Supply Chain Management for Upgrading Waste Materials to Value-Added Products

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Agenda

I. Background

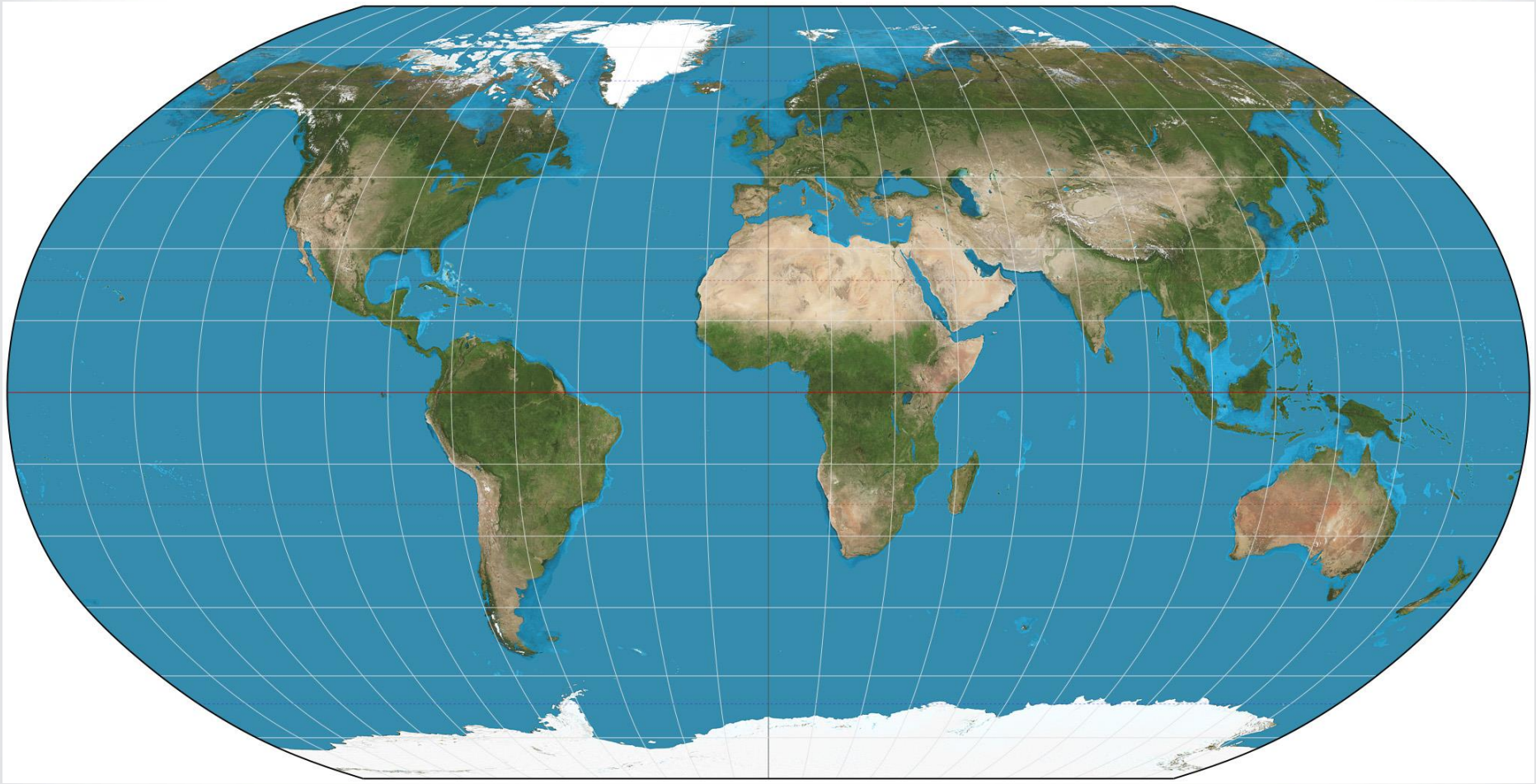
II. Problem definition

III. Approach

IV. Tool

Background

Background



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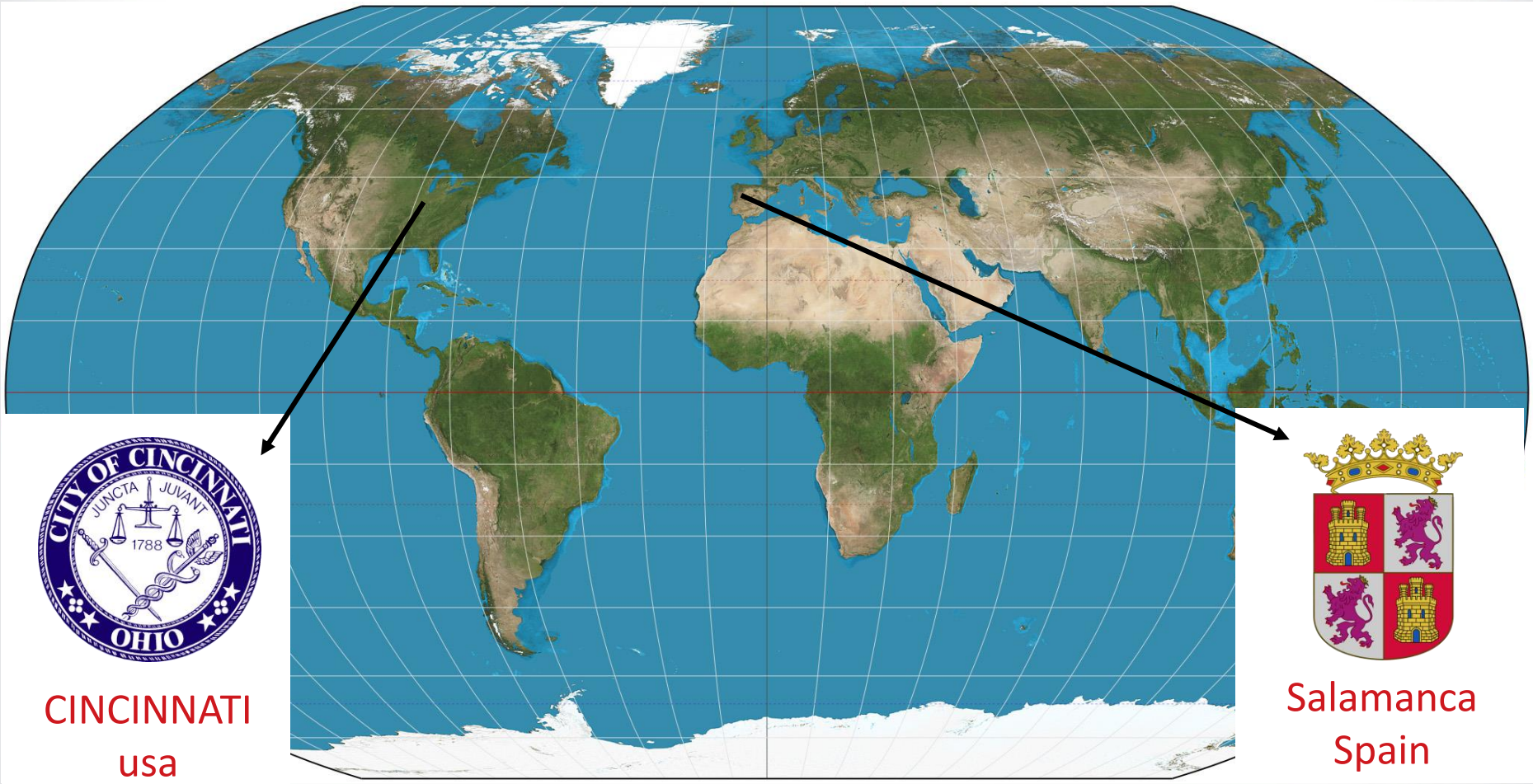


