Nutrient Cycle is described in the Soil Terminology section.

View: System Purpose

The farm is an element of the Food Infrastructure Service. The purpose of the farm is to:

- Produce types of food or feed situated in an Ecosystem
- Ensure that the food or feed production is sustainable and safe.
- Ensure that the ecosystem and infrastructure services are integrated in a way to maintain their sustainable operation.

The Farm supports the following sustainable development goals:

Primary SDG Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Primary SDG Goal 13. Take urgent action to combat climate change and its impacts*

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round

2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

View: System Properties

System Properties Overview

The System Properties identified in this section represent set of properties for the 'whole Farm as an Enterprise situated in an Ecosystem. These properties emerge from the interaction of the system elements described in the Structure of the Farm in this System Description.

Systemic Measurable Variables

The systemic properties created or used through the interaction of the system elements. This includes both desired and undesired.

- Total Food created / distributed
- Total Food sold
- Nutritional Density of Food
- Total Revenue Generated from the Farm or other businesses.
- Total Energy and Water Consumed
- Total Waste produced (not recycled)
- Total emissions produced (using Net Zero Calculations)
- Number and type of food safety issues
- Soil Health Measurements
    - pH
    - Porosity
    - Bulk Density
    - Soil Moisture
    - Total Organisms per area (microorganisms, worms, etc)

Systemic Capabilities or Functions

The core capabilities or functions the system provides.

- Food Production Management
- Food Storage and Distribution Management
- Animal and Plant Management
- Waste / Recycle Management.

System States

The various defined states that the system-of-interest can be in.

- Architectural states
    - Farm identified as possible Enterprise.
    - Owner identified with architecture in mind.
- Transformational States
    - Designed Farm.
    - Realization of farm systems.
- Operational States
    - Management of Food Life cycles in the Farm
    - Management of waste / recycle in the farm.
    - Maintenance of the farm assets.
    - Management of Risks
        - Contingency plans for Risk Events.

Systemic Quality Properties

These properties relate to qualitative properties of the system

- Food Safety and Security
- Quality of Soil
- Land usage and allocation

- Fit in Community.
- Excessive waste or pollution (non circular flows)
    - Amount and type of fertilizer and antibiotics used.
- Affordability
- Maintainability
- Use of scarce resources
- Risk Assessments: Count for each type.
- Count of High Risk Assessments without mitigation plans.

System Quantity Properties

These properties relate to aggregate totals for properties of the system (e.g. weight)

- Weight and Volume of food delivered
- Recycle counts
- Area of land available for food production
- Count of species / habitats on the farm (Biodiversity).

View: System Stakeholders and Concerns

The System-of-Interest Stakeholders are identified and their concerns or interests are included in this section.

Consumers

Food quantity, quality, safety, availability and cost.

Healthy diets and free from undesired consequences.

- People / Organisms
- Household
- Enterprise. (as consumer)
- Government.

Providers

Availability of food supplies at a sustainable price. Profitable to sustain the business.

- Grocery
- Restaurants
- Food distribution
- Food preparation
- Food production

Regulatory

Food Safety, sustainability and price to consumer.

- Consumer protection
- Standards and conformance
- Food Safety / Hygiene.

Research and Development

Research on production, consumption, distribution, storage, packaging, safety, alternative sources, nutritious, etc.

Sustainable development and operation to support sustainable development goals.

- Research and education
- Enterprise product development teams
- Enterprise strategy teams
- Government agencies looking at the future food system architecture.

Farm as a System: Stakeholder Links

This section contains a number of stakeholder links who have an interest or concerns about the Farm as a system.

Community of Practices

- Real Farming Trust
  - Oxford Real Farming Conference

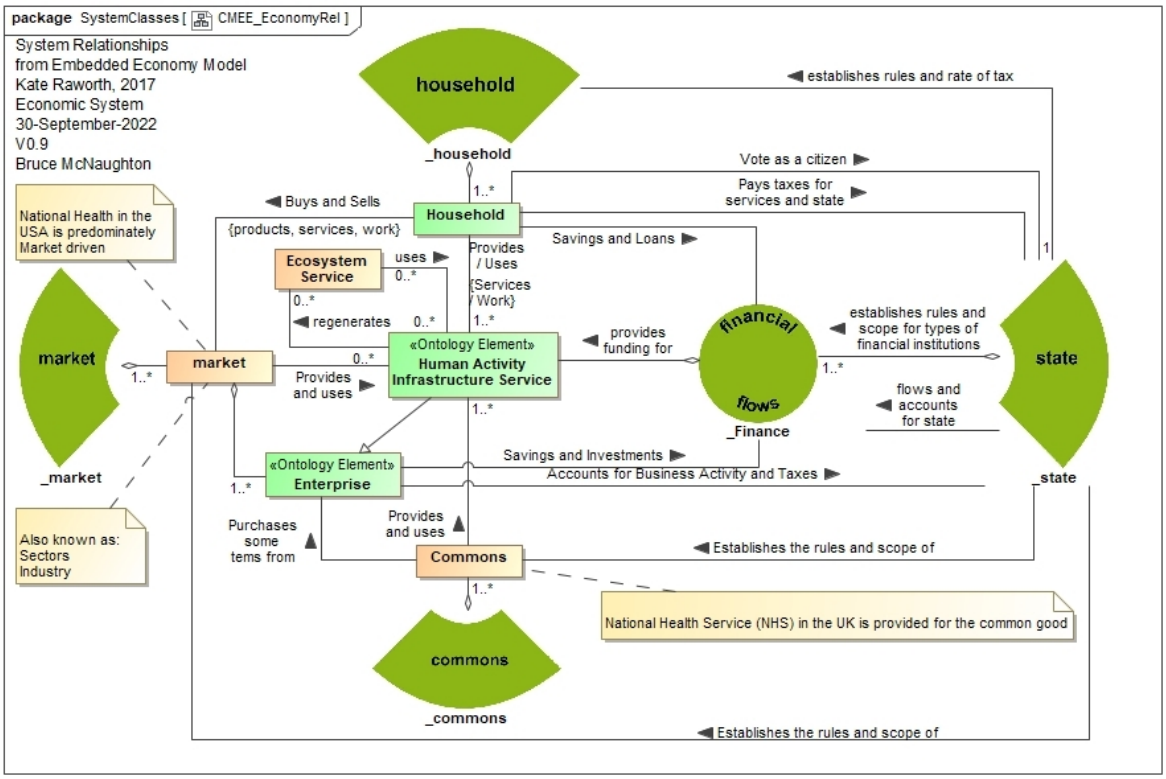
Universities focusing on the Farm and Farming

View: System Environment (Context)

