International Institute for Applied Systems Analysis
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science for global insight

System dynamics modelling for sustainable production and consumption

Agricultural fertilizer use

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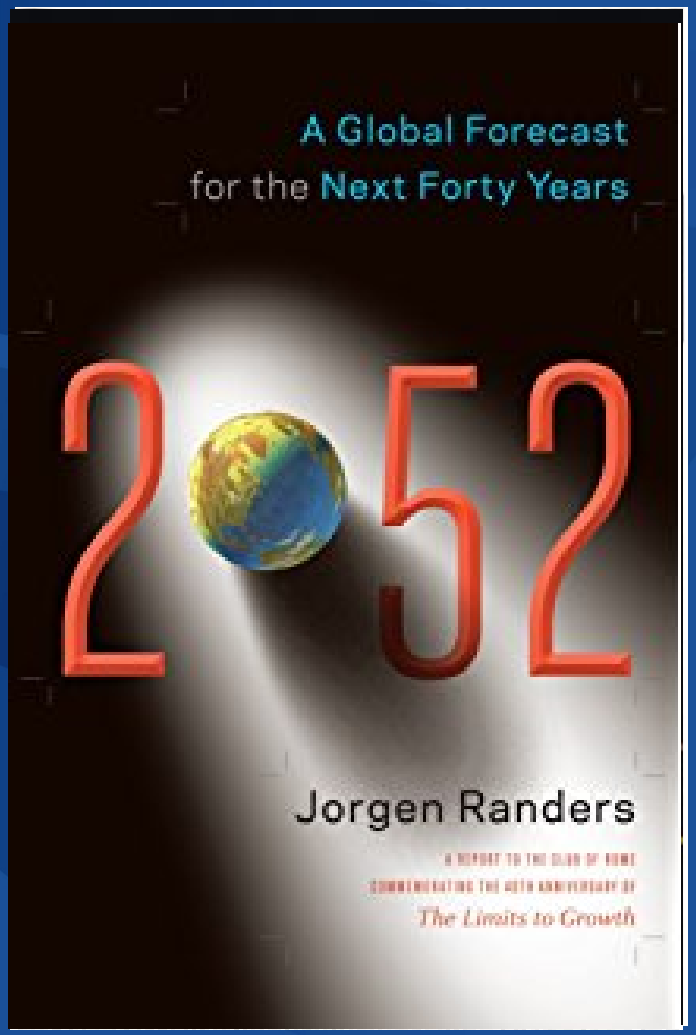
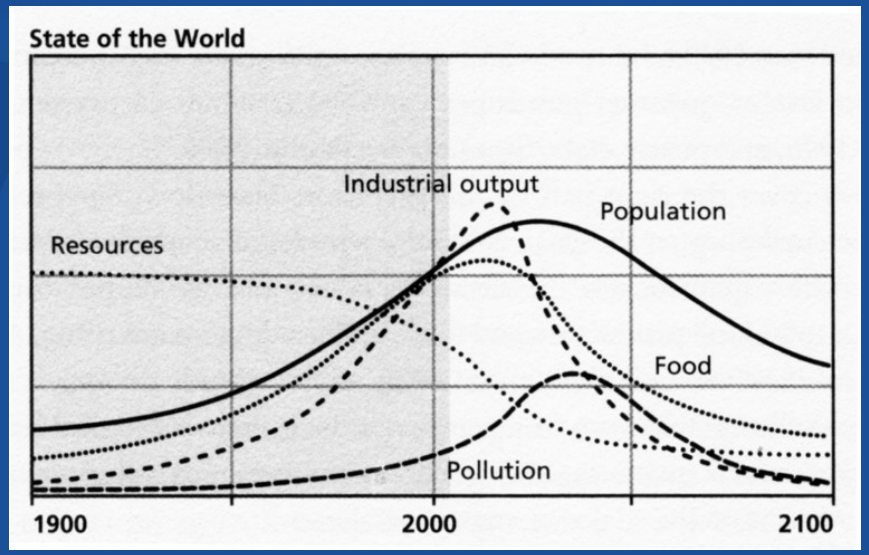
Though this be madness, yet there is method in it.

(William Shakespeare)

