



Systems Approach to Global Sustainability & Sustainable Development

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Presented at the **Virtual Public Lecture P2P**
January, 2021

Sustainability: “the integration of **environmental** health, **social** equity and **economic** vitality in order to create **thriving, healthy, diverse** and **resilient** communities for this generation and **generations** to come. “

Sustainable development: “the **pathway** to sustainability”

How to move forward for achieving Sustainable Development?

How can system perspectives and approaches help inform design and implementation?

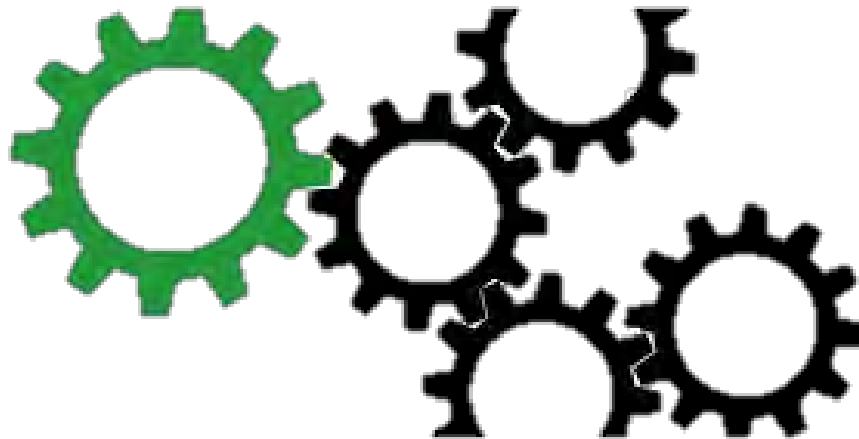
Frequently Asked Question

- WHAT IS A SYSTEM?



What is a System?...

- “An **interconnected** set of **elements** that is coherently organized around some **purpose**.” - Dana Meadows





SDGs = a System

- World Agenda
 - Where we are now and Where we want to be
- Links between human well-being, economic prosperity and a healthy environment

Challenges SDGs Implementation

- Goals are too broad, isolated, unfocused, and unrealistic
- Ensure policy coherence
- Integrated **pathways** to attain all 17 goals within planetary boundaries
- Need: an **integrated framework** to better understand the inter-connections among the seemingly disparate SDGs



SDGs: “a high school **wish-list** for how to save the world”

(Easterly, 2015)

System thinkers and the SDGs

- Big Picture
- Change with time
- System's structure
- Interdependencies and Connections
- Change perspectives
- Mental models
- Leverage
- Accumulations
- Delays
- Consequences
- Dynamics



SDGs - Big Picture

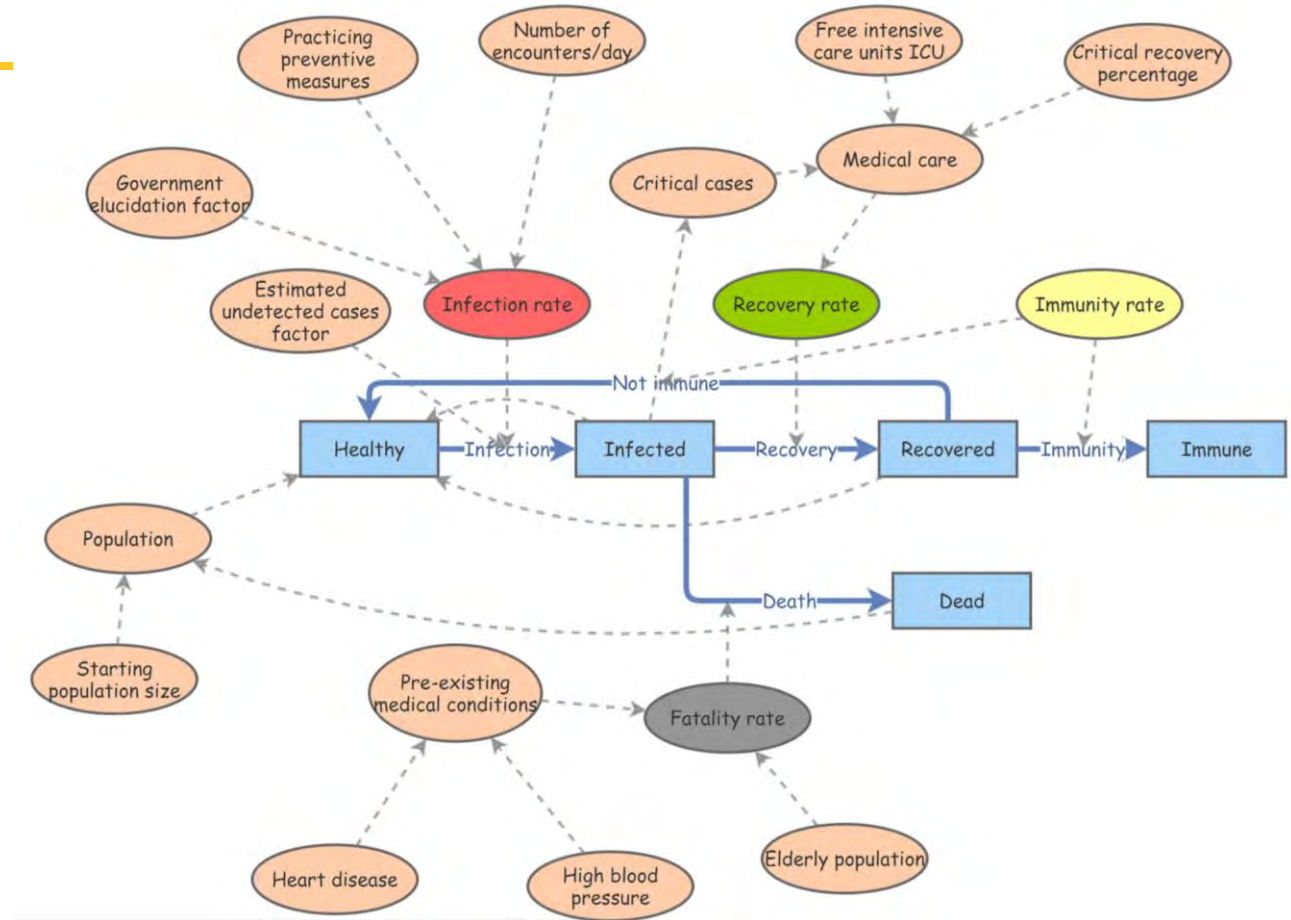


- Minor, medium, major linkages

- Earth, Social, and Economic System

Analyze All/Sub-sets of the SDGs

System's structure

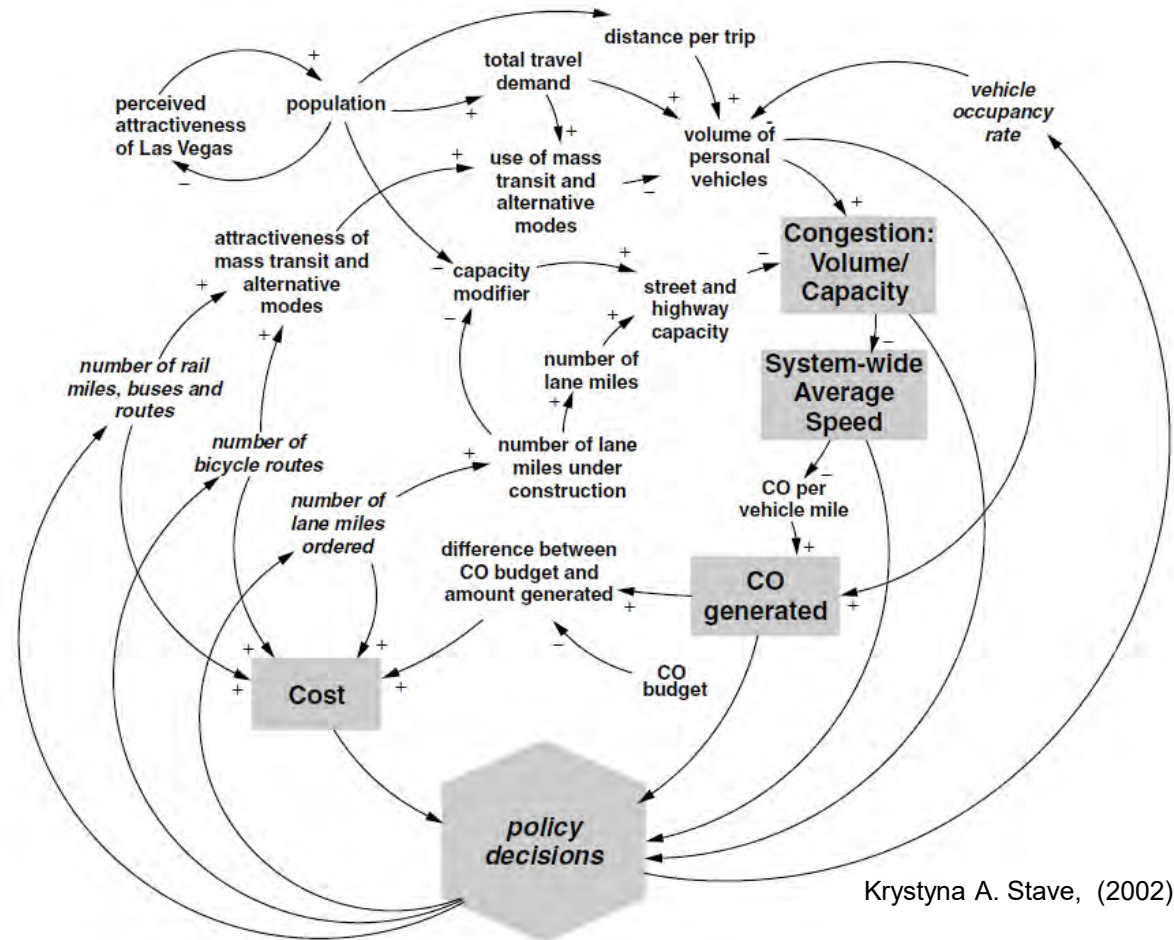


- Structure determines behavior

Leverage: Policy Options

Policy Levers:

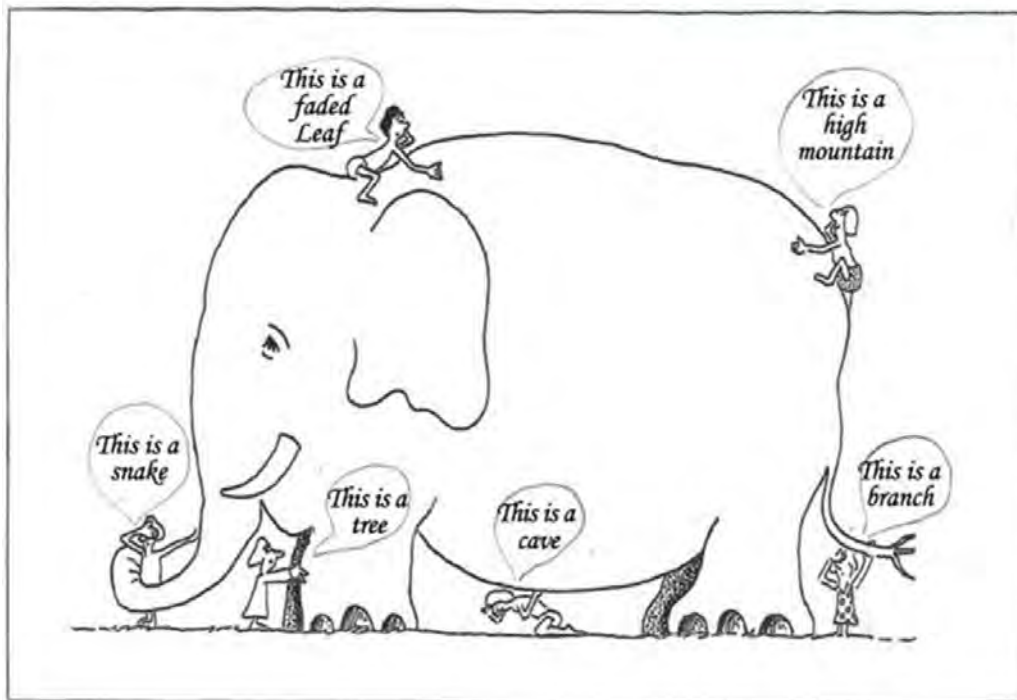
- High speed lane miles
- Low speed lane miles
- Rail miles
- Bike routes
- Mass transit buses
- Regional Transportation (RT) buses and routes
- Car pool
- Traffic signals