CINCINNATI
usa

Salamanca
Spain

Background

Background

Salamanca
Spain

Background

VNiVERSiDAD D SALAMANCA

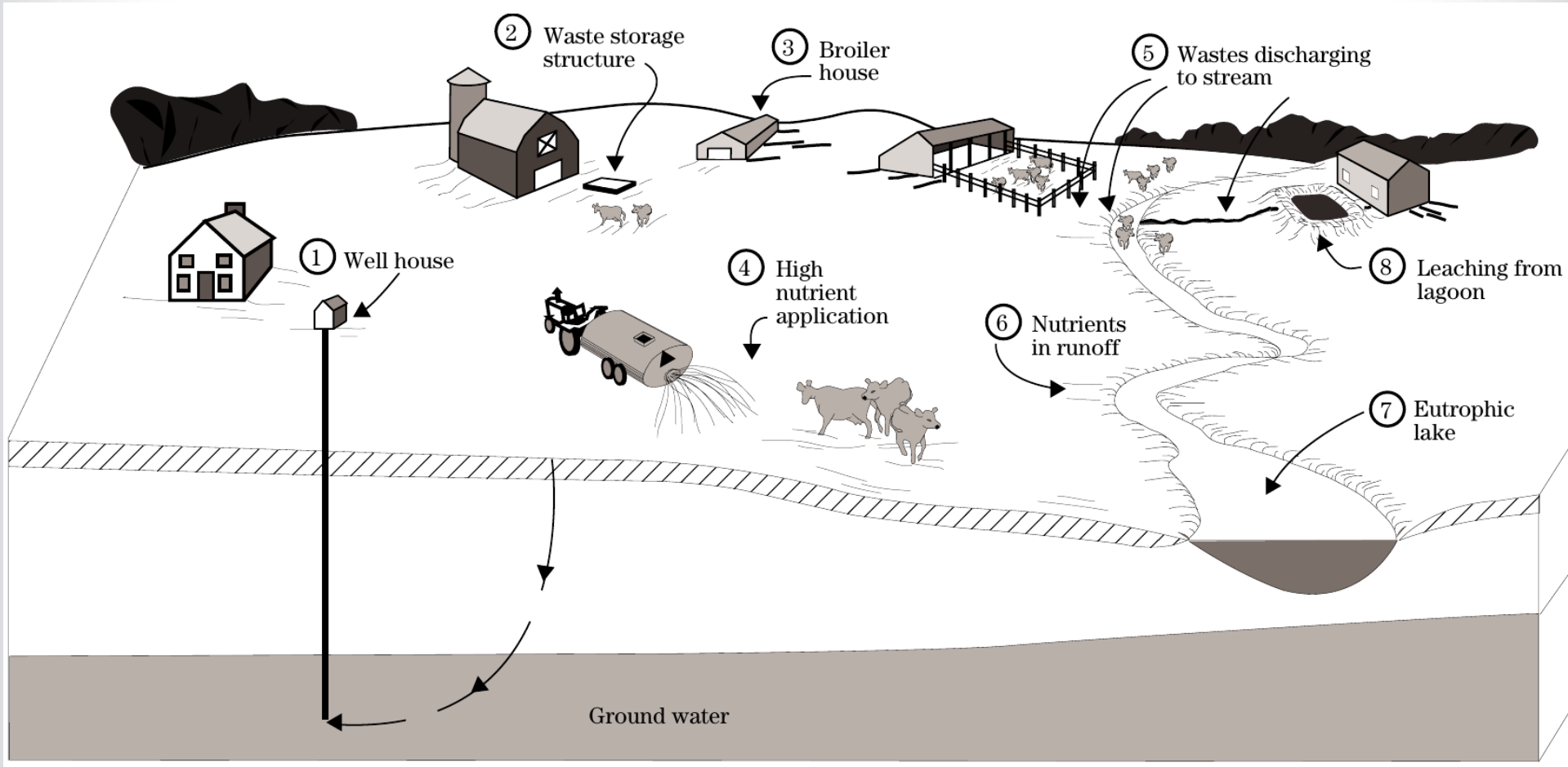
Founded in 1218

Background

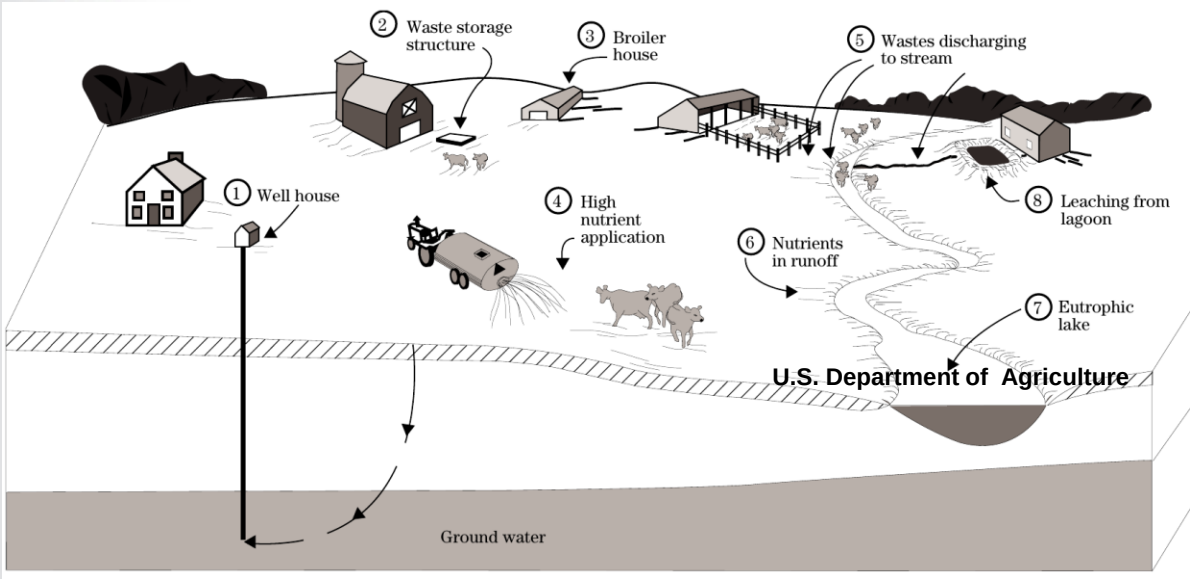
CINCINNATI
usa

Problem Definition

Problem definition



Problem definition



Nutrient pollution prevention and control

↓

Avoid the harmful algal blooms (HABs)

↓

I. Public health protection from microbial contaminants in water bodies

II. Protect aquatic life from toxic chemicals

III. Maximizing treatment effectiveness and minimizing cost

Problem definition

Nutrient pollution prevention and control

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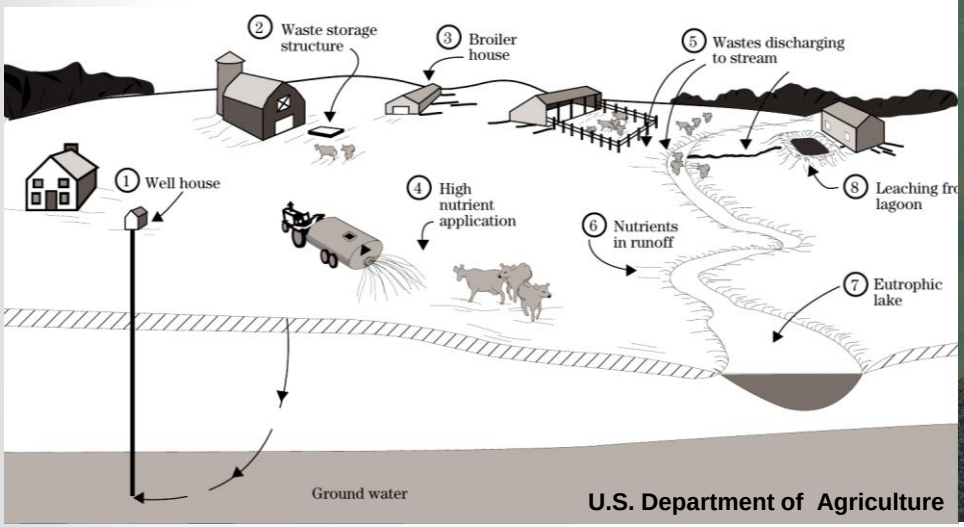
Avoid the harmful algal blooms (HABs)



U.S. Department of Agriculture

NOAA

Problem definition

Excess levels of nutrients in the watersheds of the US

↓

Impediment to water quality

Environmental issues **Economic concerns**

Problem definition

Environmental issues

The rapid growth or bloom of phytoplankton (HABs) is triggered primarily by increased nutrient levels. Also, low water flows, warmer temperatures, and other factors.

Problem definition

Economic concerns

Economic impacts may include:

- Medical and veterinary expenses
- Increased cost of drinking water treatment
- Decreased recreational revenue and property values.

Problem definition

Goal

Provide tools, technologies, and best practices to predict, monitor, manage, and assess effectiveness of nutrient-reducing efforts

Problem definition

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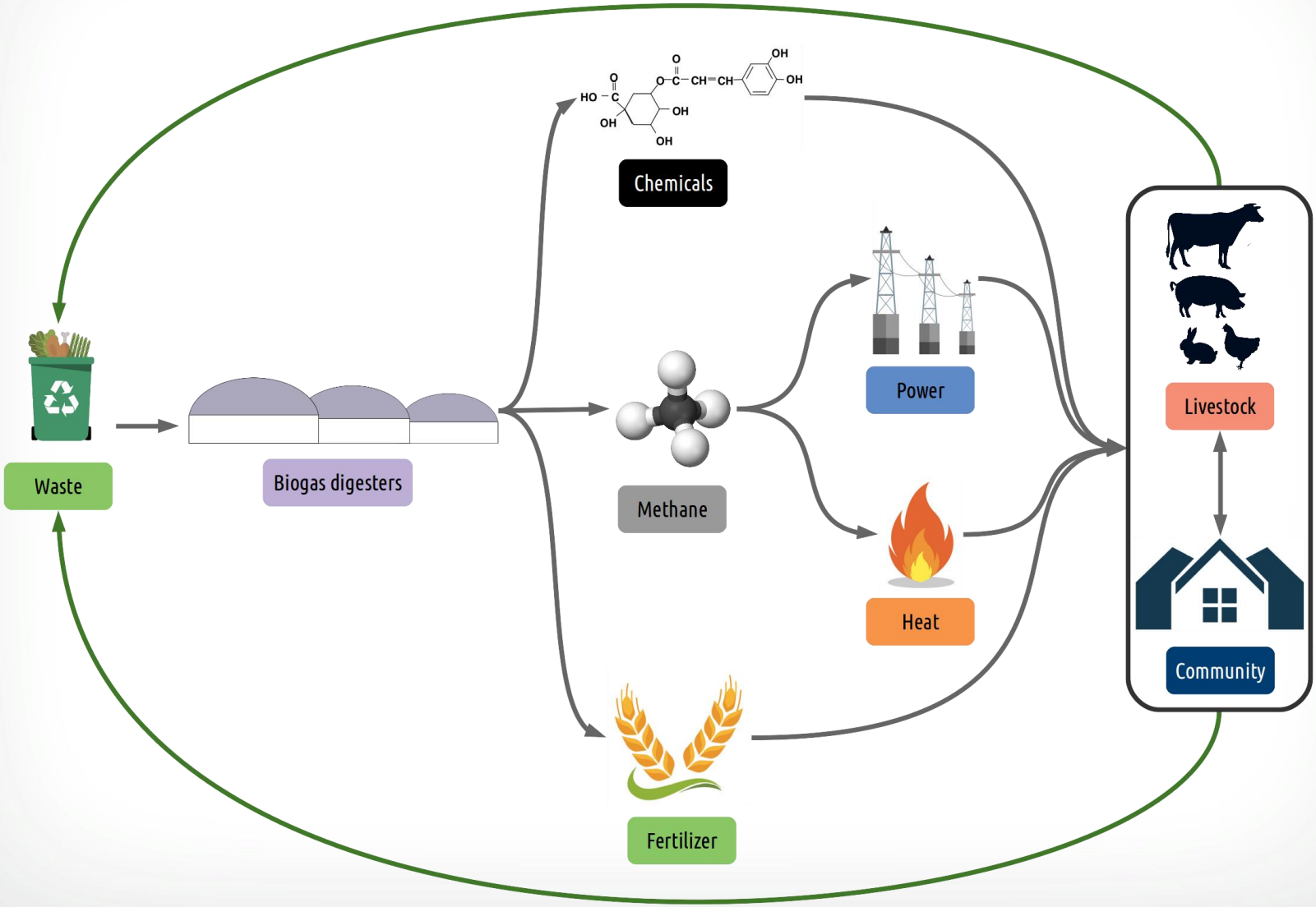
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUSTAINABLE DEVELOPMENT GOALS

