WEF Nexus Advanced Class 2026

IHE Delft Institute for Water Education

Conceptual models and the Hoff Framework

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Outline

- Overview of Conceptual models
- From the Hoff Framework to a Conceptual model

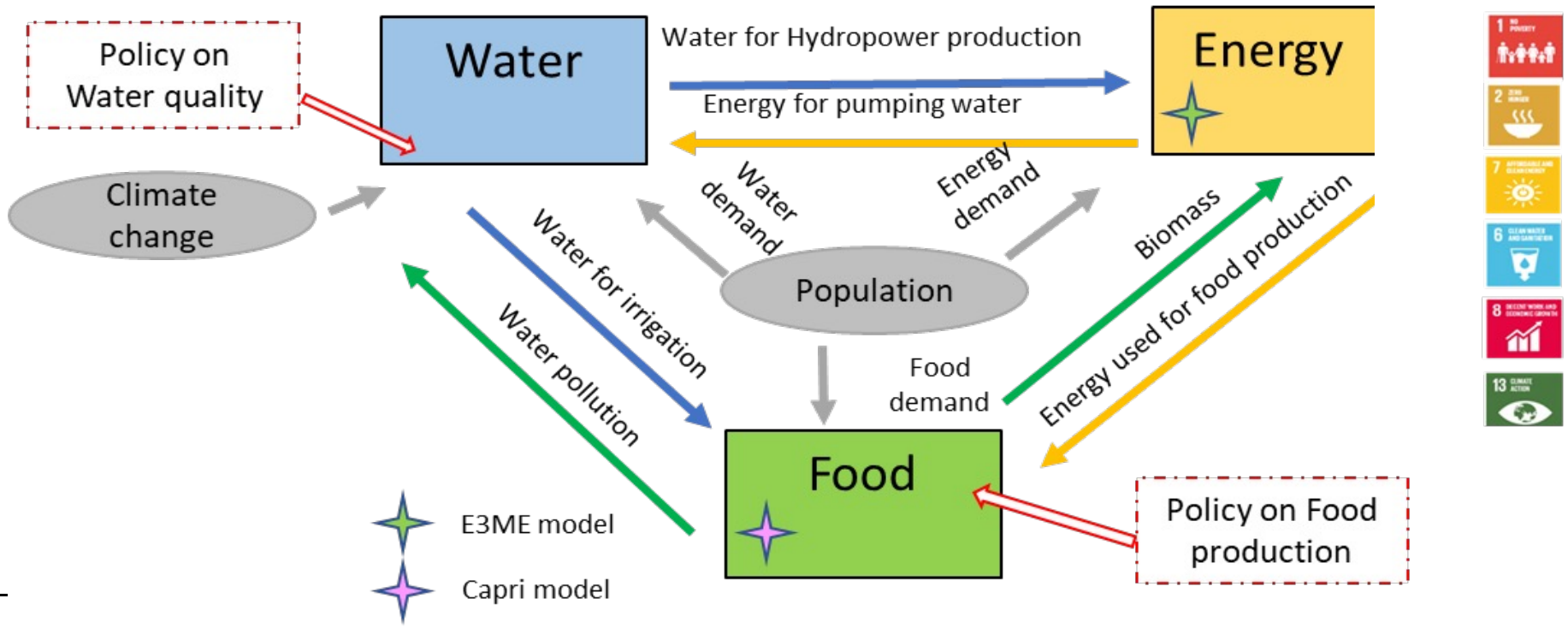
Outline

- What are conceptual models?
- Why do we use conceptual models to assess complex systems?
- How can we develop conceptual models?

What are conceptual map?

Visual aids that help to represent, understand, and analyse a system qualitatively

Graphical representation of the interlinkages between the components of a system

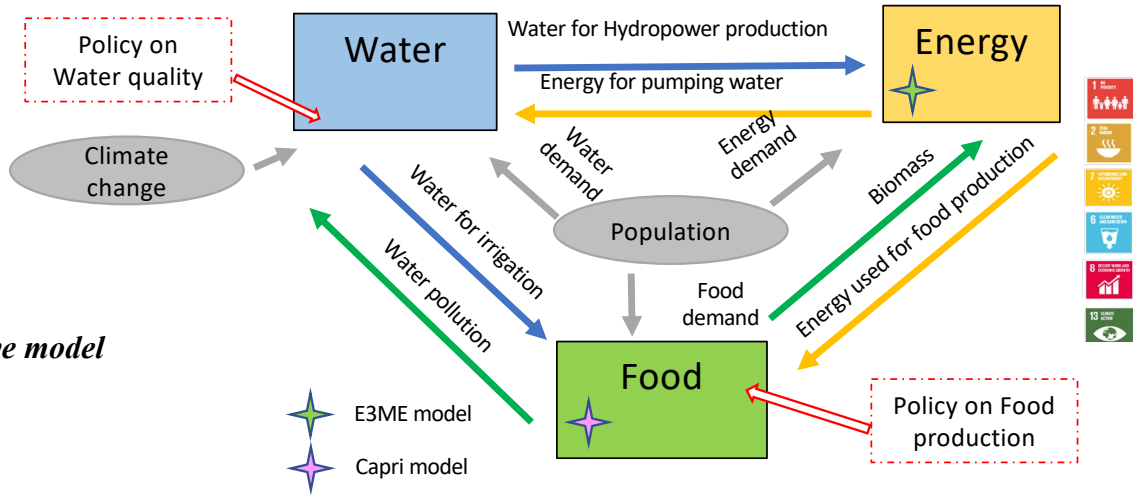


Why do we use conceptual models to assess complex systems?

