Nexus Assessment on Water-Food-Energy Security: A Case for Indonesia

MAKING SENSE OF SUSTAINABLE ENERGY SYSTEMS

A new cross-college, cross-campus lunchtime seminar series

Korinus Waimbo

kw387@Exeter.ac.uk

10th April 2019

UNIVERSITY OF EXETER

Centre for Water Systems

Outline

Introduction

- About me
- Paths to my PhD

Nexus Assessment

- Defining Nexus
- Water-Food-Energy Security Nexus

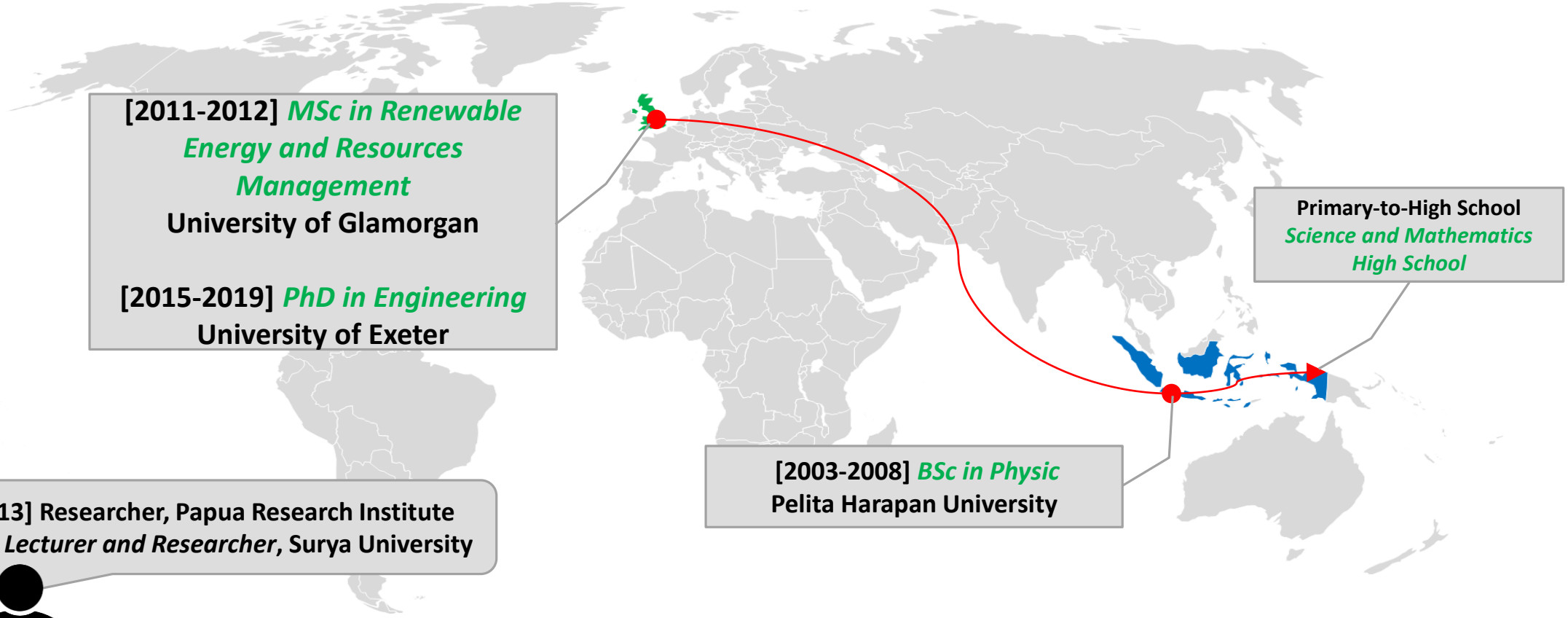
Method for WFE Nexus Assessment

- System Dynamics Modelling

Implementation

- Case for Indonesia

About me…



[2011-2012] *MSc in Renewable Energy and Resources Management*
University of Glamorgan

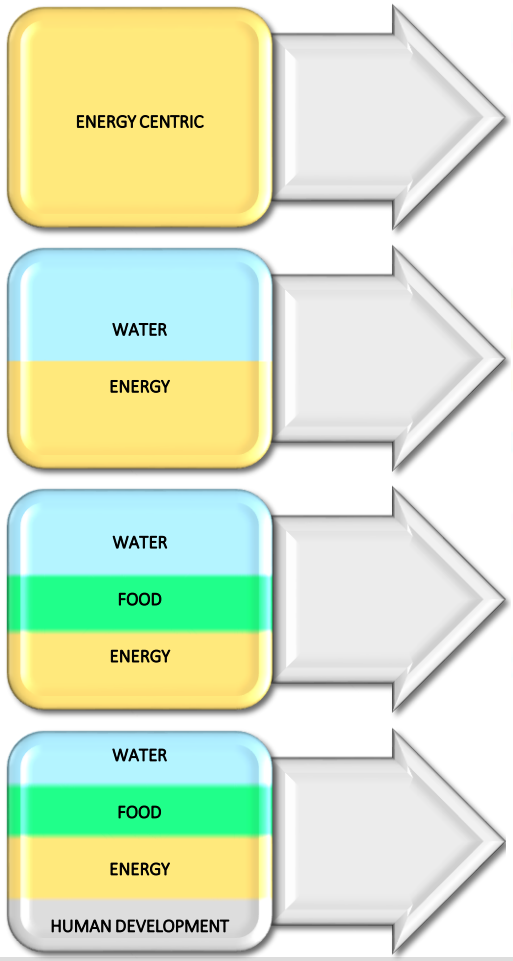
[2015-2019] *PhD in Engineering*
University of Exeter

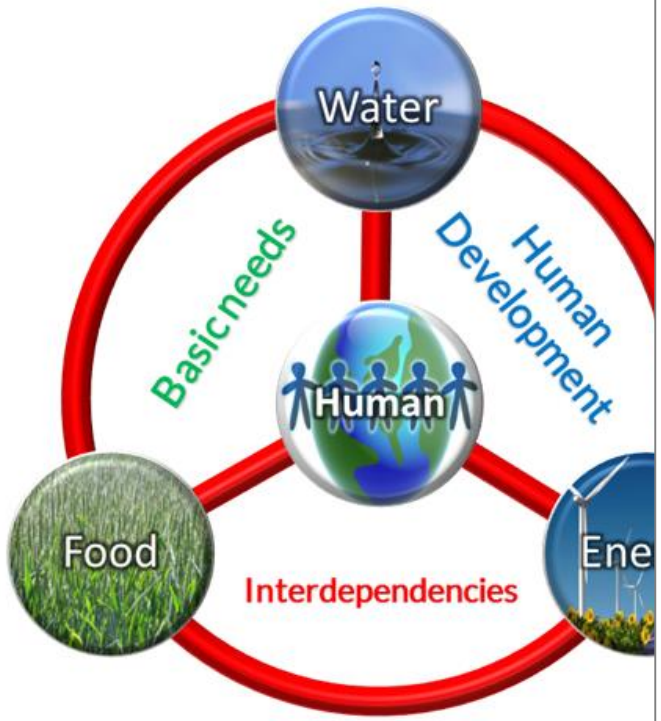
Primary-to-High School
Science and Mathematics High School

[2003-2008] *BSc in Physic*
Pelita Harapan University

[2009 – 2013] Researcher, Papua Research Institute
[2013-2015] *Lecturer and Researcher*, Surya University

Paths toward my PhD…





Nexus Implications of Water, Food, and Energy Insecurity on Human Development: A Case for Indonesia

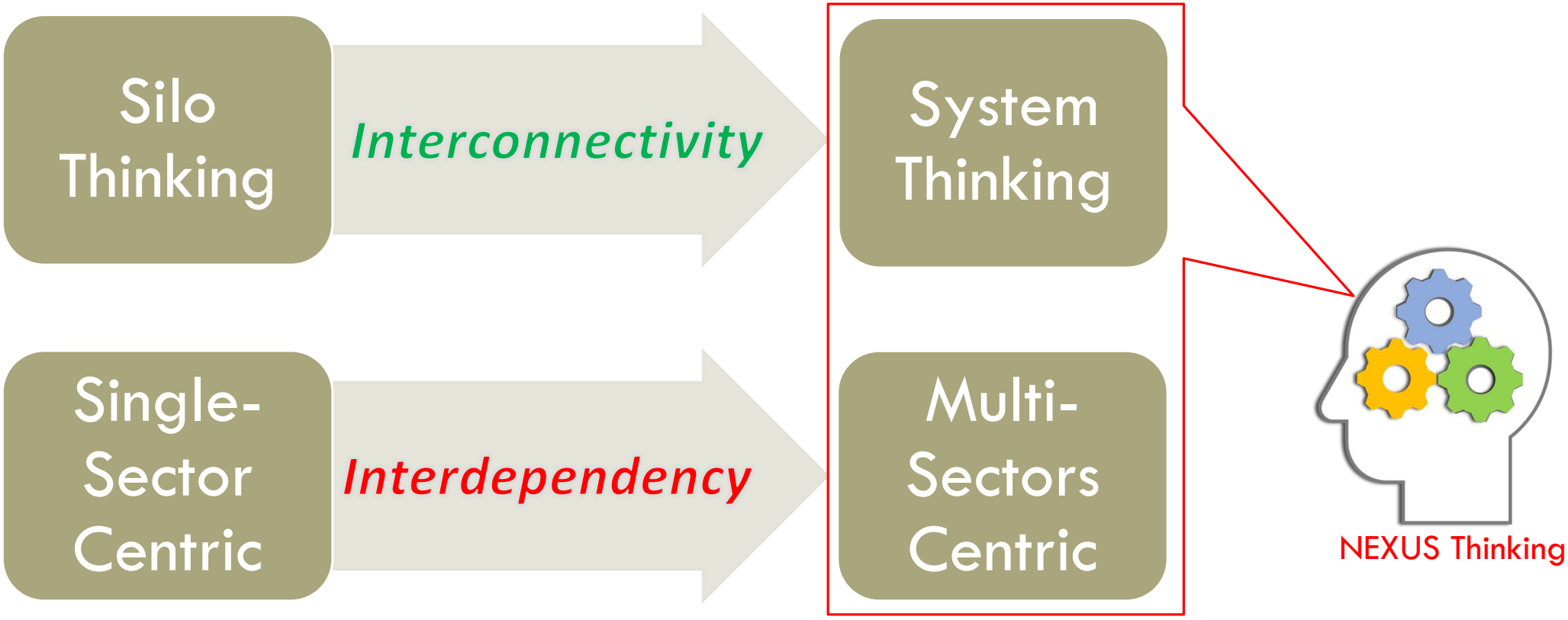
Submitted by Korinus Nixon Waimbo to the University of Exeter

as a thesis for the degree of

Doctor of Philosophy in Engineering

In May 2019

Nexus Assessment / 'Approach'