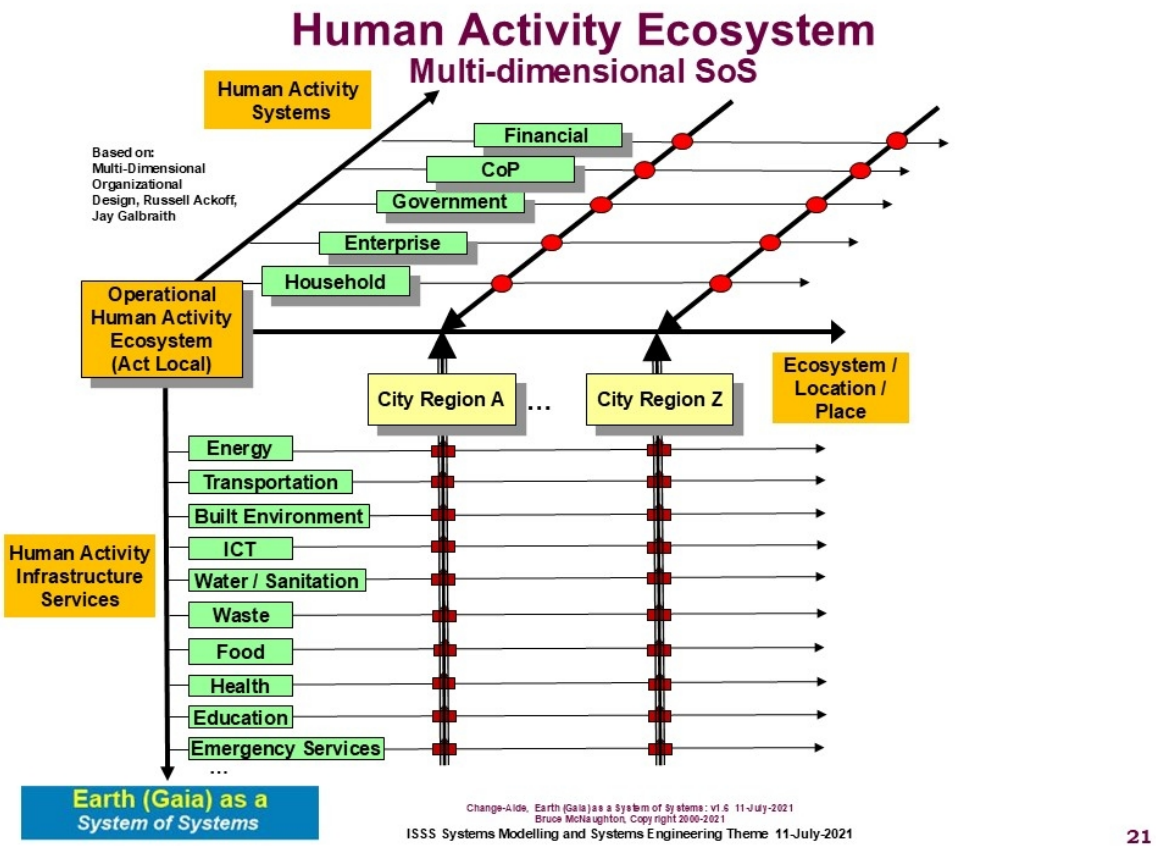
A system-of-interest is situated in its environment and interacts with other systems or objects in the environment. The system-of-interest fulfills its purpose and delivers value to the other systems.

- Other Human Activity Infrastructure Services
  - Energy
  - Water and Sanitation
  - Transportation
  - Education
  - Health
  - Information Technology and Communication
  - Food (Other elements in the Food Value System)
  - Waste and Recycle
  - Built Environment
  - Emergency Services.
- Government
  - Regulatory
  - Subsidies / incentives
  - Common funding / ownership
- Banking and Investment Funding
- Direct Ecosystem services and the ecosystem environment (weather, earthquakes, etc)
- Solar Energy.
- Threat environments for:
  - operational, resource, environmental

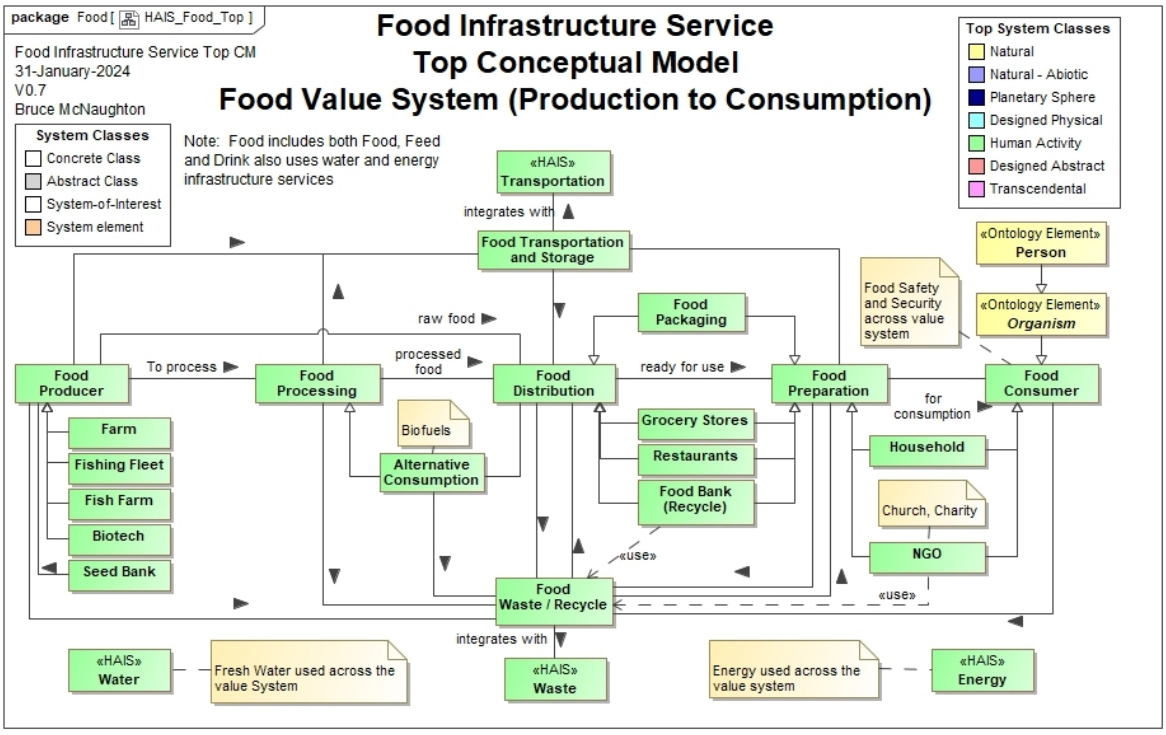
The following is the environment of the Human Activity Infrastructure Services



This next picture highlights the position of the Farm within a City-Region and other infrastructure services.



The top level view of the Food Infrastructure Service is shown below:



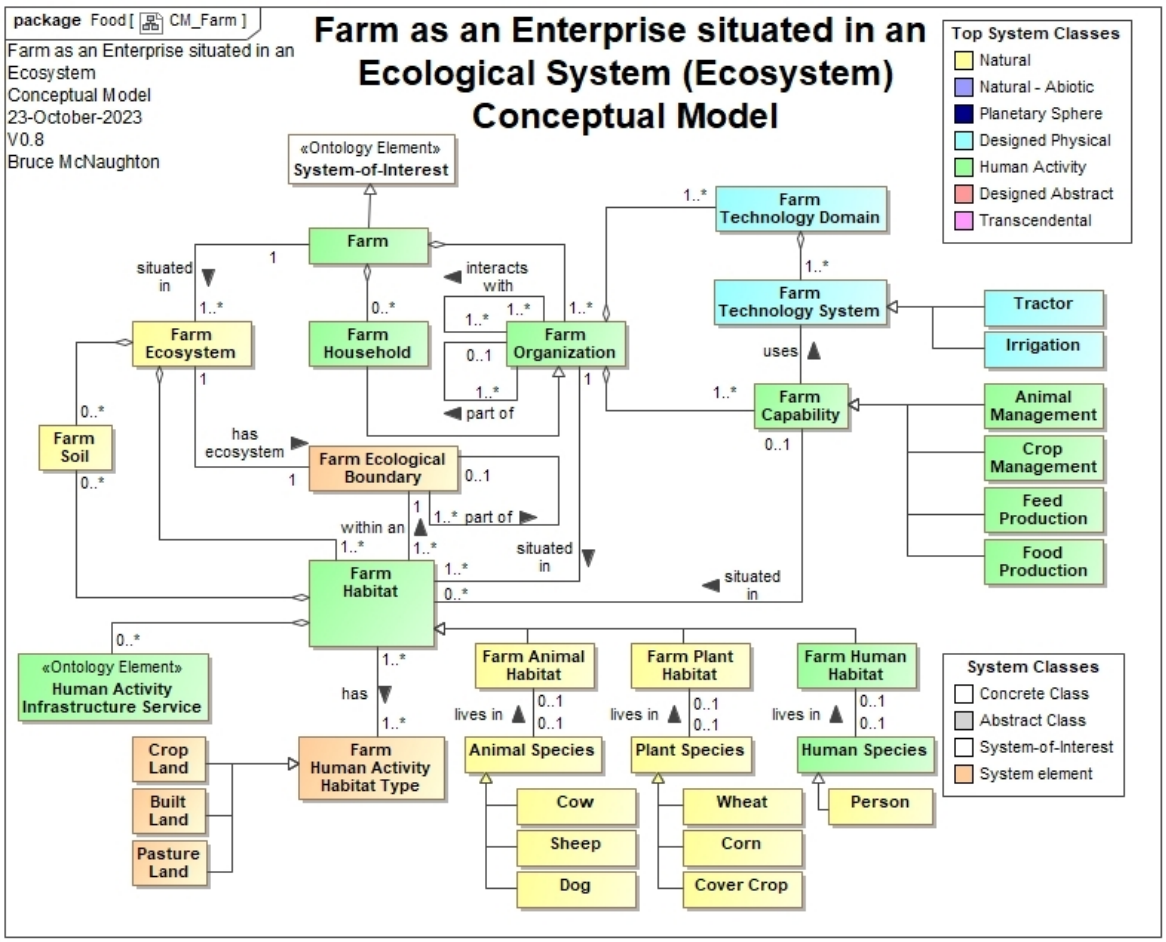
This diagram provides the environment for the farm.

View: System Structure (Pattern of Organization)

The system structure or pattern of organization represents a logical model of the system elements of the system-of-interest. This logical model is independent of any specific physical realization of any of the system elements. This logical model may also be called a conceptual model of the system-of-interest.

Concept: Identification and Relationships

The following diagram shows the key concepts and relationships for a Farm as an Enterprise situated in an Ecosystem:



Notes:

By definition, a habitat is for a single species. The habitat type is a property of the habitat. A number of habitats that can share the same habitat type / boundary. This allows multiple species to be seen living on the same habitat type. This allows multiple species to exist within a habitat type and provide a way to identify the biodiversity of a habitat type as well as the way these species collaborate in a farm habitat type.

Sheep dog trials in the UK are a great example of a multi-species example:

In a "pasture land human activity habitat type", the following species can collaborate:

- The Farmer (Person)
- Some Sheep (Animal) feeding on the grass (Plant).
- Some dogs (Animal) to move the sheep (Animal) around the pasture (habitat type) at the request of the Farmer (person)

PDF: System Description: Enterprise as a System of Systems (SoS), Version 0.20, 25-November-2024
PDF:: System Description: Ecological System (Ecosystem), Version 0.4, 06-November-2023
PDF: System Description: Household as a System, Version 0.0, 11-July-2022

View: System Behavior (Structural Changes)

In order to establish the behavior of the system or system-of-interest, some understanding of the physical system elements of the system is necessary. This allows us to understand the behavior of the system at various points in time.

The Behavior (Structural Changes) section describes a specific instance (configuration of components) of a system structure that results in systems behaviour. The system behavior includes descriptions of the following as needed:

- a specific configuration or embodiment of a system structure (pattern of organization) (e.g. specific system elements or components, their relationships)
  - including any mathematical methods or characteristics of specific interaction types
- the triggers arising from a meaningful disturbance
- the process steps or sequence and any interaction in response to a specific trigger
- any models or data supporting the response along with any mathematical methods used.
- Any behavioral system or focused models (UML Diagrams, or Causal Loop Diagrams, etc.)

Configuration / Scenario: Industrial Farming

This section describes the typical configurations of the types of farming that will be considered in the behavioural analysis of a farm. The Industrial Farming approach has the following characteristics:

- Large Mono Crop.
- Use of fertilizers and pesticides
- Large storage facilities
- Large machinery

This type of farming is looking for economies of scale in the areas of:

- Machinery vs labour
- Yield from land
- focus on single types of species.

There are a number of types of tradeoffs that become apparent:

- Soil is not seen as an integral part of the production process. (used / not maintained).
- Maximize livestock count relative to space
- Total fresh water consumption for production.

Configuration / Scenario: Organic / Regenerative Farming

This section describes the configuration of the organic / regenerative farming approach. The following elements are included:

- Regeneration of the soil
- Minimum use of pesticides / fertilizer as feed or protection
- Natural maintenance of the habitats (providing habitats for pollinators (bees)).
- Retention of water / nutrients in the soil
- Livestock management to enable healthy lives.
- Direct sales from the farm (e.g. vertically integrated or community integrated).
- 10 Elements of Agroecology from the United Nations FAO (Food and Agriculture Organization)

This may also mean that there are smaller farms with more local distribution of food. The challenge is the ability to get a sufficient return on the investment in the farm relative to the costs of running the farm.

One approach to regenerative farming is Permaculture.

Agroecology

This section contains links to the United Nations Food and Agriculture Organization on the topic of Agroecology.

- Ten Elements of Agroecology
- To download a PDF of the Ten Elements of Agroecology

Configuration / Scenario: Vertical Farming

This section describes the configuration of the vertical farming approach. The following elements are included:

- Indoor farming in a room or building
- Tiered growth areas in artificial light
- Drip irrigation (top to bottom)
- Soil management
- Similar to regenerative practices

This is very similar to some indigenous practices with tiered farming outside.

Mathematical Methods: for the various configurations

This section identifies relevant mathematical methods that can be used to understand the behaviour of the system-of-interest or a specific configuration.

Initial identification (work in progress).

- Financial models and forecasting
- Yield based upon ecosystem conditions.
- Life expectancies
- Population Density

Cyclical (Repeating / Regular) Processes

This section describes the cyclical processes in use during the life time of system operation.

These cyclical processes may be triggered by seasonal / environmental conditions. These cycles may be impacted by climate change and alter some of the cyclical processes over time.