To understand and visualize how components in a complex system interact with each other

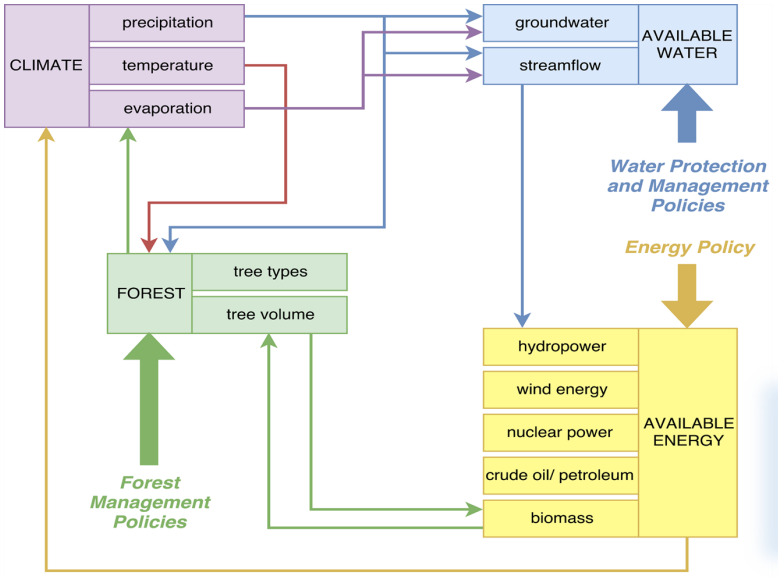
- Define system **boundaries**
- Capture the **main areas of interest and the main issues** in the case study (e.g., Water quality? Water quantity? Both?...)
- Identify the **main sectors** in the system (e.g., WEF? WEFE? WEFL?...)
- Highlight the **main interlinkages** between the sectors of the system (e.g., FW? WF? Both?)
- **How the key sectors interact each other** (**direction of the arrows**; W→F; F →W; etc…)
- **Mechanism** by which sectors interact with each other (**label in the arrows**, e.g., F → W in terms of Water pollution due to fertilizers use)

- **Driving forces** (population change, climate change impacts, etc)
- **Policies/decisions** which currently affect or may affect the system
- Identify potential **synergies and trade-offs** among sectors
  ((S) increase AW → increase Fp;
  (Tr) increase land use change, increasing pollution)
- **Stakeholders** that may be involved in each sector
- Identify **data needs, indicators, SDGs**, etc.
- *Valuable basis* ***for the development of further qualitative and/or quantitative model***

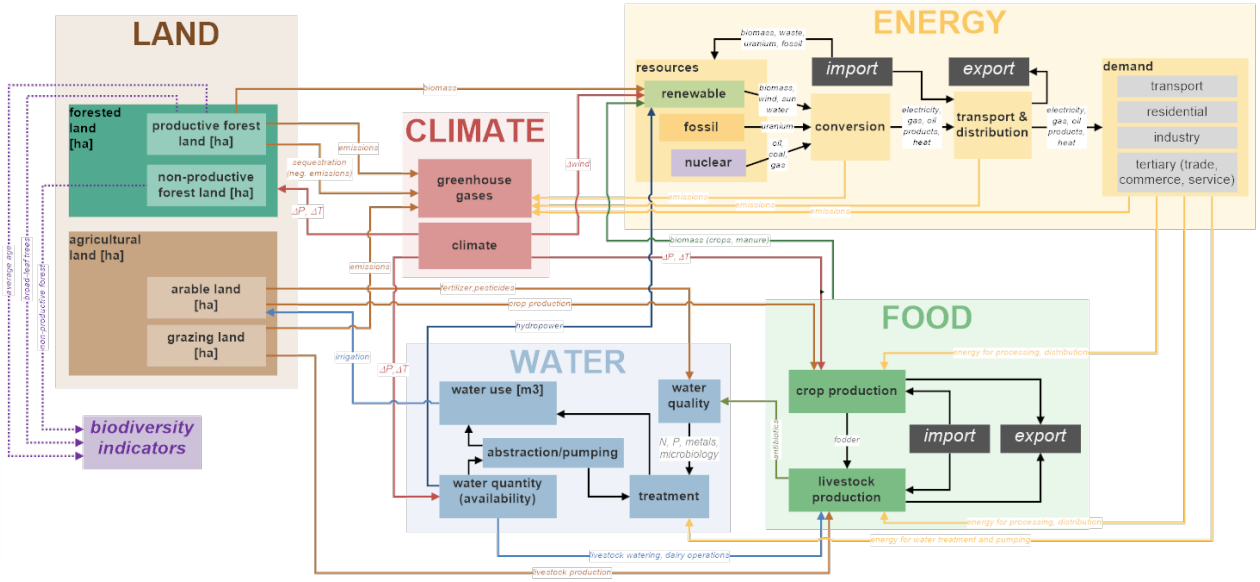


How can conceptual models be developed?

It starts in an easy way ad then it gradually becomes more complicated



Water
Land
Food
Energy
Climate



1st draft

Final draft

The conceptual map needs to be representative of the case study

How conceptual models can be developed?

To make the conceptual map as representative as possible of the system under study it should **include stakeholders and local experts inputs** from the start (if possible)

The role of stakeholders and local experts is essential to achieve on-the-ground impact

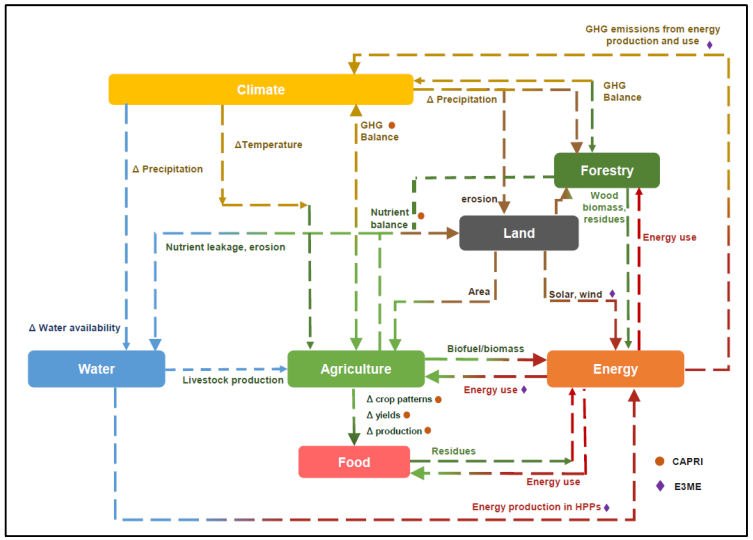
It is important to:

- Identify and engage stakeholders **from a variety of backgrounds across WEF nexus areas**
- Ensure a continued involvement of local interested stakeholders to **develop, refine, and validate** the conceptual model

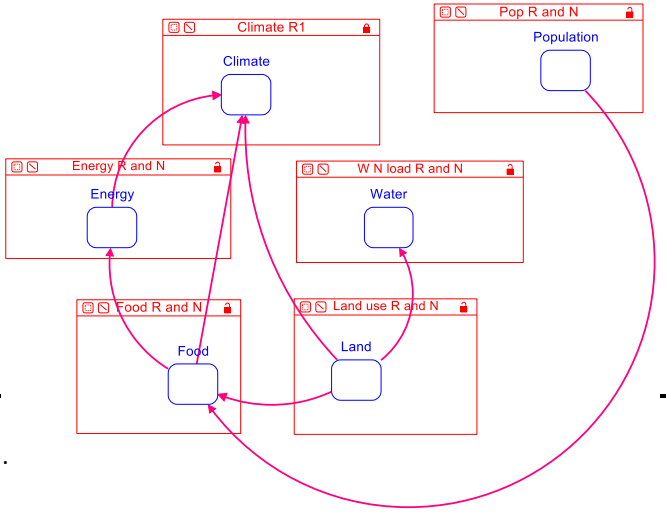
The development of the maps usually takes some **rounds of iteration**

Nexus framing	• Allow to understand the key issues from a nexus perspective • Explores the interlinkages between the different sectors • Includes synergies and tradeoffs which could be relevant for the case study
Nexus opportunities	• Identifies how a nexus approach could add value in the respective context (e.g., increasing climate resilience)
Technical and economic nexus solutions	• Assesses, and when possible quantifies, the potential benefits from the implementation of the nexus approach (e.g., benefit of potential increase in irrigated land and crop yield)
Stakeholders involved	• Specifies the different types and levels of stakeholders involved in the case study, their respective roles, and what is required to make it successful (e.g., private or public sectors, academia, NGOs, ministries, etc)
Framework conditions	• Addresses relevant conditions and context factors including type (technical solutions, policy solutions, mix of measures), scale and level (e.g., farm-level, community-level, national-level etc.), and the actual implementation of a nexus approach
Monitoring, evaluation and next steps	• Defines indicators and required data for monitoring and evaluation of the implementation of the nexus approach • Provides an outlook to the potential of the case study for replication and upscaling

Hoff Framework, qualitative tool



e.g., Conceptual maps. Qualitative tool



e.g., System Dynamics model. Quantitative tool

- Conceptual model can be used as a base for further analysis (qualitative and/or quantitative)
- Other previous analyses can be used as a base for the development of conceptual models

- What is the Hoff WEF Nexus analytical framework?

A Nexus Approach for the MENA Region—From Concept to Knowledge to Action (Hoff et al., 2019)

A practice-oriented analytical framework which enables comparative analysis and guidance for future nexus implementation

6 categories to in detail describe and analyse the case study:

1. Nexus framing
2. Nexus opportunities
3. Technical and economic nexus solutions
4. Stakeholders involved
5. Framework conditions
6. Monitoring, evaluation and next steps

Nexus framing	
Nexus opportunities	
Technical and economic nexus solutions	
Stakeholders involved	
Framework conditions	
Monitoring, evaluation and next steps	

Hoff et al., 2019 https://www.frontiersin.org/articles/10.3389/fenvs.2019.00048/full

- What is the Hoff WEF Nexus analytical framework?
- How can we develop it?

1) Nexus framing:

Allows to:

- identify the key sectors and issues from a nexus perspective
- identify the interlinkages between the different sectors
- identify synergies and tradeoffs which could be relevant to the case study

2) Nexus opportunities:

- Identifies how a nexus approach could add value in the respective context
  (e.g., reducing resource and environmental degradation, reducing human insecurities/poverty/unemployment.

Increasing water and energy efficiencies can improve agricultural productivity; solar energy and seawater for improving water availability and agricultural/biomass production, etc)

3) Technical and economic nexus solutions:

- Assesses, and when possible quantifies, the potential benefits from the implementation of the nexus approach

(e.g., the use of drip irrigation can increase water and energy use efficiency; wastewater treatment and reuse for crop irrigation; sludge reuse and soil amendment, use of solar water pumps for irrigation, etc)

Hoff et al., 2019 https://www.frontiersin.org/articles/10.3389/fenvs.2019.00048/full

- What is the Hoff WEF Nexus analytical framework?
- How can we develop it?

4) Stakeholders involved:

- Specifies the different types and levels of stakeholders involved in the case study, their respective roles, and what is required to make it successful *(e.g., private or public sectors, academia, NGOs, ministries, etc)*

5) Framework conditions:

- Addresses relevant conditions and context factors including type (technical solutions, policy solutions, mix of measures), scale and level (e.g., farm-level, community-level, national-level etc.), and the actual implementation of a nexus approach

(e.g., investments, subsidies, legislation, policies, plans and strategies, knowledge transfer, technical assistance, etc)

6) Monitoring, evaluation and next steps:

- Defines indicators and required data for monitoring and evaluation of the implementation of the nexus approach (e.g., monitoring *re-use of treated wastewater in agriculture as an alternative source of water; monitoring knowledge transfer; monitor cooperation between different sectors, etc*)

- Provides an outlook to the potential of the case study for replication and upscaling

Hoff et al., 2019 https://www.frontiersin.org/articles/10.3389/fenvs.2019.00048/full