Problem definition



Problem definition

Problems of nutrients in agriculture:		
	Organic	Inorganic
N	• Chemically bounded to C • Must be converted to inorg. N by microorganisms to be available to plants • Mostly present in the solid phase of manure.	• Immediately available to plants • Mostly available in the liquid phase of the manure.
P	• Chemically bounded to C • Must be converted to inorg. P by microorganisms to be available to plants • Mostly available in the solid phase of manure.	• P in phosphate form • Available disolved and bounded to minerals • Soluble P is immediately available to plants • Mostly available in the liquid phase of the manure.

Approach

Approach

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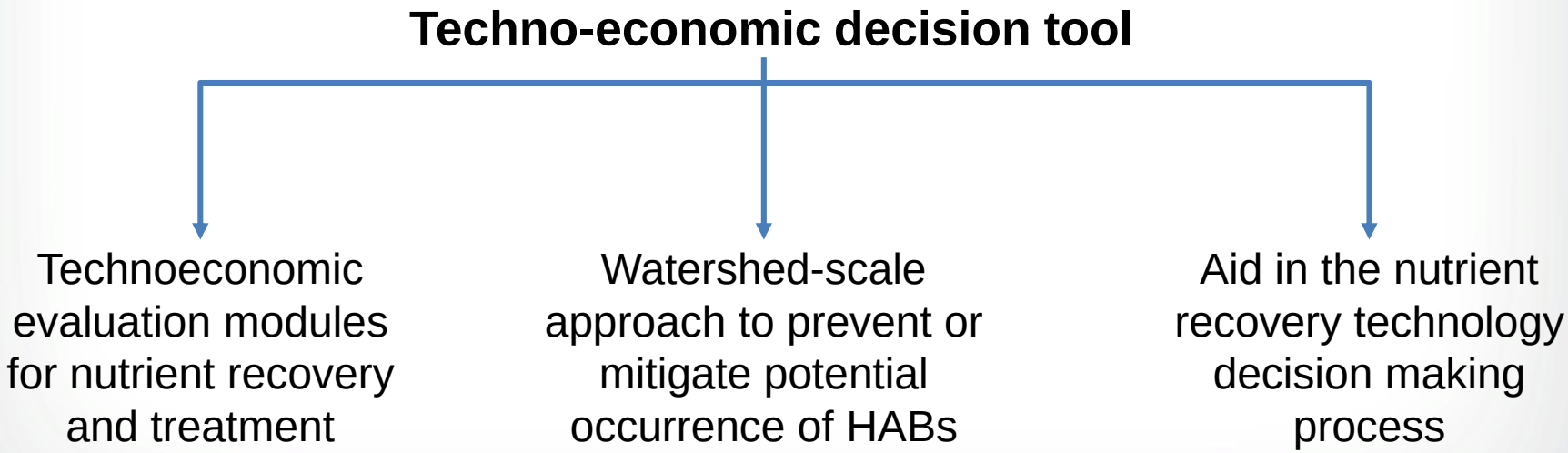
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUPPLY CHAIN DESIGN FOR UPGRADING WASTE MATERIALS TO VALUE-ADDED PRODUCTS

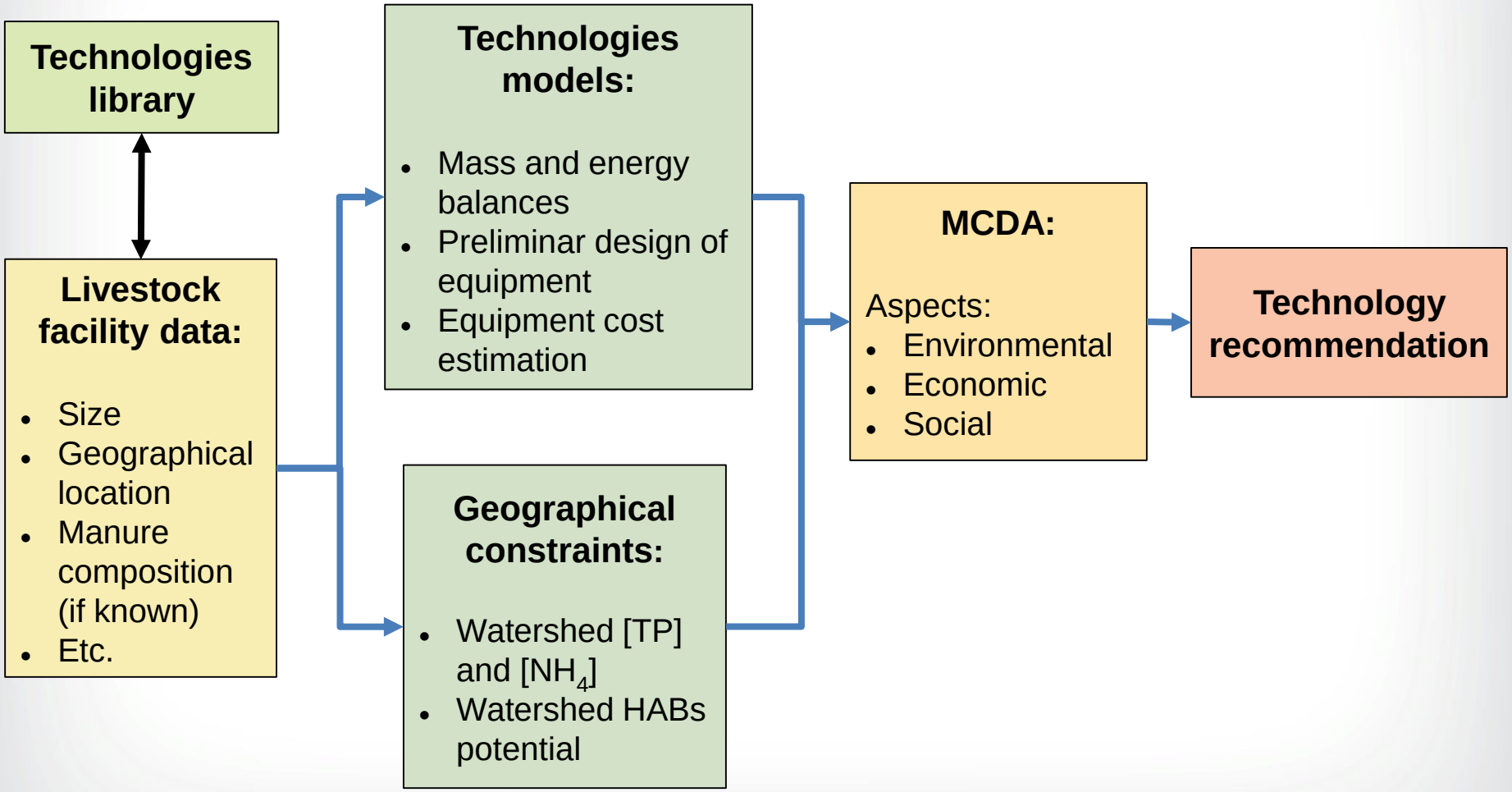
Develop a techno-economic decision tool for nutrient management from animal waste to guide decision maker's to design the optimal waste management system for nutrient pollution prevention and control