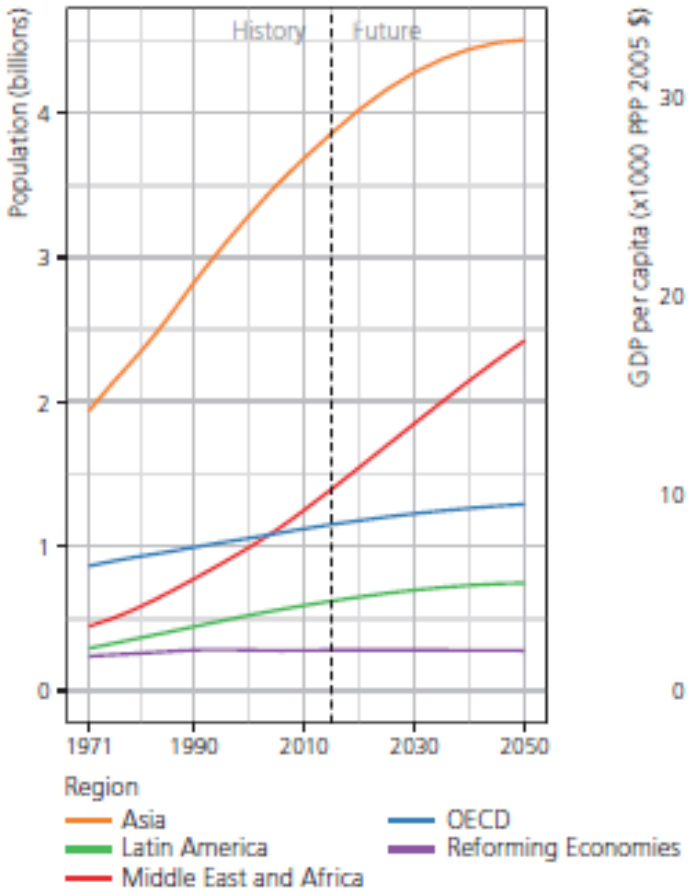
Water-Food-Energy Demand

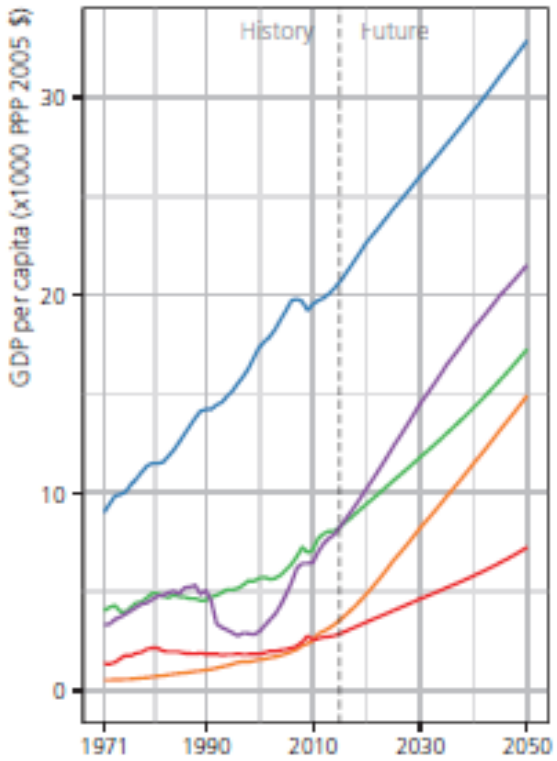
	FDM and IMAGE calculation			Other models
	Developed countries	Developing countries	World	World
Food Use	15%	29%	26%	
Food + Feed Use	45%	57%	54%	47-64%
Energy	1%	78%	50%	50-85%
Water	-26%	20%	10%	10-45%

Increase in water, food, and energy consumptions (2015-2050)

(*Van Vuuren et al., 2016*)

Driver of Changes…



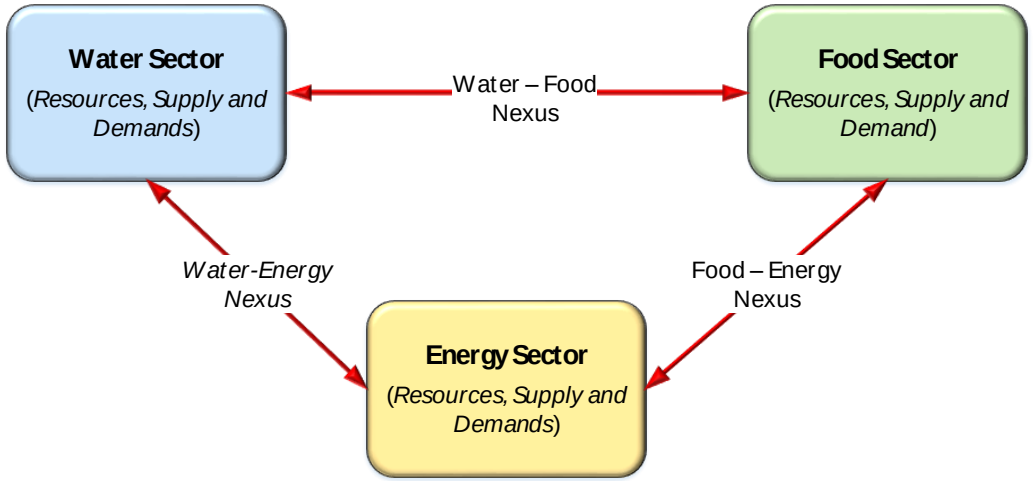


(*Van Vuuren et al., 2016*)

- The global population is projected to have grown by around 2.2 billion people by 2050, attaining a level of approximately 9.5 billion (medium projection).

- The growth rate of income (GDP per capita) in OECD countries is projected to be around 1.4% per year. In low-income regions, the income growth rates are assumed to be in the order of 3-5% per year.

Water-Food-Energy Security



F-E linkages to Water Security:

- Food system influence water resources mostly through agriculture activities
- Water supplies require energy

W-E linkages to Food Security:

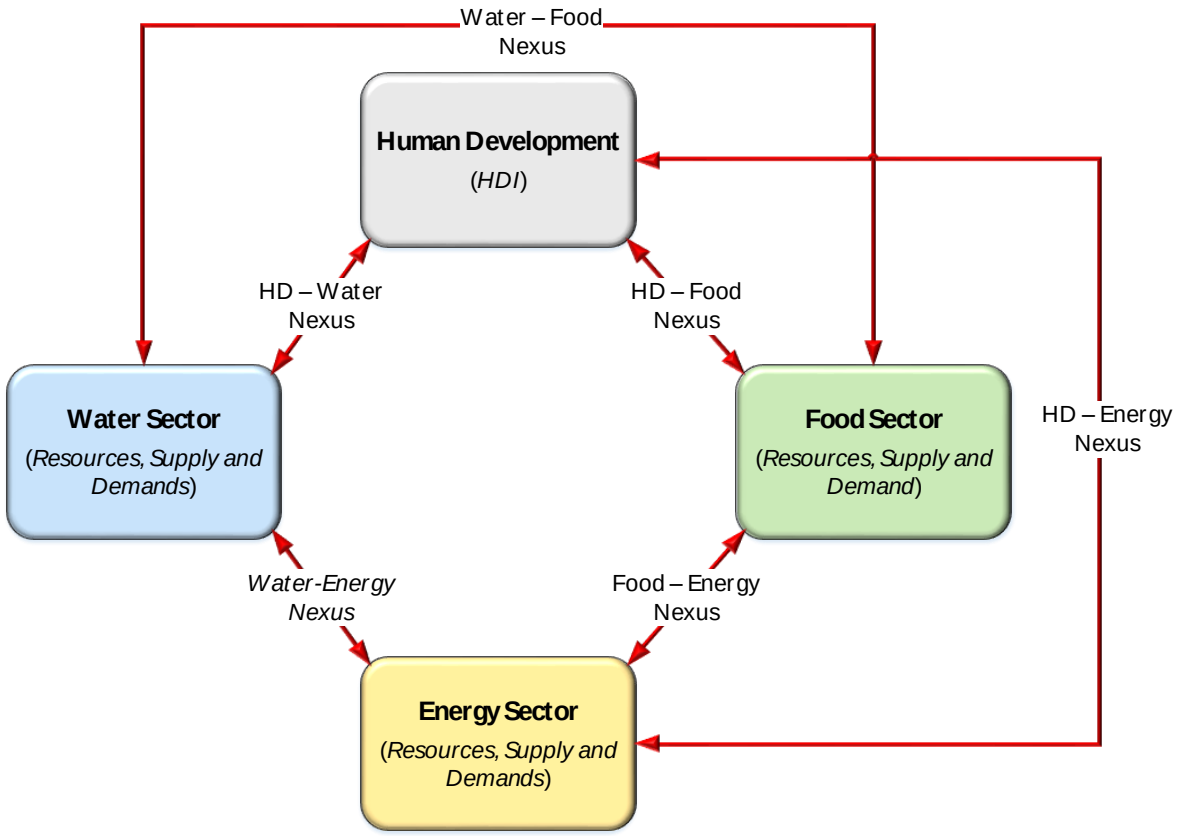
- Food production - either plant or animal production - depends on water supply and water quality
- Energy is needed in almost all food production chain to final consumption to food waste disposal

W-F linkages to Energy Security:

- Water is required in almost all energy production and electrical power generation
- Bioenergy such as biodiesel, bioethanol, and anaerobic digestion, present direct and indirect link between energy and food/food waste. Land as a means for growing food crops now can be used to grow energy crops

Continue…

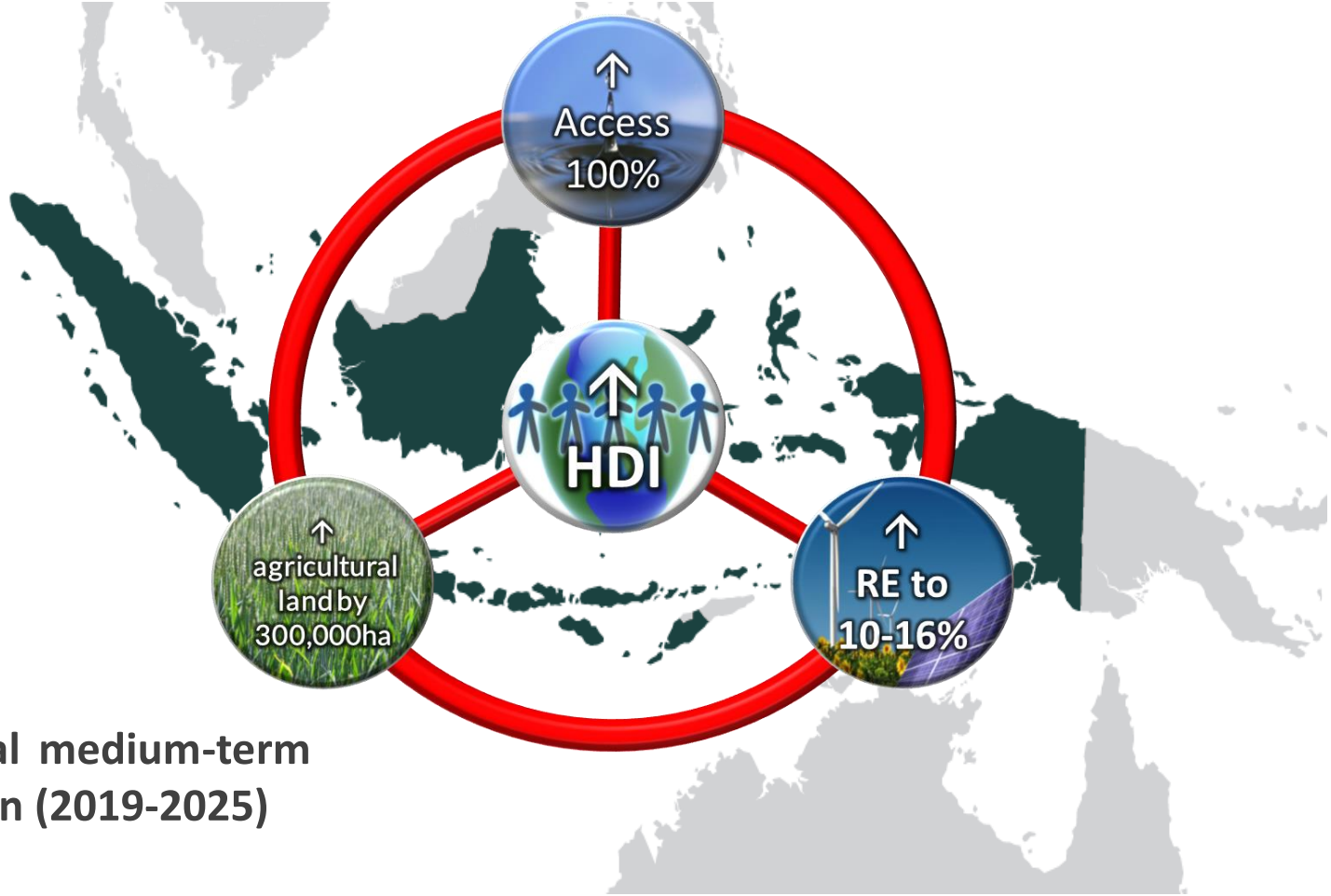
W-F-E Linkages to Human Development



WFE linkages to HDI:

- Water shortage for irrigation associate with malnutrition which could causes three years lifetime lost. (Pfister et al, 2009).
- water poverty of a nation is not related to water scarcity but, rather, with the development level and per capita GNP. (Jimenez et al, 2007)
- The expansion of sanitation contributed to a 15-year increase in life expectancy in Great Britain in the four decades after 1880 as reported in (UNDP, 2006)
- There is a strong correlation between HDI and per capita energy consumption. (Dias et al, 2006 and Martínez & Ebenhack, 2008)
- By changing the use of traditional energy conversion technology for cooking, lighting and other usage to modern and cleaner one, can increase HDI. (Ray, Ghosh, Bardhan, & Bhattacharyya, 2016)

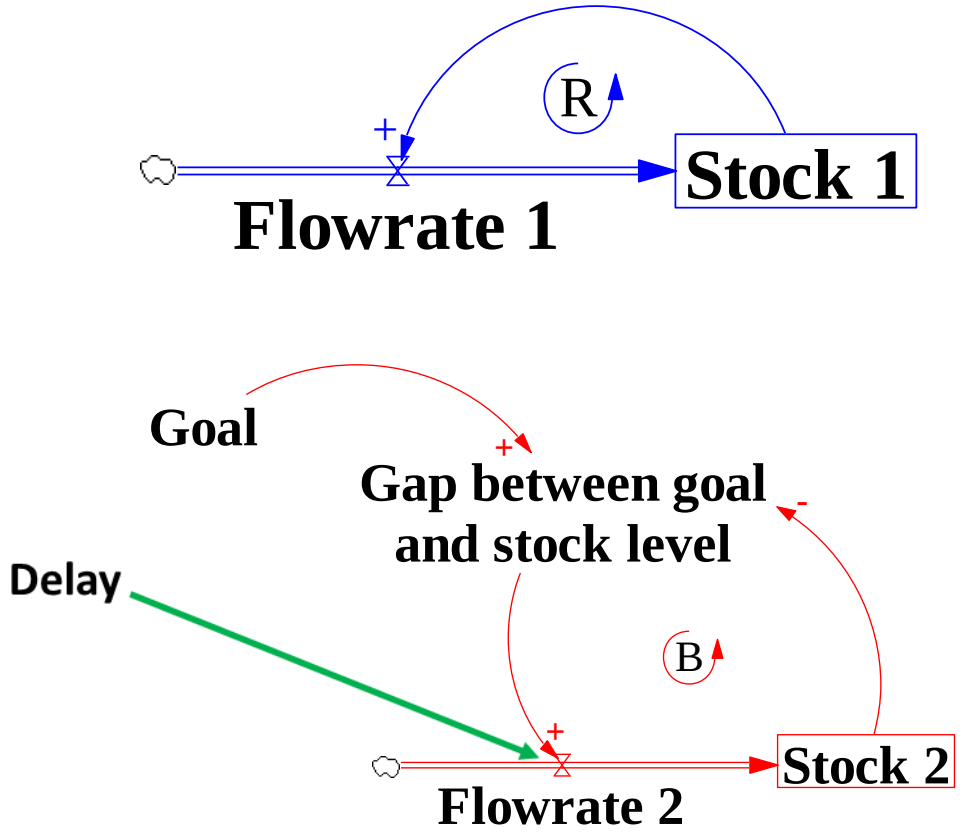
Case for Indonesia

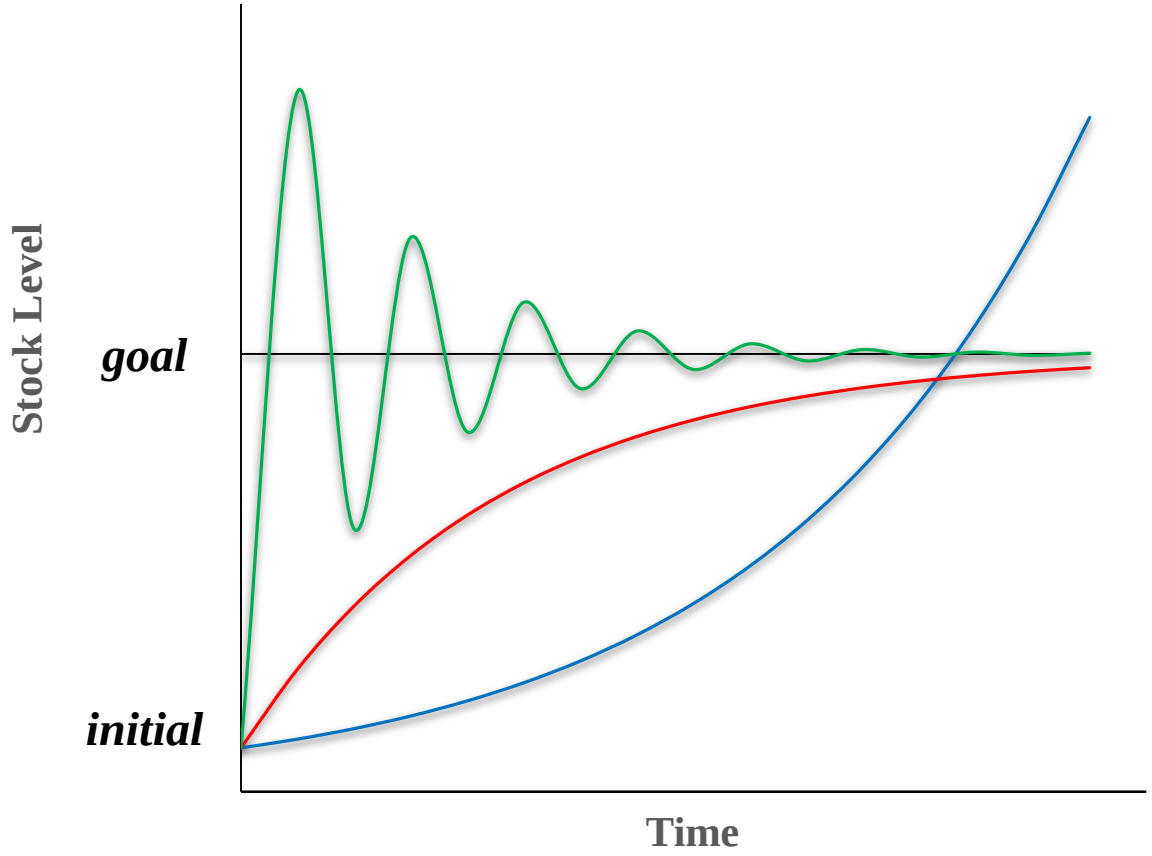


SDG and national medium-term development plan (2019-2025)

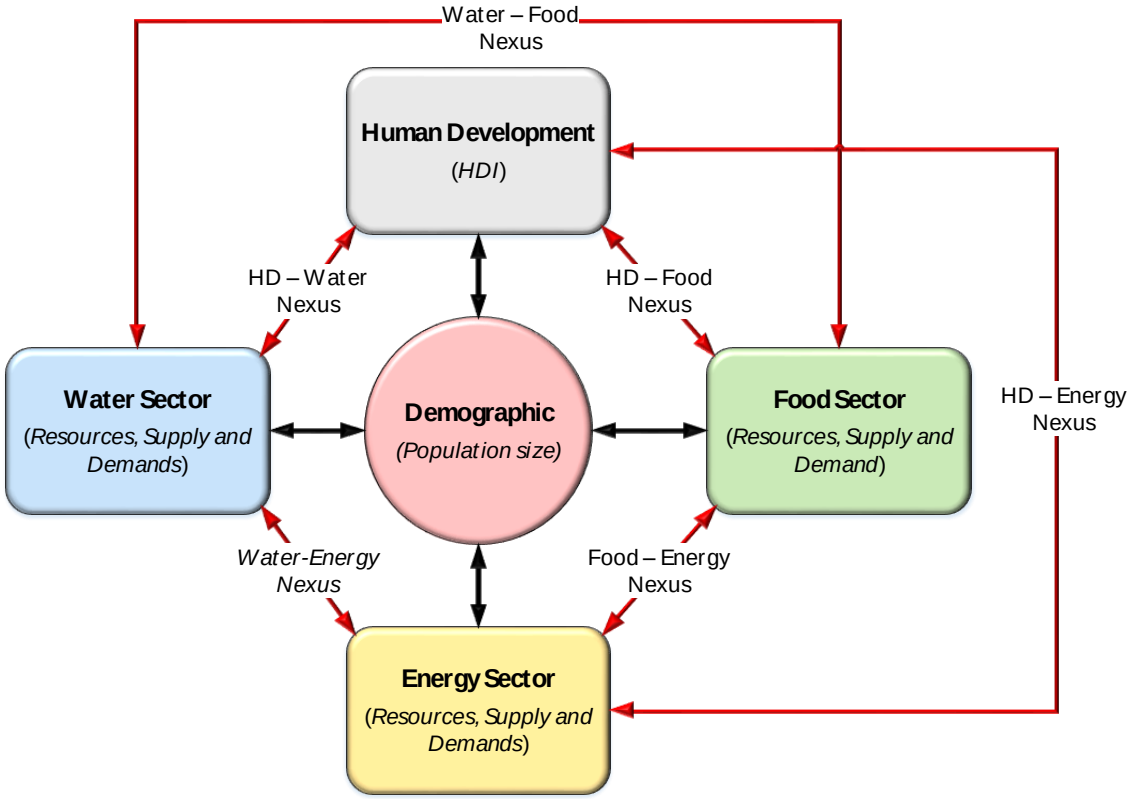
[Bellfield, et al., 2017]