Production processes

- Crop Management (Seeds to Harvest)
  - including (watering, weeding, feeding, pollination, health of crops (diseases, pests), etc)
  - Process (Prepare, Plant, nurture, Harvest)
- Animal Management. (Birth to Release)
  - including (feeding, water, health, shelter, etc)
  - Process (Birth, Feed, Exercise, Health Care, Release)
- Food Production (Humans)
  - Including food safety, food packaging, food storage, distribution, etc
  - animals and crops
  - Process (Prepare, Package, Store, Distribute)
- Feed Production (Animals)
  - including food safety, food packaging, food storage, distribution, etc
  - can include local feed production on a farm (for local use)
  - Process (Prepare, Package, Store, Distribute)

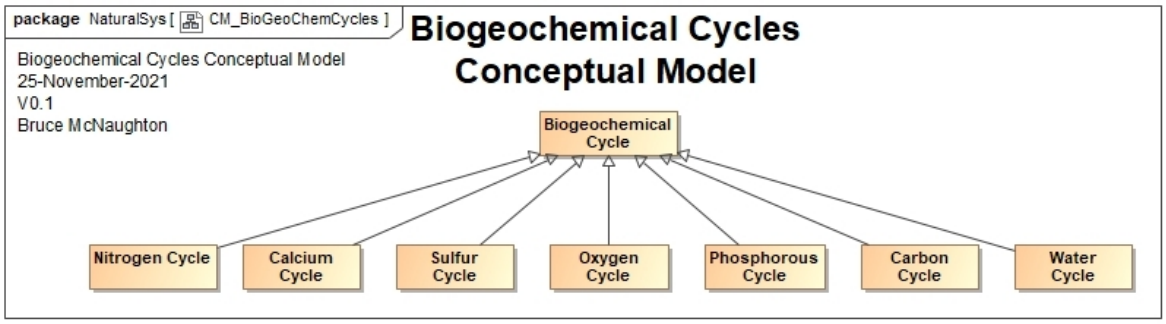
Farm Processes

- Sales and Order Management Processes
  - order to cash in the bank
- People Management.
- Asset Management (including maintenance)
- Facilities Management. (including maintenance)
- Safety and Traceability
- Waste and Recycle
- Procurement
- Performance assessment and reporting.

Maintenance / Repair processes

- as appropriate to maintain resilience
  - Production, Crop and Animal Management technology systems
  - Flood / weather impacts (as trigger)
  - Earthquakes / Fires (as trigger).

Biogeochemical Cycle Types



See Biogeochemical Cycle

Each cycle has particular steps that are ongoing and continuous. Impacts to any of these cycles may damage the ecosystem.

- Nitrogen Cycle
- Calcium Cycle
- Sulfur Cycle
- Oxygen Cycle
- Phosphorous Cycle
- Carbon Cycle
- Water Cycle

See also Soil Terminology for the Nutrient Cycle and Nutrient Types.

Other Biogeochemical Cycles

- Rock Cycle
- Marine Cycles
- Methane Cycles

Development Life Cycle Processes

This section describes the developmental processes in use as the system evolves through its life cycle or for new products and services (cycles of development).

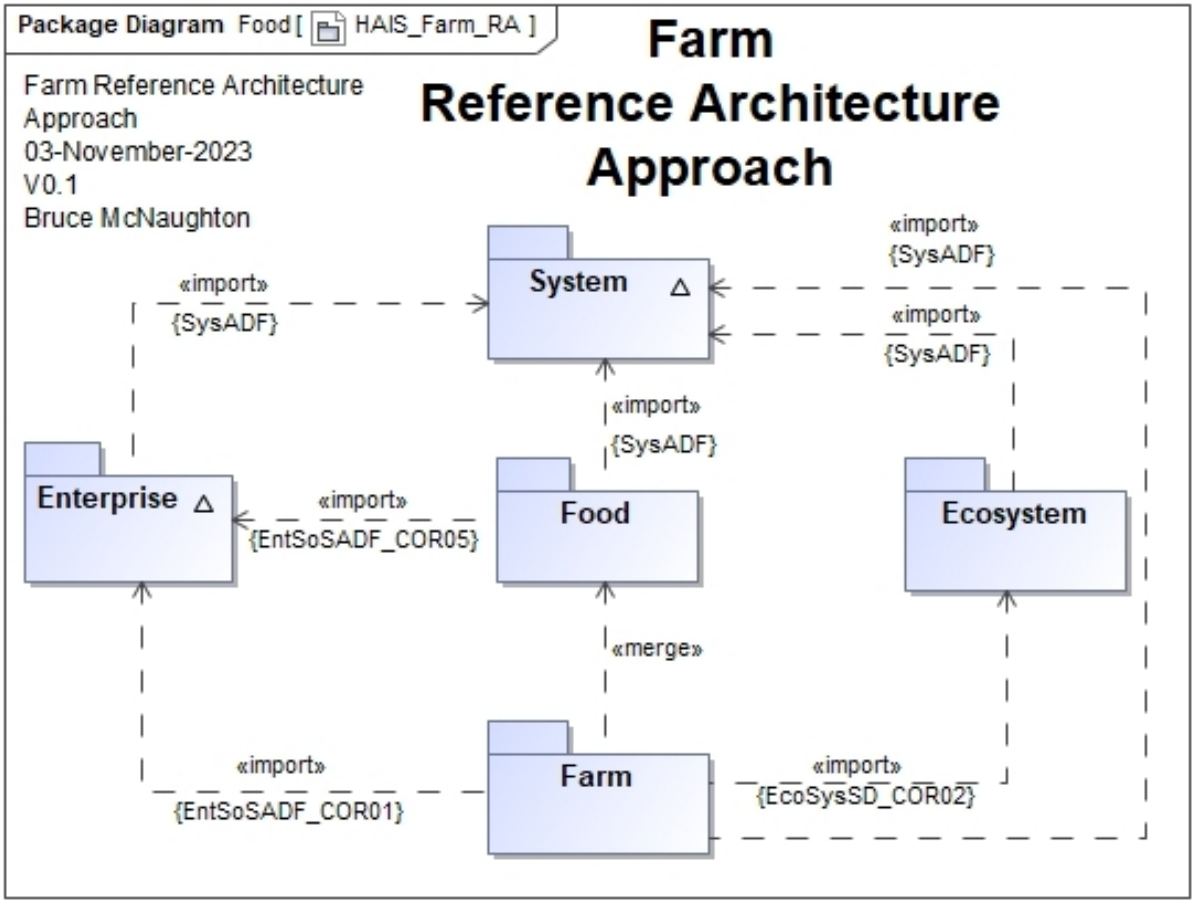
The farm as a system has a life cycle for the development of the enterprise. This includes the following types of activities:

- Continual improvement of the Farm across the whole life cycle
  - Improving the soil
  - Improving the irrigation
  - improving the shelter and work places
  - improving the recycling of waste.
  - improving use of water and energy
  - improving resilience to weather events (rain, drought, wind, etc)
  - improving resilience to fires / earthquakes
  - improving resilience to lack of necessary food, water, energy, etc
- New products and services
  - new varieties of crops or livestock.
  - new ways to distribute or position farming
  - new farming techniques (vertical farming).

Correspondences

The following correspondences apply to the Farm as an Enterprise situated in an Ecosystem:

- EcoSysSD_COR02: Ecosystem Habitat extended for use in Farm
- EntSoSADF_COR01: Enterprise to Farm as an Enterprise
- SysADF_CM02: Extend Ontology Elements for new System Type



EntSoSADF_COR01: Enterprise to Farm as an Enterprise

ID and Title

EntSoSADF_COR01: EntSoSADF conceptual model ontology elements extended to a Farm as an Enterprise

Description

The farm can have multiple generalizations .. each generalization allows the individual ontology elements to be redefined in a local conceptual model.

In addition, the household is also defined as a Farm Organization which is a type of organization.