Approach

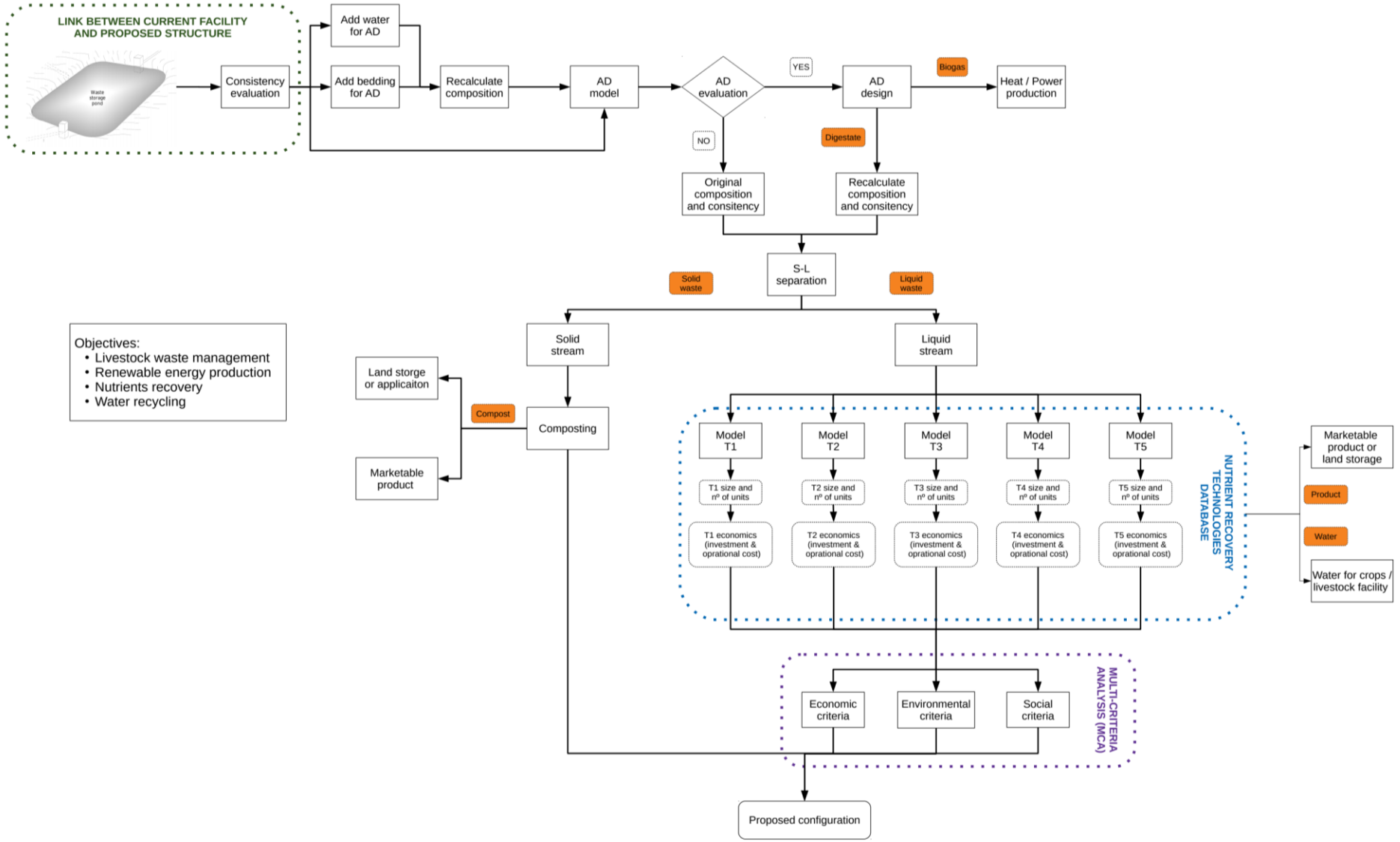
SUPPLY CHAIN DESIGN FOR UPGRADING WASTE MATERIALS TO VALUE-ADDED PRODUCTS



Approach

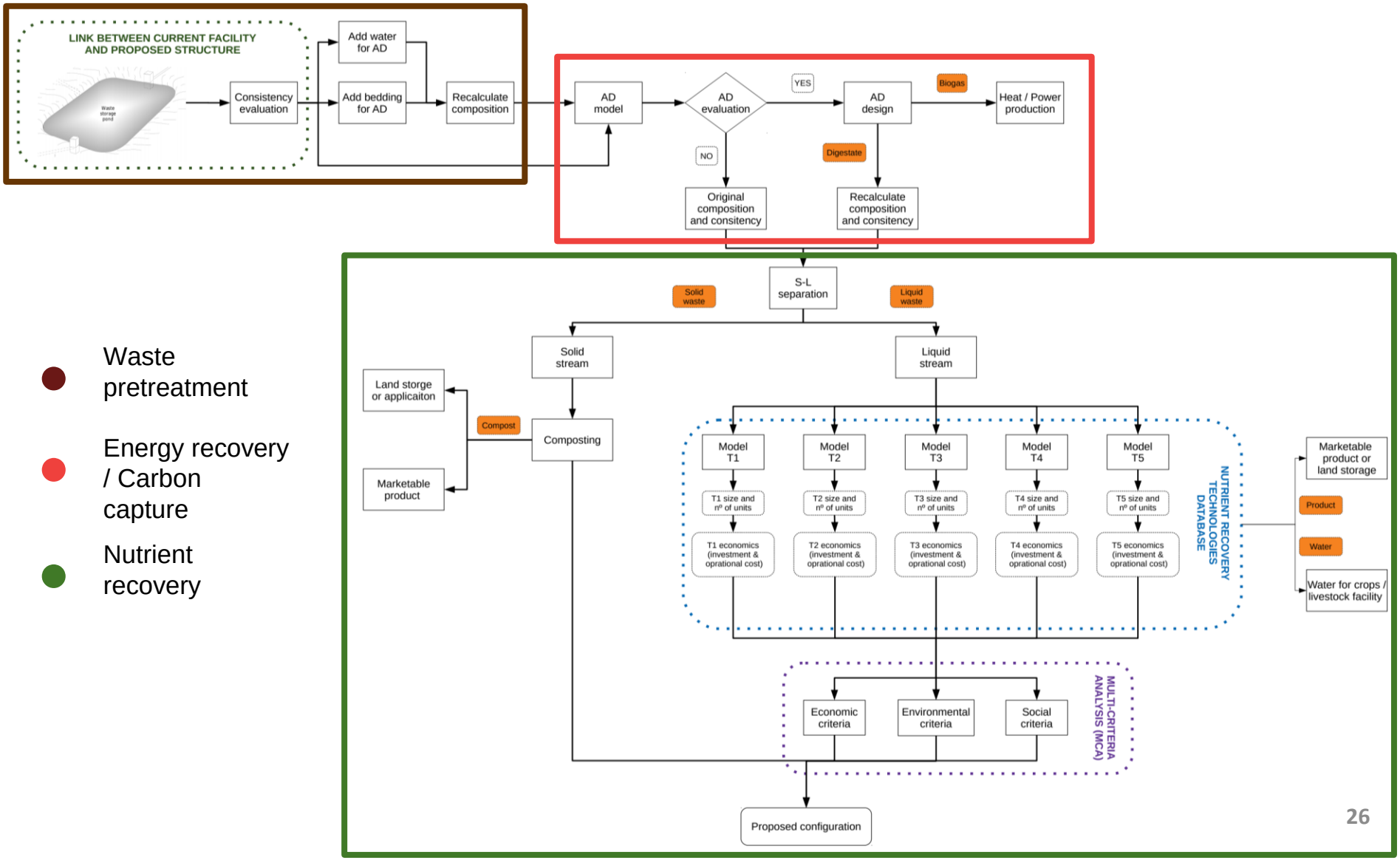

Technologies library
Livestock facility data:
Size
Geographical location
Manure composition (if known)
Etc.
Technologies models:
Mass and energy balances
Preliminar design of equipment
Equipment cost estimation
Geographical constraints:
Watershed [TP] and [NH4]
Watershed HABs potential
MCDA:
Aspects:
Environmental
Economic
Social
Technology recommendation

Approach

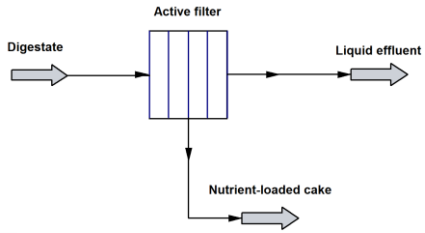

LINK BETWEEN CURRENT FACILITY AND PROPOSED STRUCTURE
Consistency evaluation
Add water for AD
Add bedding for AD
Recalculate composition
AD model
AD evaluation
YES
AD design
Biogas
Heat / Power production
NO
Digestate
Original composition and consitency
Recalculate composition and consitency
S-L separation
Solid waste
Liquid waste
Solid stream
Liquid stream
Land storge or applicaiton
Compost
Composting
Marketable product
Objectives:
• Livestock waste management
• Renewable energy production
• Nutrients recovery
• Water recycling
Model T1
Model T2
Model T3
Model T4
Model T5
T1 size and nº of units
T2 size and nº of units
T3 size and nº of units
T4 size and nº of units
T5 size and nº of units
T1 economics (investment & oprational cost)
T2 economics (investment & oprational cost)
T3 economics (investment & oprational cost)
T4 economics (investment & oprational cost)
T5 economics (investment & oprational cost)
NUTRIENT RECOVERY TECHNOLOGIES DATABASE
Marketable product or land storage
Product
Water
Water for crops / livestock facility
Economic criteria
Environmental criteria
Social criteria
MULTI-CRITERIA ANALYSIS (MCA)
Proposed configuration

Approach

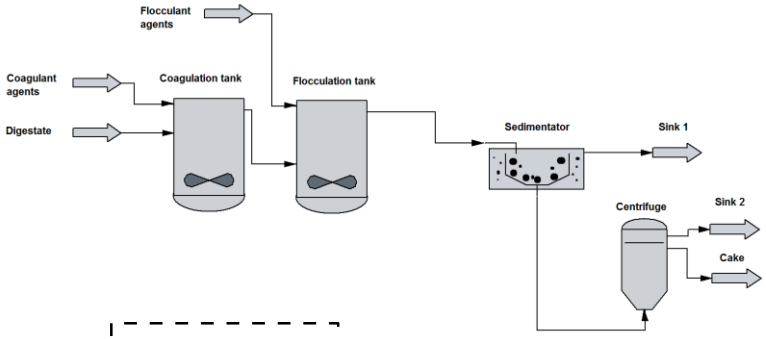
- Waste pretreatment
- Energy recovery / Carbon capture
- Nutrient recovery