….From Hoff framework to Conceptual model…

Nexus framing	• Allow to understand the key issues from a nexus perspective • Explores the interlinkages between the different sectors • Includes synergies and tradeoffs which could be relevant for the case study
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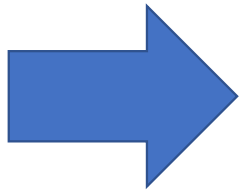
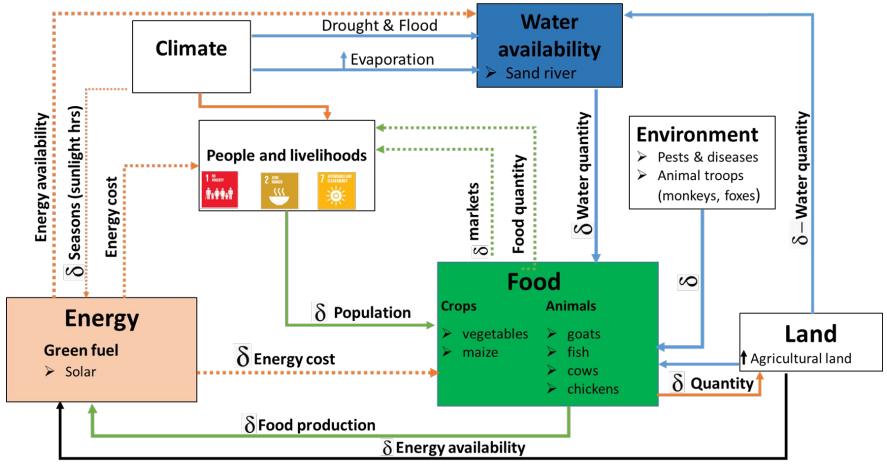
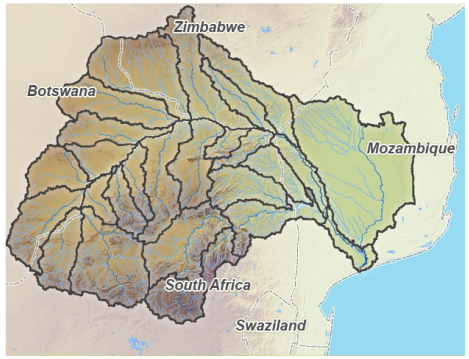




- How can we develop the Hoff Framework?

- Example

Limpopo case study → Sand rivers aquifers in southern Zimbabwe



- Main activities:
- Dryland farming and livestock herding
- Rainfed agriculture is predominantly maize, combined with groundnuts, sorghum, millet and some vegetables

- The area is characterised by a single rainy season from November to March

- Annual rainfall averages about 339 mm

Rain-fed agriculture is a very unstable source of livelihood

Area and percentage of the river basin for the four riparian states.

Country	Area in each country (km²)	Percentage of the Basin
Botswana	81 400	20 %
Mozambique	79 800	20 %
South Africa	184 150	45 %
Zimbabwe	62 900	15 %
Total	**408 250**	

https://www.limpopo.riverawarenesskit.org/LIMPOPORAK_COM/EN/RIVER/HYDROLOGY/HYDROLOGY_OF_THE_LIMPOPO.HTM

- The small-scale farmers in the basin rely on water from sand rivers for irrigating their fields

Recently a shift from diesel pumps to solar-powered pumps

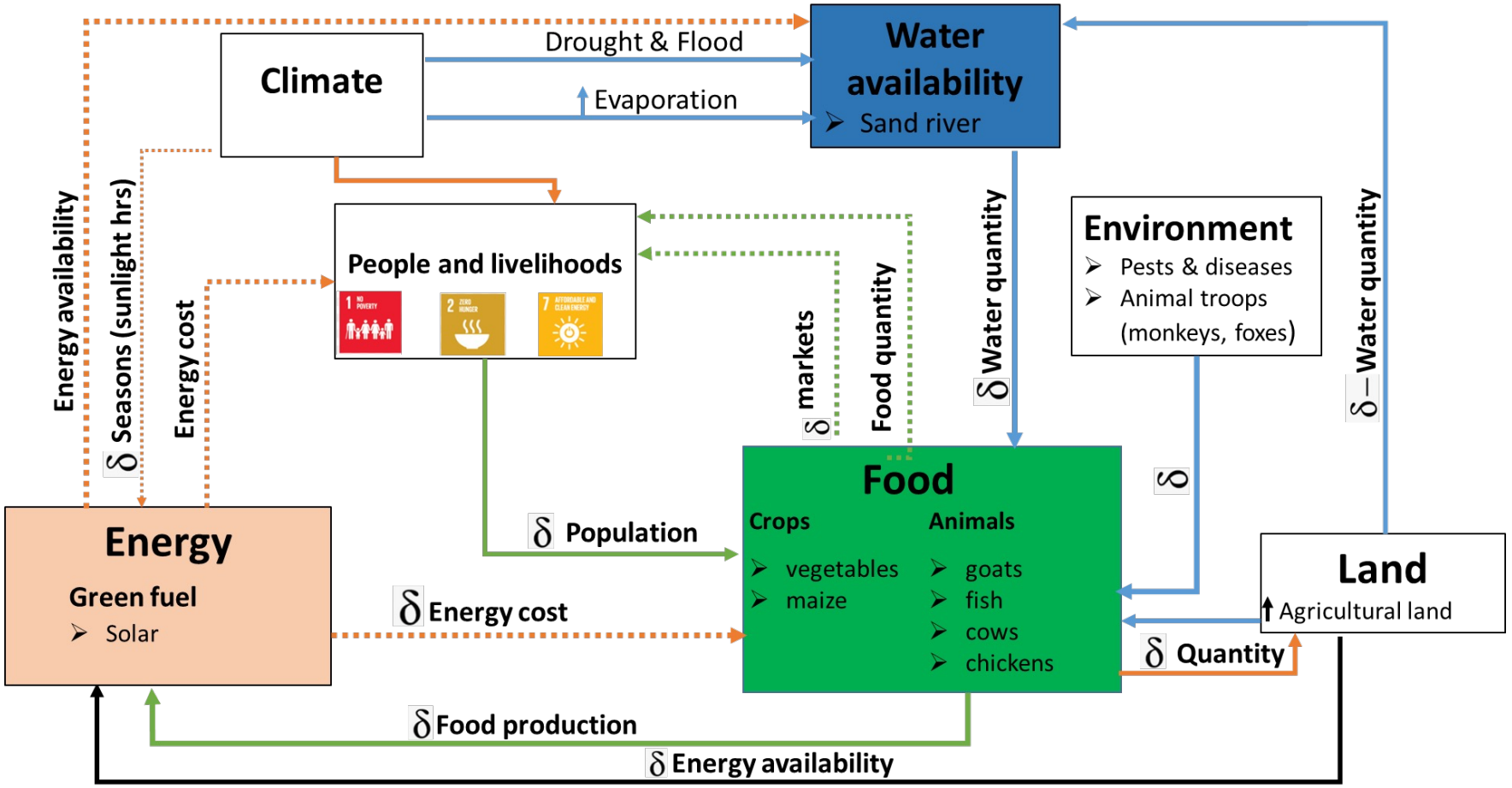
"Sand rivers are ephemeral watercourses containing sand that are occasionally flooded with rainwater runoff during the rainy season. Although the riverbed appears dry for most of the year, there is perennial groundwater flow within the sand." *Mpala et al., 2016*.