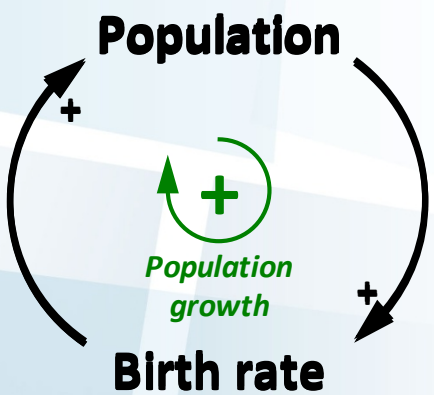
izquotes.com

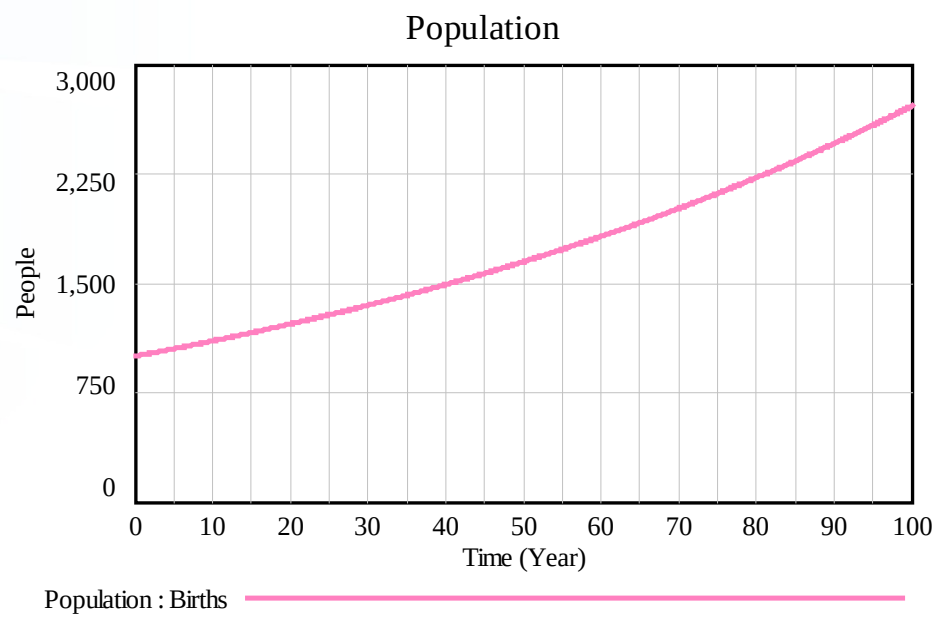
Sustainability and System Dynamics





System Dynamics





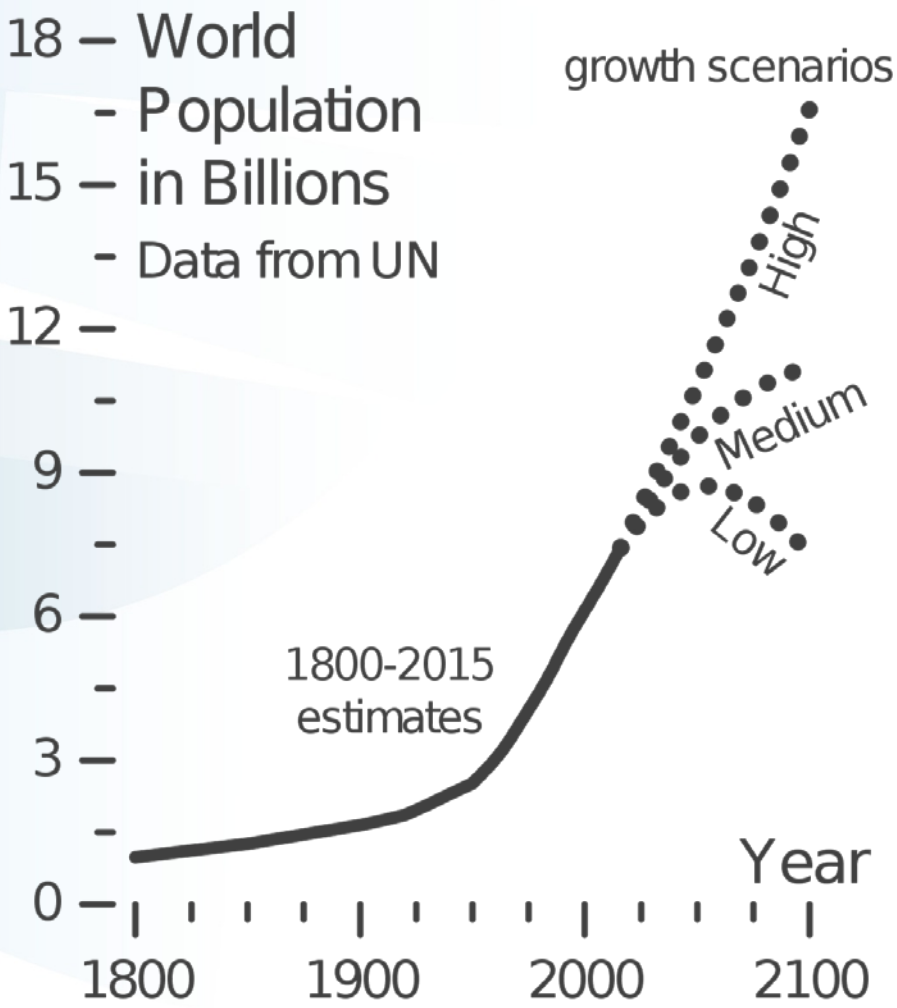
$$\frac{dP}{P} = f * dt$$

$$\int \frac{dP}{P} = \int f * dt$$

$$ln(P) = f * t + c$$

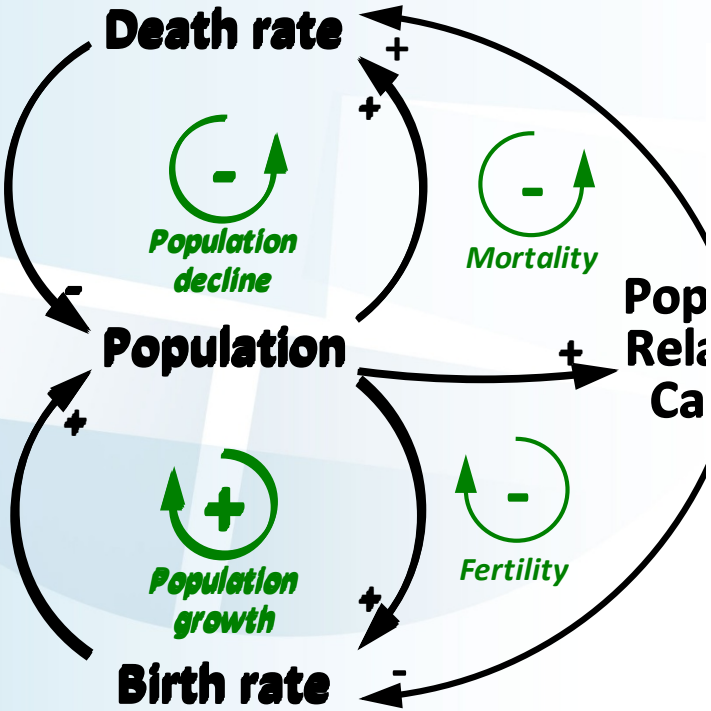
$$P(t) = P(0) * e^{ft}$$

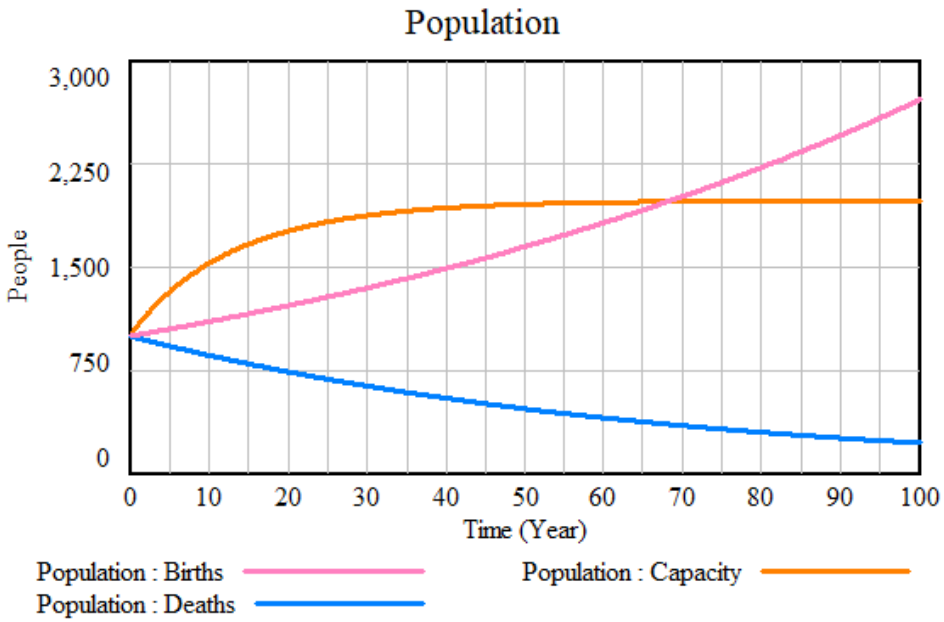
Population



Source: World Population Prospects 2017, UN DESA

System Dynamics

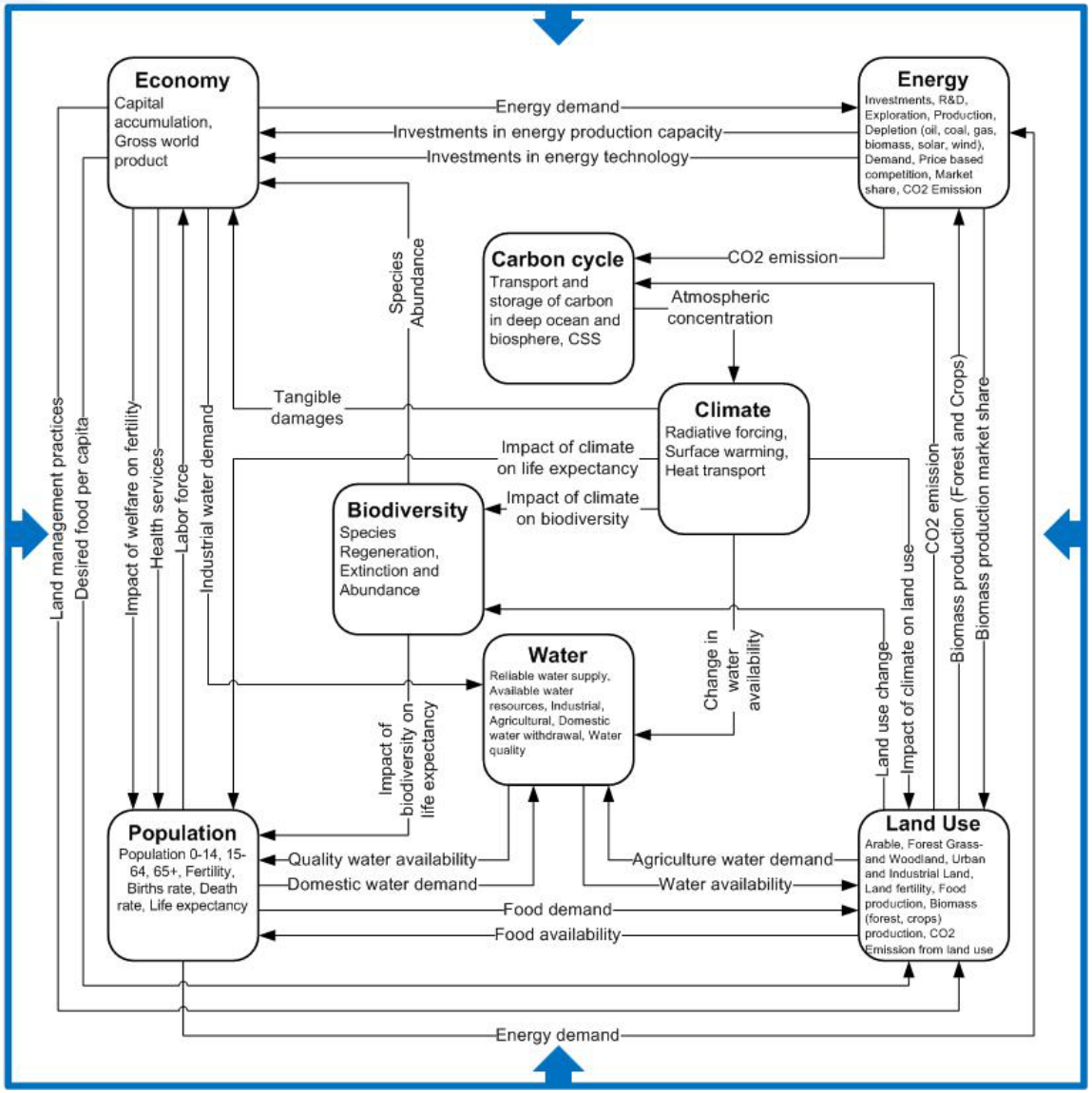




System dynamics

- Top-down
- Descriptive (causal relations)
- Continuous
- Feedback-rich and nonlinear

FeliX Model


Economy
Capital accumulation, Gross world product
Energy
Investments, R&D, Exploration, Production, Depletion (oil, coal, gas, biomass, solar, wind), Demand, Price based competition, Market share, CO2 Emission
Energy demand
Investments in energy production capacity
Investments in energy technology
Carbon cycle
Transport and storage of carbon in deep ocean and biosphere, CSS
CO2 emission
Atmospheric concentration
Climate
Radiative forcing, Surface warming, Heat transport
Tangible damages
Impact of climate on life expectancy
Impact of climate on biodiversity
Biodiversity
Species Regeneration, Extinction and Abundance
Water
Reliable water supply, Available water resources, Industrial, Agricultural, Domestic water withdrawal, Water quality
Population
Population 0-14, 15-64, 65+, Fertility, Births rate, Death rate, Life expectancy
Land Use
Arable, Forest Grass- and Woodland, Urban and Industrial Land, Land fertility, Food production, Biomass (forest, crops) production, CO2 Emission from land use
Quality water availability
Domestic water demand
Agriculture water demand
Water availability
Food demand
Food availability
Energy demand
Land management practices
Desired food per capita
Impact of welfare on fertility
Health services
Labor force
Industrial water demand
Species Abundance
Impact of biodiversity on life expectancy
Change in water availability
Land use change
Impact of climate on land use
CO2 emission
Biomass production (Forest and Crops)
Biomass production market share


SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

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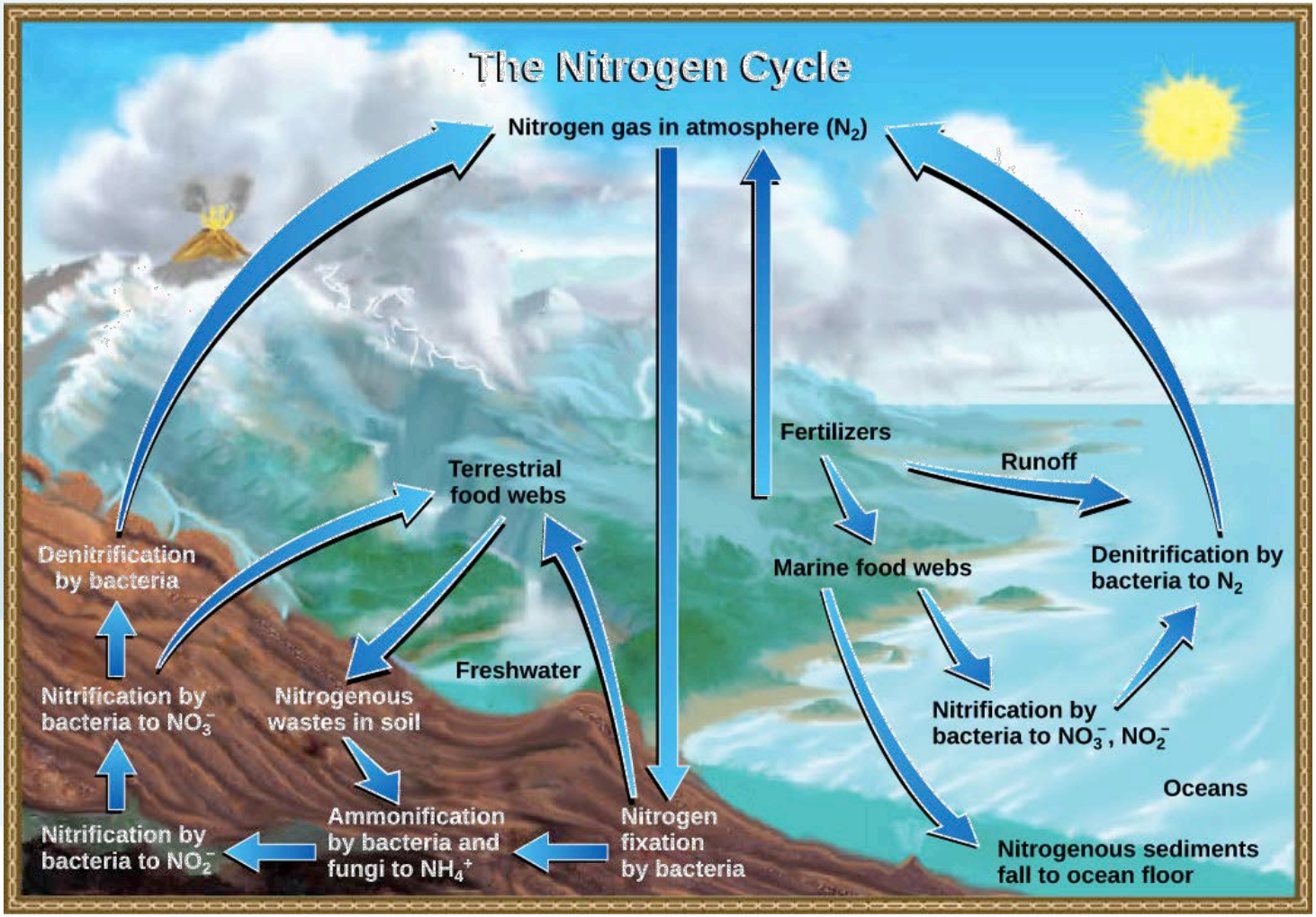
Nitrogen Cycle