The model being extended is based upon the Enterprise (SoS) System Description (an AD Element)

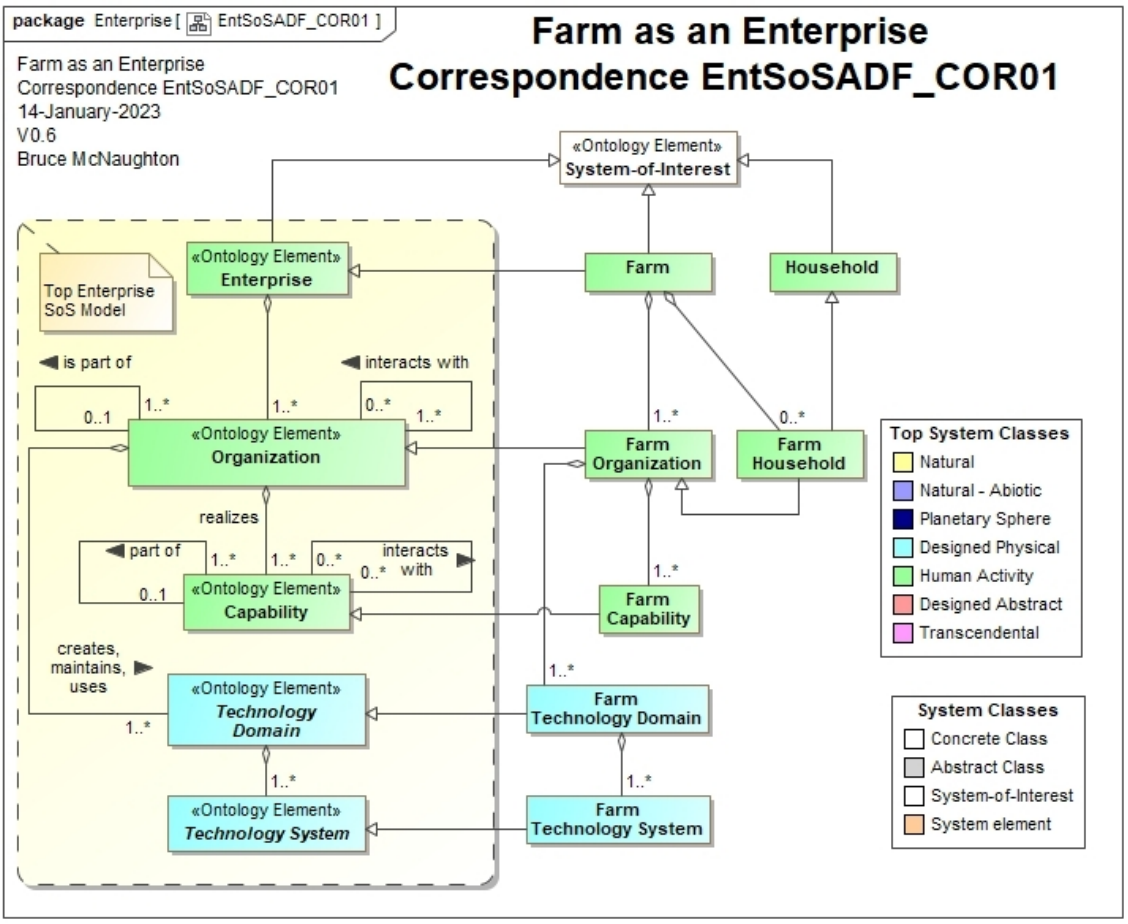
PDF: System Description: Enterprise as a System of Systems (SoS), Version 0.20, 25-November-2024

Methods Used

SysADF_CM02: Extend Ontology Elements for new System Type

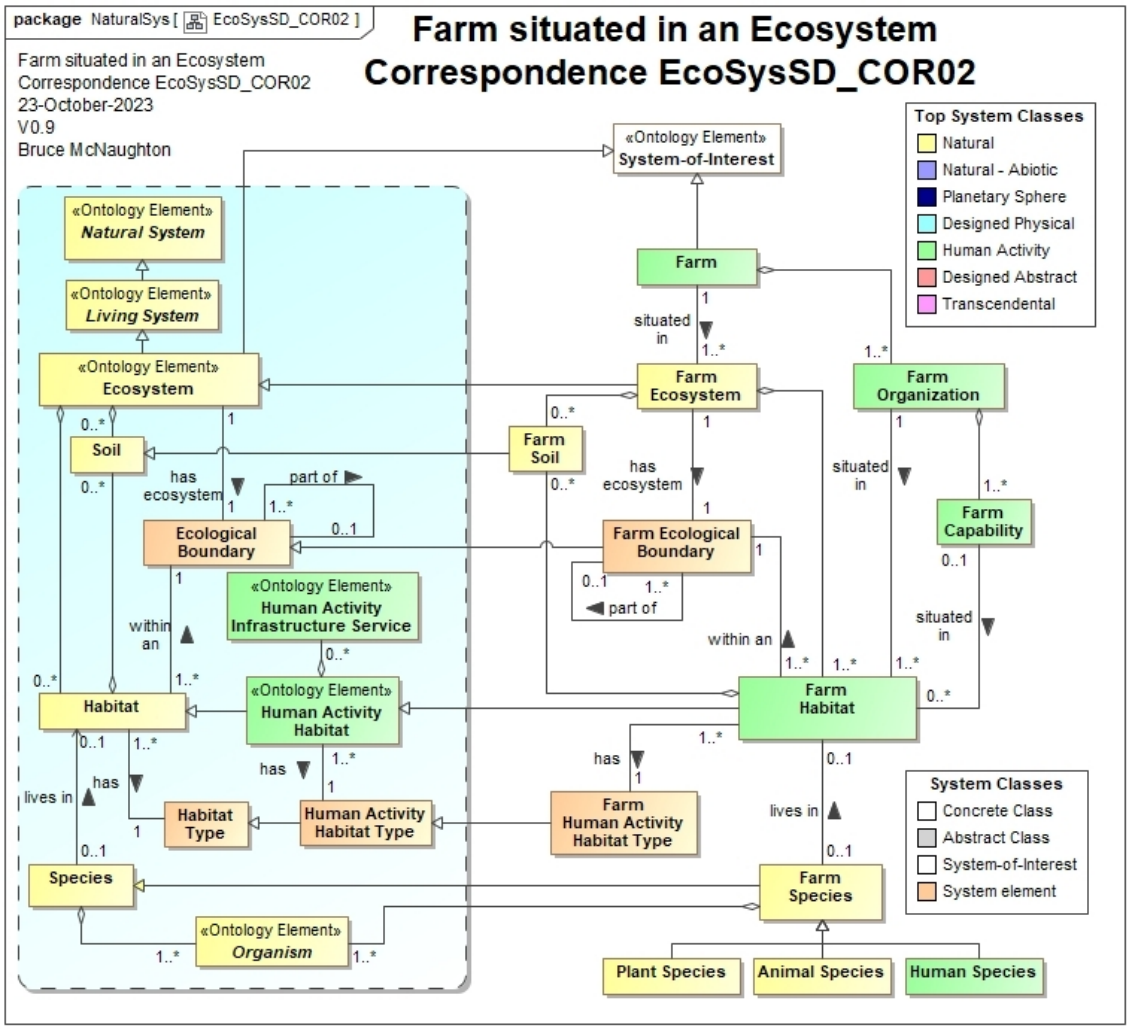
Correspondence Results

The following model shows the new elements created for the Farm as an Enterprise



EcoSysSD_COR02: Ecosystem Concepts and Classes extended for use in Farm

ID and Title
EcoSysSD_COR02: Ecosystem Concepts and Classes extended for use in Farm
Description
The farm includes a number of species that live in ecosystem habitats and habitat types. This correspondence creates sub-classes of ontology elements for use in a Farm as an Enterprise situated in an Ecosystem. The model being extended is based upon the conceptual model in the Ecosystem System Description (an AD Element). PDF:: System Description: Ecological System (Ecosystem), Version 0.4, 06-November-2023
Methods Used
SysADF_CM02: Extend Ontology Elements for new System Type
Correspondence Results
The following model shows the new elements created for use in the Farm situated in an Ecosystem


package NaturalSys [EcoSysSD_COR02]
Farm situated in an Ecosystem Correspondence EcoSysSD_COR02
Farm situated in an Ecosystem
Correspondence EcoSysSD_COR02
23-October-2023
V0.9
Bruce McNaughton
Top System Classes
Natural
Natural - Abiotic
Planetary Sphere
Designed Physical
Human Activity
Designed Abstract
Transcendental
«Ontology Element» System-of-Interest
«Ontology Element» Natural System
«Ontology Element» Living System
«Ontology Element» Ecosystem
Farm
Farm Ecosystem
Farm Organization
Soil
Farm Soil
Ecological Boundary
Farm Ecological Boundary
Farm Capability
«Ontology Element» Human Activity Infrastructure Service
Habitat
«Ontology Element» Human Activity Habitat
Farm Habitat
Habitat Type
Human Activity Habitat Type
Farm Human Activity Habitat Type
Species
Farm Species
«Ontology Element» Organism
Plant Species
Animal Species
Human Species
situated in
has ecosystem
part of
within an
has
lives in
System Classes
Concrete Class
Abstract Class
System-of-Interest
System element