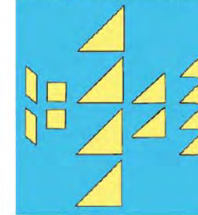
Krystyna A. Stave, (2002)

Identify leverage points for the SDGs

Mental Model



<https://unstats.un.org/>



Sectoral Data

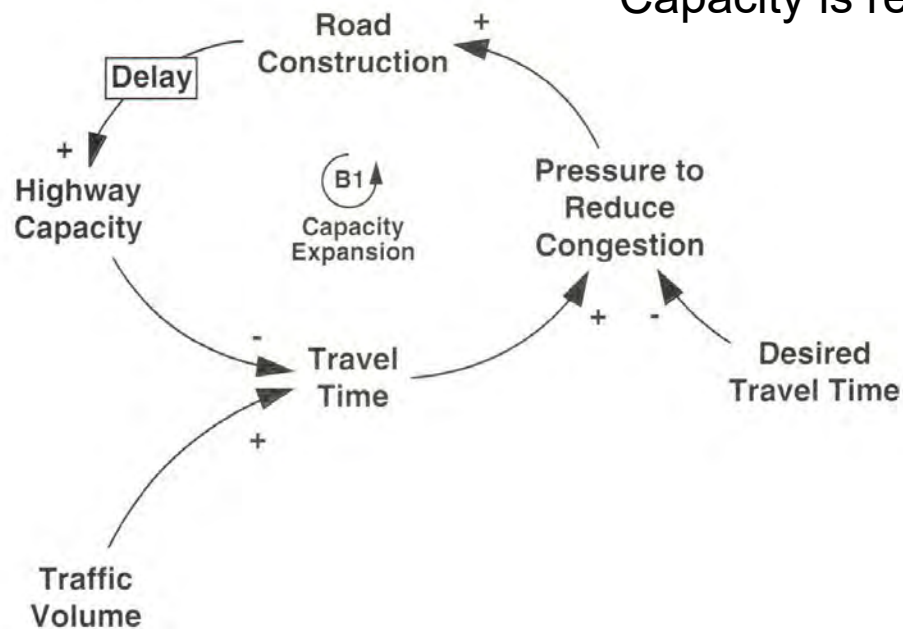


Integrated information

- Mental models influence perspectives and ultimately any actions taken

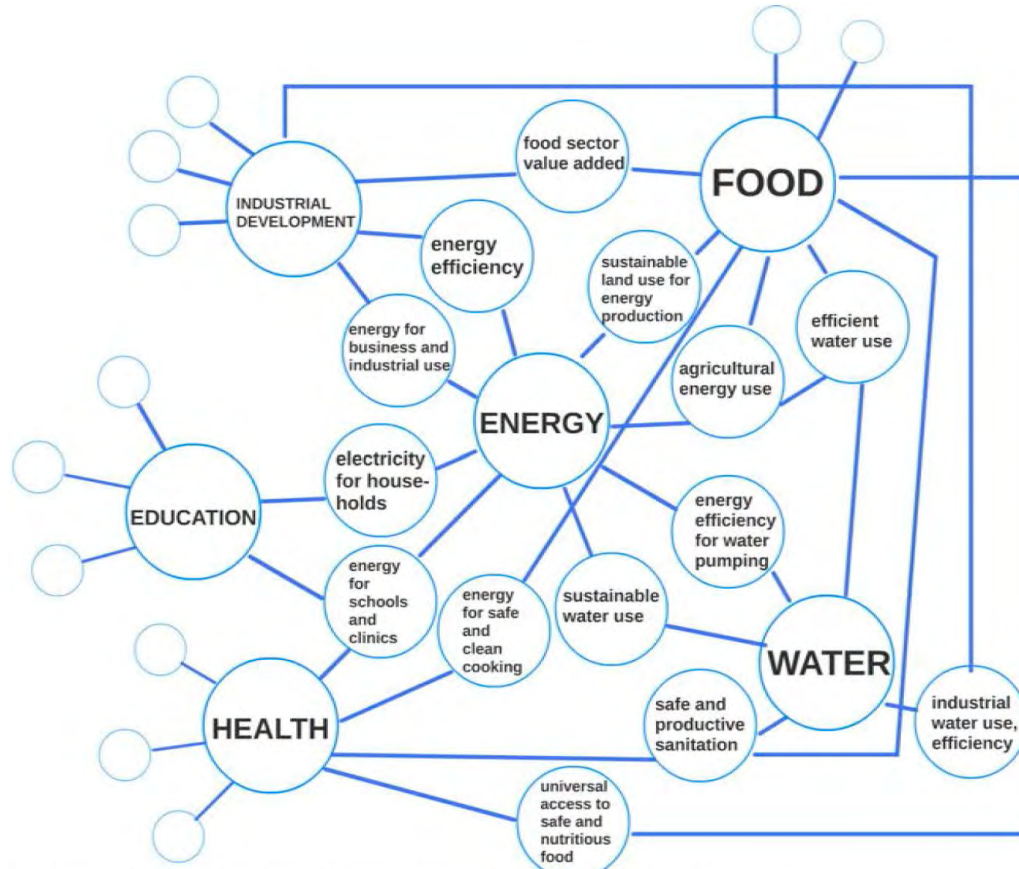
Time Delay

Due to delay:
Capacity is reduced In the short term



- Implementing policies for the SDGs will take time
- The effects of those policies will take time to be felt