Source: Khan Academy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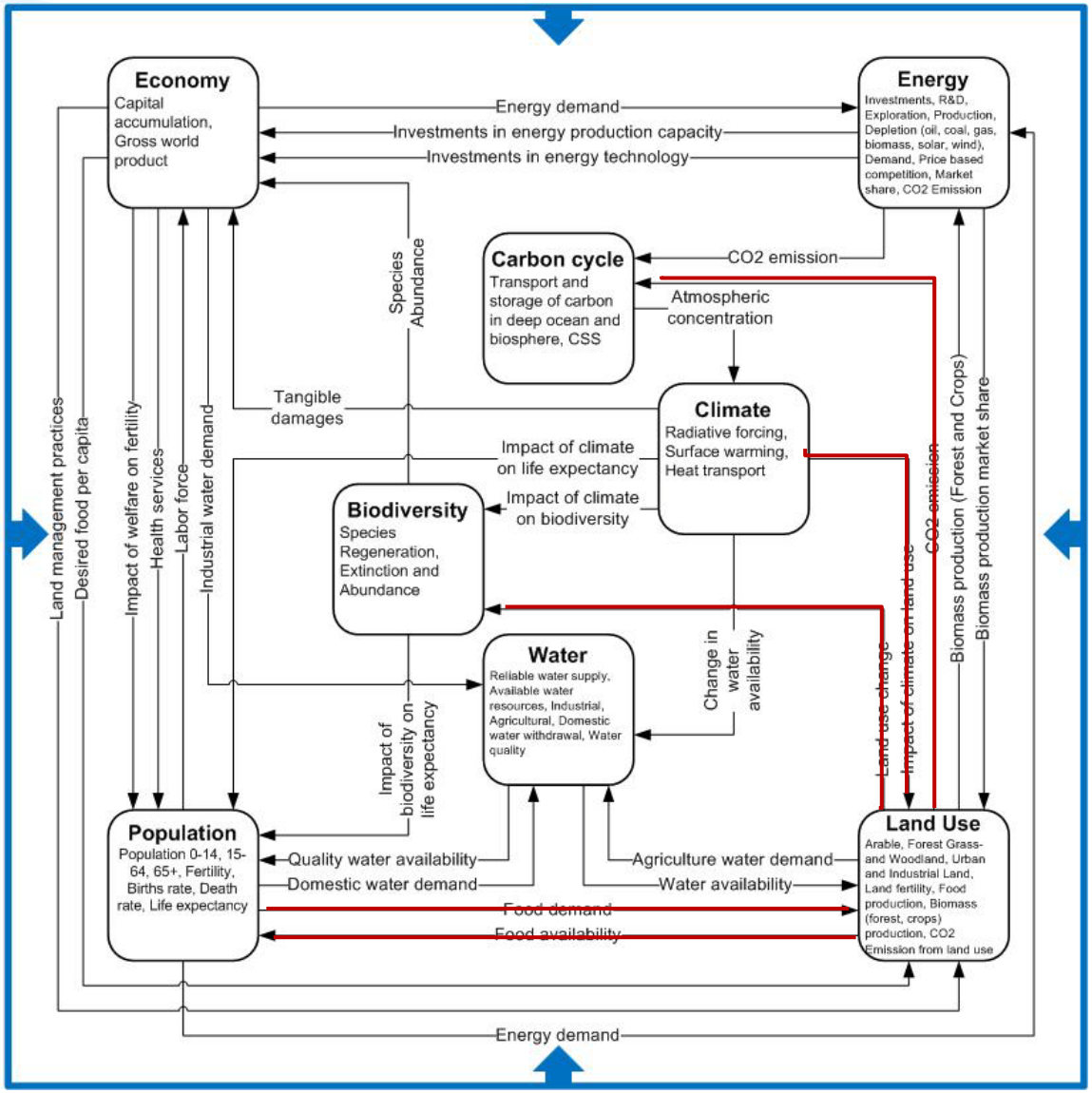
FeliX Model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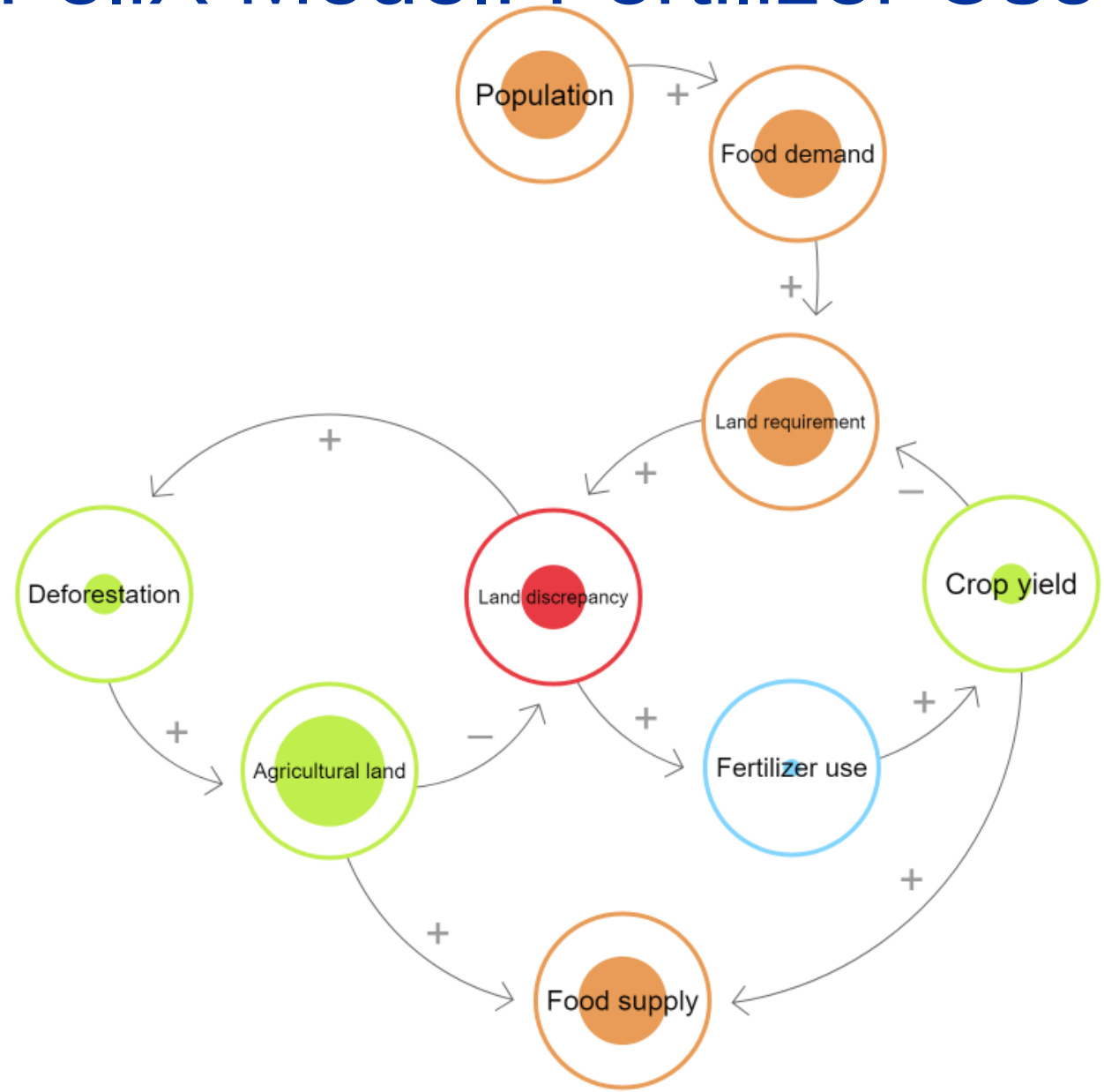
Biomass production market share
Energy demand

FeliX Model: Fertilizer Use



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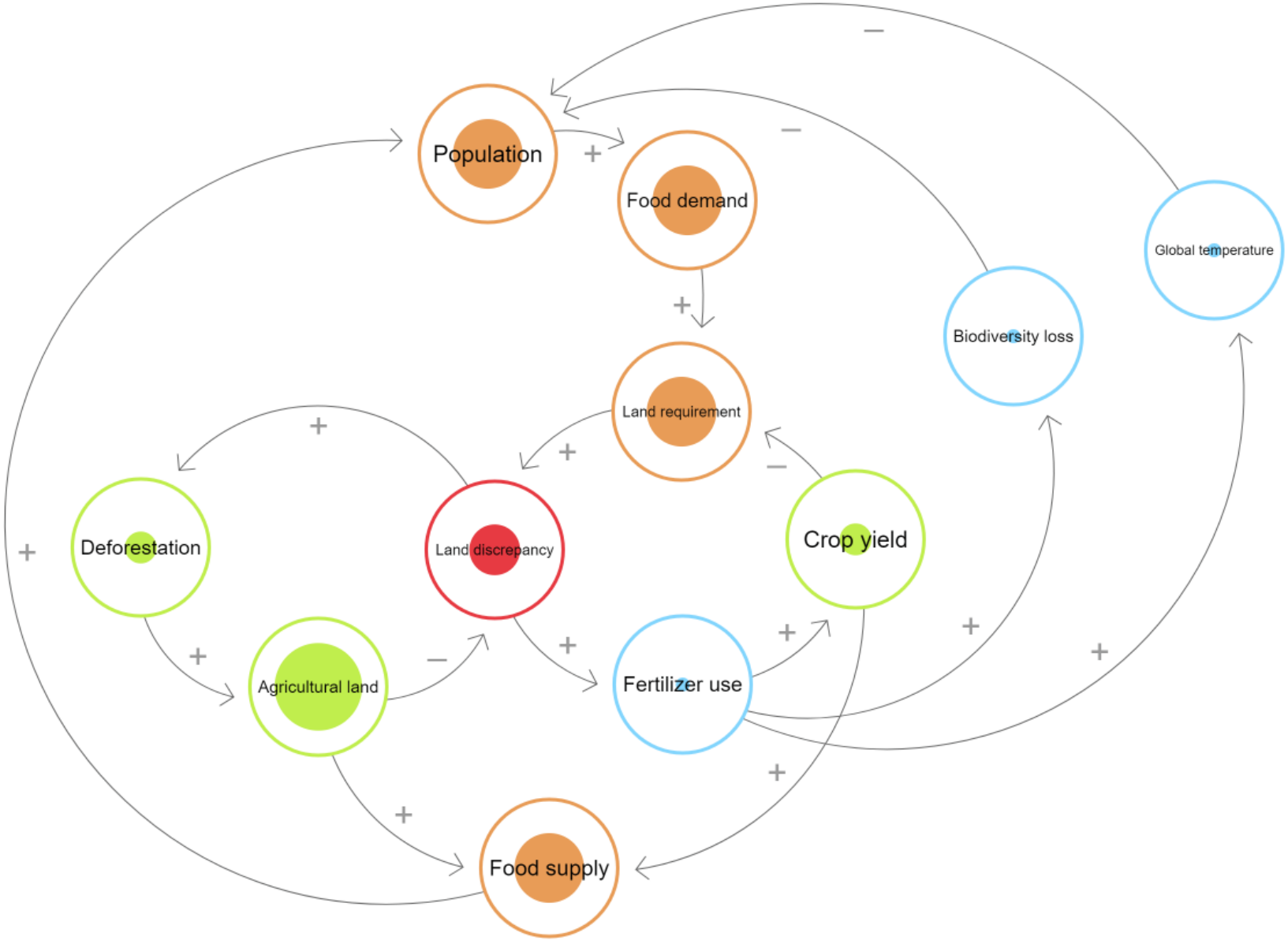