Views from Correspondence with Enterprise (SoS) ADF

The following views have been included based upon the Enterprise SoS Correspondences:

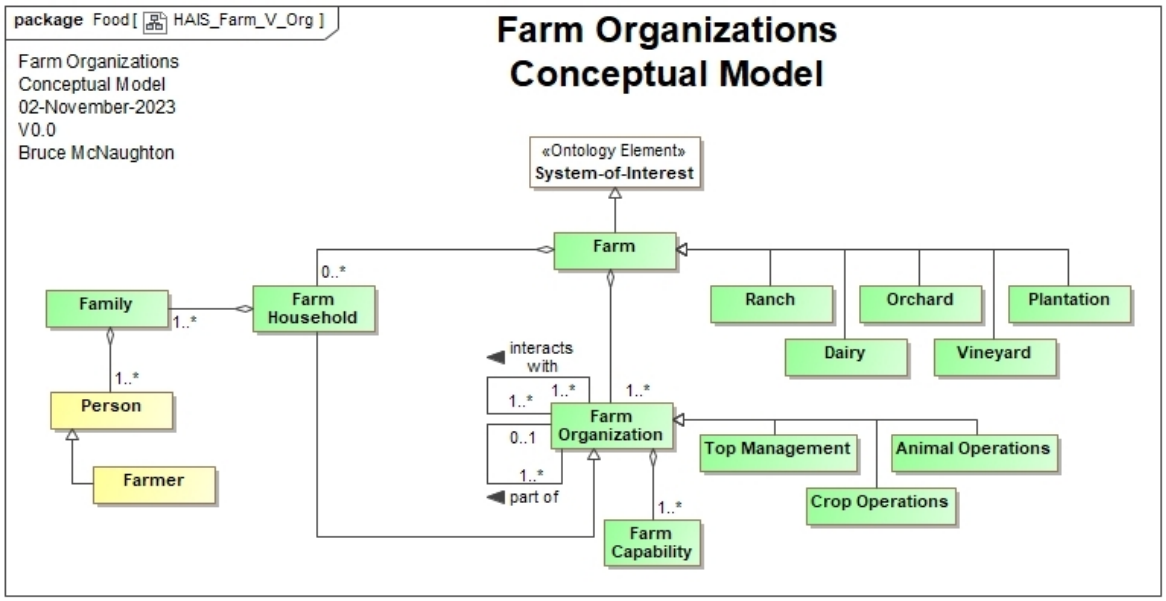
- Organization View
- Capability View
- Technology View

See: SysADF_CM04: Include one or more Views from another ADF

View: Organization

This view identifies the organizational role of each organization and highlights the relationship between the organizations. This view establishes the value system for the enterprise.

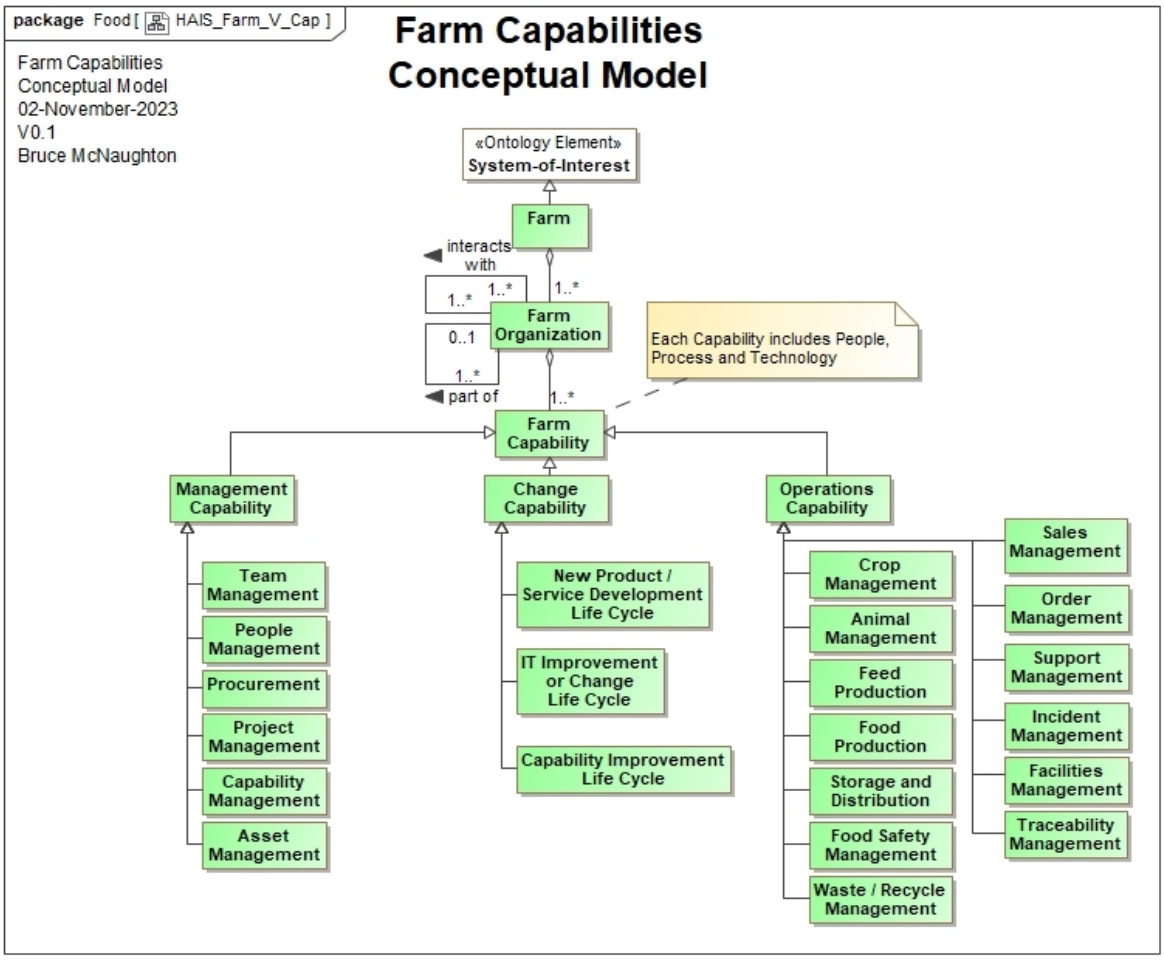
The Farm Organization consists of a number of types of organizations. The diagram below (Class Diagram) identifies the key types of Farm Organizations in the Farm value system:



Organization

View: Capability

The Capability View identifies the capabilities that are established and used within the Farm as an Enterprise. The Farm Capabilities are generally established and managed by the Farm Top Management Organization. The Farm Capabilities are generally available for use across all of the farm product lines. Organizations (teams) can implement these capabilities through their normal planning process.