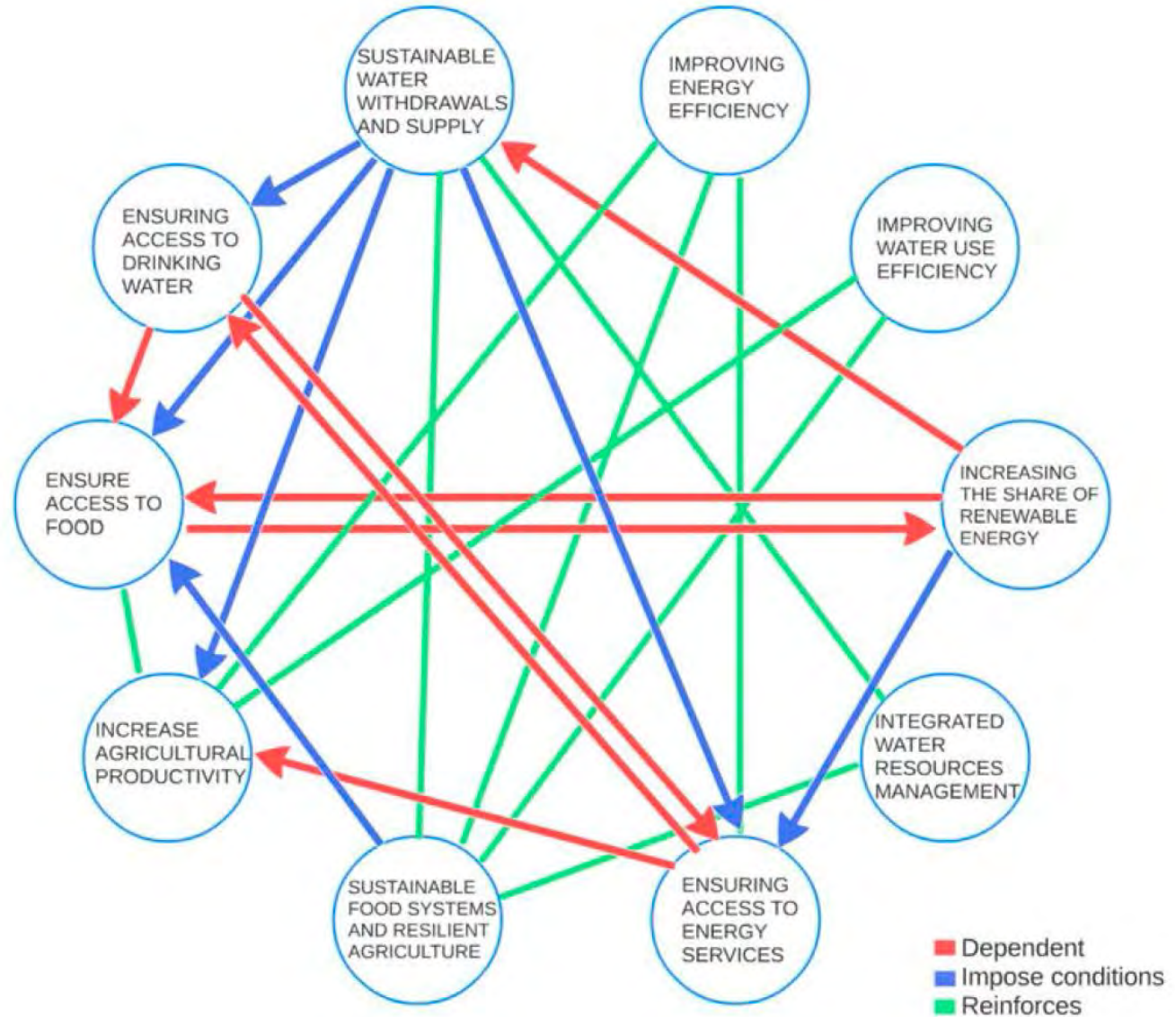
Interconnections



Weitz et al., 2014

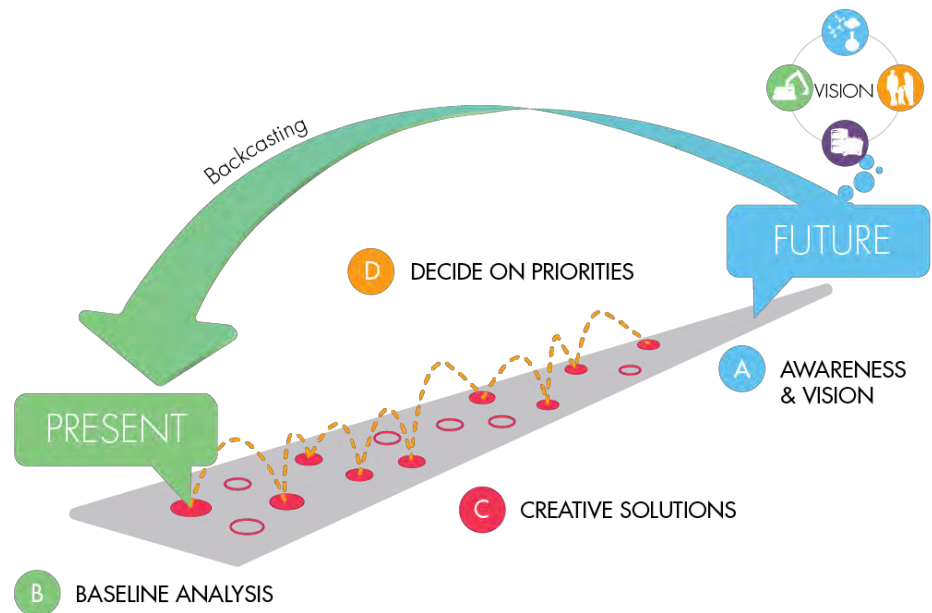
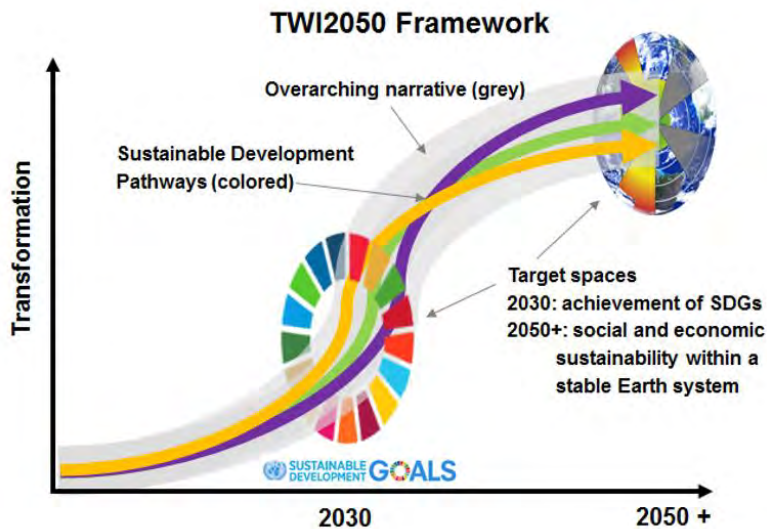
- Food-Energy-Water-Health Nexus

Interdependencies



Change with time

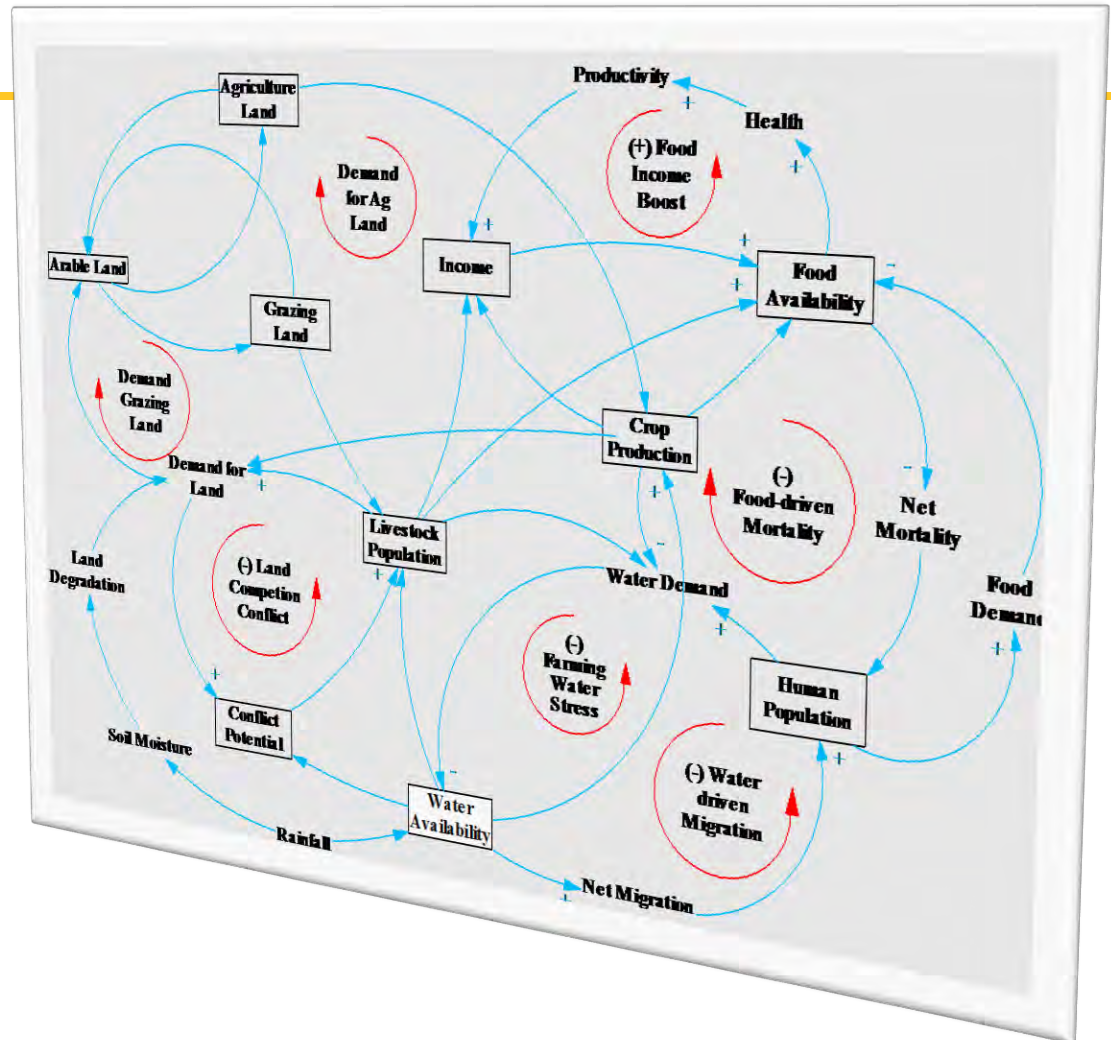
BACKCASTING FROM SUSTAINABILITY PRINCIPLES



- Focus on areas of uncertainties that are most important in choosing among a range of alternative options

Consequences

- Weighs the possible short-term, long-term, and unintended outcomes of the action



Dynamics: Modes of System Behavior

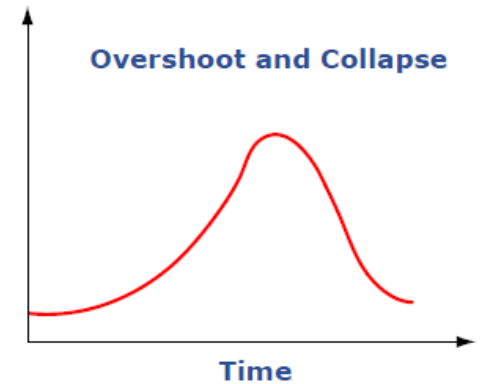
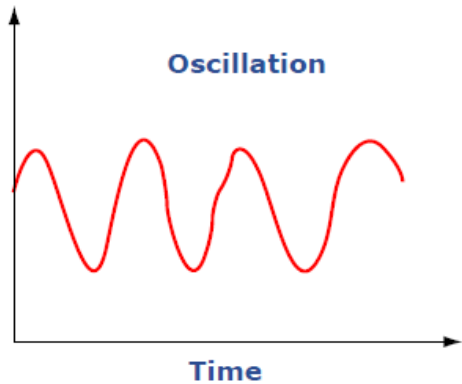
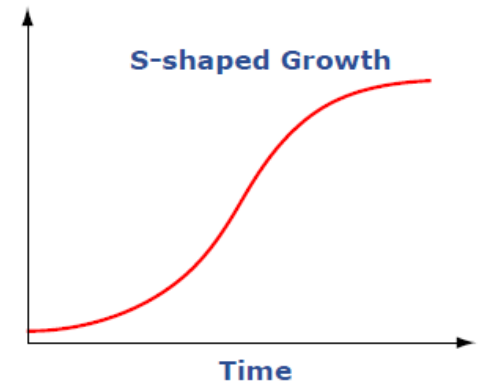
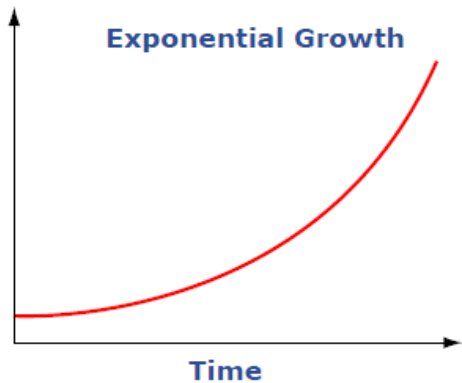


Image by MIT OpenCourseWare.