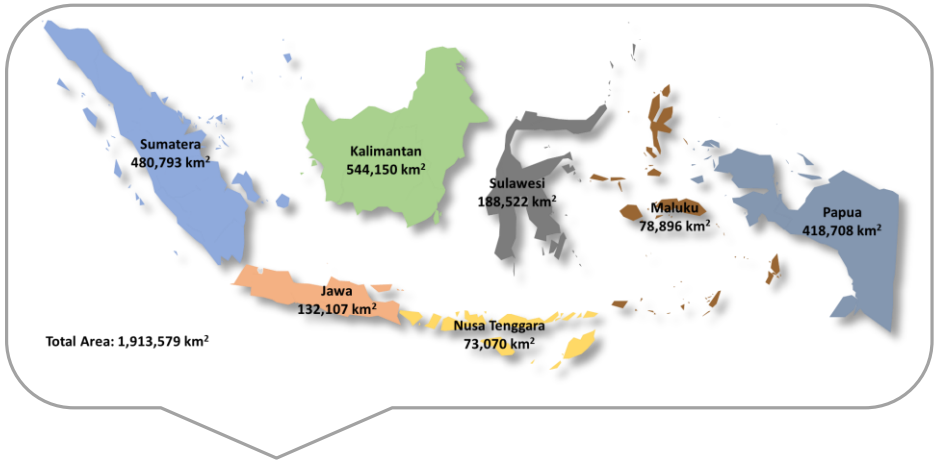
System Dynamic Modelling



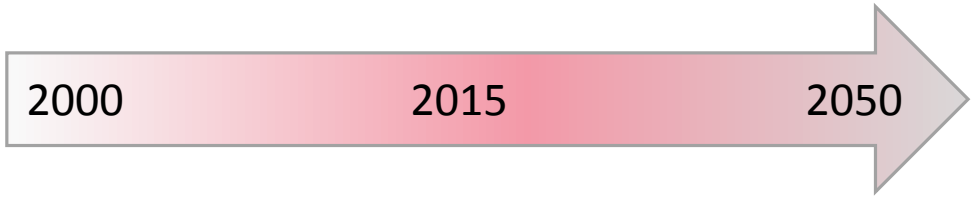


System of Interest



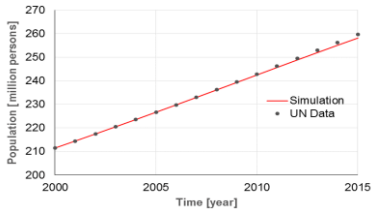


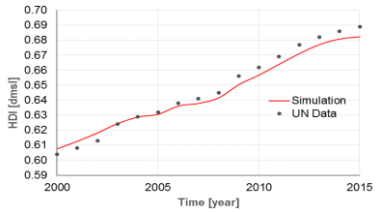
National Scale

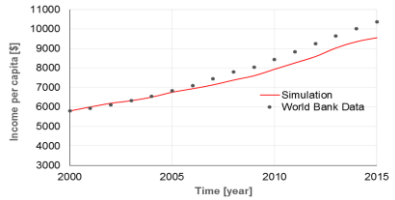


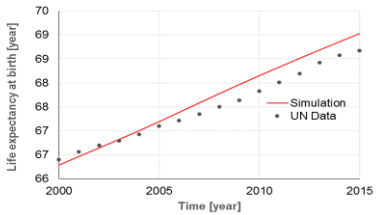
Annual Timestep

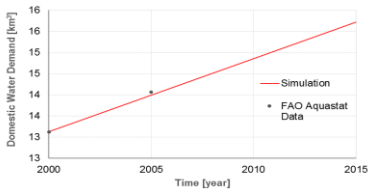
Model Structure

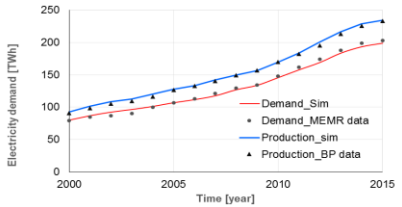


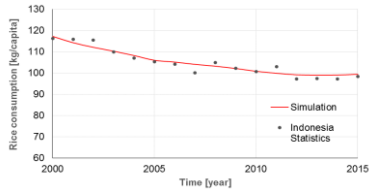












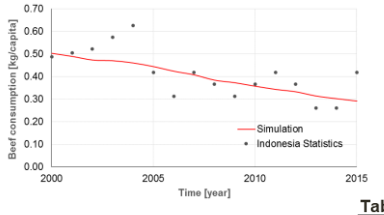
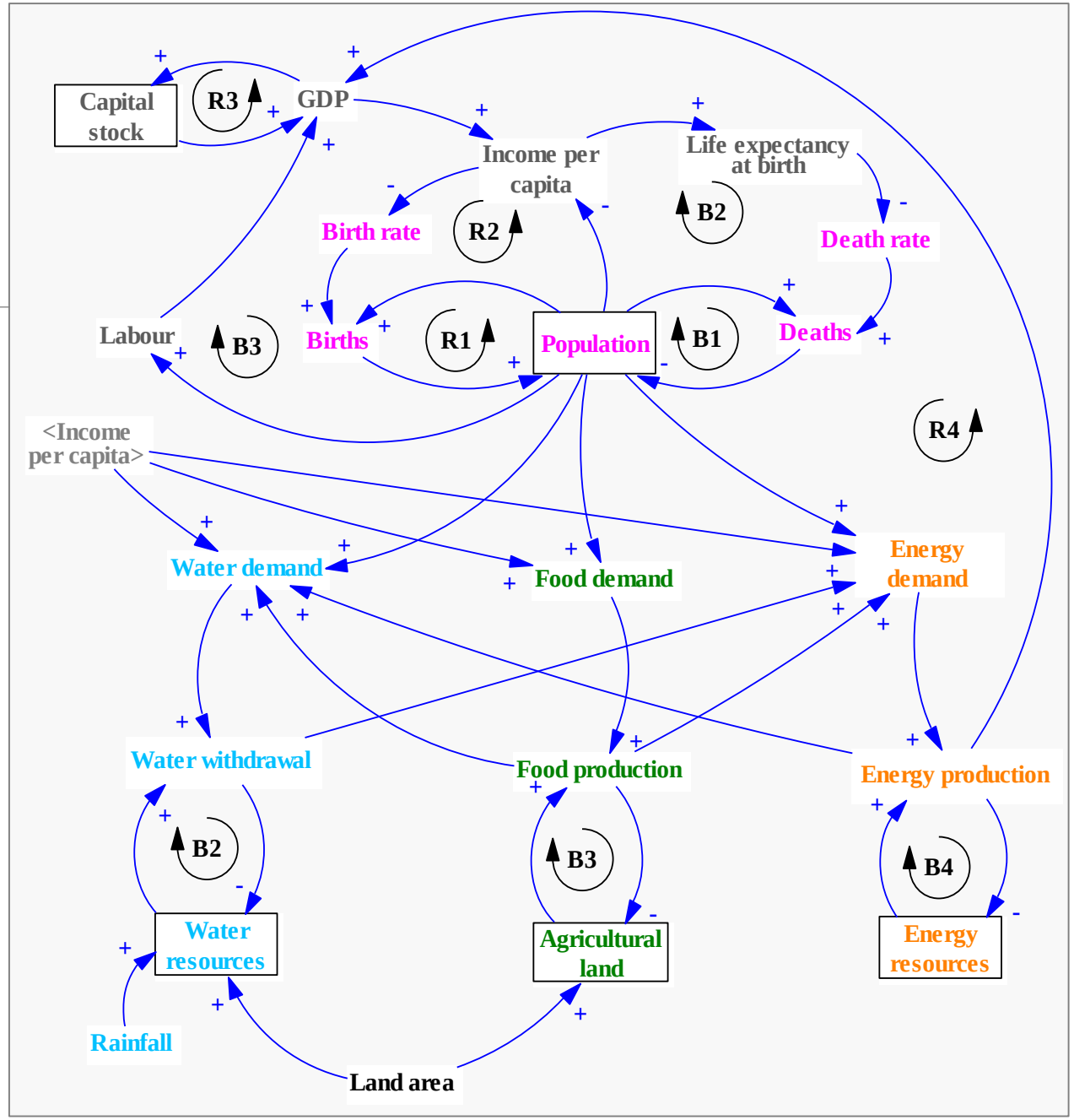


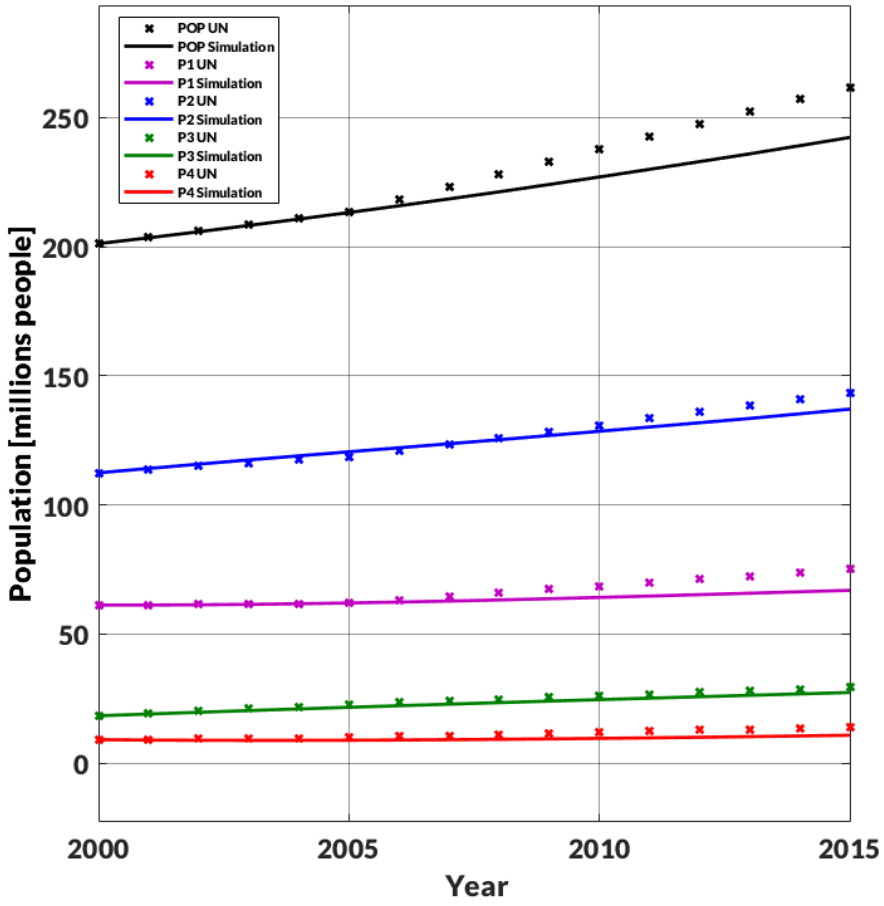
Table: Error analysis results

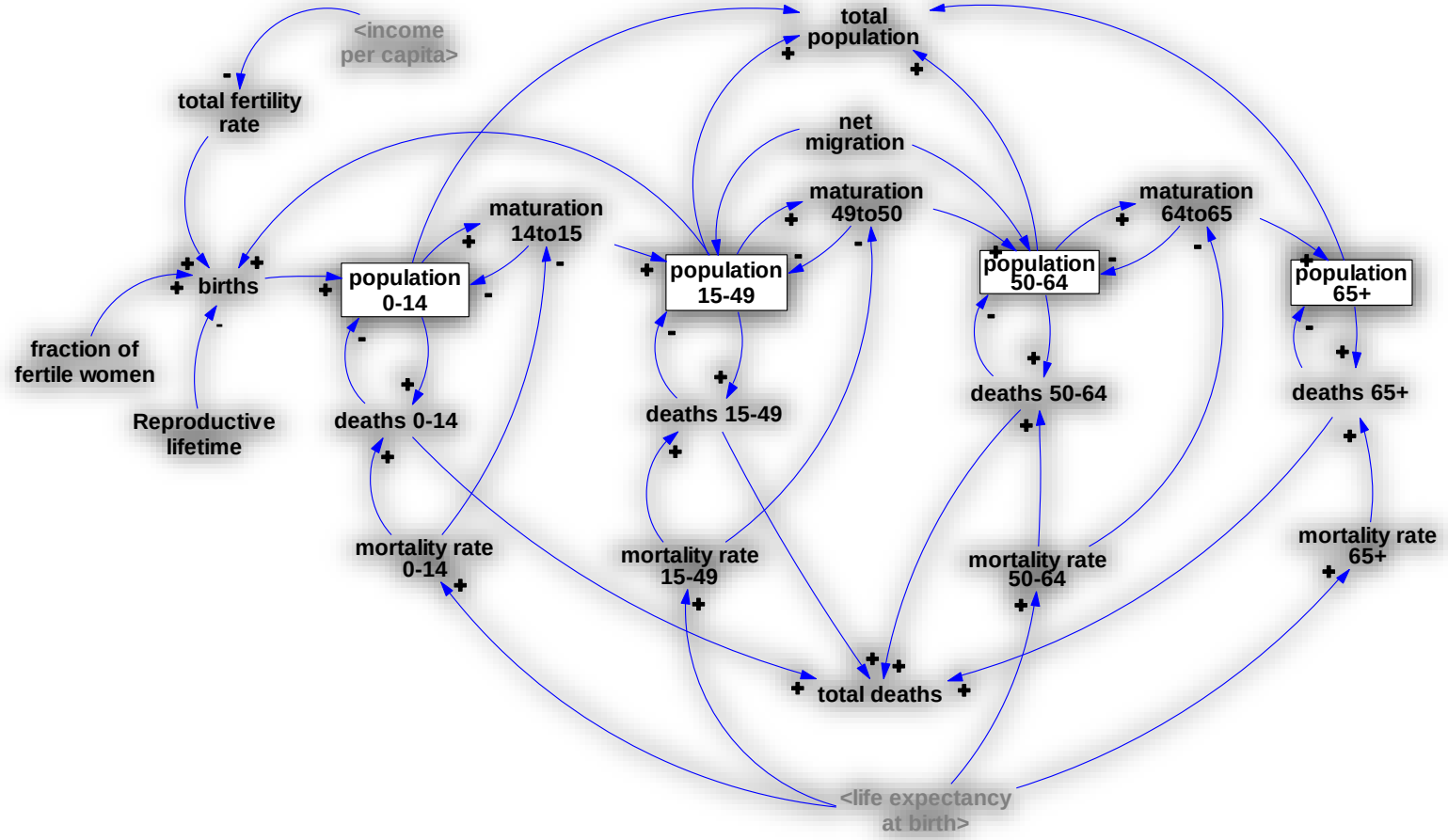
Components	Unit	MSE [unit²]	RMSPE [%]	U^m	U^c [dmsl]	U^s
Total population	*million person*	0.35816444	0.2341054	0.29902	0.54254	0.15845
HDI	*dmsl*	1.88887E-05	0.6618499	0.24147	0.62798	0.13055
Income Per Capita	*$*	190445.226	4.7826427	0.55712	0.41892	0.02396
Life Expectancy at Birth	*year*	0.05482469	0.3445307	0.55701	0.36108	0.08191
Domestic Water Demand	$10^9\ m^3$	0.04506629	1.3634738	0.59645	0.39435	0.0092
Electricity Production	*TWh*	5.55599966	1.7373286	0.57689	0.0003	0.42281
Electricity Demand	*TWh*	12.6106259	2.9805814	0.07301	0.64592	0.28107
Rice Demand	*kg/capita*	3.54331451	1.8063779	0.024	0.14576	0.83024
Beef Demand	*kg/capita*	0.00531133	17.276876	0.04903	0.22543	0.72554