Some of the capabilities may be outsourced. The decision for outsourcing the capability management needs to be part of the enterprise architecture decisions and rationale provided.

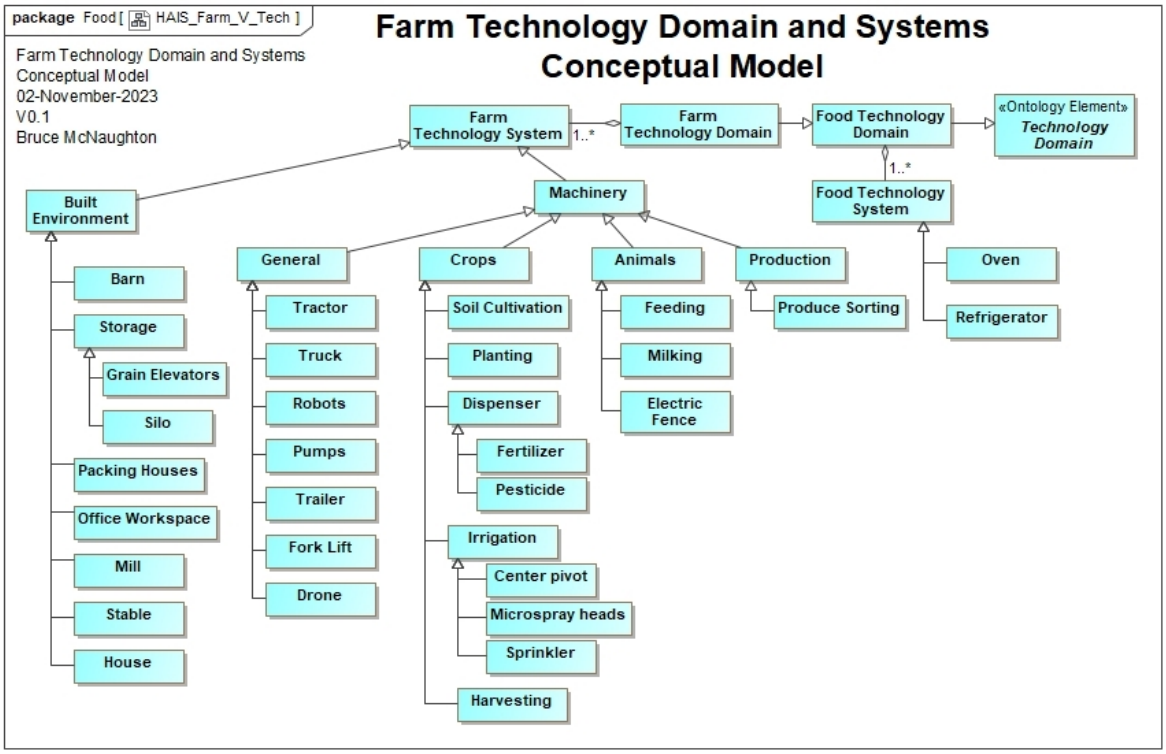
PDF: System Description: Capability as a System, Version 0.17 27-November-2024

-

View: Technology

The Technology view identifies any technology or industry areas that require development and maintenance capabilities to exist in the organization (e.g. whole life cycle as in ISO 15288:2023).

The Farm Organization supports a number of Farm Technology Domains. Some are dependent upon the types of farm products and some are independent of the type of products.


package Food [HAIS_Farm_V_Tech]
Farm Technology Domain and Systems
Conceptual Model
Farm Technology Domain and Systems
Conceptual Model
02-November-2023
V0.1
Bruce McNaughton
Farm Technology System
1..*
Farm Technology Domain
Food Technology Domain
«Ontology Element»
Technology Domain
1..*
Food Technology System
Built Environment
Machinery
General
Crops
Animals
Production
Oven
Refrigerator
Barn
Storage
Grain Elevators
Silo
Packing Houses
Office Workspace
Mill
Stable
House
Tractor
Truck
Robots
Pumps
Trailer
Fork Lift
Drone
Soil Cultivation
Planting
Dispenser
Fertilizer
Pesticide
Irrigation
Center pivot
Microspray heads
Sprinkler
Harvesting
Feeding
Milking
Electric Fence
Produce Sorting

Systemic Problems

The following are descriptions of the systemic problems identified in the Farm as an Enterprise situated in an Ecosystem

Ecosystem and Ecosystem Services

- Water runoff with pollutants from the farm.
- Lack of Pollinators (Bees and other insects)
- Water usage and approach to irrigation
- Soil degradation
- Seed banks (retaining species and biodiversity)
- Toxic chemicals (mercury, lead, etc) into water and feed and passed on into food chain.
- Use of plastics and degredation into micro-plastics and entering the food chain.
    - effecting both water and animal feed and then into food chain (e.g. PFAS).

Human Activity Habitat impacts

- Use of pesticides
- Use of Antibiotics
- Single species farm. (e.g. monocrop and lack of biodiversity)
- Use of fertilizers

Economic / Market / Household

- Dependencies on major corporate products (lock in and monopoly).
    - Product dependencies: Fertilizer / Pesticides and Engineered Seeds causing dependencies on multiple products.
    - Squeeze on prices through the four major organizations supplying to supermarkets.
    - Resulting in lower cost food - however at risk of lower quality produce or higher impacts to the environment.
    - Lack of buying products locally to support the community (e.g. feed imported from low cost countries rather than grown locally).
- Farm households in rural settings (lack of infrastructure)
- Lack of experience being on a farm.
- Lack of appropriate infrastructure services
    - Lack of food hubs to minimise transport / distribution costs
- Food Packaging from producer to consumer
- Packing from inputs to the farm (fertilizers, etc)
- Cost of Farming Equipment
- Lack of workers at times of harvest
- Insufficient income to create a sustainable enterprise.
-

State / Government

- Subsidies
- Monopoly enforcement actions
- Removal of Regulation (safety / quality)
- Lobbying for specific positions (risk of bribery)

FarmSysP_001, Water Runoff with Pollution

With the use of fertilizers and pesticides, these chemicals find their way into water rivers, streams, drains or soaking into the ground to underground streams. The waste from livestock (pigs, sheep, cows, etc) also forms part of this water runoff pollution.

This causes the pollution in rivers and streams to rise, with associated impacts on biodiversity and water supply.

In particular, nutrients, like nitrogen or phosphorus, cause algae growth (Algal Bloom) in rivers and deplete the dissolved oxygen levels which is harmful to fish and other organisms.

This has impacts on the Water and Sanitation Infrastructure Service and the Ecosystem.

FarmSysP_002, Lack of Pollinators

Crops and other plants rely on the ecosystem service - Pollination. When large farms only have a single crop, the habitats for pollinating insects are reduced or eliminated. This has caused the transport of pollinators to farms to compensate for the lack of pollination of crops.

In addition, the use of pesticides can also kill or damage habitats of pollinators.

This is becoming a serious problem.

FarmSysP_003, Water Usage

Crops and other plants and animals rely on the ecosystem service - Water. The water can either be provided as an ecosystem service from the land or through the Water and Sanitation Infrastructure Service.

In either case, some styles of farming are water intense (crops and / or animals).

Some supplies of fresh water are being depleted through farms extracting water at the high end of rivers and depleting the resource at the end (e.g. Colorado River). We are also faced in increasing droughts (lack of water) and atmospheric rivers (too much water and unable to store).