Season	Seasonal precipitation (mm/year)	Monthly precipitation (mm/month)			
		Nov.	Dec.	Jan.	Feb.
2009/10	291	81	55	53	18
2010/11	359	57	120	139	0
2011/12	271	58	96	43	30
2012/13	298	39	29	153	10
2013/14	372	71	70	74	26
2014/15	310	52	131	13	35
2015/16	289	45	35	40	43
2016/17	567	71	197	139	89
2017/18	382	72	25	32	148
2018/19	250	31	70	33	73
Mean	*339*	*58*	*83*	*72*	*47*
SD	*87*	*15*	*52*	*49*	*42*
CV	*26%*	*26%*	*62%*	*69%*	*90%*

Variability of seasonal and monthly precipitation in the cropping season, based on daily data retrieved from CHIRPS, 2019. Duker et al., 2020

Duker, A. E. C., Mawoyo, T. A., Bolding, A., de Fraiture, C., & van der Zaag, P. (2020). Shifting or drifting? The crisis-driven advancement and failure of private smallholder irrigation from sand river aquifers in southern arid Zimbabwe. Agricultural Water Management, 241, [106342]. https://doi.org/10.1016/j.agwat.2020.106342
Mpala et al., 2016. https://doi.org/10.1016/j.pce.2016.03.004

Draft High-level conceptual model of the Limpopo case study



…Work in progress…

….From Hoff framework to Conceptual model…

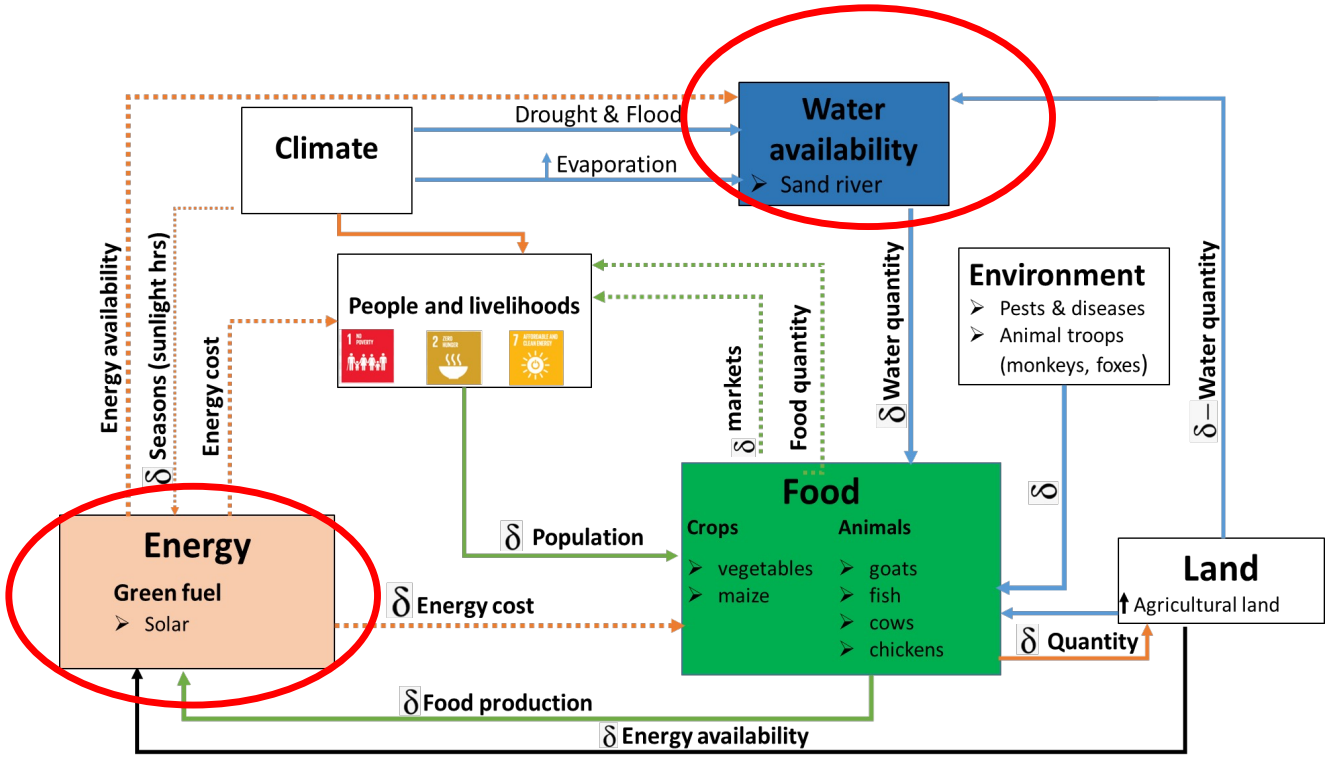
1. Nexus framing

Water

- The water is available from the sand rivers and is key for food production
- The basin faces the problem of water accessibility
- Although climate change is expected to amplify the natural variability of water, the basin has not experienced water shortages

Energy

- Solar energy is used, replacing previous diesel and petrol pumps; link to available water
- Maintenance and installation of the solar system is expensive
- Cost, availability and accessibility of solar installation and maintenance is a challenge



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Draft High-level conceptual model of the Limpopo case study