Conversation
CAFÉ



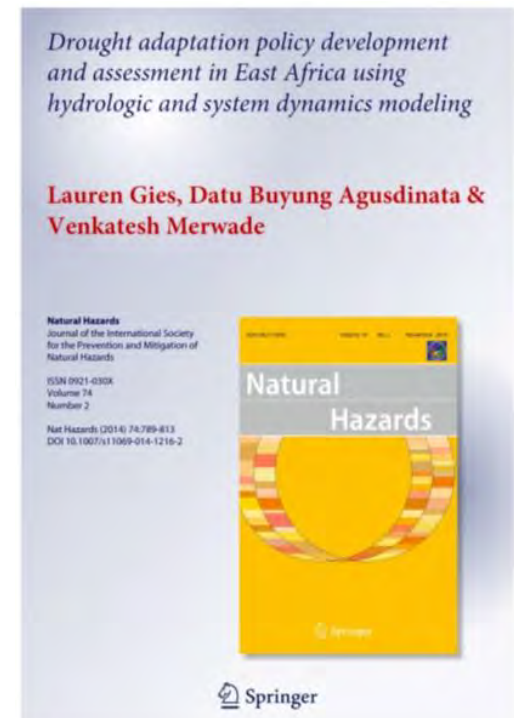
Case Study-1

Drought Adaptation Policies in East Africa

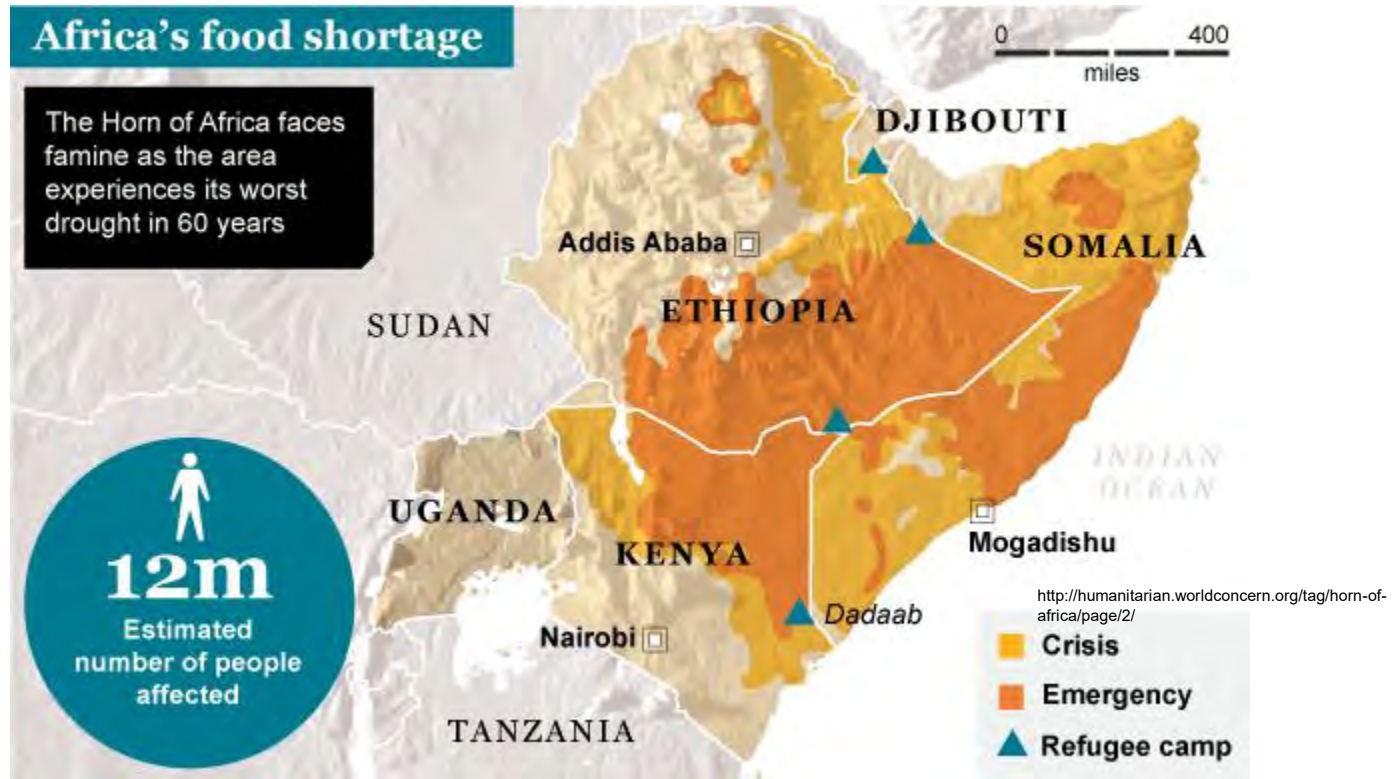
Gies, L., Agusdinata, D. B., & Merwade, V. (2014). Drought adaptation policy development and assessment in East Africa using hydrologic and system dynamics modeling. *Natural hazards*, 74(2), 789-813.

Case study Summary

- Research questions:
 - What are the effects of drought due to limited water availability to livelihoods?
 - What are the most cost-effective policies to support drought adaptations?
- Method:
 - Hydrological model
 - System dynamics
- Results:
 - Dynamics of policy impacts
 - Distribution of costs and benefits among stakeholders

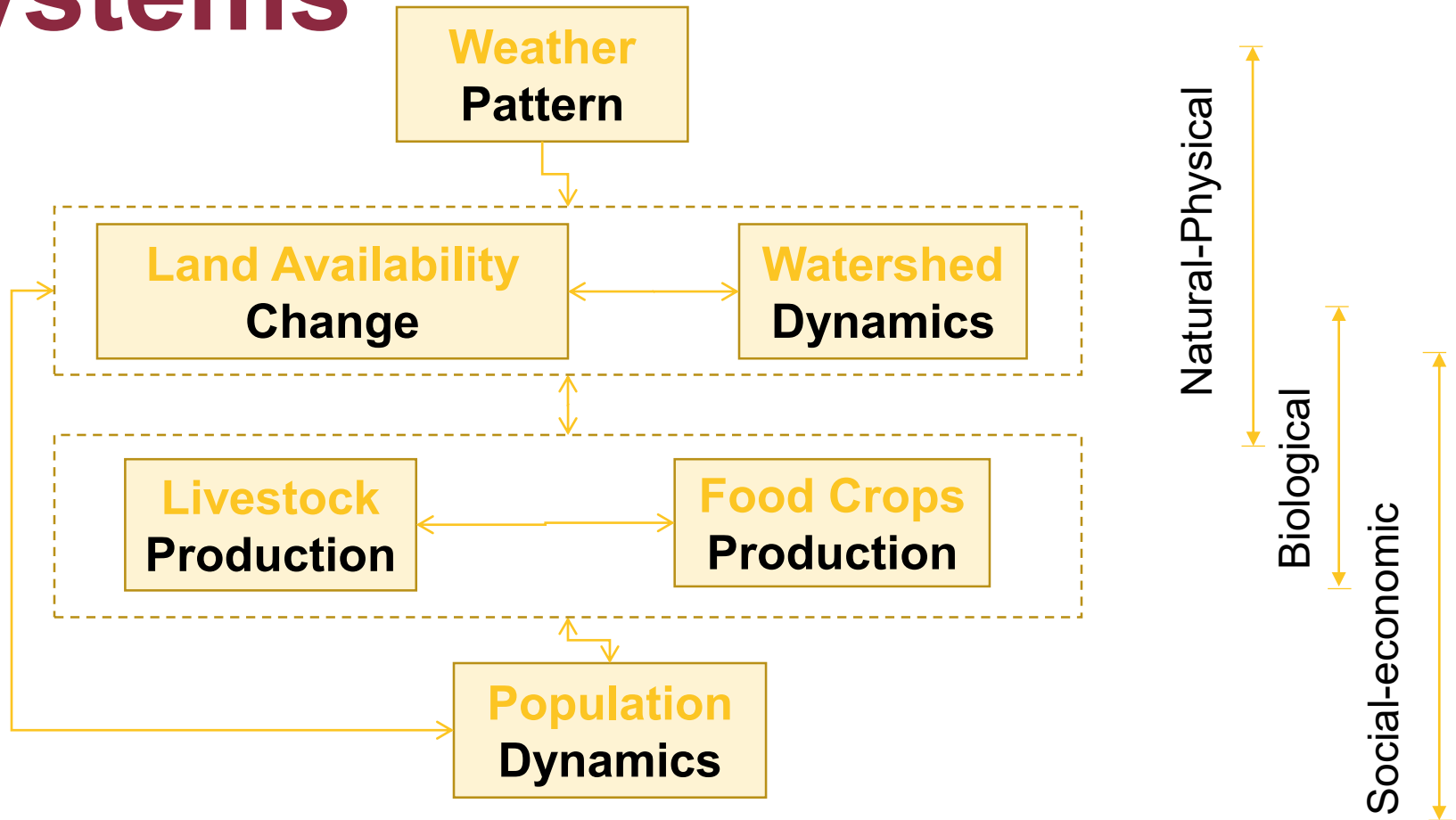


Background



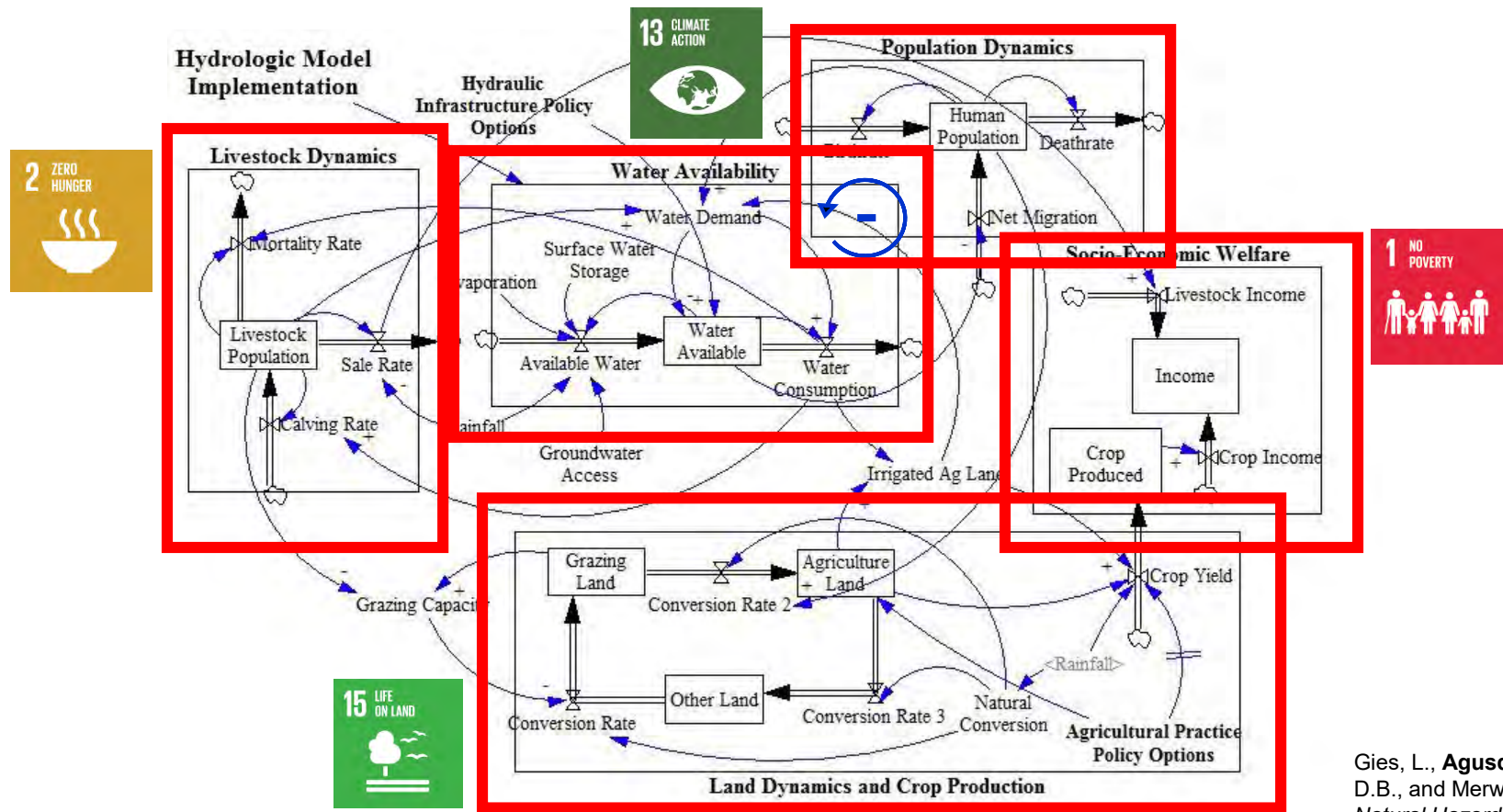
Build a system-based tool to support policies to mitigate drought impacts in East Africa

Systems



- Understand fundamental causes, process, interdependencies, and impacts of drought
- Build a representative systems model

An Intermediate Outcome: A System Dynamics Model



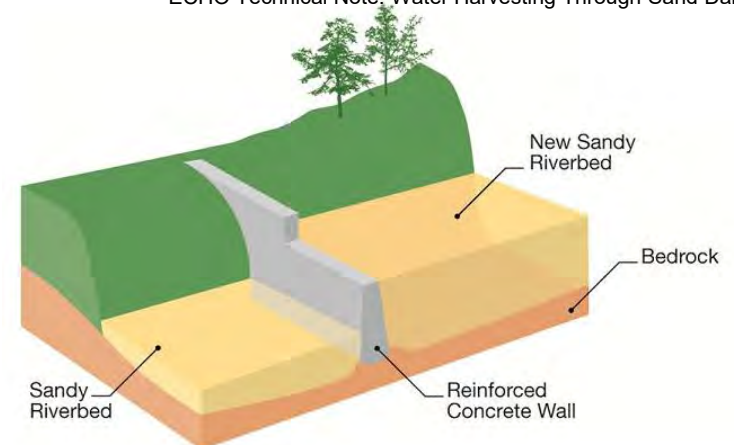
Gies, L., Agusdinata, D.B., and Merwarde, V., *Natural Hazards*, 74 (2), 2014

Adaptation Policy Options

- Hydraulic Infrastructure
 - Sand dam
 - Dam built along river, must have a sand bed
 - Stores water in “perched” aquifer
 - Natural filtration
 - Evaporation is less of a factor
 - Multiple extraction options