Approach

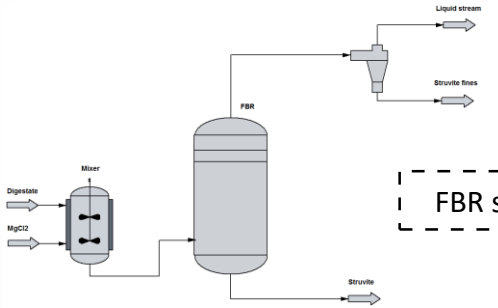


Filtration



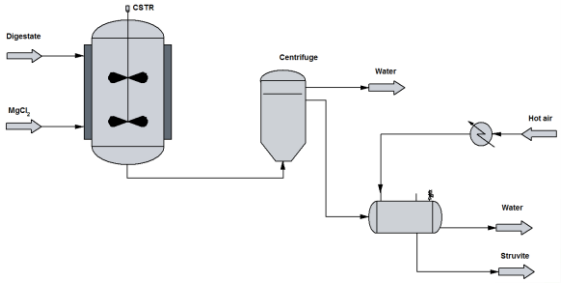
Coagulation

TECHS



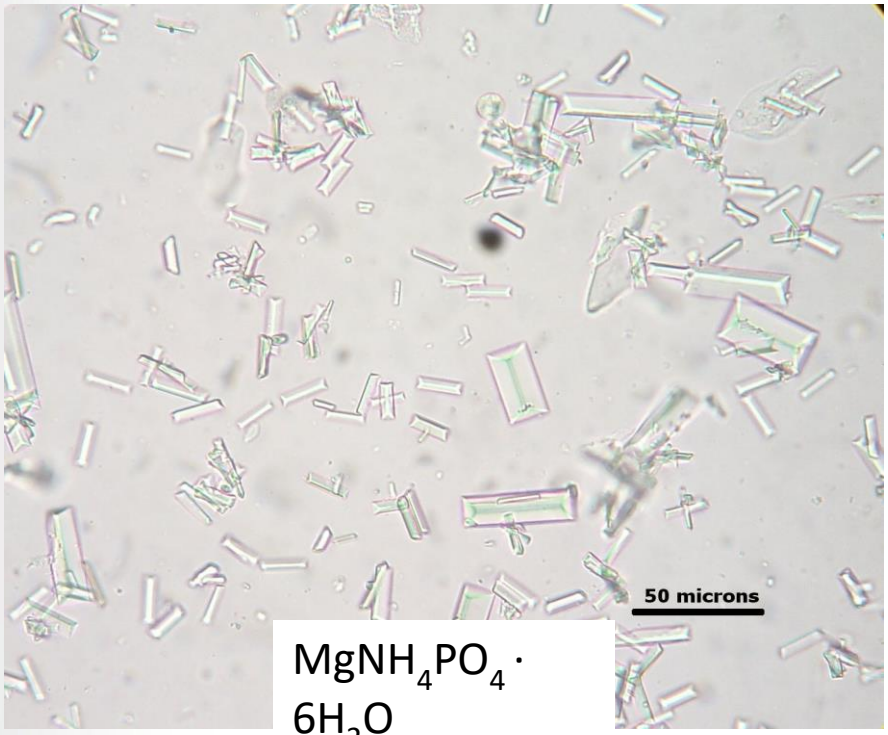
FBR struvite

CSTR struvite

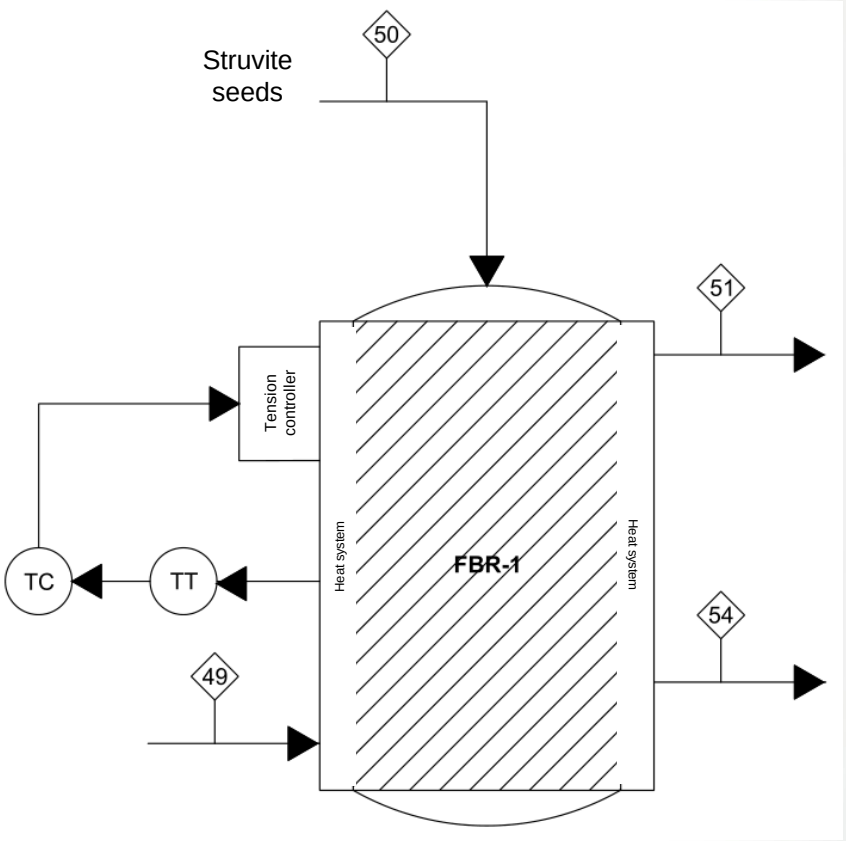


Approach

Struvite production



$MgNH_4PO_4 \cdot 6H_2O$



Approach

Cattle digestate hindrances:

High variability in the composition

Complex matrix

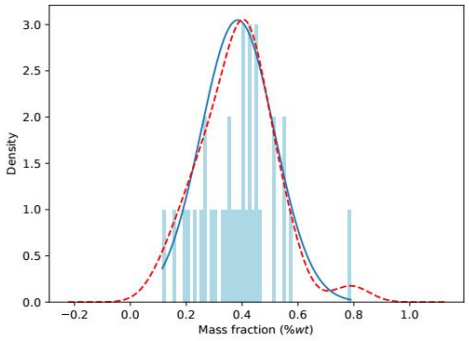
I. Complex Interactions between different chemical systems

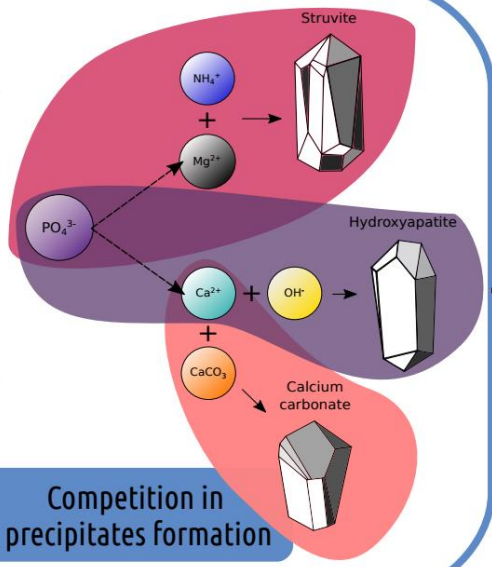
II. High ionic strength (reduce the availability of ions for product formation)