Continue…

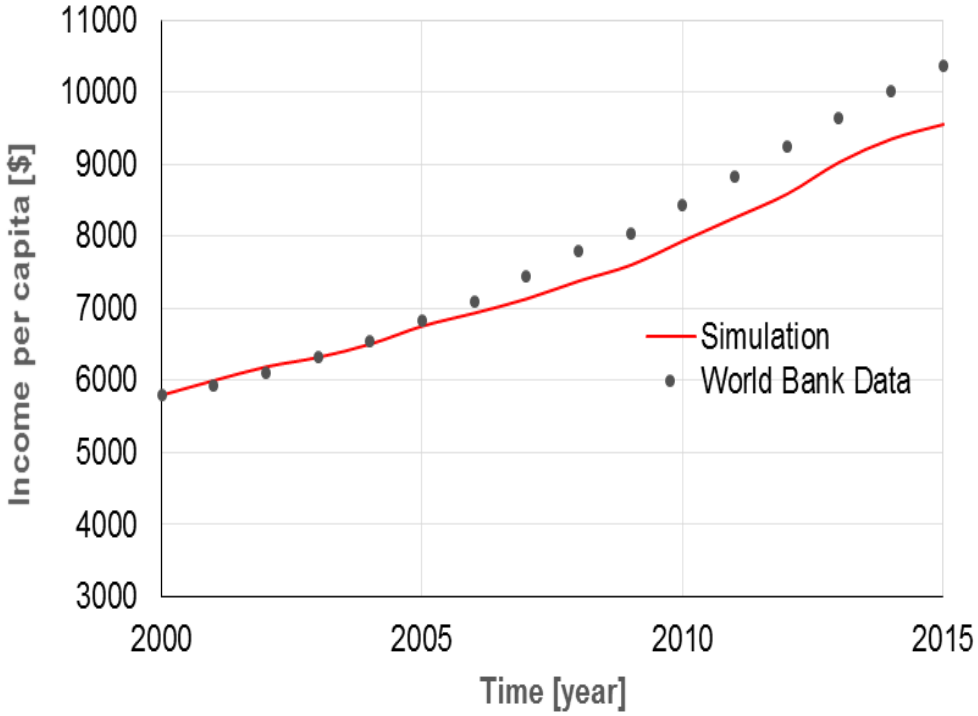
Population



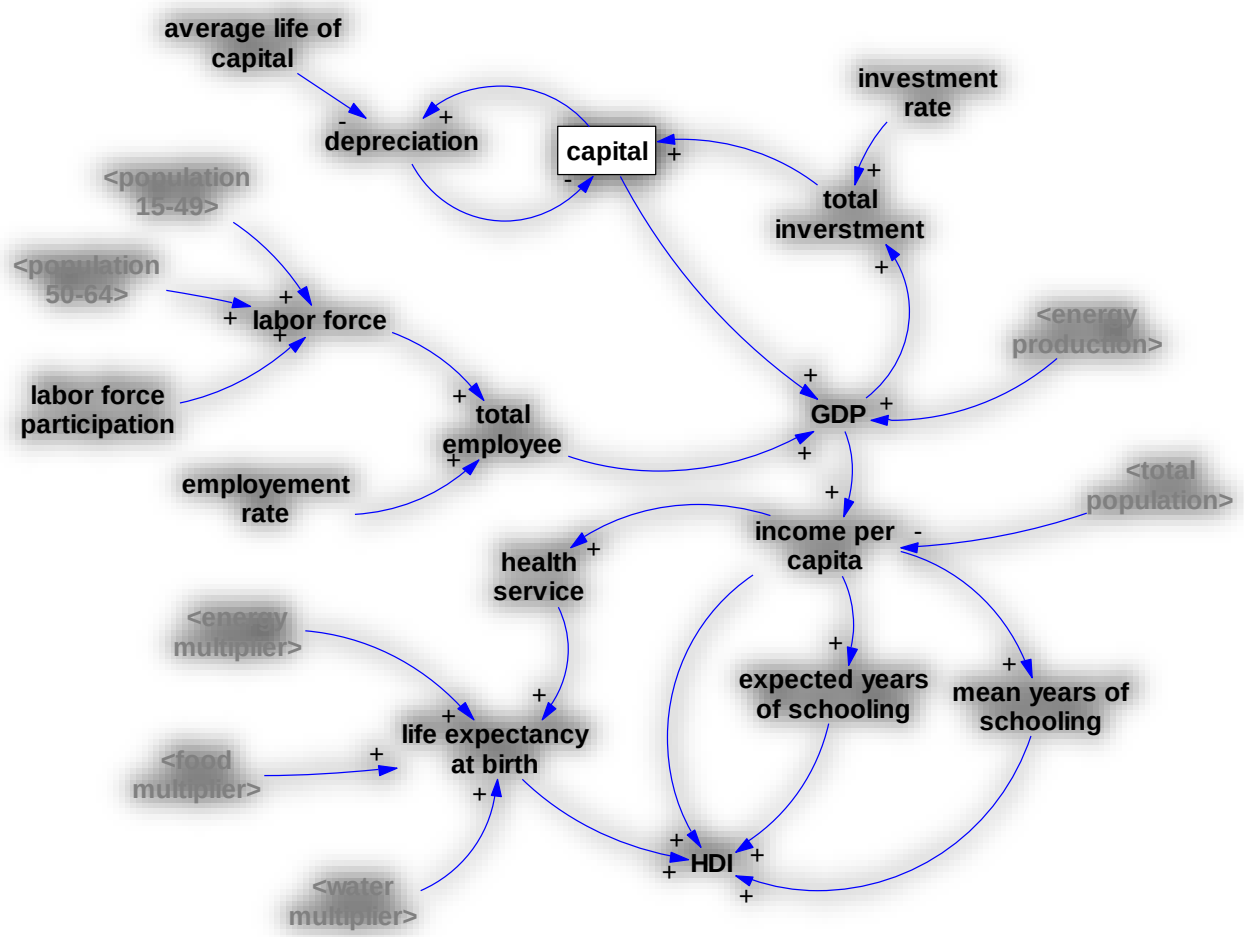


Continue…

Human Development

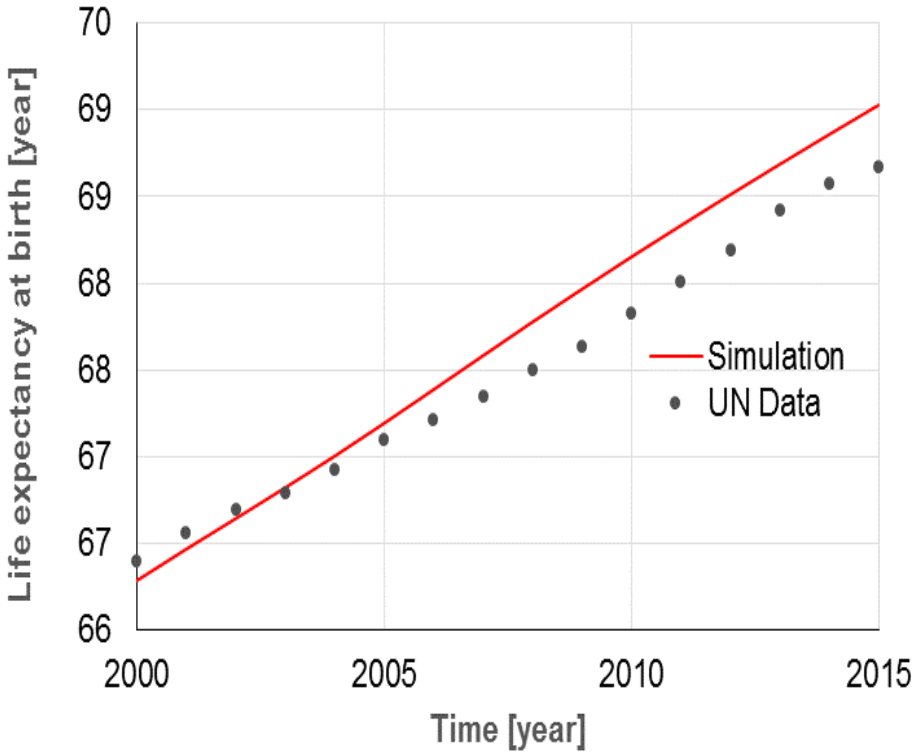


Income per capita

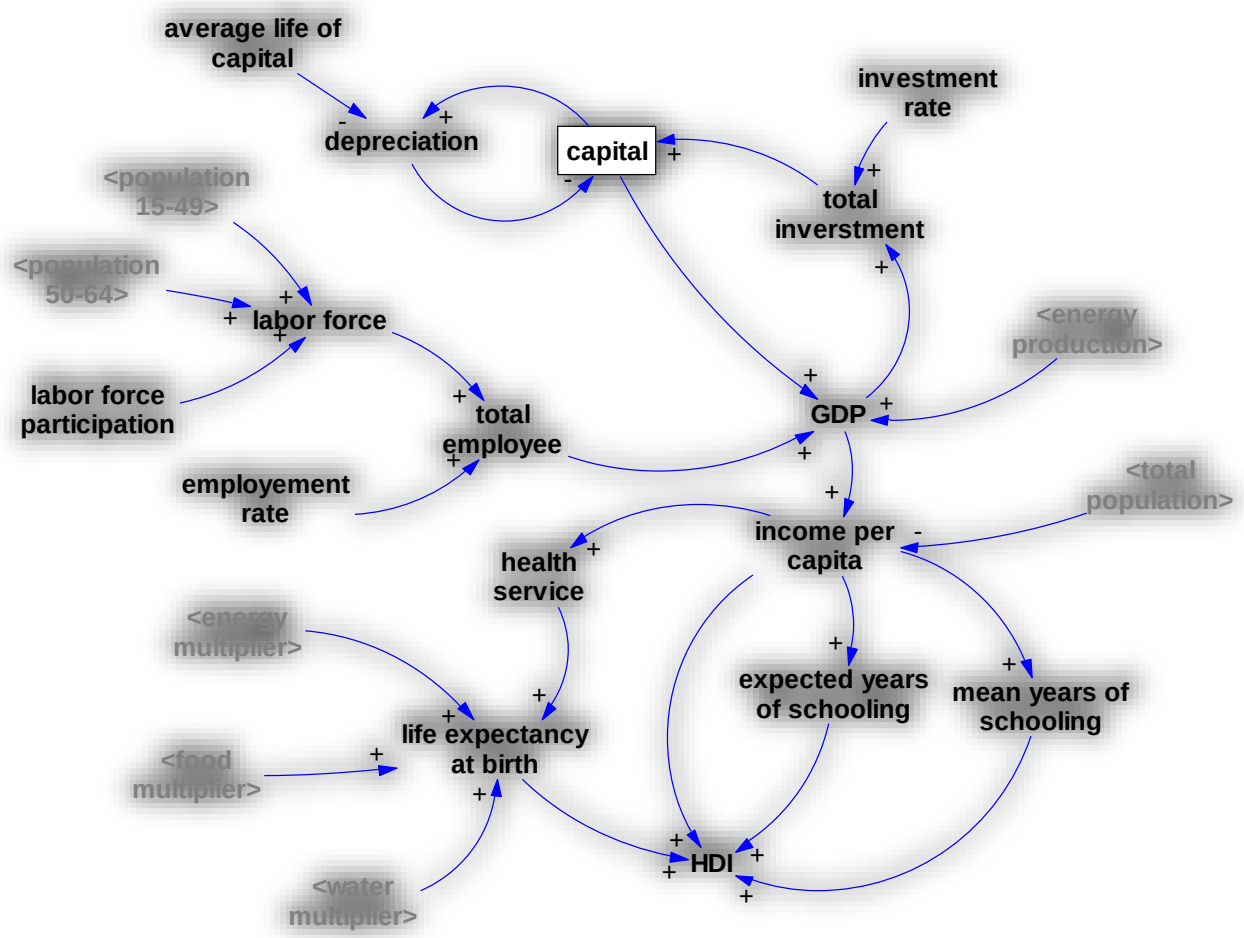


Continue…

Human Development

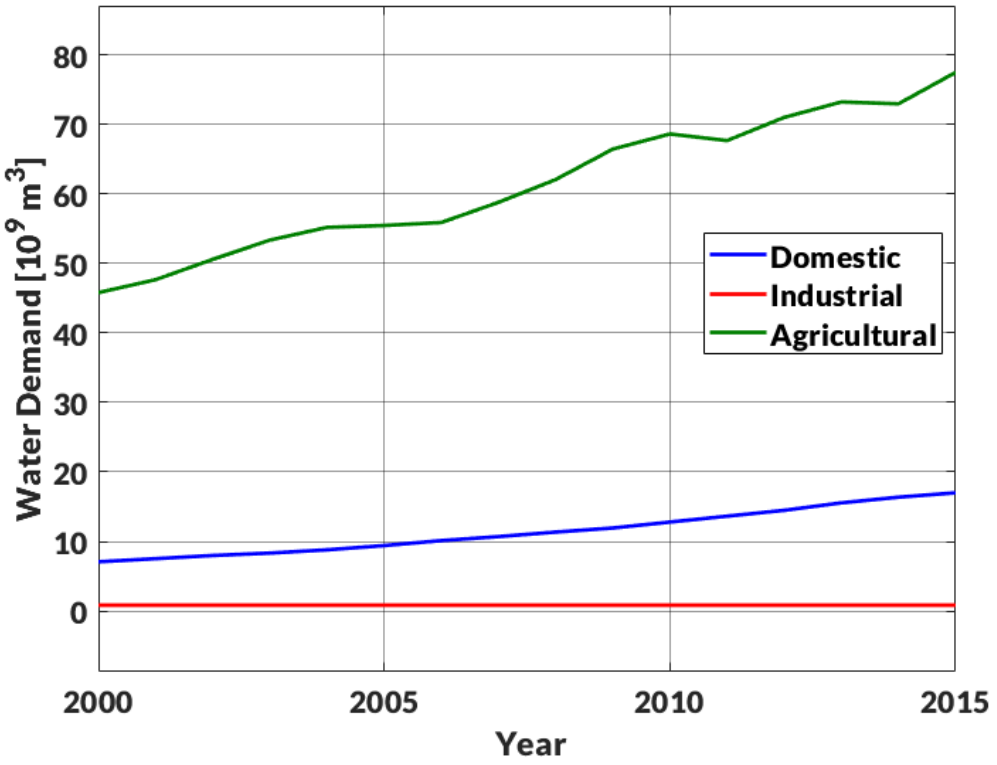


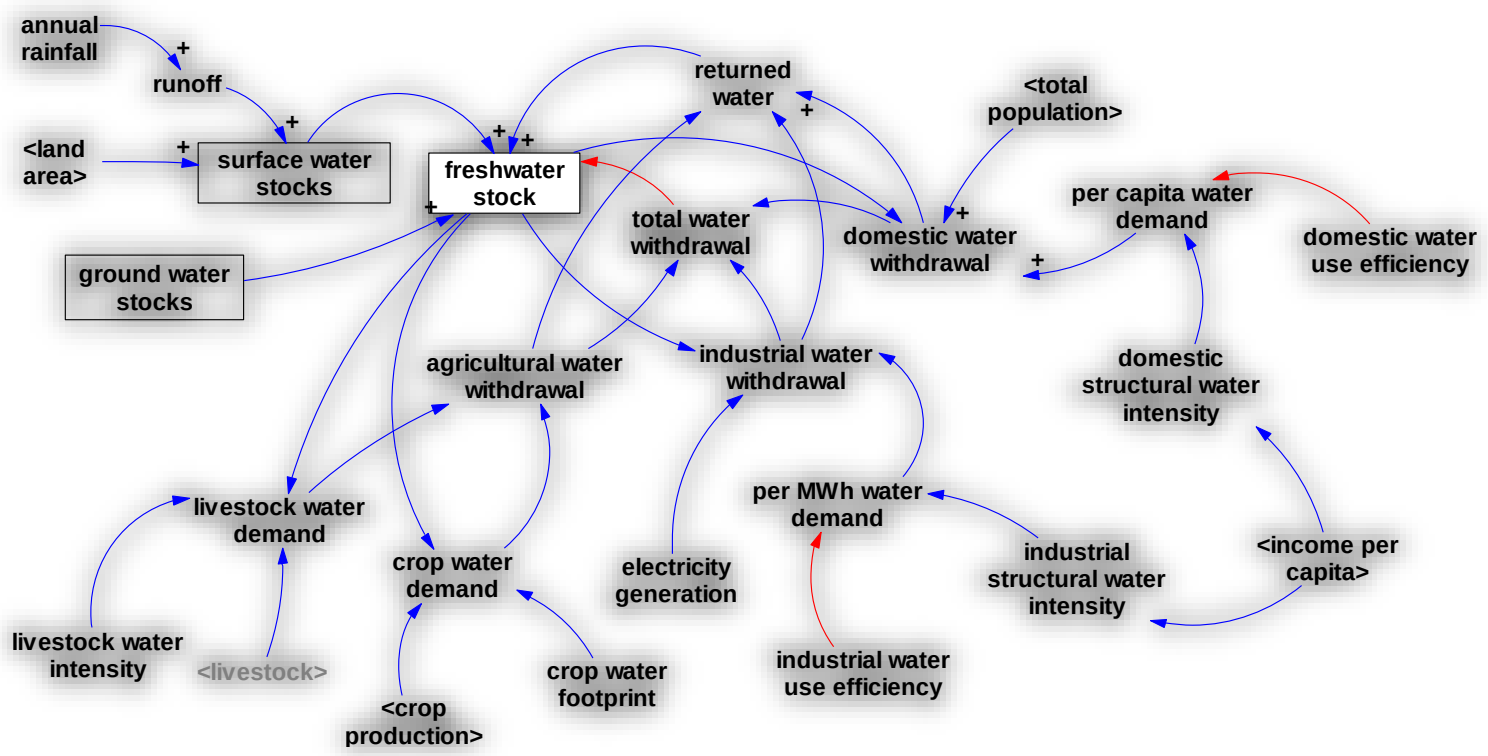
Life expectancy



Continue…

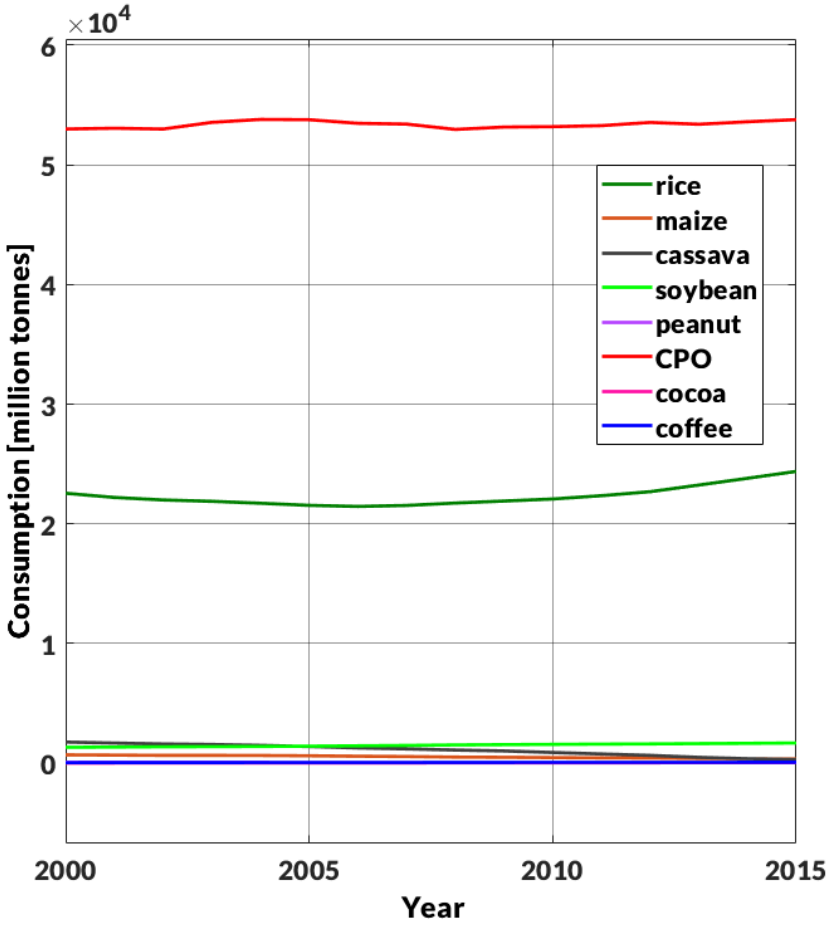
Water Sector