ECHO Technical Note: Water Harvesting Through Sand Dams



Adaptation Policy Options

- Rainwater Harvesting (RWH)
 - Rooftop
 - Tanks store rainwater runoff from impermeable surfaces
 - Ideal for towns/settlements
 - Ponds / Pans
 - Strategically dug to collect surface runoff
 - Key issues: evaporation, siltation



Worldagroforestry.org



FAOSWALIM.org

Adaptation Policy Options

■ Wells

■ Shallow / Hand dug

- require little technical skills and are inexpensive
- Access shallow aquifers, can dry up during drought

■ Boreholes

- costly, require high technical skills, knowledge of surrounding subsurface hydrology
- Much more reliable but encourage settlement



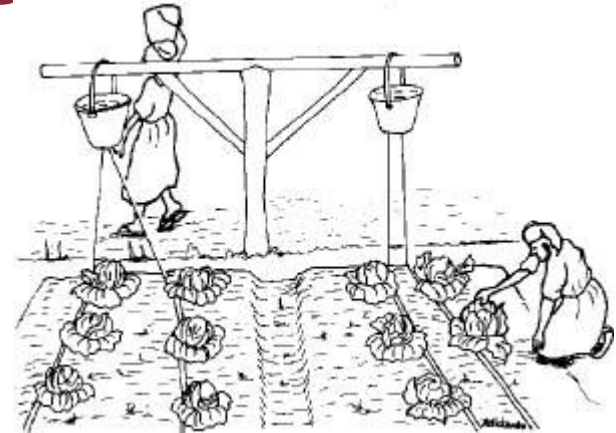
www.investinpeople.ca



Unicef.org

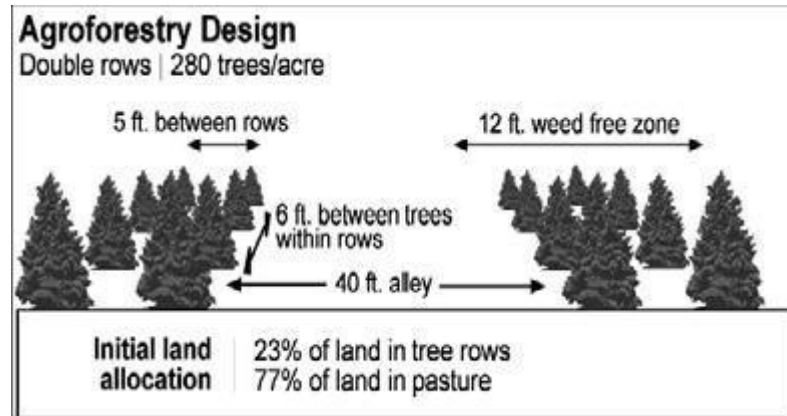
Adaptation Policy Options

- Drip Irrigation
 - Drip irrigation is a unique method suitable for use as “supplementary irrigation”
 - Crop yield improvement up to 98%
 - Water saving up to 79%



Adaptation Policy Options

- Agroforestry
 - Combining trees and shrubs with crops and/or livestock
 - Benefits
 - Reduce soil erosion
 - Decrease runoff
 - Increase crop yield



Smallfarms.oregonstate.edu



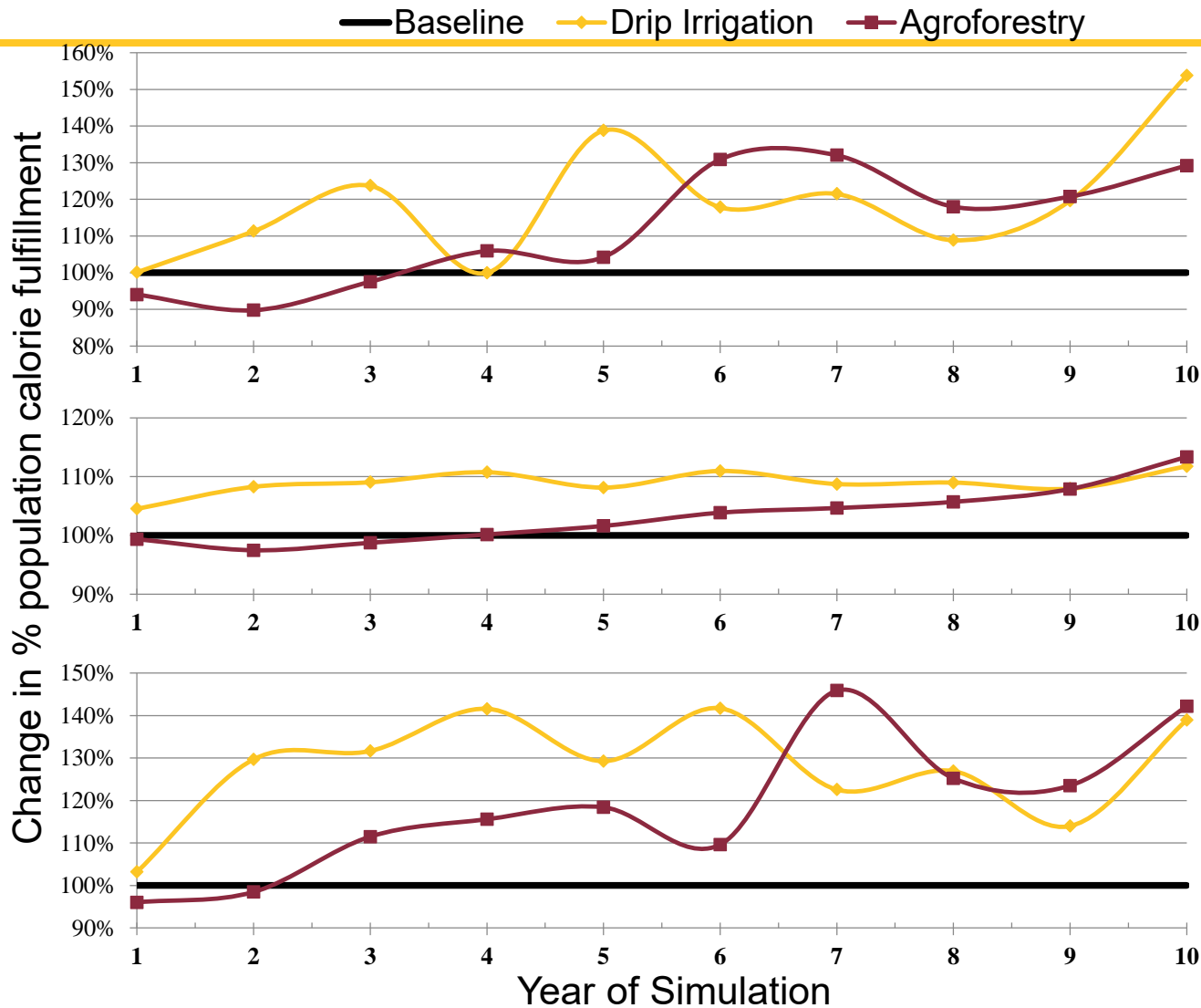
Study Results

Policy – Improved Agricultural Practice Food Availability Analysis

Ethiopia

Somalia

Kenya



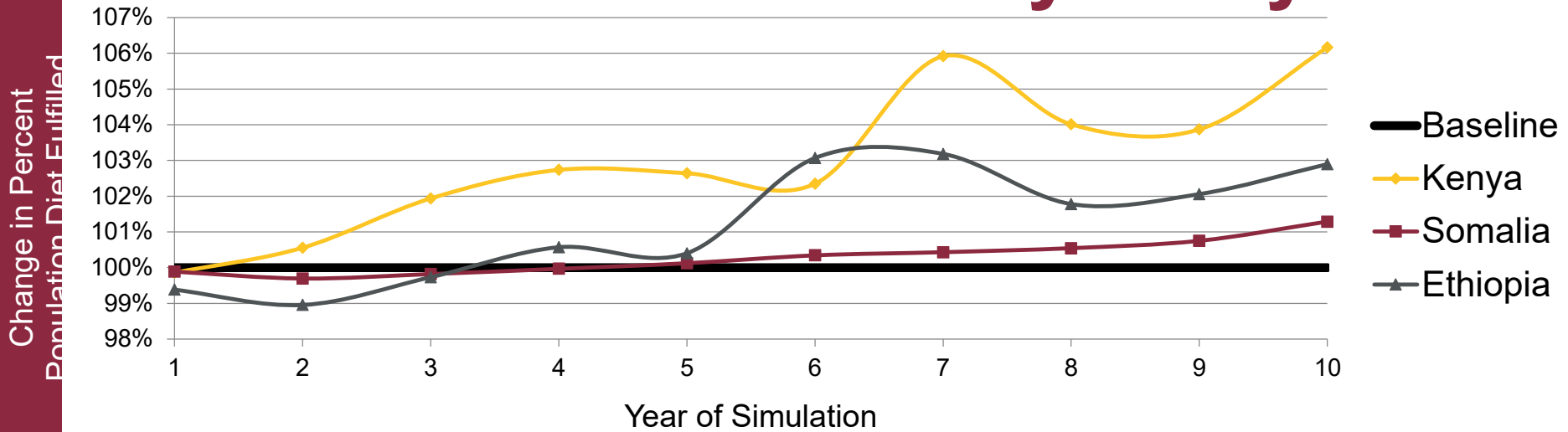
■ Yield still fluctuates with rainfall

■ More cultivated land in Ethiopia and Kenya

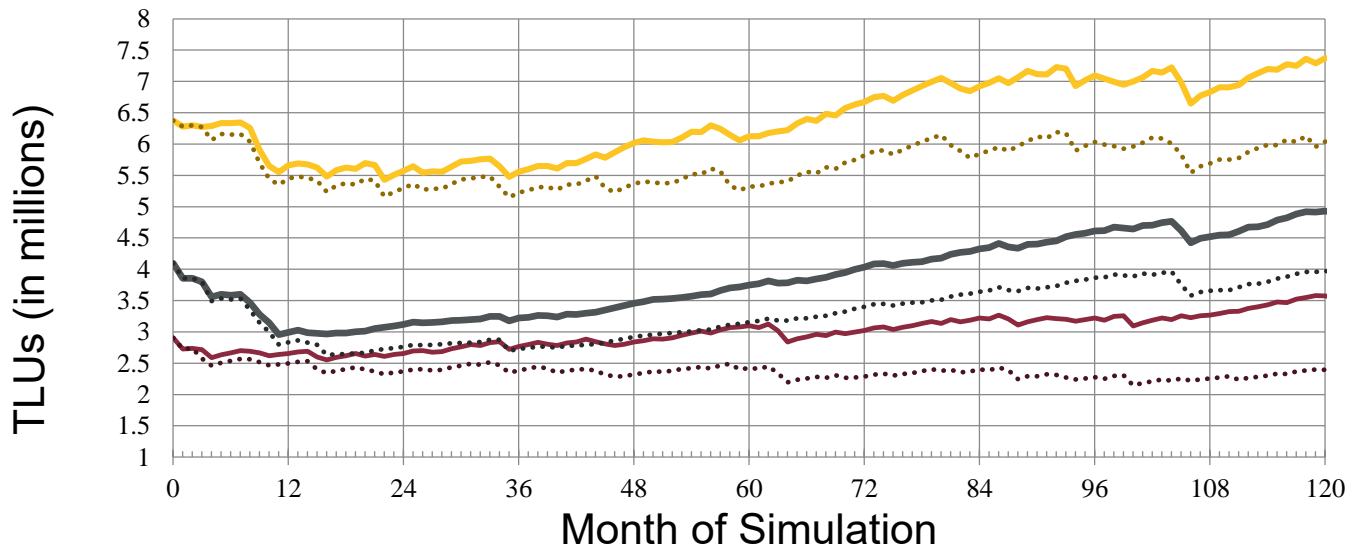
■ Gradual increase with agroforestry

■ Consistently higher yields with drip irrigation

Policy – Combined Policy Food Availability Analysis



- Combined Policy Ethiopia
- Combined Policy Kenya
- Combined Policy Somalia
- Baseline Ethiopia
- Baseline Kenya
- Baseline Somalia