III. Presence of calcium ions (compete for phosphate ions and reduce the selectivity for struvite)

Approach

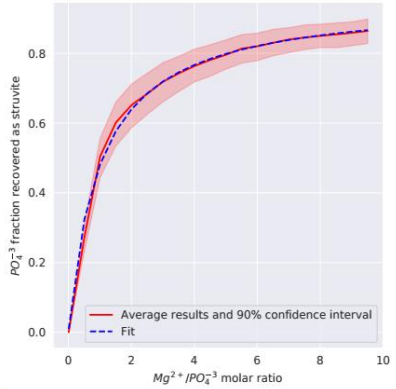
1. Organic waste generation





2. Evaluation of the uncertainty in digestate composition + Competition in precipitates formation

3. Development of rules of thumb for struvite formation

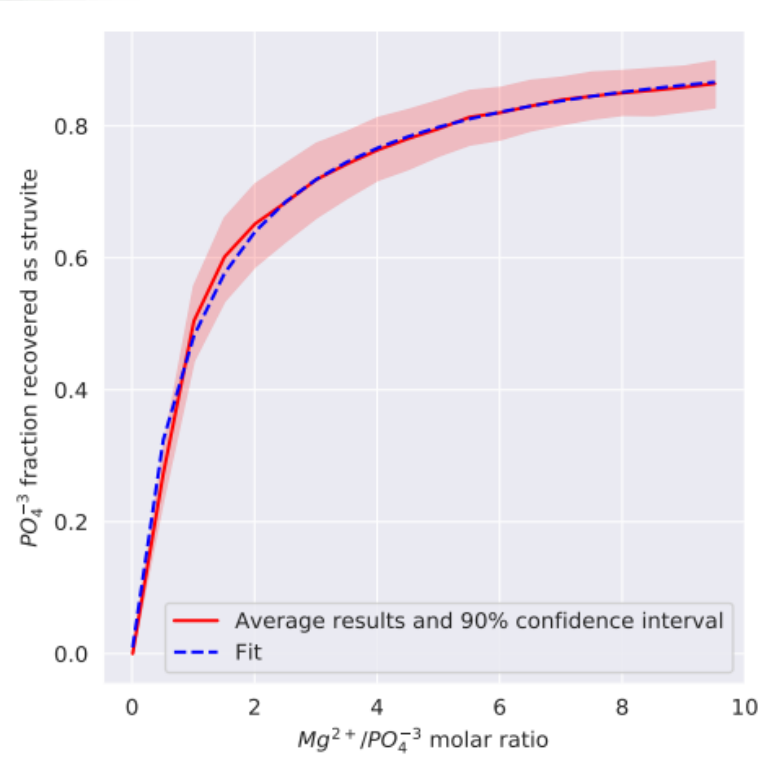


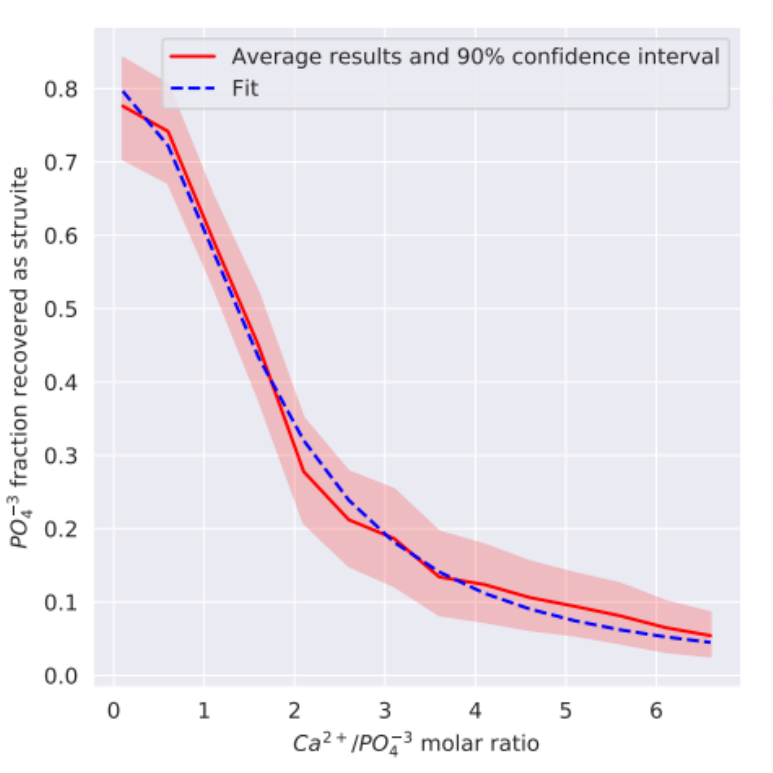
Influence of:

- Mangesium
- Calcium
- Alkalinity

4. Reincorporation of nutrients to production cycle as fertilizers

Approach

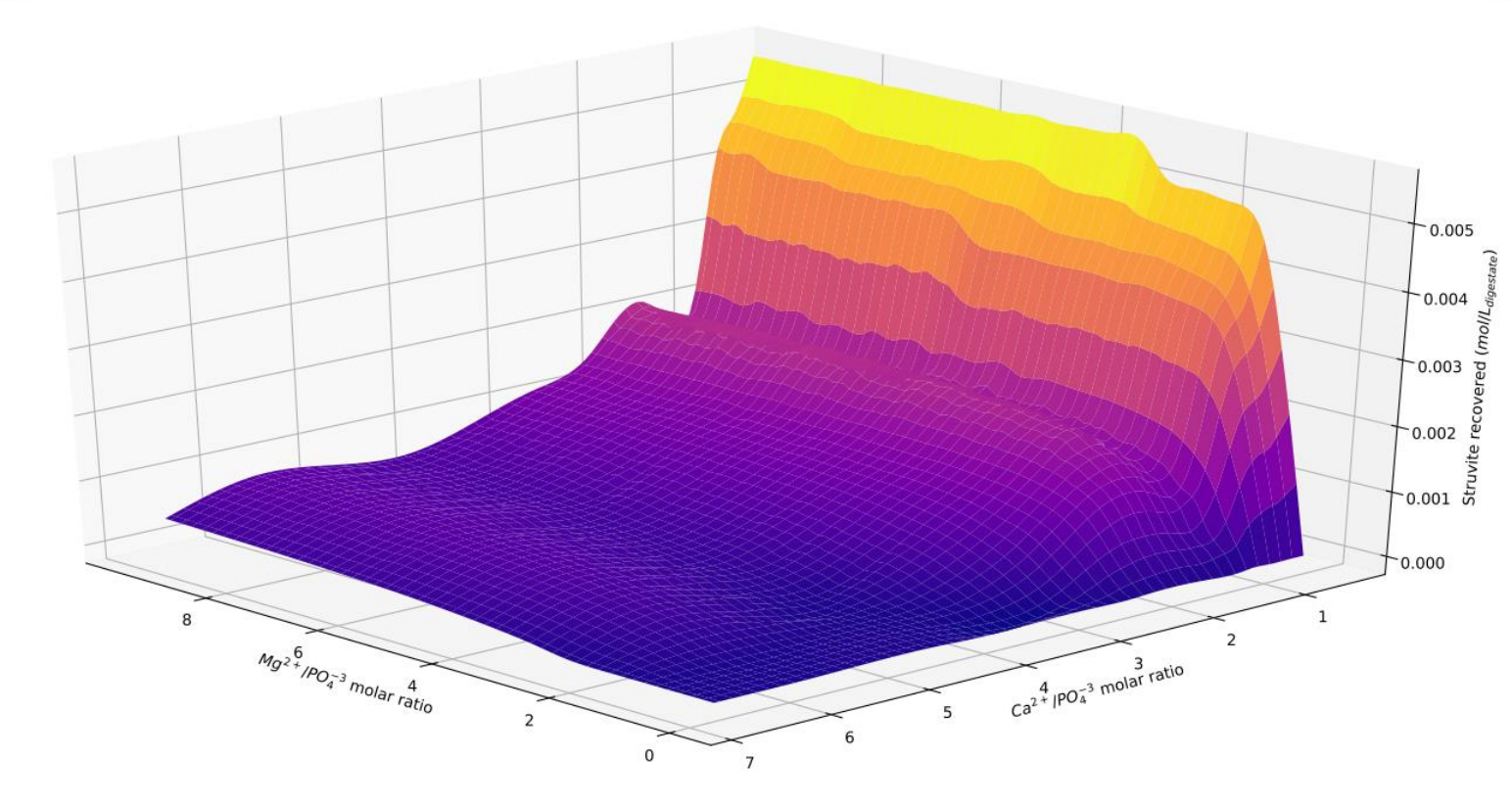




$$x_{struvite\left(PO_4^{3-}\right)} = \frac{0.957 \cdot x_{Mg^{2+}:PO_4^{3-}}}{0.996 + x_{Mg^{2+}:PO_4^{3-}}}$$

$$x_{struvite\left(PO_4^{3-}\right)} = \frac{0.798}{1 + \left(x_{Ca^{2+}:PO_4^{3-}} \cdot 0.576\right)^{2.113}}$$

Approach


0.005
0.004
0.003
0.002
0.001
0.000
Struvite recovered (mol/L$_{digestate}$)
8
6
4
2
0
Mg^{2+}/PO_4^{-3} molar ratio
7
6
5
4
3
2
1
Ca^{2+}/PO_4^{-3} molar ratio

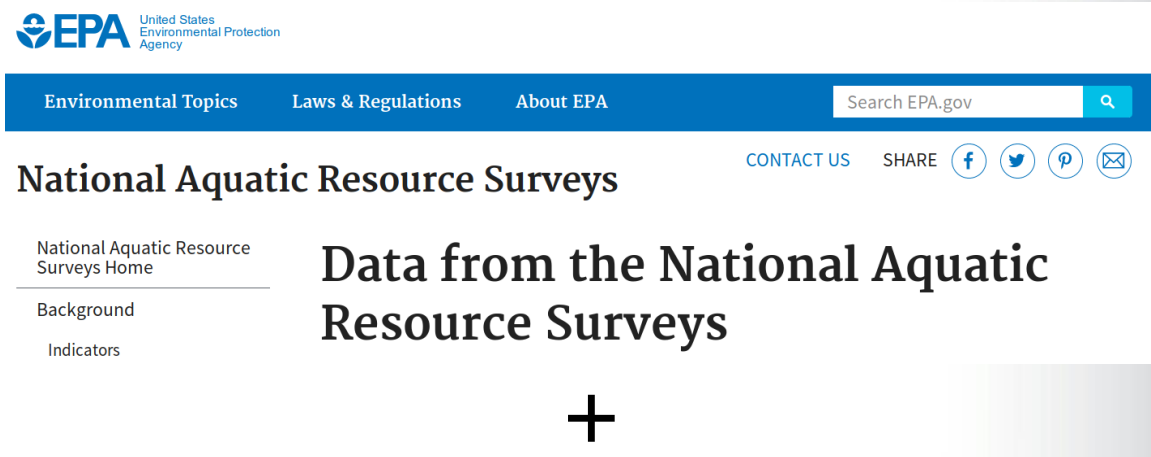
Approach

Geographic data

NARS data: TP and NH_4

+

HUC8: extent of surface water drainage using a hierarchical system of nesting hydrologic units (USGS)