….From Hoff framework to Conceptual model…

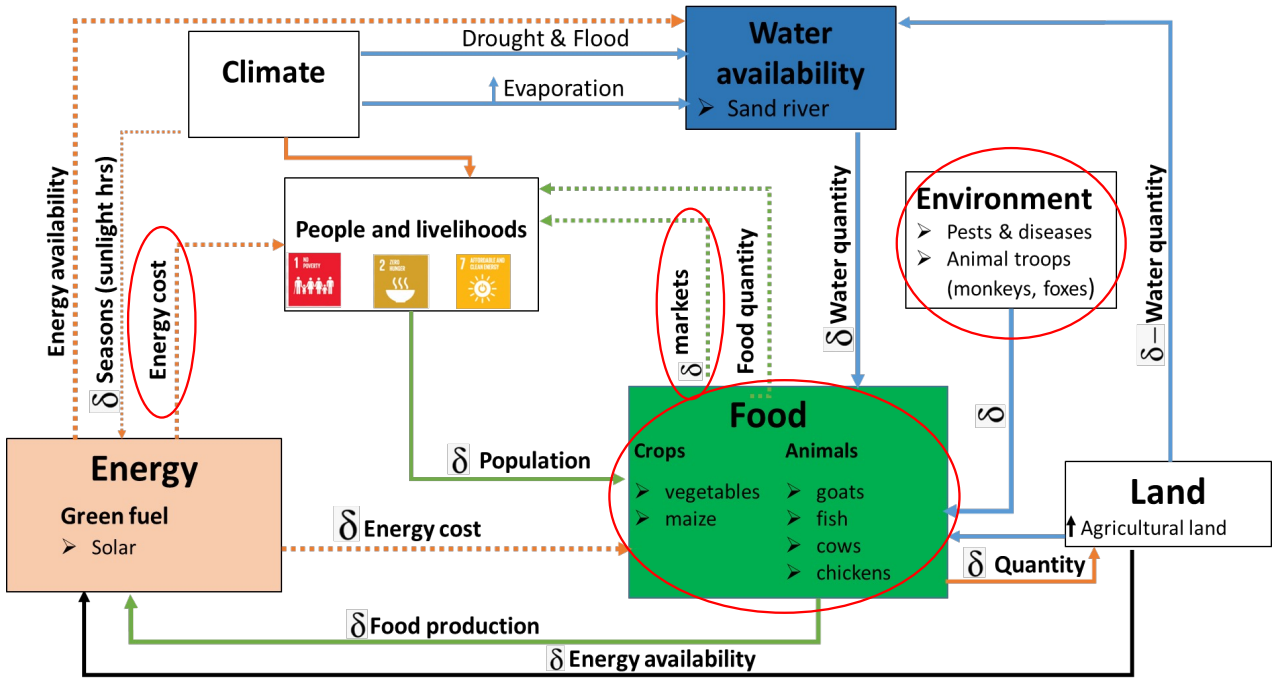
1. Nexus framing

Food

- The farmers grow covo/ kale, potatoes, tomatoes, rape, sweet potatoes, corn, carrots, pumpkins, onions, butternuts, watermelons amongst others
- They also keep goats, cows and chickens
- Planning to increase land under irrigation and add more crops
- Start fish farming

Socio-economic

- The land use change might have a considerable impact on increasing food production hence increase in profits thus improving socio-economic livelihoods of local people.
- The basin is facing challenges specifically for markets availability, cost of transport to the markets,
- Furthermore, the cost of energy (e.g., maintenance and installation) from various sources can have an impact on the socio-economic development
- Controlling of pests and diseases as well as wild animals



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Draft High-level conceptual model of the Limpopo case study

….From Hoff framework to Conceptual model…

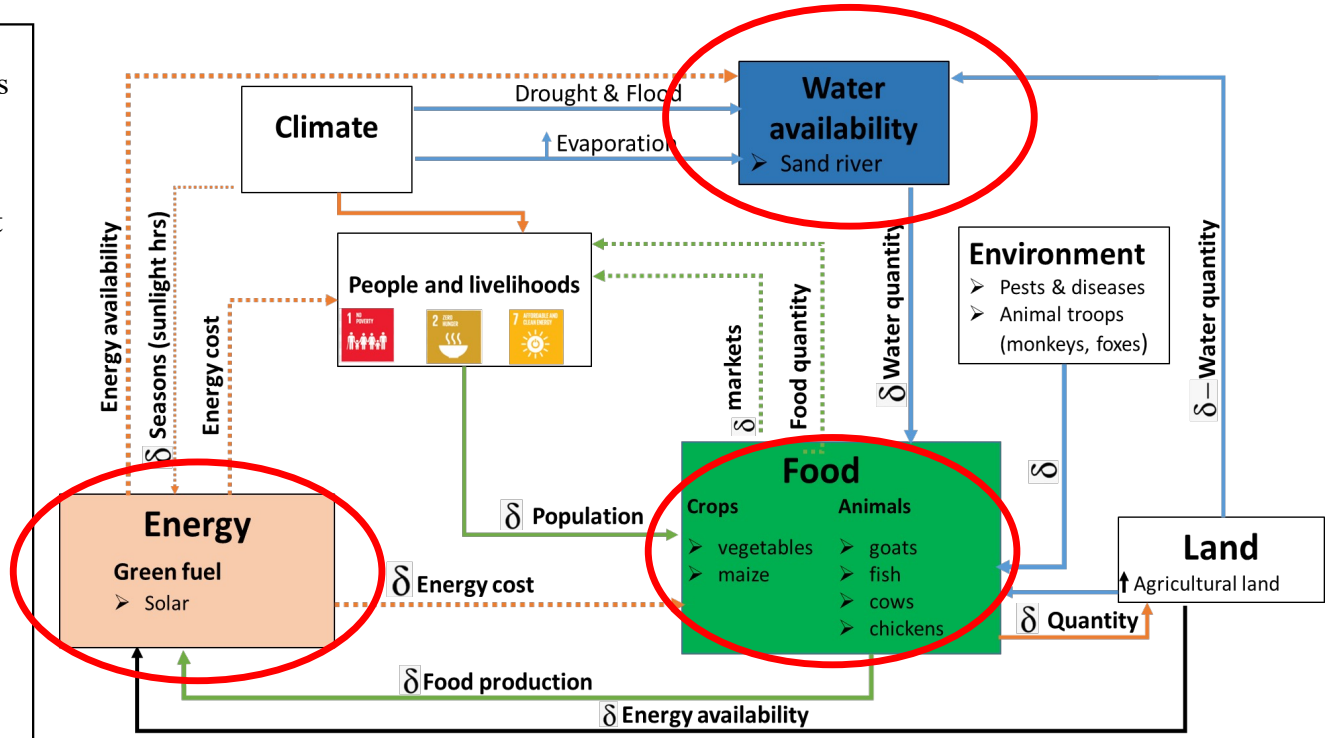
2. Nexus opportunities

The main activities in the case study are crop irrigation, livestock rearing and fish farming using water from sand rivers. The farmers are using solar energy to pump the water. Solar pumping provides energy- and climate-smart agricultural water supply and supports the shift of the energy system to renewables. With that it contributes to climate change mitigation and it can reduce the cost of irrigation and improve farmers' income and then their livelihoods.