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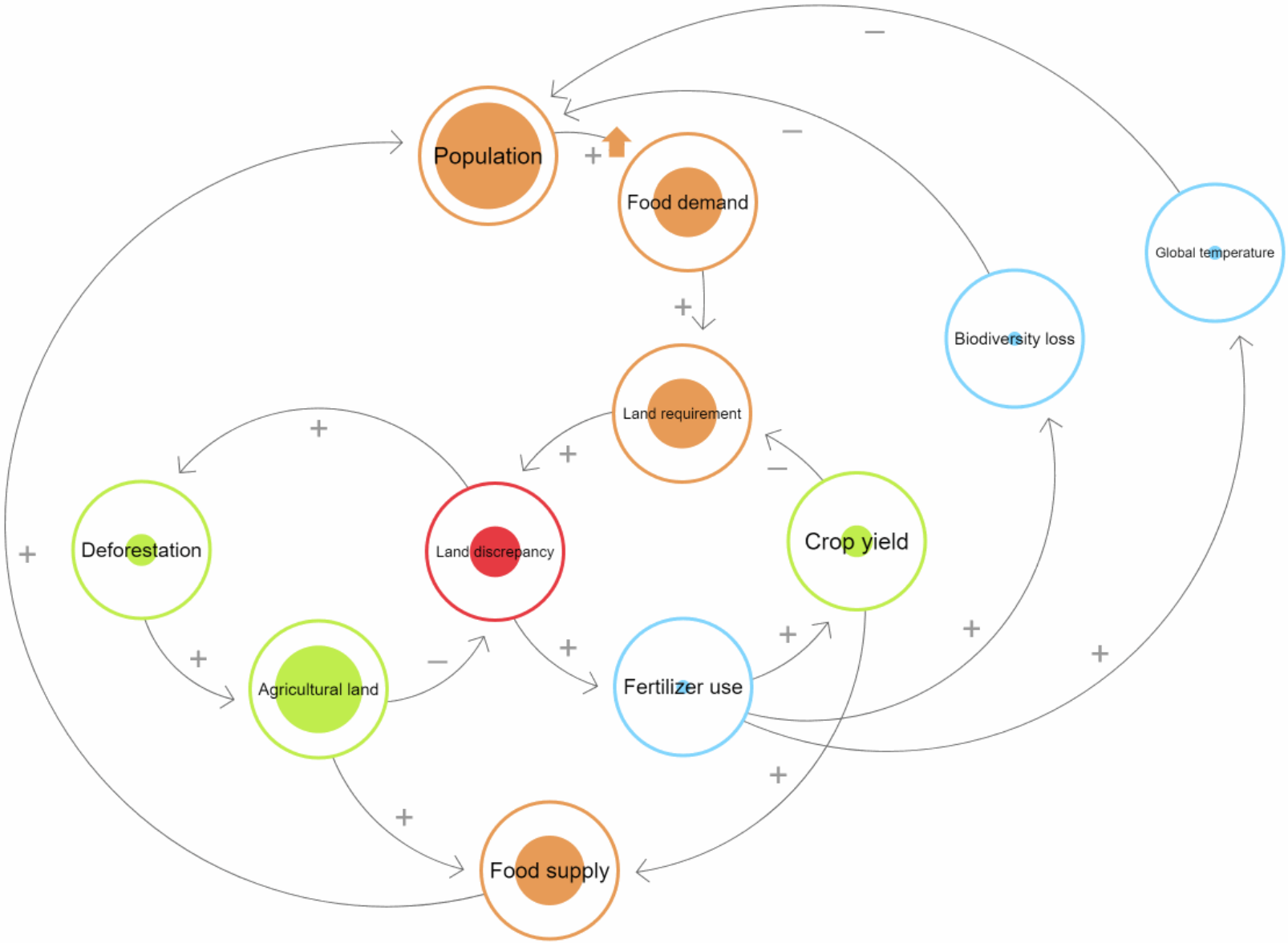