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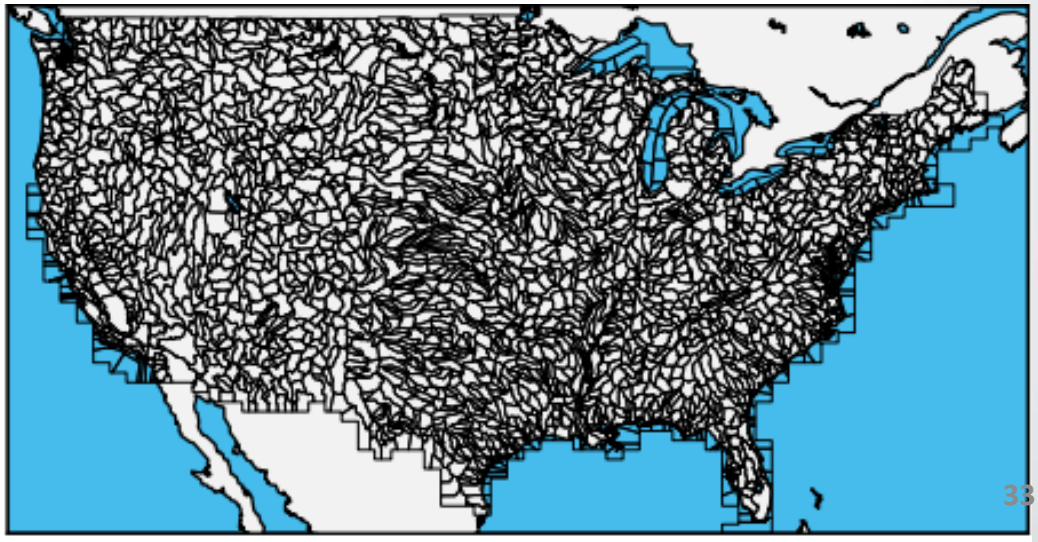
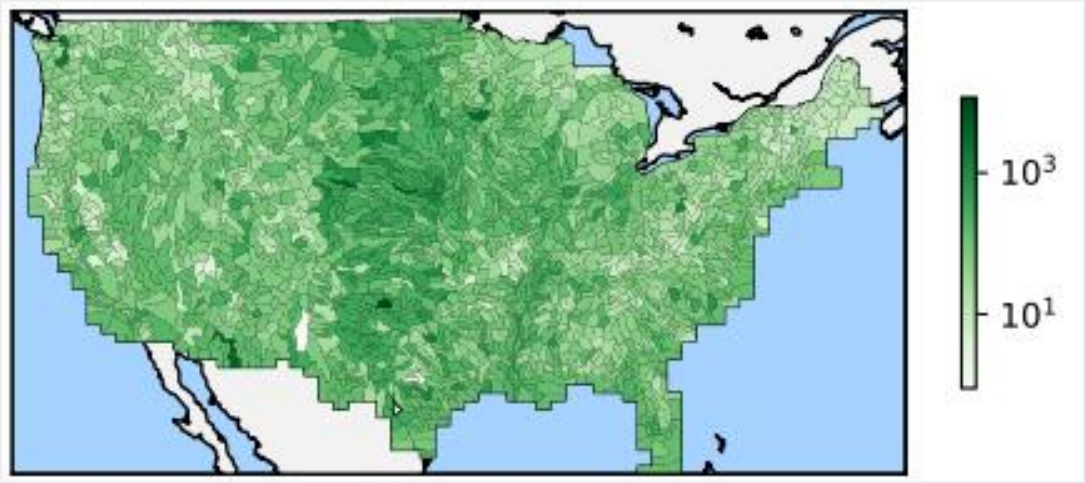


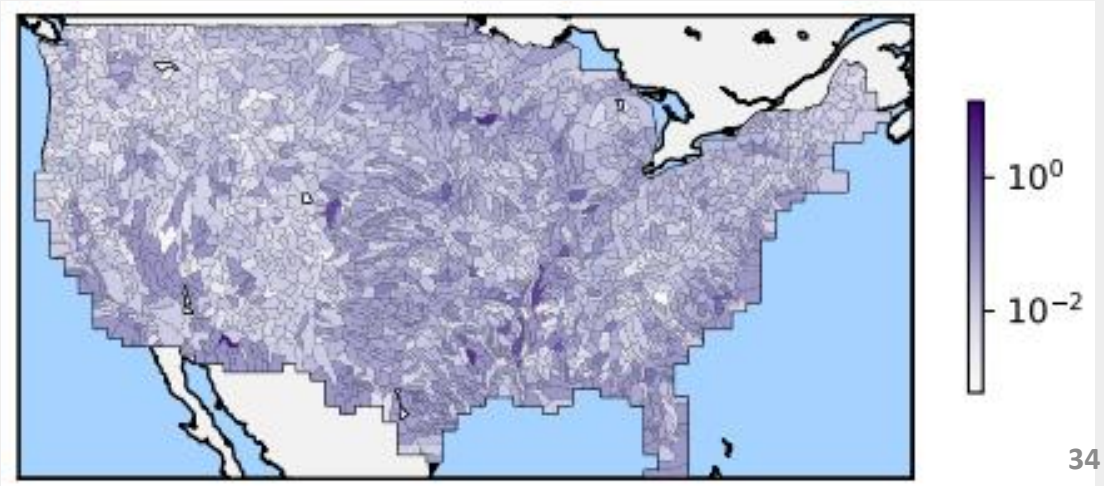
Approach

Geographic data

[TP] (µg/L)



[NH_4] (mg/L)



Tool under development

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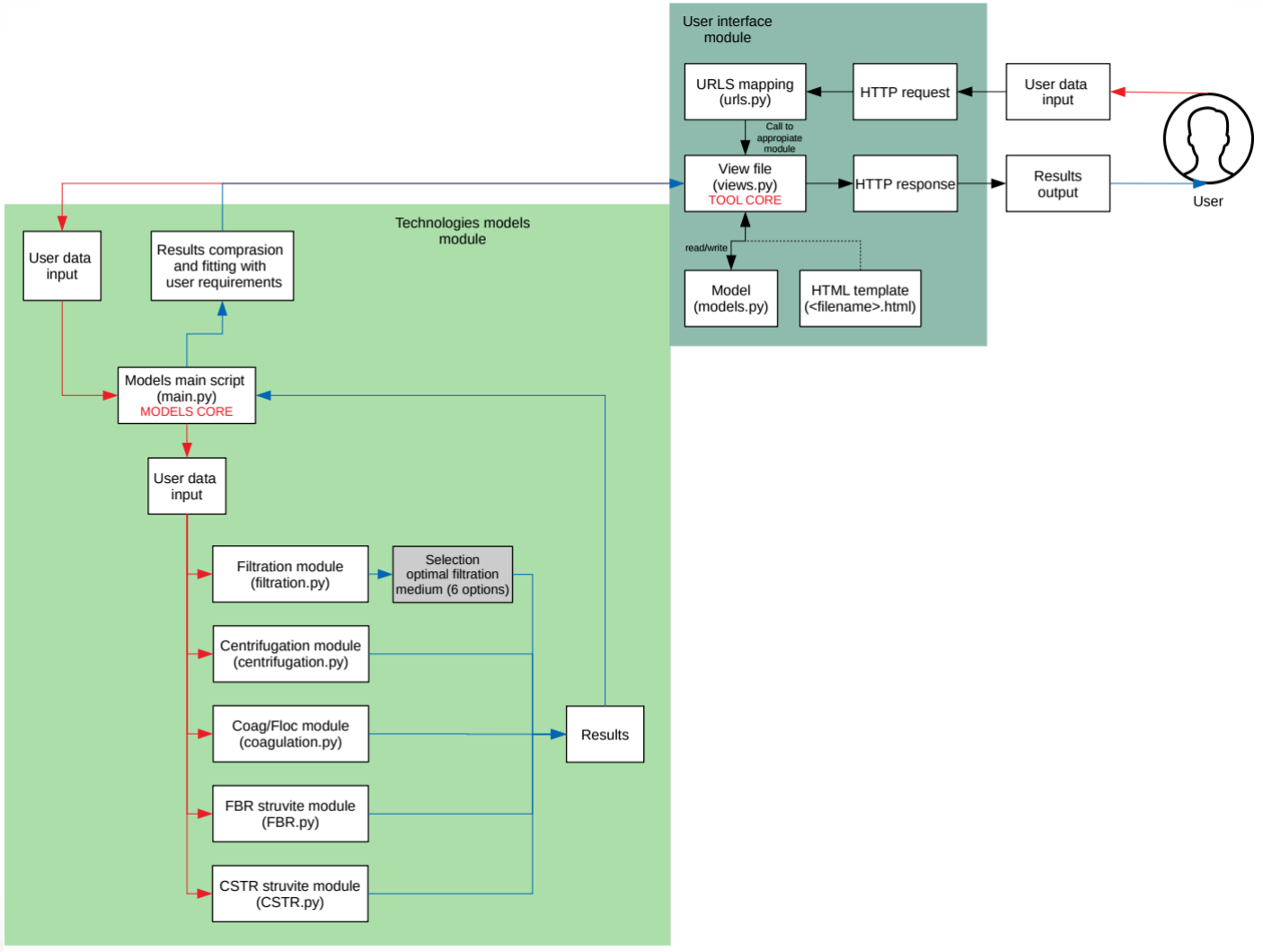