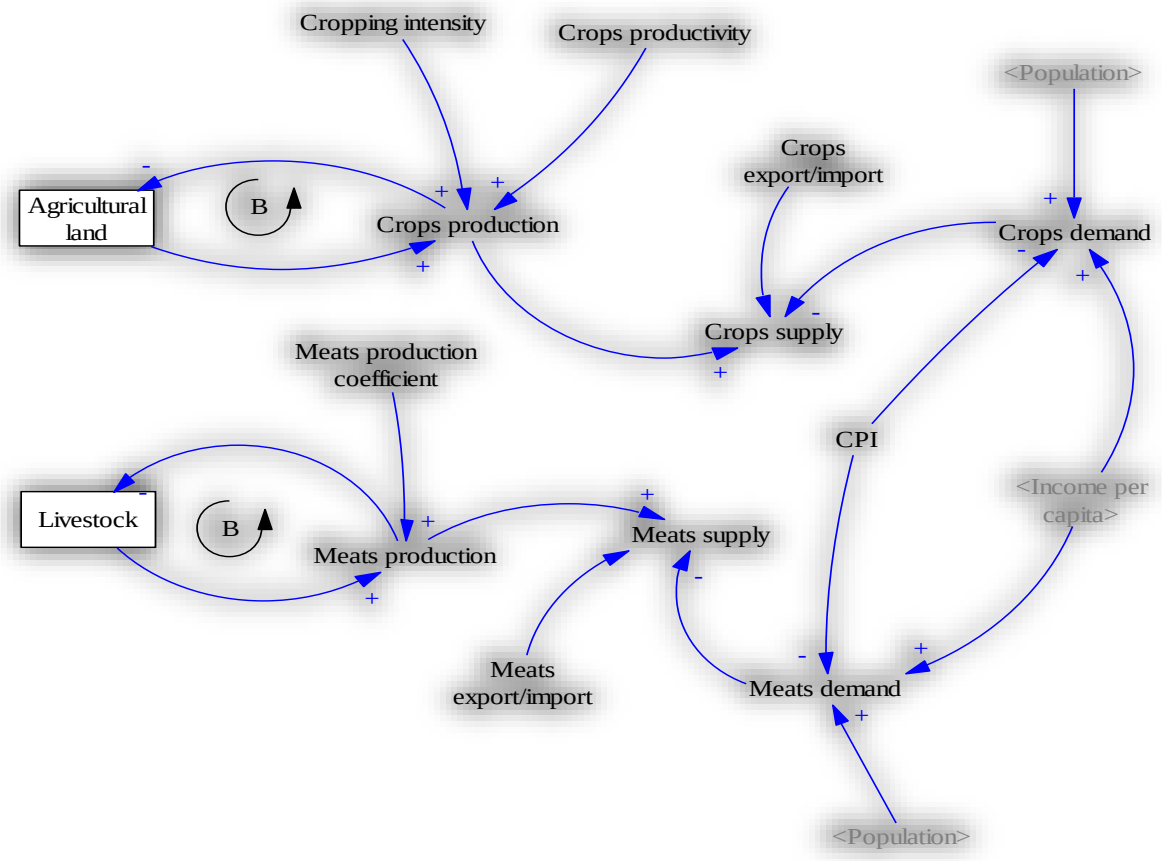




Continue…

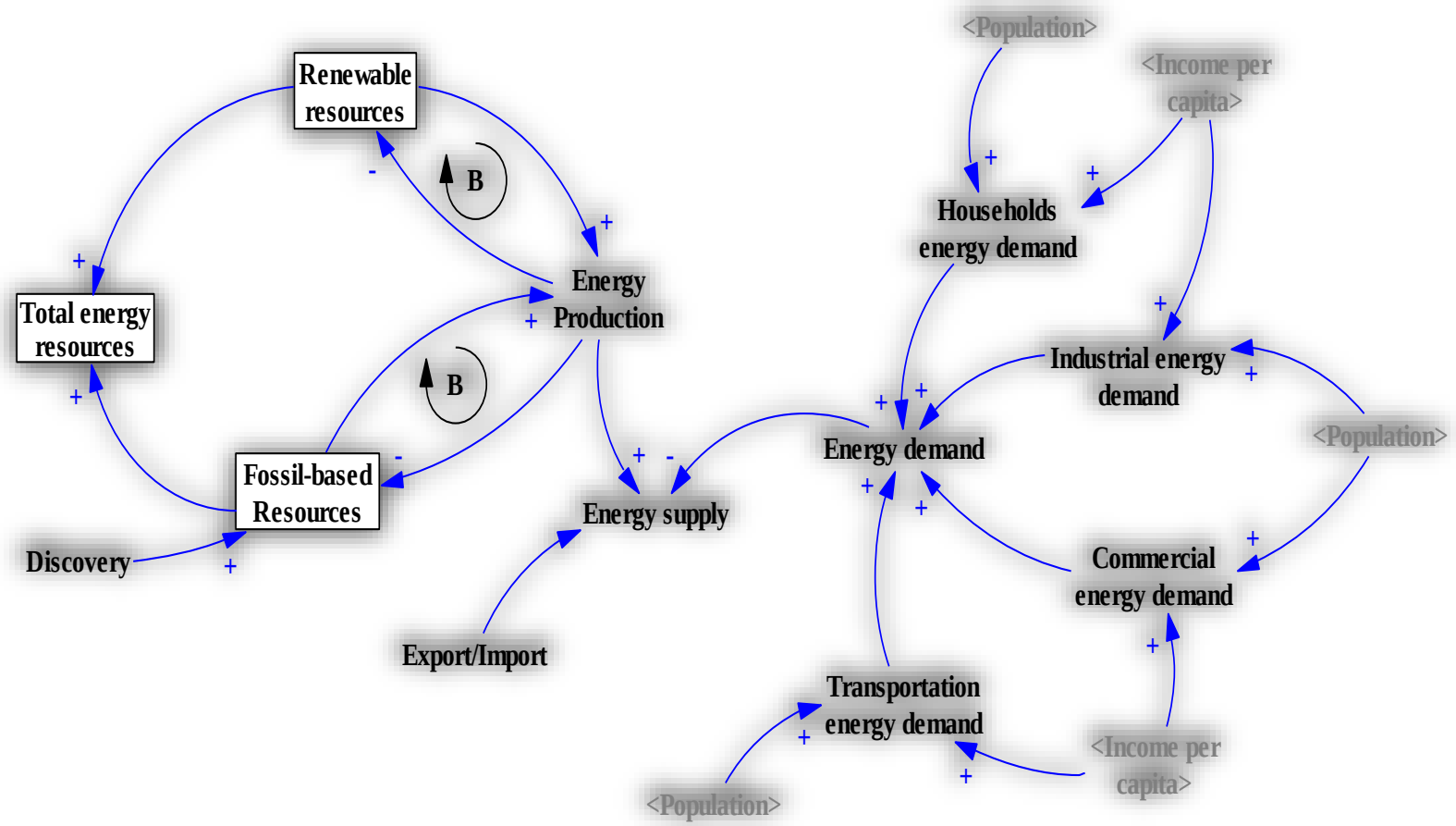
Food Sector





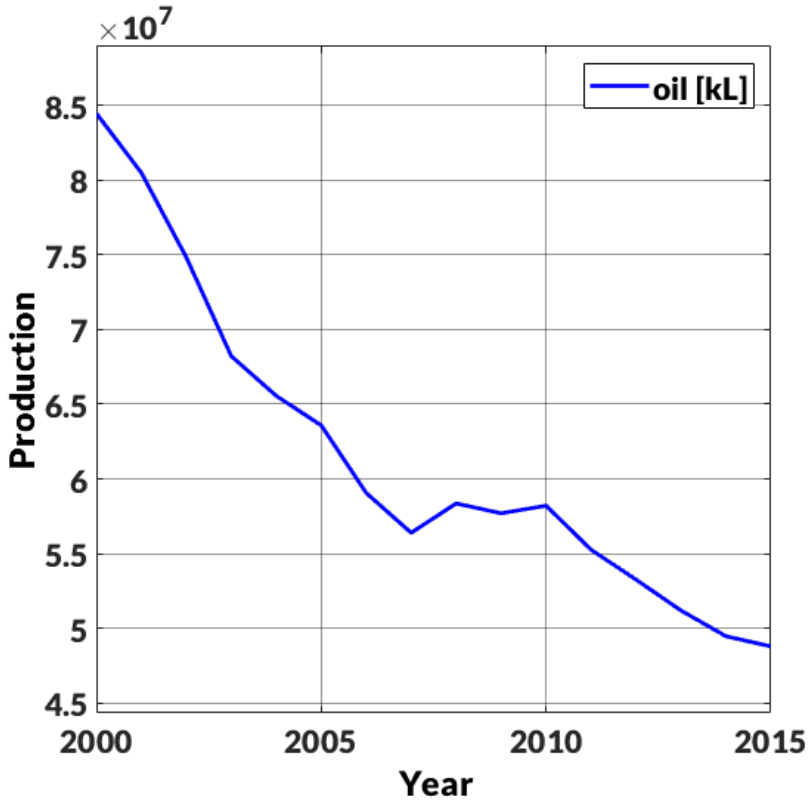
Continue…

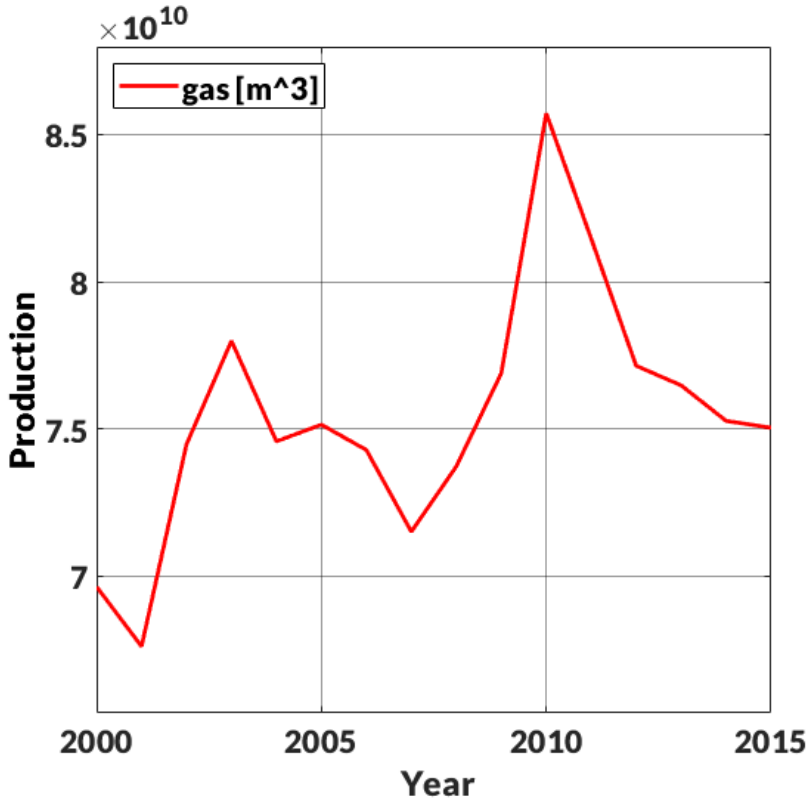
Energy Sector

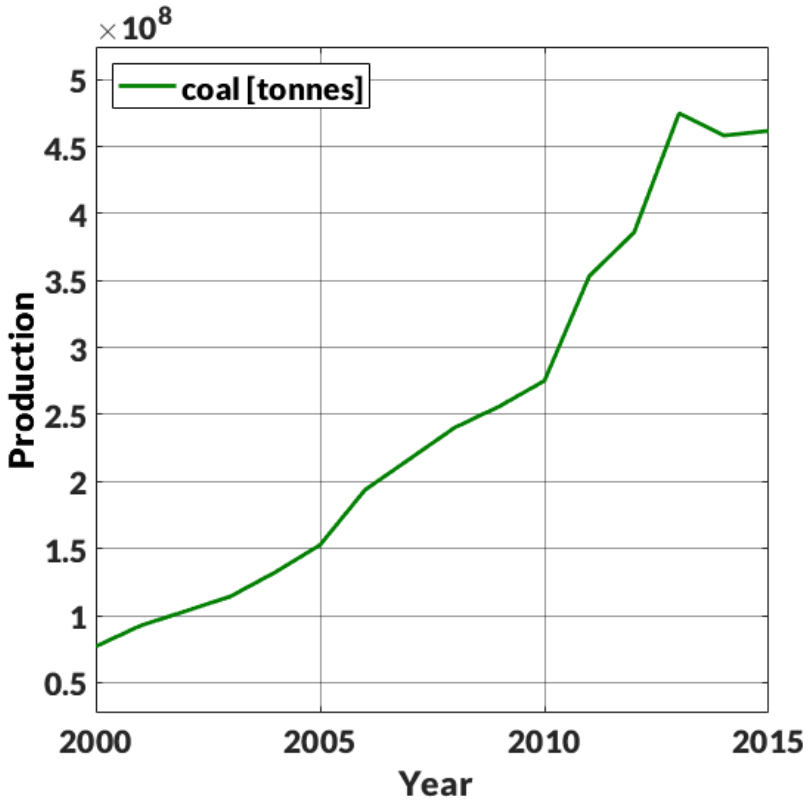


Continue…

Oil, Gas and Coal production

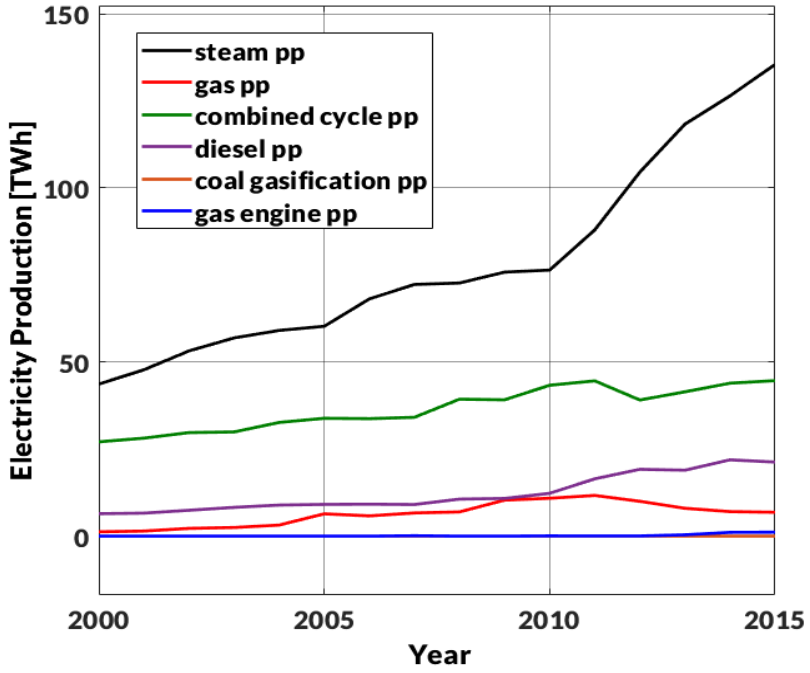




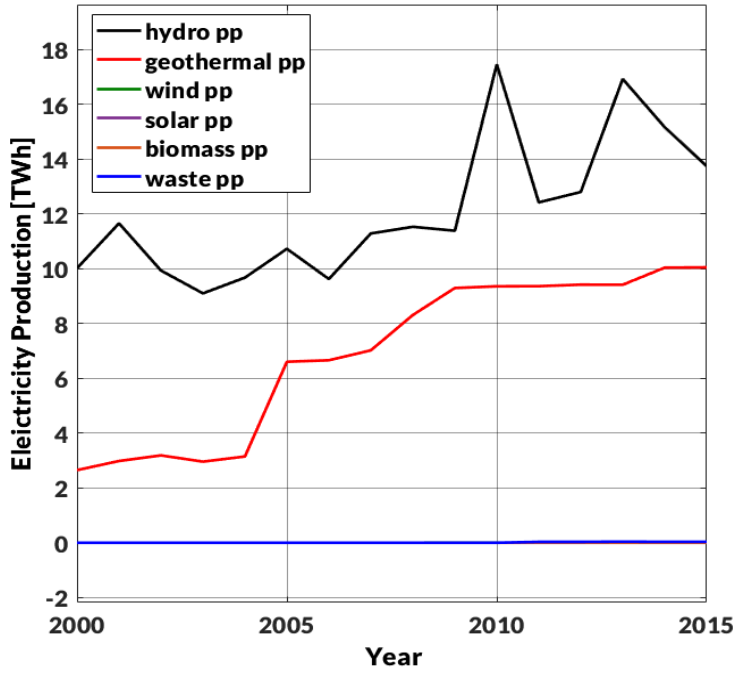


Continue…

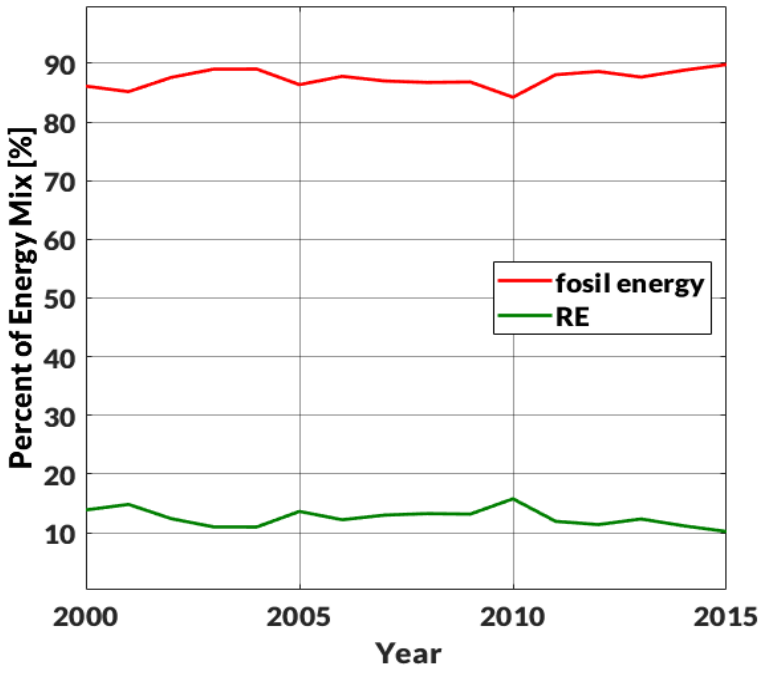