The easy accessibility to water enhances crop diversification and yield, hence improving food security

Higher yields will lead to higher income; hence farmers can also increase the number of livestock they own.

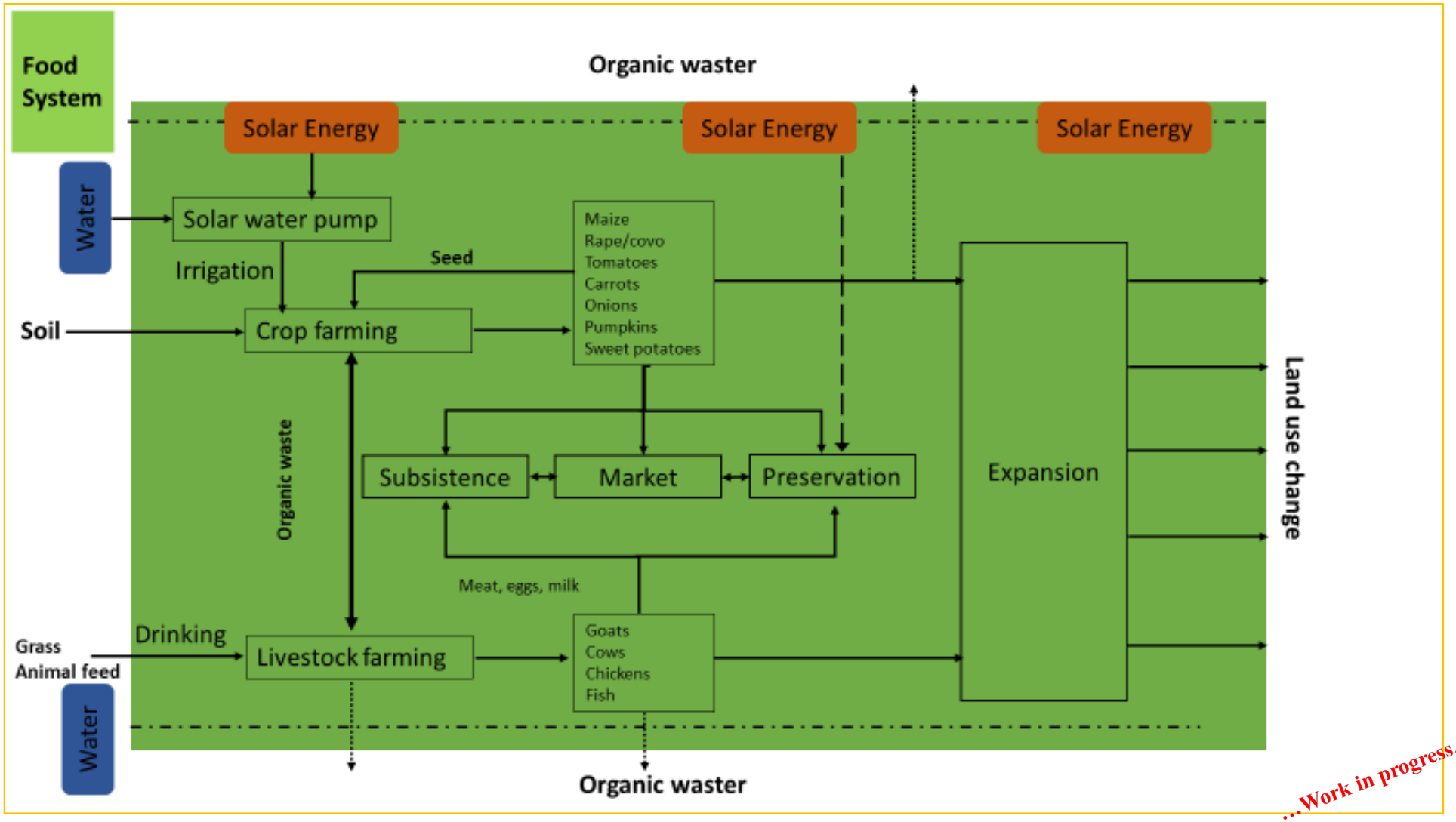
More livestock will result in more manure which can be used to increase crop yield.