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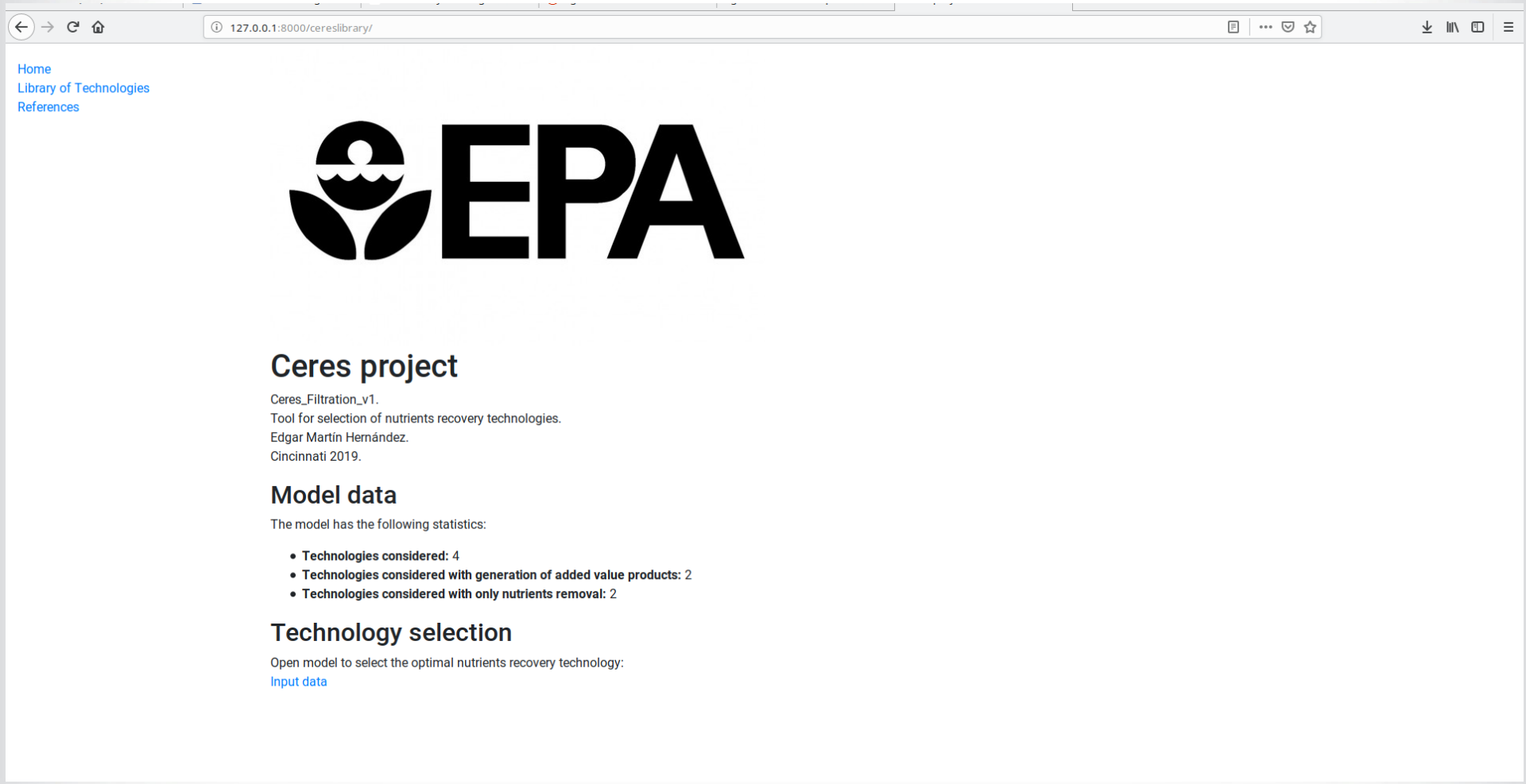
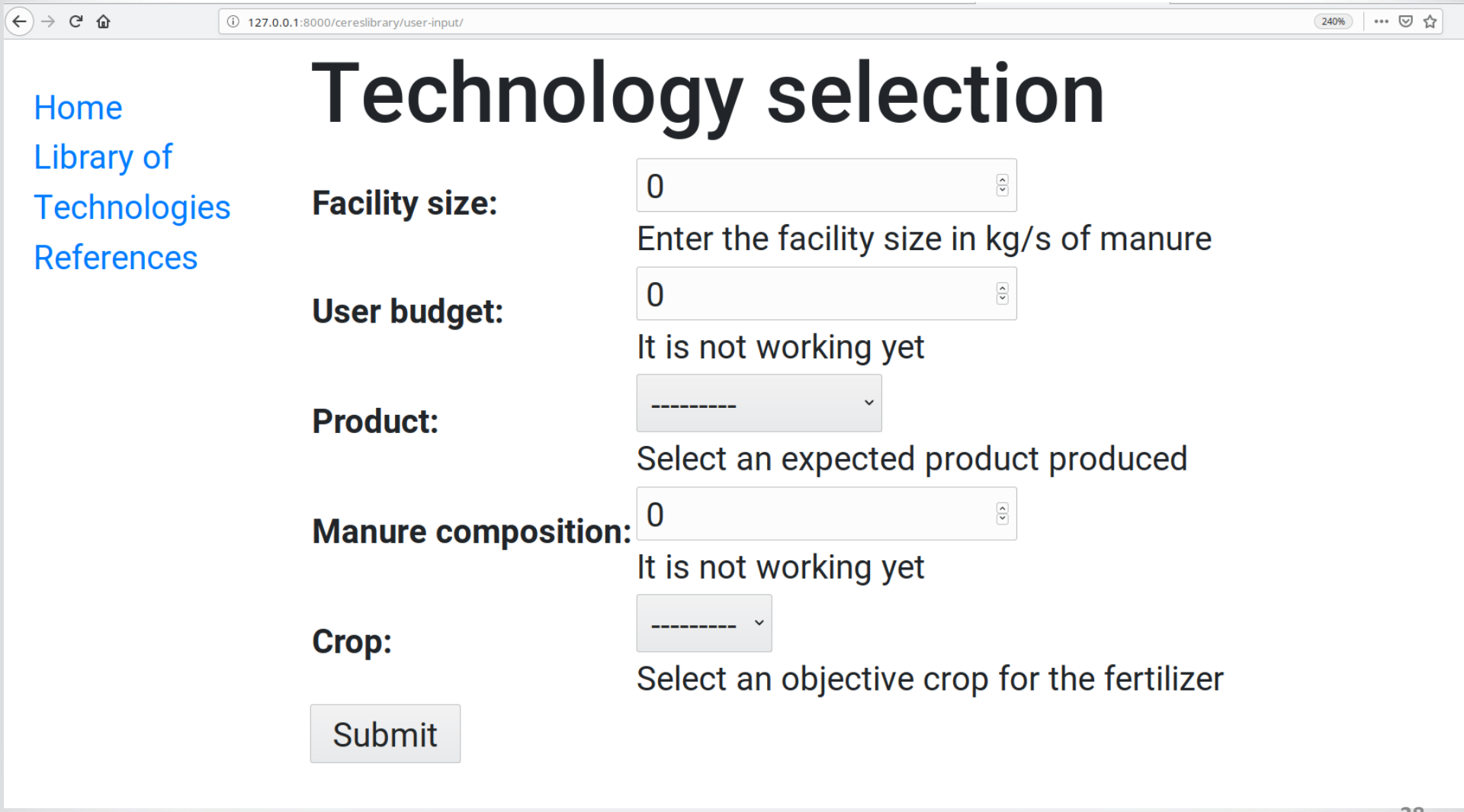


Tool under development



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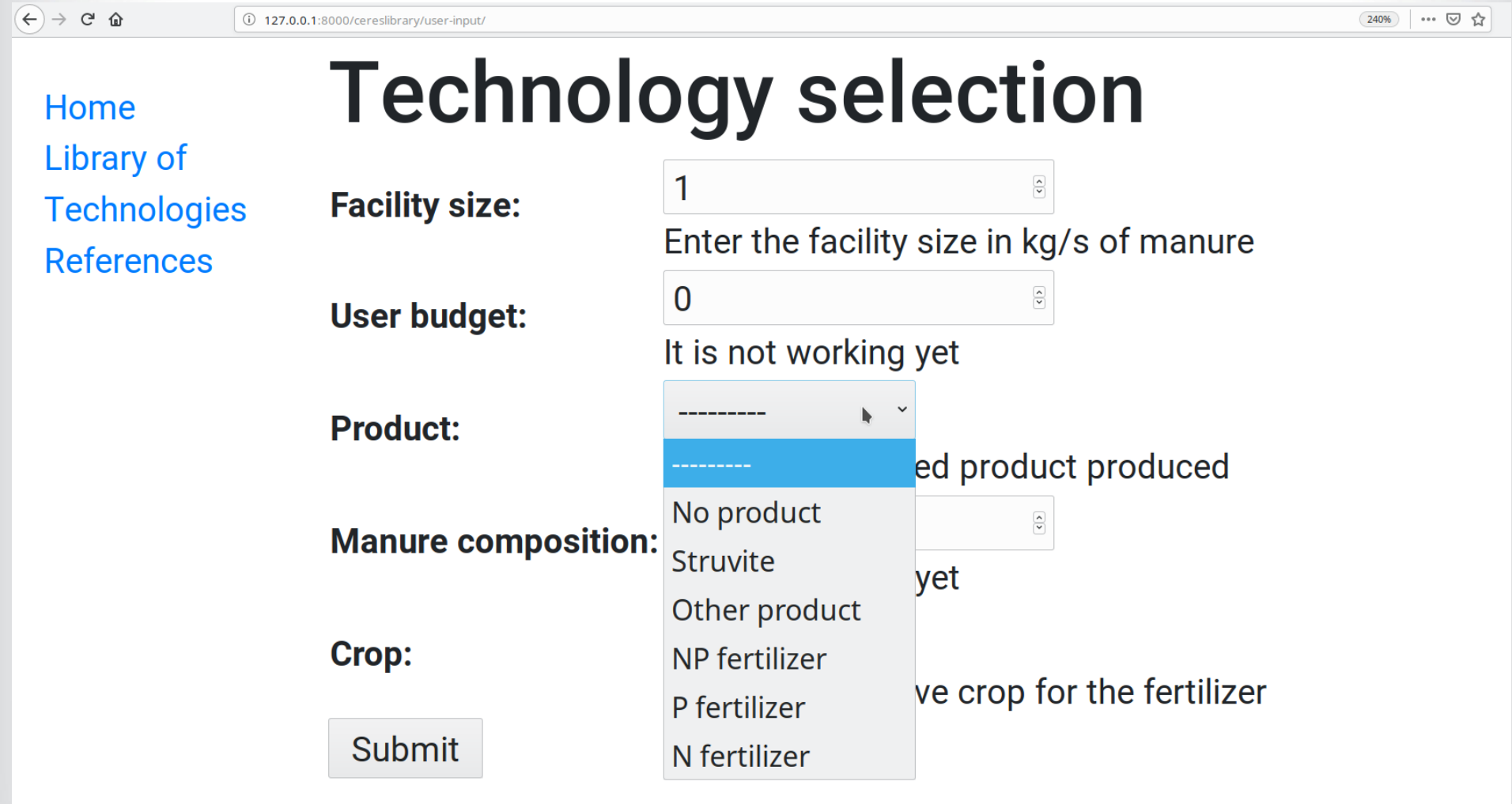

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