Policy – Increased Hydraulic Infrastructure Livelihood Income Analysis

	Ethiopia			Somalia			Kenya		
	AP	Pastoral	Farmer	AP	Pastoral	Farmer	AP	Pastoral	Farmer
Baseline Income	\$558	\$95	\$704	\$125	\$368	\$143	\$668	\$456	\$444
Sand Dam Income	\$562	\$107	\$705	\$130	\$396	\$143	\$708	\$510	\$458
	0.8%	13.0%	0.1%	3.5%	7.6%	-0.2%	6.0%	11.9%	3.1%
RWH Tank Income	\$558	\$97	\$704	\$123	\$354	\$143	\$669	\$457	\$44
	0.1%	2.0%	0.0%	-1.9%	-3.9%	-0.1%	0.1%	0.2%	0.0%
Shallow Well Income	\$577	\$153	\$705	\$143	\$477	\$143	\$755	\$580	\$471
	3.5%	61.4%	0.2%	14.0%	29.6%	-0.4%	13.1%	27.1%	6.0%
Pond Income	\$570	\$132	\$704	\$136	\$431	\$143	\$720	\$536	\$457
	2.2%	38.5%	0.1%	8.1%	17.1%	-0.2%	7.8%	17.5%	2.9%
Borehole Income	\$581	\$169	\$705	\$168	\$629	\$142	\$798	\$676	\$467
	4.3%	77.8%	0.1%	33.6%	70.8%	-0.7%	19.4%	48.0%	5.1%

*Per capita income over 10 year simulation

Policy – Improved Agricultural Practice

Livelihood Income Analysis

	Ethiopia			Somalia			Kenya		
	AP	Pastoral	Farmer	AP	Pastoral	Farmer	AP	Pastoral	Farmer
Baseline	\$558	\$95	\$704	\$125	\$368	\$143	\$668	\$456	\$444
Drip Irrigation	\$842	\$24	\$1,112	\$257	\$214	\$487	\$1,087	\$177	\$1,001
	51.0%	-74.3%	58.0%	104.8%	-41.9%	240.1%	62.8%	-61.3%	125.2%
Agroforestry	\$661	\$95	\$842	\$208	\$368	\$324	\$1,240	\$456	\$1,017
	18.6%	0.0%	19.7%	65.8%	0.0%	126.4%	85.7%	0.0%	128.8%

*Per capita income over 10 year simulation

- Agricultural water demand competes with livestock & domestic demands

Summary of Results

	Ethiopia			Somalia			Kenya			
	AP	P	F	AP	P	F	AP	P	F	
Benefits	●	◐	◐	●	◐	●	◐	◐	◐	Financial Gains
	◐	◐	◐	◐	◐	●	◐	◐	◐	Increased Food Availability
	◐	○	◐	◐	○	◐	◐	○	◐	Improved Land
	◐	◐	◐	◐	◐	◐	◐	◐	◐	Other Minor Benefits
Costs	●	◐	●	●	◐	●	●	◐	●	Financial Burden
	◐	◐	◐	◐	◐	◐	◐	◐	◐	Competition for Resources
	○	◐	○	○	◐	○	○	◐	○	Other Minor Costs

● = Very Significant
 ◐ = Significant
 ◐ = Indirectly Significant
 ○ = Insignificant

AP = Agro-pastoralist
 P = Pastoralist
 F = Farmer

- Farmers and Agro-pastoralists are direct beneficiaries
 - Increased and diversified income
 - More food and water availability
- Pastoralists are indirect beneficiaries
 - Lower herd mortality with increased water
 - Still suffer from competition of resources
 - Land and water

Conversation
CAFÉ



Case Study-2

Economic Growth-Inequality- Environmental Quality Nexus

Agusdinata, D. B., Aggarwal, R., & Ding, X. (2020). Economic growth, inequality, and environment nexus: Using data mining techniques to unravel archetypes of development trajectories. *Environment, Development and Sustainability*, 1-25.

Case study Summary

- Research questions:
 - What are the different kinds of sustainable and unsustainable development pathways followed by countries around the world?
 - What do these different pathways reveal about tradeoffs and synergies between growth, inequality and climate action?
- Methods:
 - Data mining
 - Archetype analysis
- Result:
 - Country's development trajectories

Environment, Development and Sustainability
<https://doi.org/10.1007/s10668-020-00775-1>

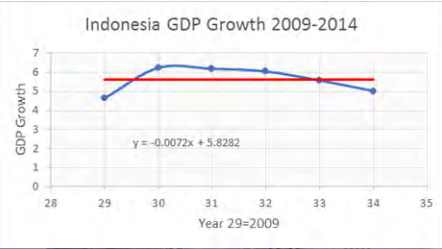
Ecosystem services and trade-offs: implications for land dynamics and sustainable livelihoods in Northern Lombok, Indonesia

Puyang Li¹ · Datu Buyung Agusdinata²  · Putu Hery Suditha³ · Yujia Zhang¹

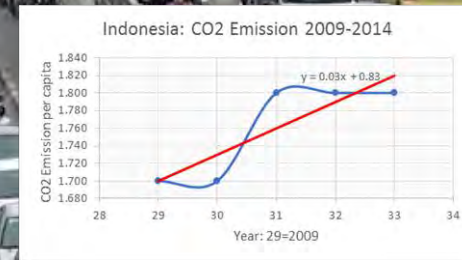
Received: 15 October 2019 / Accepted: 12 May 2020
© Springer Nature B.V. 2020



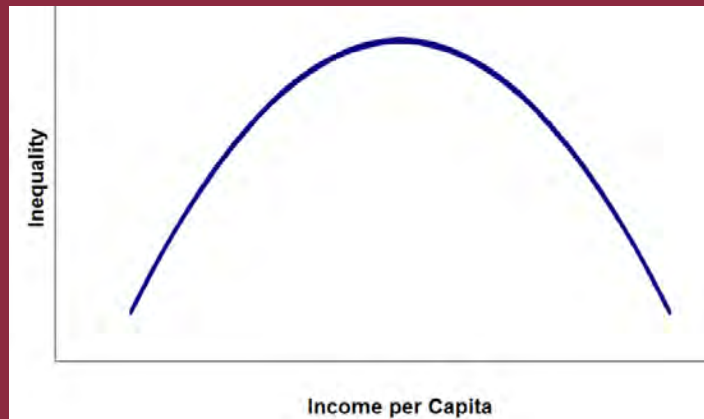
Economic growth & inequality



Environmental impact

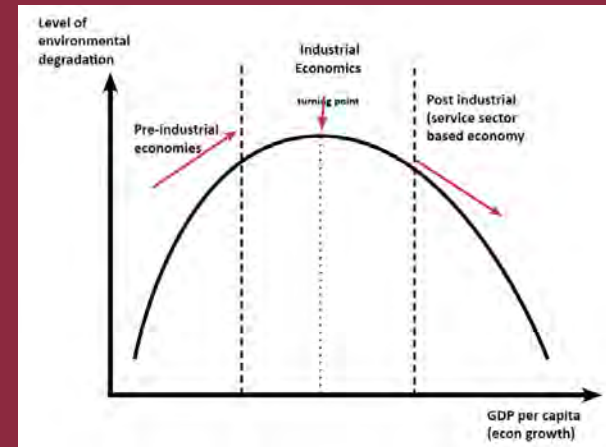


Kuznets Curve (Simon Kuznets, 1955)



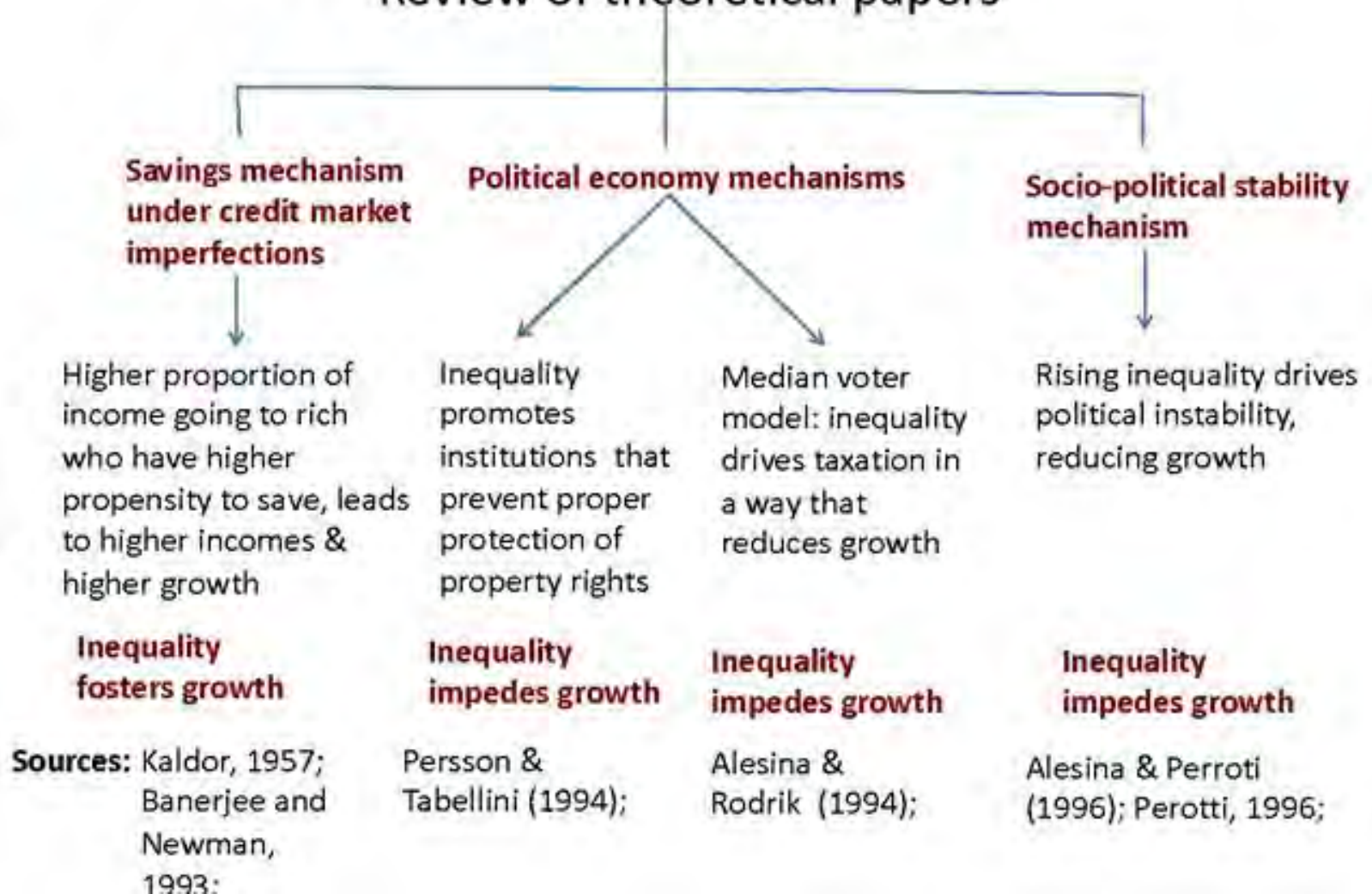
- Cross-sectional data for US, England, Germany, India, Ceylon and Puerto Rico
- Late 19th century- first half of 20th century
- Inequality first increases up to certain threshold then declines
- Weak support in later studies [Saith, 1983, Anand & Kanbur, 1993]
- Piketty (2013) refuted its universal applicability