…Work in progress…

Draft High-level conceptual model of the Limpopo case study

Draft of the Extended version of the FOOD sector



...From Hoff framework to Conceptual model…

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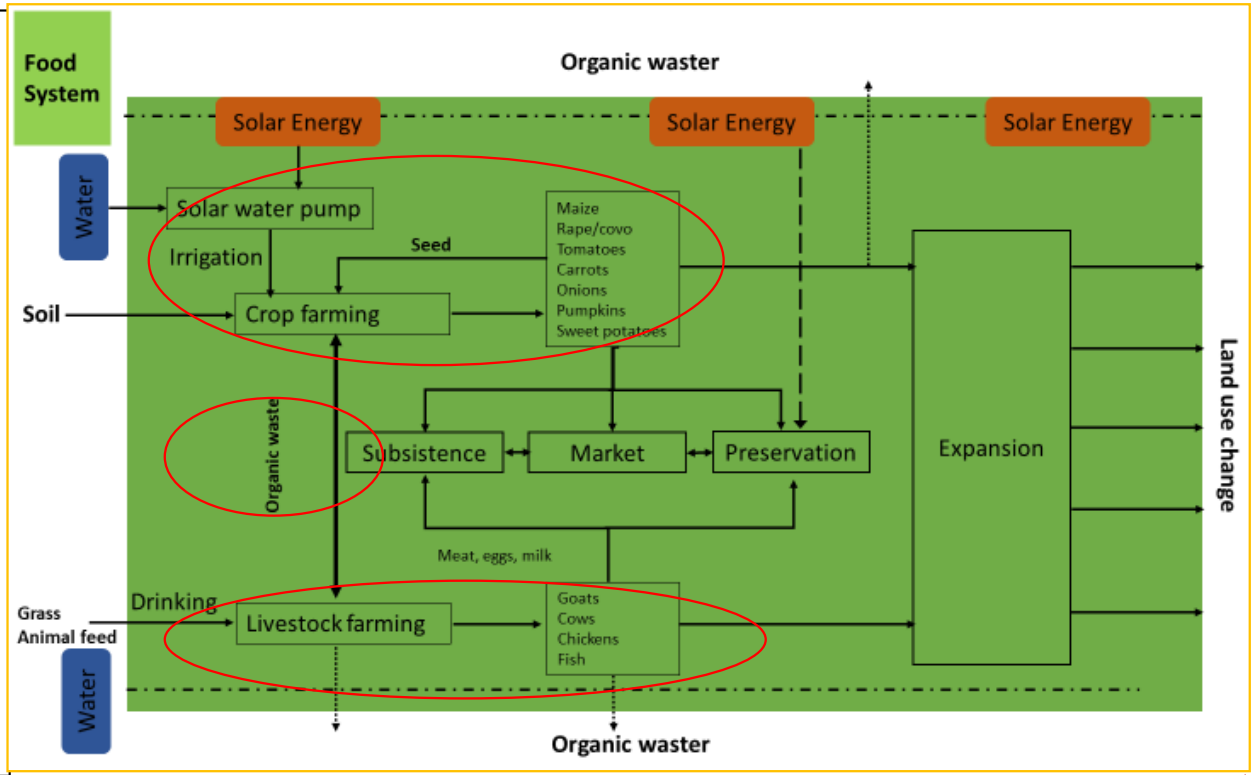
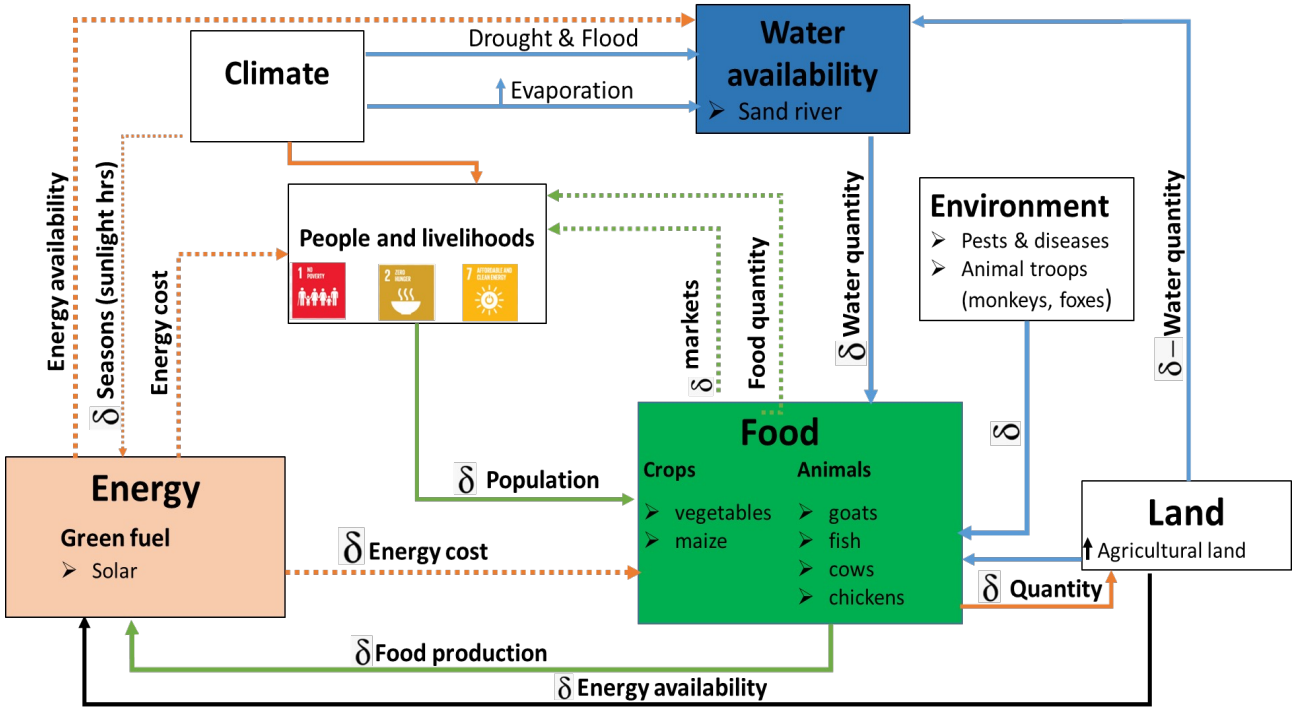


…Work in progress…

….From Hoff framework to Conceptual model…

*A **map could include***, but is not limited to:

- **Main nexus sectors** (WEF, WEFE, WEFL, etc)
- **How the key sectors interact each other** (→; ←)
- **Mechanism** by which sectors interact with each other (**labels**)
- **Driving forces** (population change, climate change)
- **Sustainable Development Goals, targets, and indicators**
- **Policies/decisions**
- **Available data and source of data**
- **Stakeholders** that may be involved in each sector
- …



Take home messages

The conceptual maps:

- Help to understand and visualize how components in a complex system interact with each other
- Start in an easy way and then they build up in complexity
- Can be developed in two parts: 1) high-level, 2) extended version
- Have to be representative of the case study
- Give a clear overview of the WEF nexus in the case study
- Have to be clear and readable
- If possible, they should be co-developed with stakeholders and local experts
- They can be used as a base for further analysis (qualitative and/or quantitative)
- Other previous analysis can be used as a base for the development of conceptual model

Thank you
for your attention

Q&A

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