Also the increased rate of melting of glacial ice reduces a freshwater source. Due to increasing temperatures, this glacial ice may be more difficult to renew as a renewable resource.

The net result is that the renewable supply of freshwater is being consumed at a faster rate than it can be restored.

FarmSysP_004, Soil Degradation

The Quality of the Soil on a farm is key to sustainable yields and healthy ecosystems.

Soil degradation occurs through overuse of chemicals, lack of water and rebuilding the microorganisms living in the soil.

Natural History Museum: Soil Degradation

Systemic Solutions

This section includes the description of possible solution options.

Examples of possible solutions

- Move to organic or permaculture style farming
- Use the 10 Elements from Agroecology.
- No till farming
- Multi-product lines (other business products / services in addition to core farming)
  - Farm tours, Education services, Conference services, on site food / restaurants
- Local production
- Local Food Hubs (to minimize distribution / transportation costs) and provide full range of food produce.
- Change Consumption Patterns
- Restore local environments and encourage local pollinators
- Project Drawdown: Food, Agriculture and Landuse
  - These solutions will be reviewed to identify specific solutions for the Farm.
- Alternative Food Production / Solutions
  - Fish Farms. Though increasing volume of food, this approach may be damaging normal life cycles of fish (e.g. salmon runs in Northwest, USA).
  - Biotechnology
    - Genetically Modified Organisms (GMO) may impact seed banks with side effects and have unknown health implications
    - Alternative protein production techniques: may have projected benefits in production but may carry risk in long term to humans.

Examples of Actions being taken

UK to replace Farm Subsidies. The following are types of positive incentives to change and improve:

- **Sustainable Farm Incentive Scheme**
  - Improve carbon storage capacity for soils
  - Looking after hedgerows
- **Countryside Stewardship Plan.**
  - Working with neighbouring Farmers and Landowners
    - Introduce natural flood management.
    - enhanced wooodland and peatland restoration
- **Landscape Recovery Scheme**
  - Boost biodiversity
  - Move towards net zero (including rewilding projects)

Implementation Challenges

Cash needs to come from somewhere and awards may not compensate for loss of subsidy

Voluntary incentives and may fall short of what is actually needed

Issues not addressed by the incentives

- Industrial farming will still reduce the carbon storage potential of soil.
- Water pollution from pesticides and reduction of insects to support pollination.
- Intensive poultry and pig farm runoff into rivers
- Ammonia from manure and nitrogen based fertilizer

FarmSysS_001, Permaculture

Permaculture is an approach to farming that is regenerative and healthy for soil and crops.

Permaculture

Permaculture Principles

FarmSysS_002, Vertical Farming

Vertical and Indoor farming provides a way to protect the growing environment and grow crops in an artificial sun-light environment.

These are suitable for Urban environments where local production and distribution are prioritised.

Wikipedia: Virtical Farming

FarmSysS_003, Change Consumption Patterns

Changing consumer consumption patterns will have a direct impact on the farming approach.

- Reducing the demand for meat
  - Reduces water and feed (from other crops)
  - Reduces methane and waste issues
  - Less intensive demand for farms and improved health for organisms.
- Increasing the demand for crop / plant based food.
  - Organic demand
  - Local production demand
- Reducing food waste.
  - Reduced food demand
- Recycling food waste
  - Food to Energy.
  - Compost to soil for farms.
  - Food to others.

References

References: Earth

Please see the following Links for the System Description: Ecosystem

- PDF:: System Description: Ecological System (Ecosystem), Version 0.4, 06-November-2023
- Website:: desc.systems: Ecological System (Ecosystem)

The Physics of Living Systems, Fabrizio Cleri

The Physics of Living Systems
Basic textbook providing an understanding of the physics of living systems.

Ecosystem Services, Mark Everard

Ecosystem Services

Animate Earth, Stephan Harding

Animate Earth

Earth System Science, Tim Lenton

Earth System Science, A Very Short Introduction
Pages 14 to 17 Defining the Earth system

Gaia, James Lovelock

Gaia
A new look at life on Earth.

Environmental Engineering, James R. Hihelcic, Julie Beth Zimmerman

Environmental Engineering
Fundamentals, Sustainability, Design

Living Systems

The Systems View of Life, Fritjof Capra and Pier Luigi Luisi

The Systems View of Life
This book is supported by the Capra Course which provides a 12 week course covering the four dimensions of life: Biological, Cognitive, Social, and Ecological.
A Capra Course Glossary is available in the Capra Course Alumni Network - A global Community of Practice related to the book.
See chapter 14 for information on social systems.

The Hidden Connections, Fritjof Capra

The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life Into a Science of Sustainability
Some additional information related to social systems.: See page 70 to page 128.
Principles of Ecology: See page 231.

The Turning Point, Fritjof Capra

The Turning Point: Science, Society, and the Rising Culture

The Embodied Mind, Francisco J. Varela, Evan Thompson, Eleanor Rosch

The Embodied Mind
Cognitive Science and Human Experience

Ecological Economics and Ecological Worldview

Doughnut Economics, Kate Raworth

Doughnut Economics
Two models in the book are being used heavily in the development of the Human Activity Ecosystem models: The **Doughnut** and the **Embedded Economy**. The Doughnut is like a balanced scorecard for the planet and the Embedded Economy model is a good starting point to explore the systems that are creating the doughnut problems and the changes that are needed to bring the world into the doughnut safe and just place.
Kate Raworth and Herman Daly Video
Doughnut Economics pictures used with permission, Kate Raworth, 2017

Beyond Growth, Herman E. Daly

Beyond Growth
Kate Raworth and Herman Daly Video

Stockholm Resilience Centre

Stockholm Resilience Centre
Two major areas of interest:

- Planetary Boundaries
- Reconnecting to the Biosphere

Drawdown, Paul Hawken

Drawdown
The Most Comprehensive Plan Ever Proposed to Reverse Global Warming
Project Drawdown

Small is Beautiful, E. F. Schumacher

Small is Beautiful
A Study of Economics as if People Mattered

Governing the Commons, Elinor Ostrom

Governing the Commons, Elinor Ostrom
Approaches to collectively governing the Commons in society.

Kenneth Boulding

This topic contains a number of links to articles on various websites:

- Wikipedia: Kenneth Boulding
- General Systems Theory
- Spaceship Earth

Natural Capital, Dieter Helm

Natural Capital
Valuing the Planet, Restoring the Ecosystems
What would a Sustainable Economy look like.. Dieter Helm at the Oxford Martin School

---

Designing Regenerative Cultures, Daniel Christian Wahl

Designing Regenerative Cultures
Focuses on Whole Systems thinking for society, economy and the environment.

The Great Transition: Using the Seven Disciplines of Enterprise Engineering, James Martin

Great Transition: Using the Seven Disciplines of Enterprise Engineering
Extending Enterprise (SoS) Capabilities to the Planet in the 21st Century
His work continues at the Oxford Martin School

Ellen MacArthur Foundation

Ellen MacArthur Foundation

- Circular Economy
- Publications
- A new Dynamic 2

Transformative Ecological Economics, Ove Jakobsen

Transformative Ecological Economics
Supports the paper by Fritjof Capra on framework for Ecological Economics.

FSSC 22000: Food Safety System Certification

The FSSC is a Food Safety System Certification Sector Scheme based upon ISO 22000.
ISO 22000 is a harmonized standard of ISO 9001.
FSSC 24000 Social Management System
Integrated Management System

International Farming Systems Association (IFSA)

International Farming Systems Association (IFSA)
An organization taking a systems approach to Farming.