Environmental Kuznets Curve Grossman & Krueger (1991, 1995)

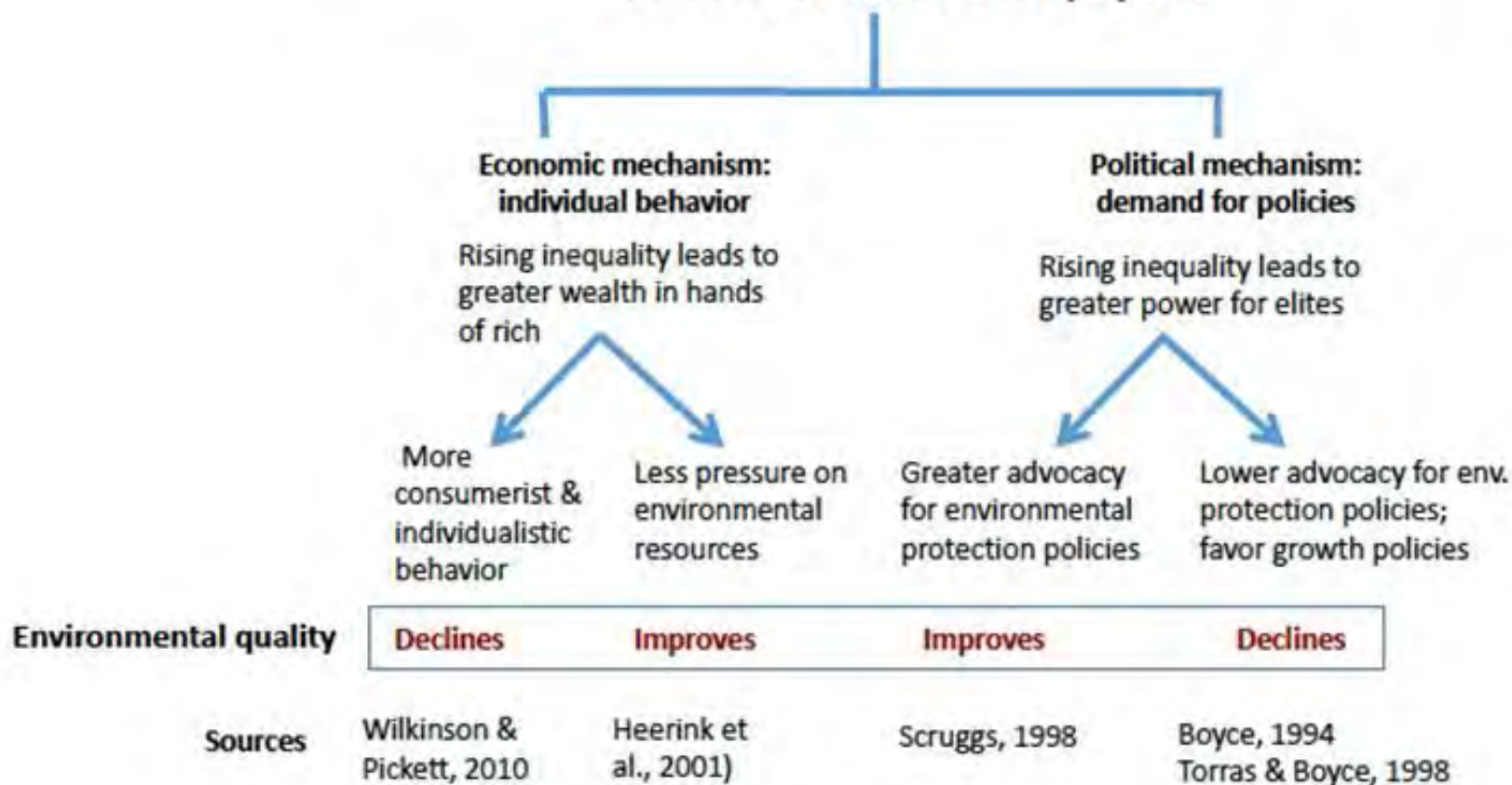


- Environmental quality declines in the early stage of economic growth, but beyond certain level of income per capita, the trend reverses
- Results vary depending on samples of countries/ regions, time periods, and type of pollutant
- Out of 8 studies on emissions, 3 studies could not verify EKC [Shafik, 1994, De Bruyn et al. 1998, Friedl and Getzner, 2003]

Impact of increase in inequality on income growth: Review of theoretical papers



Impact of increase in inequality on environmental quality: Review of theoretical papers



The Model & Data

Dependent variable = {PerCapita_CO₂_Slope_post_2008}

Independent variables = {PerCapita_CO₂_Slope_pre,
Avg_CO₂/GDP_pre,
Avg_CO₂/GDP_post
GDP_Growth_Slope_pre,
GDP_Growth_Slope_post,
GDP_Growth_SD_pre,
GDP_Growth_SD_post,
Gini_Slope_pre,
Gini_Slope_post}



Data Source = World Income Inequality Database (Gini)
World Bank (GDP growth rate, and per capita CO₂ emissions)