Electricity Production



Fossil Based Power Plant



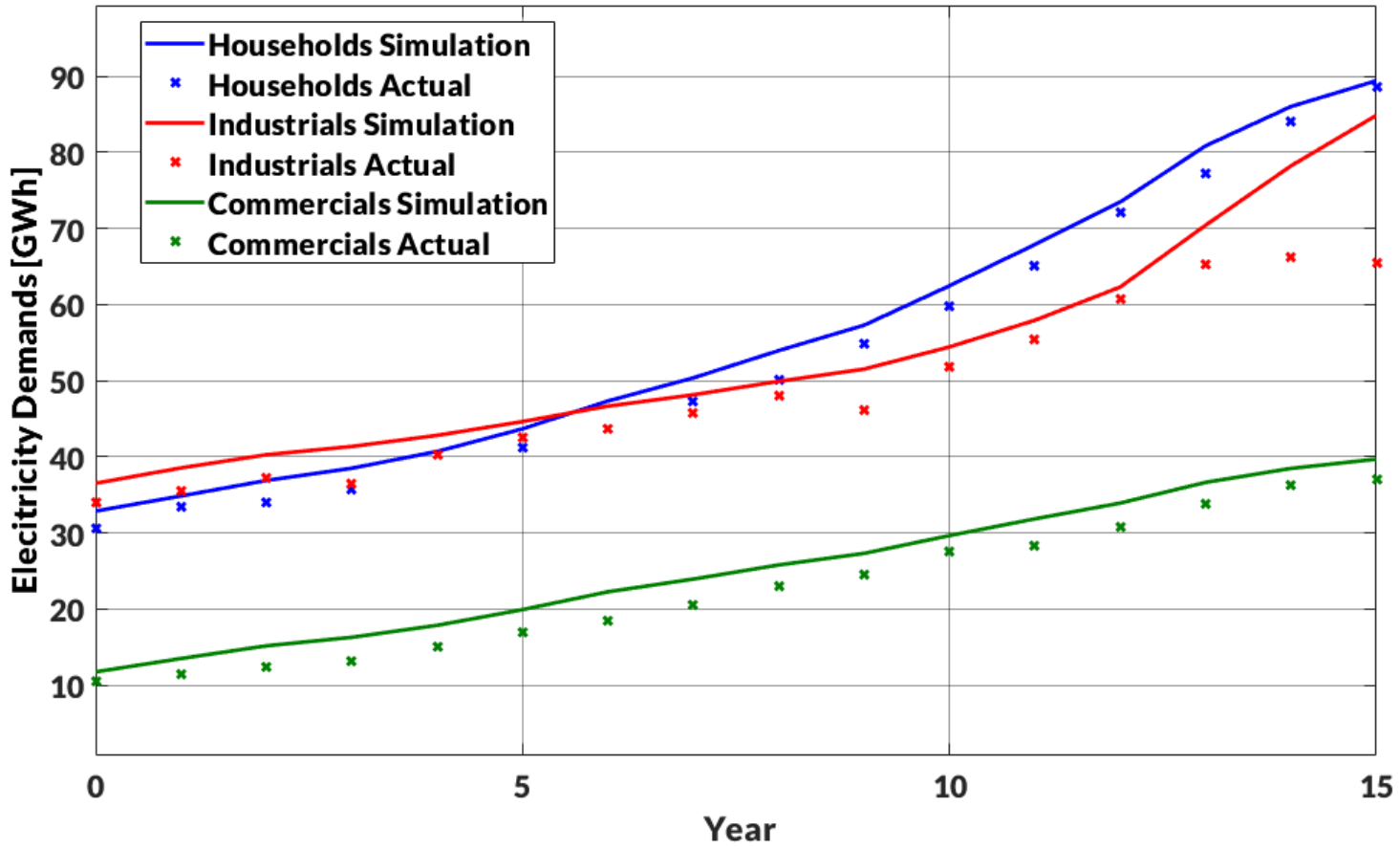
Renewable Energy Power Plant



Share of Electricity Production

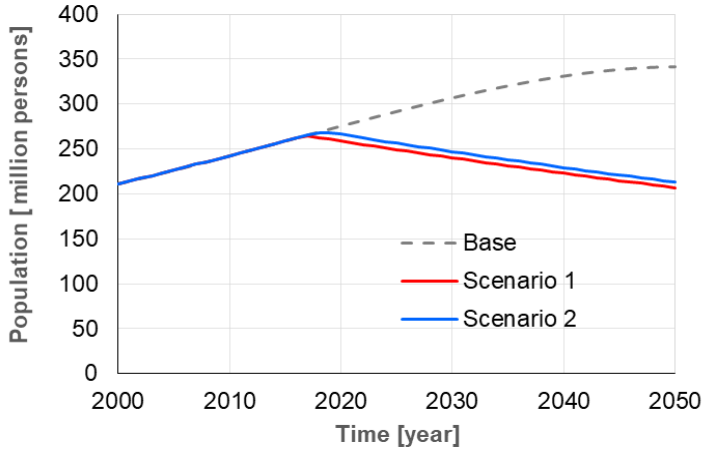
Continue…

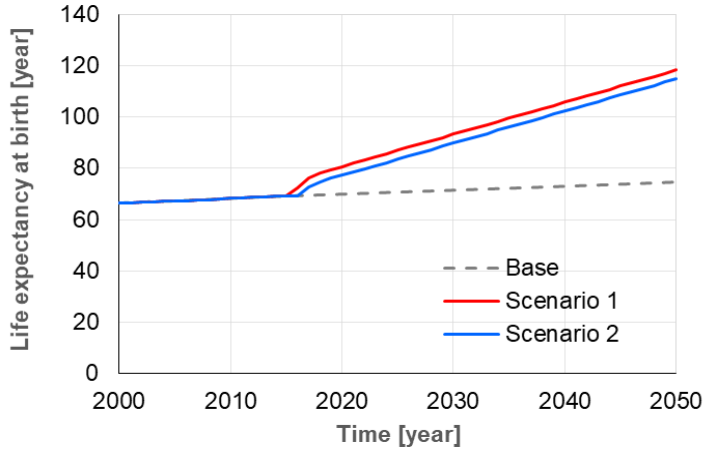
Electricity Demand

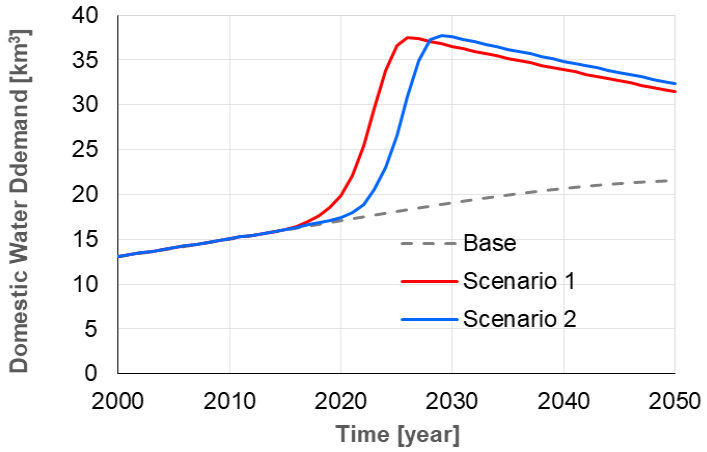


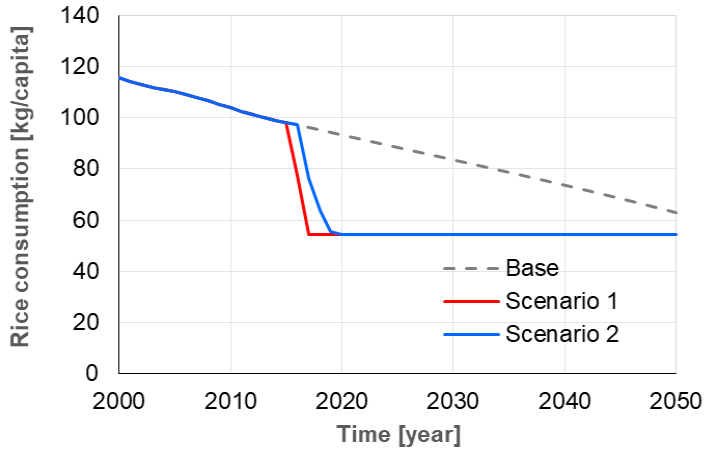
Continue…

Model Experiments









Scenario 1: Doubling Income per capita

Scenario 2: Doubling Energy Demand

Conclusions

- Water, Food, and Energy are Interdependent and interplays with human development
- System Dynamics Modelling is a way to carried out Nexus Assessment
- Population and Income per capita are two of the drivers of change in the system
- There exist reinforcing and balancing mechanism through the nexus within and across sectors

Funding:

Supervisors:

Professor Dragan Savic

Professor Fayyaz Ali Memon

Acknowledgment

Thank You