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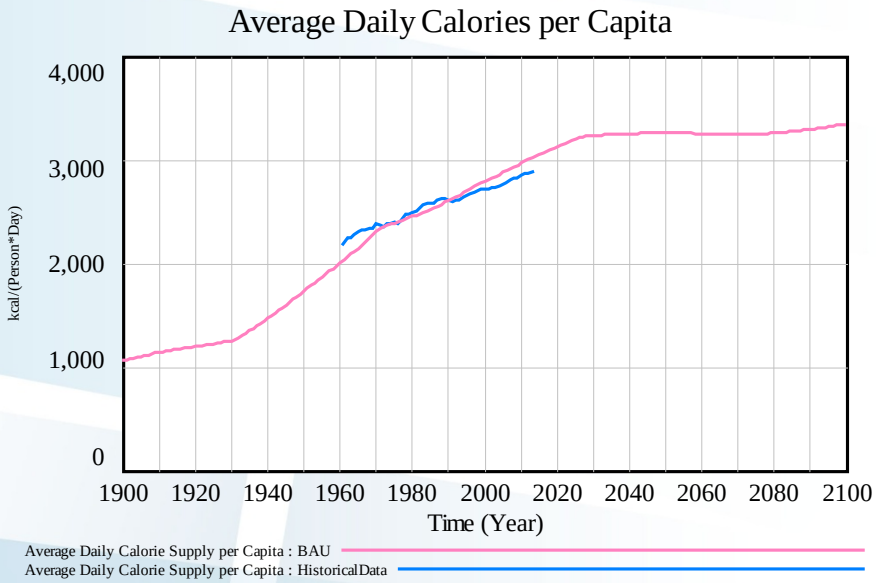
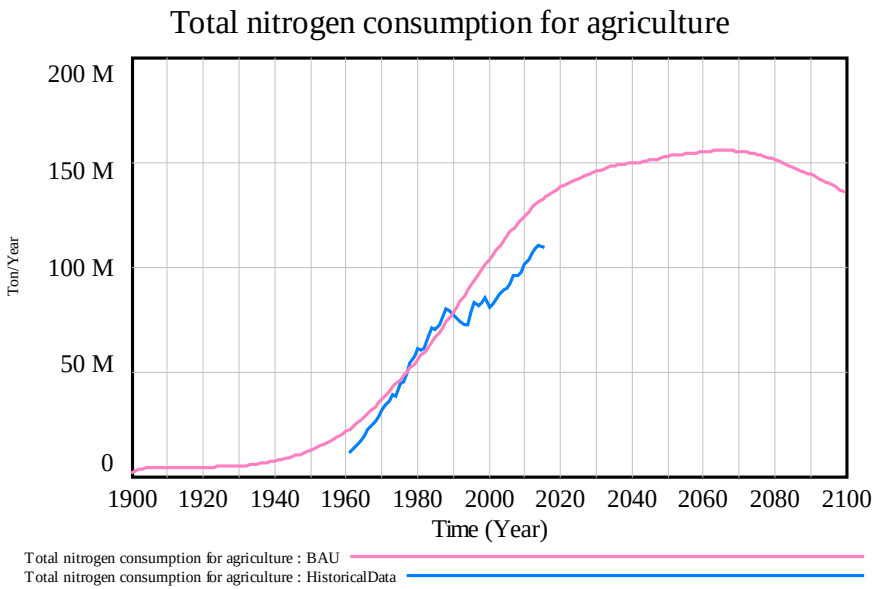
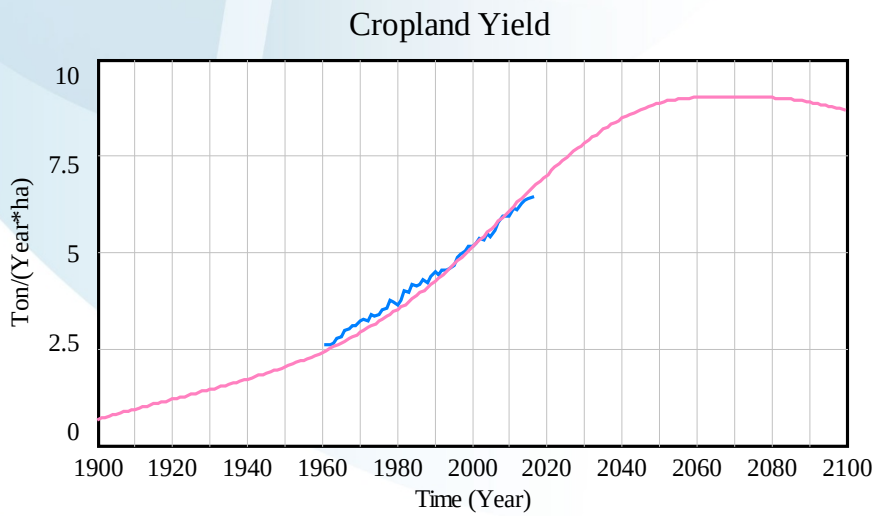
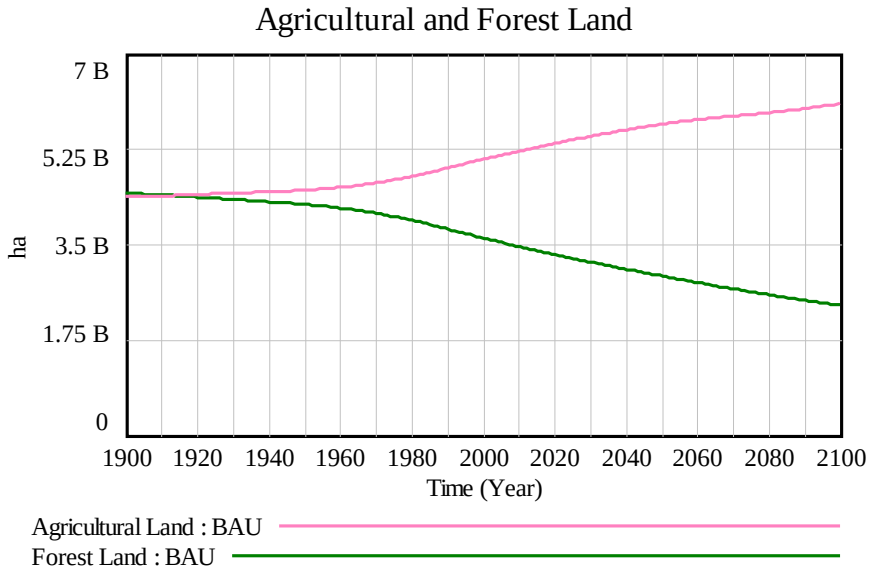