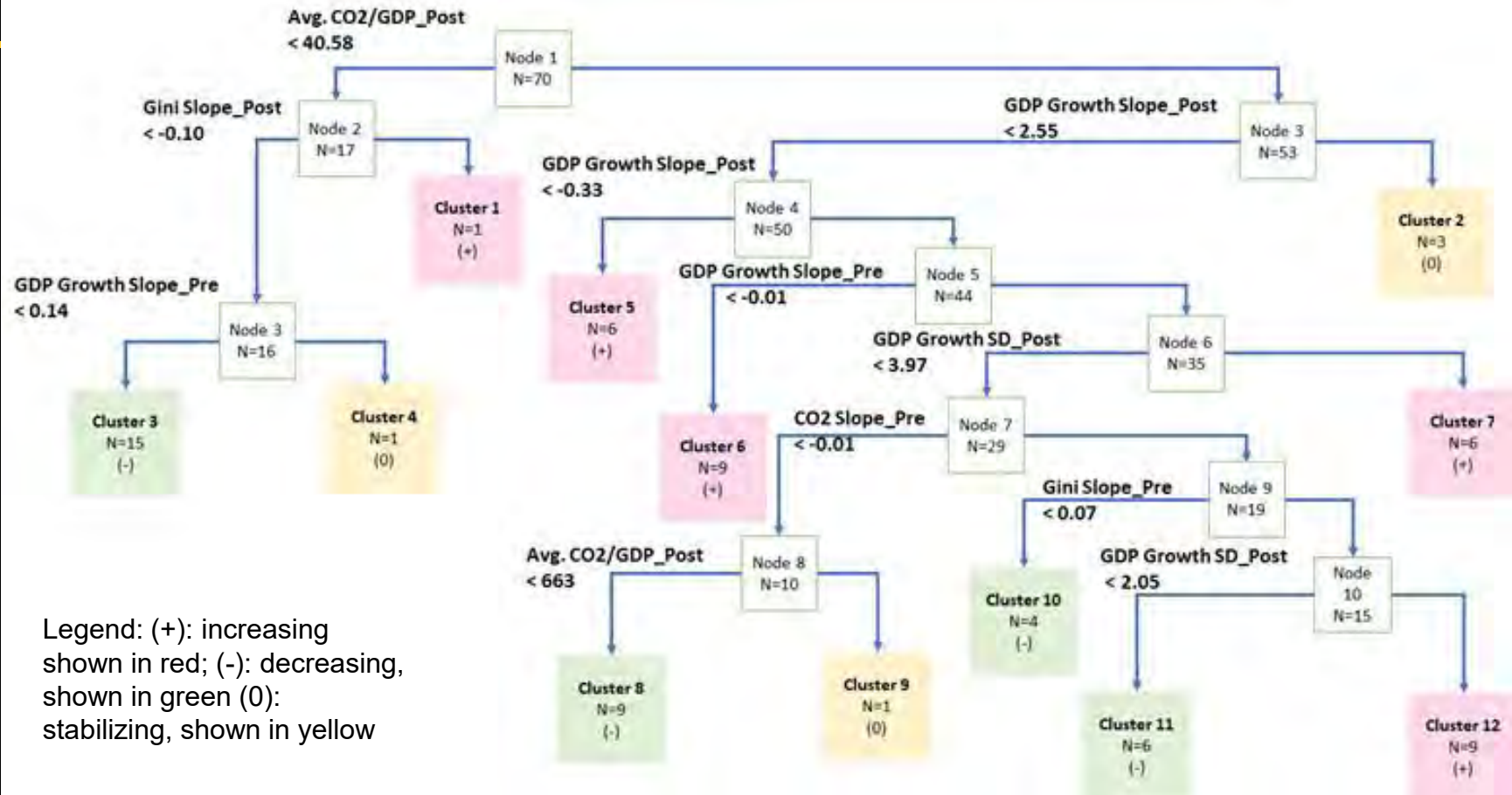
Time period = 1980-2014

**Total
countries =** 70

Countries' Carbon Emissions Trajectories

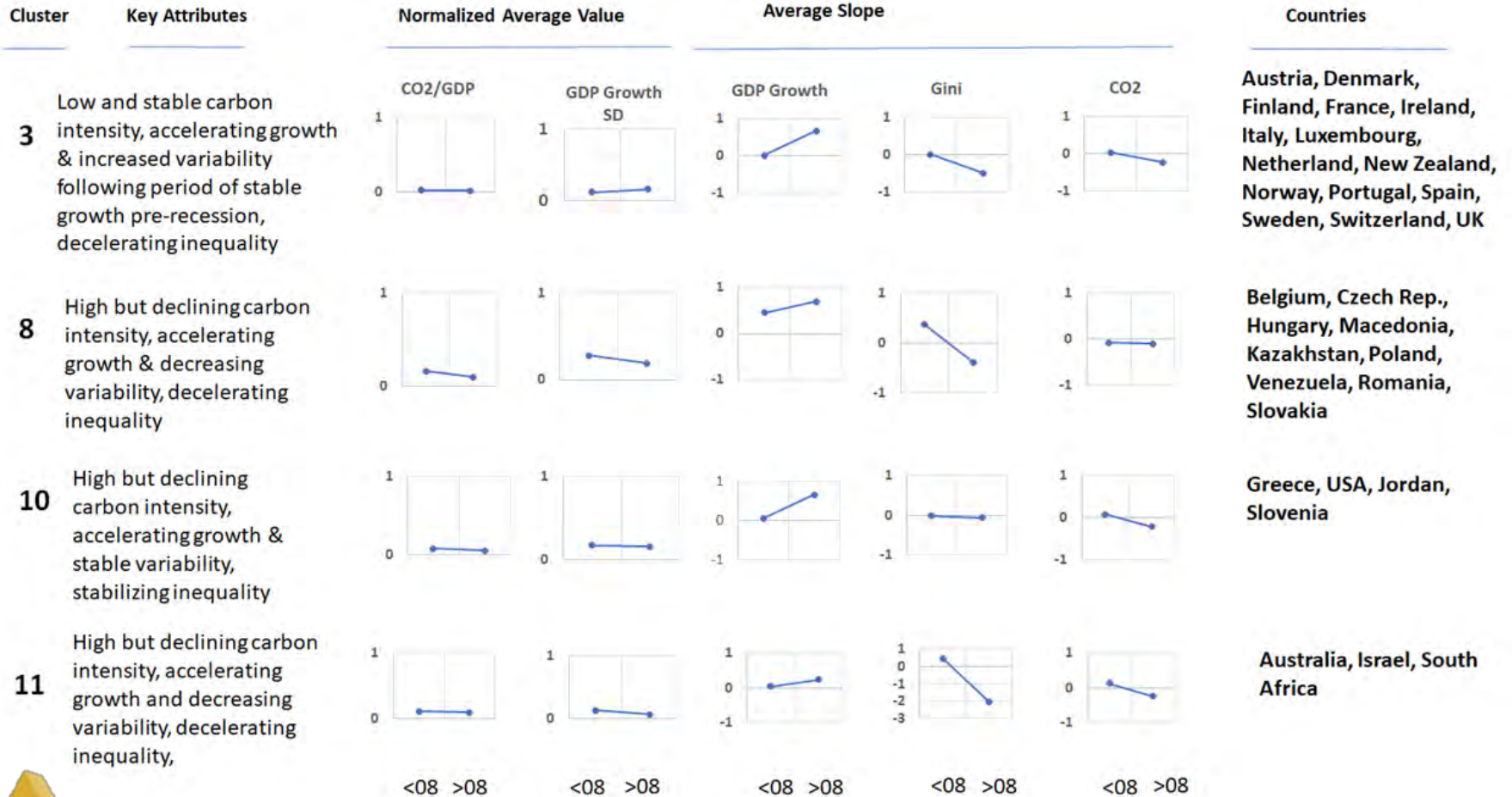


12 Development Pathways



Economy energy intensity is the most important factor

Cluster (-)



More equal society is associated with increasing environmental quality





Cluster (+)

Cluster	Key Attributes	Normalized Average Value		Average Slope			Countries
		CO2/GDP Ratio	GDP Growth SD	GDP Growth	Gini	CO2	
1	Low and stable carbon intensity, accelerating growth & increasing variability, stabilizing inequality						Japan
5	High but declining carbon intensity, decelerating growth & decreasing variability, decelerating inequality						Argentina, Belarus, Brazil, China, India, Uruguay
6	High and stable carbon intensity, accelerating growth and decreasing variability, stabilizing inequality						Estonia, Germany, Indonesia, Paraguay, Korea, Malaysia, Singapore, Thailand
7	High and increasing carbon intensity, accelerating growth and decreasing variability, decelerating inequality						Georgia, Kyrgyzstan, Moldova, Russia, Turkey
12	Low and stable carbon intensity, accelerating growth & stable variability, decelerating inequality,						Canada, Chile, Dominican Rep., Ecuador, Panama, Sri Lanka



More complexity and diversity in country experiences

Summary

CO2 per Capita		<ul style="list-style-type: none">• High-medium income countries with positive & accelerating GDP growth• Decreasing Gini
CO2 per Capita		<ul style="list-style-type: none">• Lower-middle, upper-middle (Brazil), and high (Canada) income countries• Mixed Gini trajectories


- 12 country clusters with distinctive characteristics
- Direction and Rate of Change vs. Level

SDGs Integration into Learning

“Universities can play a crucial role for successful implementations of SDG initiatives through a meaningful engagement with diverse stakeholders ”

Leal Filho, et al., 2019

SDGs Student Projects



Sustainable Fishing: Chiloé Island

14 LIFE BELOW WATER


7 AFFORDABLE AND CLEAN ENERGY

Electrifying Lagos, Nigeria

By: Scott Semken, Kaitlin Kreck, Steven Owens, Jared Chernack
SOS 311 Professor Datu B. Agusdinata April 25th 2018

Introduction

SDG Target: By 2030, effectively regulate harvesting and end overfishing, illegal, unreported, and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.




Case Study: Chiloé Island

- Chiloé is a small island located off of the northern coast of Chile.
- Many of the locals are employed at the docks, processing facilities, or on fishing boats in order to support their families.
- Given the exceptional biodiversity of the surrounding waters, the island has fallen victim to harmful and unsustainable fishing practices.
- Our research and scenario implementation explores the role of policy and community involvement in solving this problem.

Introduction

The dire state of the electrical grid in Lagos



Sustainability Development Goal 7.1.1

- Increase the proportion of the population with access to clean energy

Lagos, Nigeria

- Largest metropolitan area in Africa
- 2016 Population: 21 million
- Corporate & financial capital


Energy, Oil, and Petroleum

- 14% of GDP
- 90% of Foreign Exchange Earnings

Access to Power

- 80% of pop. rely on diesel generators
- 40% have no access to the power grid

Decision Tree

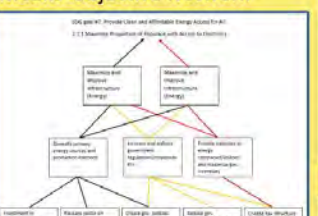


The user starts here in the scenario implementation phase of the project and then moves to the implementation phase.

System Framework Diagram

Decision Maker/Philanthropist/Investor	System/Outputs	Value System (V)
<ul style="list-style-type: none"> Level of intervention in local fishing market Incentives for local fishing behaviors 	<ul style="list-style-type: none"> Environmental protection for the regulated fishing market livelihood for the local villagers 	<ul style="list-style-type: none"> Profitability of local fishing behaviors Profitability of local fishing market
<ul style="list-style-type: none"> Population growth of fish throughout the coastal ecosystem Climate change impact on fishing industry Change in the fish market 	<ul style="list-style-type: none"> Cultural significance of fishing to the local villagers Local business interest in the fishing market Local economy interest in the employment of fishing 	<ul style="list-style-type: none"> Job availability for locals Fish population security for the city Environmental protection for all marine species

Means-Objective Network



System Framework

Decision maker: Philanthropist & Business Investor	Policies/Decisions (P)	Value System (V)
<ul style="list-style-type: none"> Extern. Res. Qu. Infr. Text. Avi. Ent. Fut. Sci. 	<ul style="list-style-type: none"> Amount of investment Timeline for investment 	<ul style="list-style-type: none"> Risk attitude Profit

References

[https://www.sustainabledevelopment.go...](#)

[https://www.un.org/sustainabledevelo...](#)

[https://www.researchgate.net/publicat...](#)

[https://www.researchgate.net/publicat...](#)

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Introduction

In 2020, promote the rehabilitation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and/or reforestation globally.

SDG Goal 15 – Target 2

By 2030, promote the rehabilitation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and/or reforestation globally.



Introduction

- Indonesia's rich natural resources have led to an abundance of forests with 82% of land cover being wooded.
- Jakarta, the capital, has been experiencing a decline in forest cover over time.
- In Indonesia, the **2nd highest rate of deforestation** in Indonesia. From 2000-2009 alone, the country lost 6.9 million ha of forest.
- One factor driving deforestation is reliance on swidden agriculture and slash-and-burn agriculture.
- In 2017, the Indonesian agricultural sector made up 14% of the country's aggregate GDP and at least 26 million Indonesians depend on forests for their livelihoods.
- Another challenge is a **lack of government capacity** to combat deforestation.
- The governance system is **opaque** and lacks conflict resolution capabilities, the central government, and resource companies.
- Finally, there is a **lack of women representation** in the decision-making process.
- Women in Indonesia play a central role in driving deforestation because of their role as head of the household and primary maintainer of the farms. Therefore, they have the capacity to contribute to the local decision-making process, especially in regards to how sustainably they manage their farming.

References

[1] Ministry of Forestry. (2011). Indonesian Forest Statistics 2008. Indonesian Ministry of Forestry, Jakarta, Indonesia.

[2] Brock, M., de Haan, A., Stille, P., Pranga, S., & Alermeida, J. (2011). Restoring natural forest cover using high spatial and temporal resolution satellite data and techniques. *Indonesia 2010-2011: Environmental Research Letters* (3), 140.

[3] FAO. (2014). *World Agriculture Statistics*. Rome, Italy: Environmental Research Letters.

[4] FAO. (2014). *World Agriculture Statistics*. Rome, Italy: Environmental Research Letters.

<http://www.fao.org/docrep/012/i1660e/i1660e01.htm#3>

Decision Tree

Will Forests Flourish or Flop?

SOS 311: The Future of the Kalimantan Forest

Hailey Campbell and Danielle Vermeer



Scenarios

Forests Flourish

- Greenhouse and Grow
- United Nations to the Rescue

Forests Flop

- United Nations to the Rescue
- Forests Flourish

Conclusions

- Deforestation of the Kalimantan forests is a critical concern and complex sustainability challenge.
- Without action, the entire forest will be destroyed.
- Lands will be left unproductive for the many people who live in the forest and will be unable to support themselves in the soil or outcrop of its resources.

Recommendations

- Based on the ANF calculation, the recommended solution would be to **maximize local economic opportunities** followed by **empowering women in increasing government capacity**.
- Increased collaboration between women, the government, and communities.
- Work of efforts to **educate** the community about the negative implications of deforestation/swidden agriculture industry.
- The implementation of sustainable government regulations**
 - New laws limit the agriculture industry to prohibit slash-and-burn agriculture practices.
- The establishment of new economic opportunities by the UN and the government**
 - Includes rural from all members of the communities affected.

Key Takeaway

- As long as people are entirely dependent on swidden agriculture and the government fails to recognize women's role in the community, the negative implications of deforestation will remain unaddressed and will be nearly impossible to create a solution that allows the people and saves the forest.

■ SDGs Posters

SDGs Student Projects

INDONESIA

AGRICULTURE

TOURISM

WASTE

SANITATION

SOS 498
Sustainable Development in Action

INDIA

INDONESIA - AGRICULTURE
Hassini Delvinne
Ian Thompson
Jeremy Hitzel
Sara Aly El Sayed

INDONESIA - TOURISM
Anna Marie Kristjansen
Leah Castle
Maryam
Shelbie Draper

INDIA - WASTE
Jonela Balasta
Junkee Ahn
Pallavi Chandra
Vanya Bisht

INDIA - SANITATION
Emily Bondank
Jagadish Parajuli
Natalie Mallue

Student-led SDGs Projects



U.S. GLOBAL
DEVELOPMENT
LAB Powered by **USAID**



ASU Global Development
Research
Arizona State University



Delivering impacts with Co-design & partnership



Building livelihood skills



- Gumantar, North Lombok



Cocoa Bean Drying Greenhouse for West Papuans

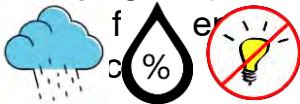


How can we increase the efficiency and yield of the cocoa processing system in West Papua to aid economic independence?

Dryer Design Solution

- **20-30%** of the yield is lost in the drying stage.
- **Natural convection greenhouse** allows for a low-tech method of controlling humidity.

- Allows for **consistent** cocoa bean drying despite da rai f e COVCI.



- **Simple** and **low-cost** design
- **Locally-sourced** materials
- **No electricity**

Potential benefits:

- Shorten drying time by half
- Reduce loss. Target: reduced the spoilage rate to 7%
- Increase quality of cocoa beans



Working with the Komoro Tribe in the Lowland region

Concluding points

SDGs as a System

Synergies-and-Trade offs

Policy Implementation

SDGs as a Learning Platform

Thank You