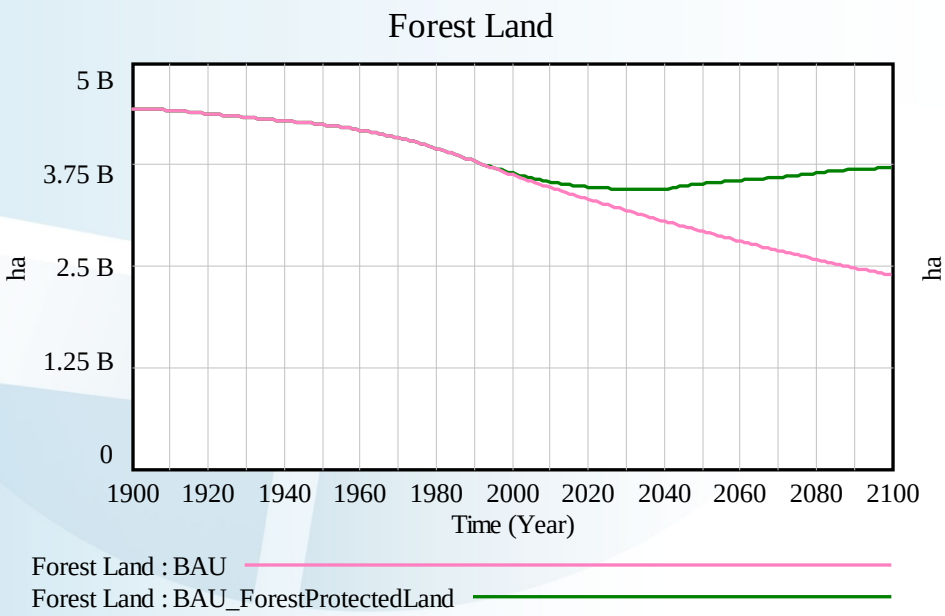


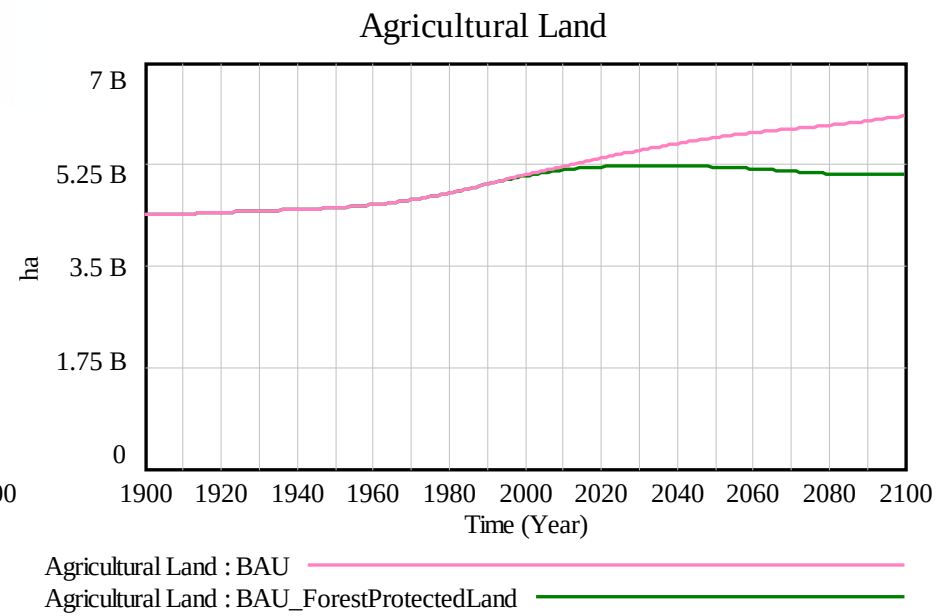




FeliX Model

Forest Protection Scenario





FeliX Model

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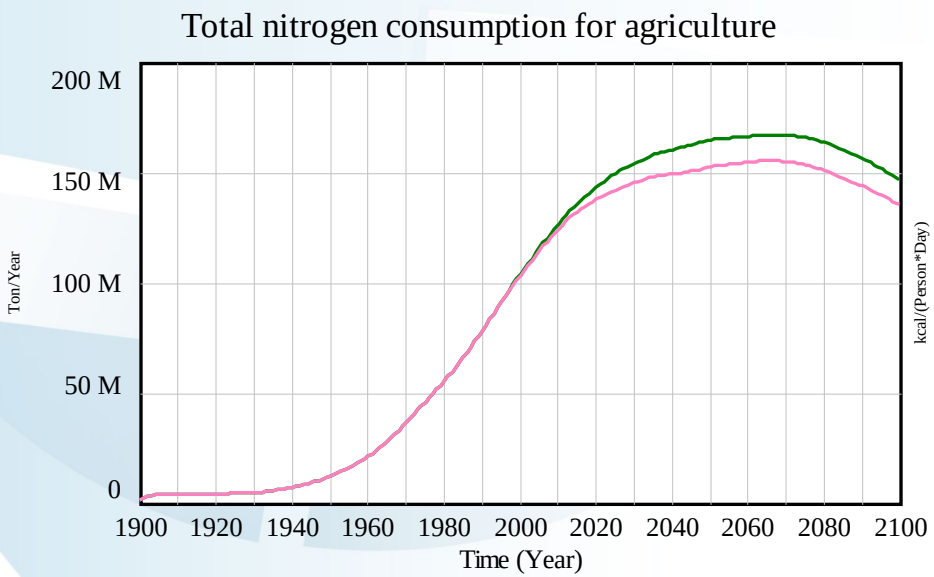

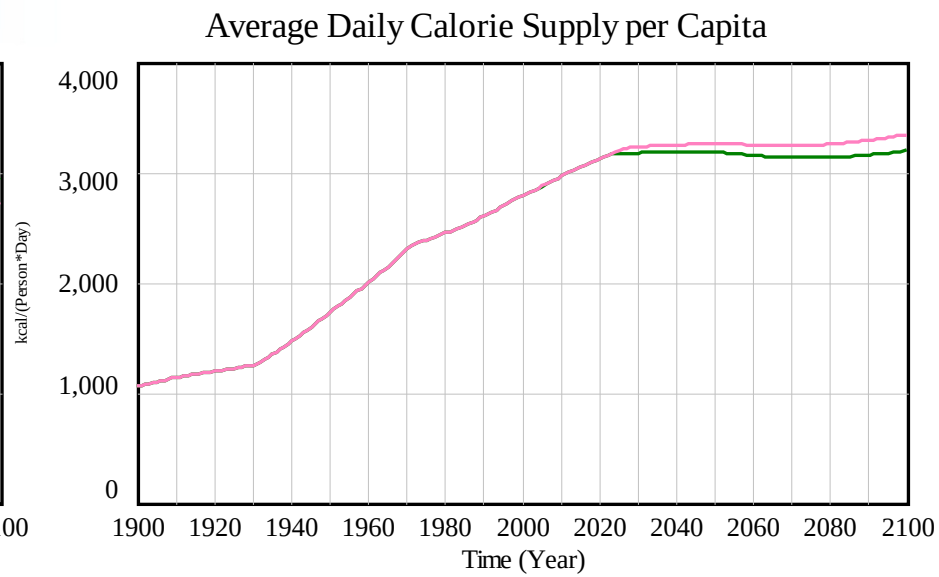

Total nitrogen consumption for agriculture : BAU
Total nitrogen consumption for agriculture : BAU_ForestProtectedLand
Average Daily Calorie Supply per Capita : BAU
Average Daily Calorie Supply per Capita : BAU_ForestProtectedLand

Conclusions

- System dynamics
  - to capture the core mechanisms behind sustainability challenges
  - to explore the future dynamics
  - to test our assumptions and policy interventions