UNITED NATIONS UNIVERSITY

UNU-FLORES

Institute for Integrated Management of Material Fluxes and of Resources

TECHNISCHE UNIVERSITÄT DRESDEN

ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

INTERNATIONAL KICK-OFF WORKSHOP

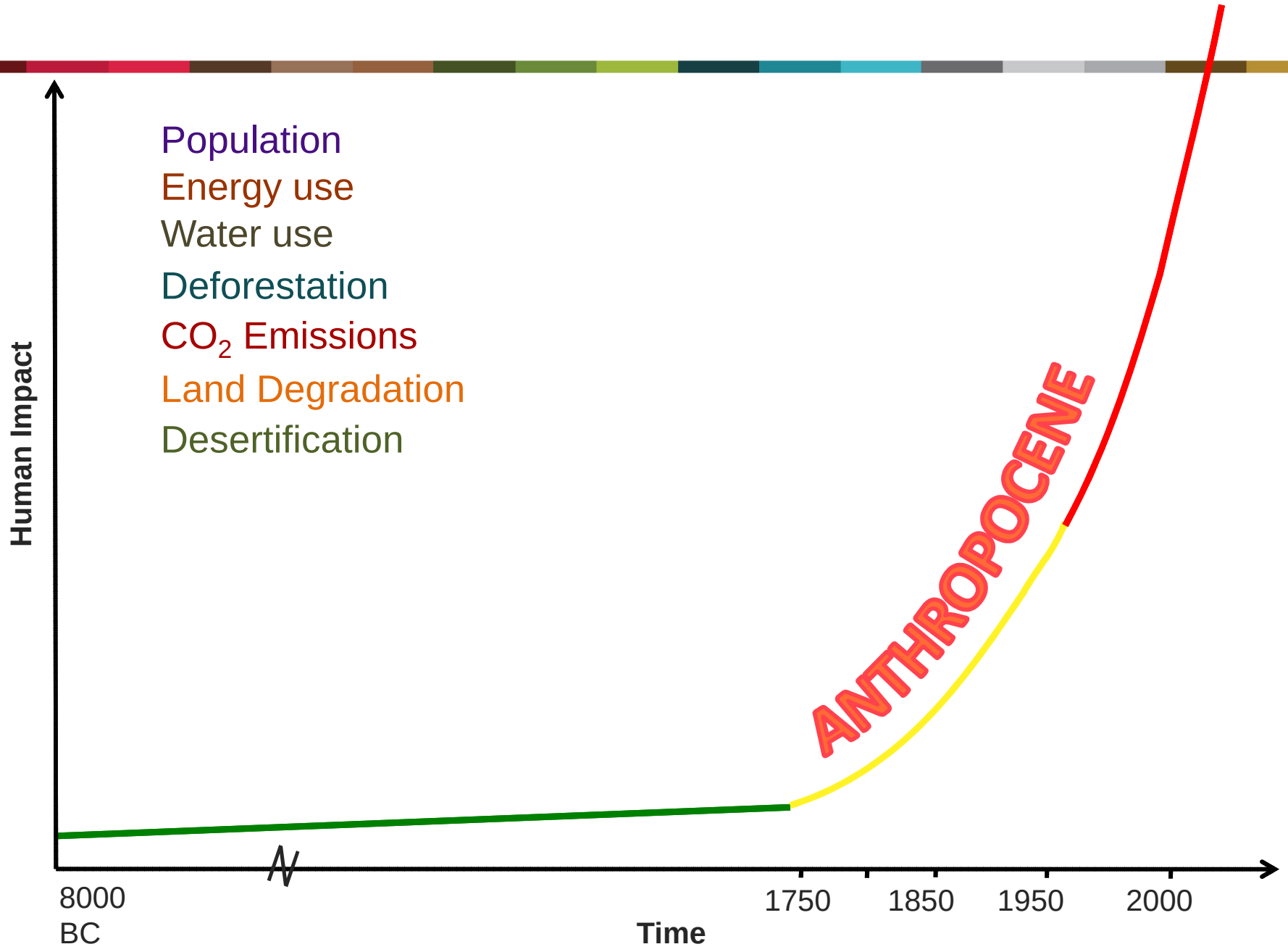
11-12 NOVEMBER 2013

DRESDEN, GERMANY

ADVANCING A **NEXUS APPROACH**
TO THE SUSTAINABLE MANAGEMENT
OF **WATER, SOIL** AND **WASTE**

THE NEXUS APPROACH TO MANAGING WATER, SOIL AND WASTE

Carbon Management and Sequestration Center
Dr. Rattan Lal


Population
Energy use
Water use
Deforestation
CO_2 Emissions
Land Degradation
Desertification
Human Impact
ANTHROPOCENE
8000
BC
1750
1850
1950
2000
Time

EARTH PROCESSES TRANSFORMED BY AGROECOSYSTEMS

Land Area : 38% of the Terrestrial Surface

GHG Emissions : 30-35% of the Global

Fresh Water Withdrawa l: 71%

Increase Since 1960s : i) Irrigation : x2

ii) Fertilizer : x5

iii) Nitrogen : x8

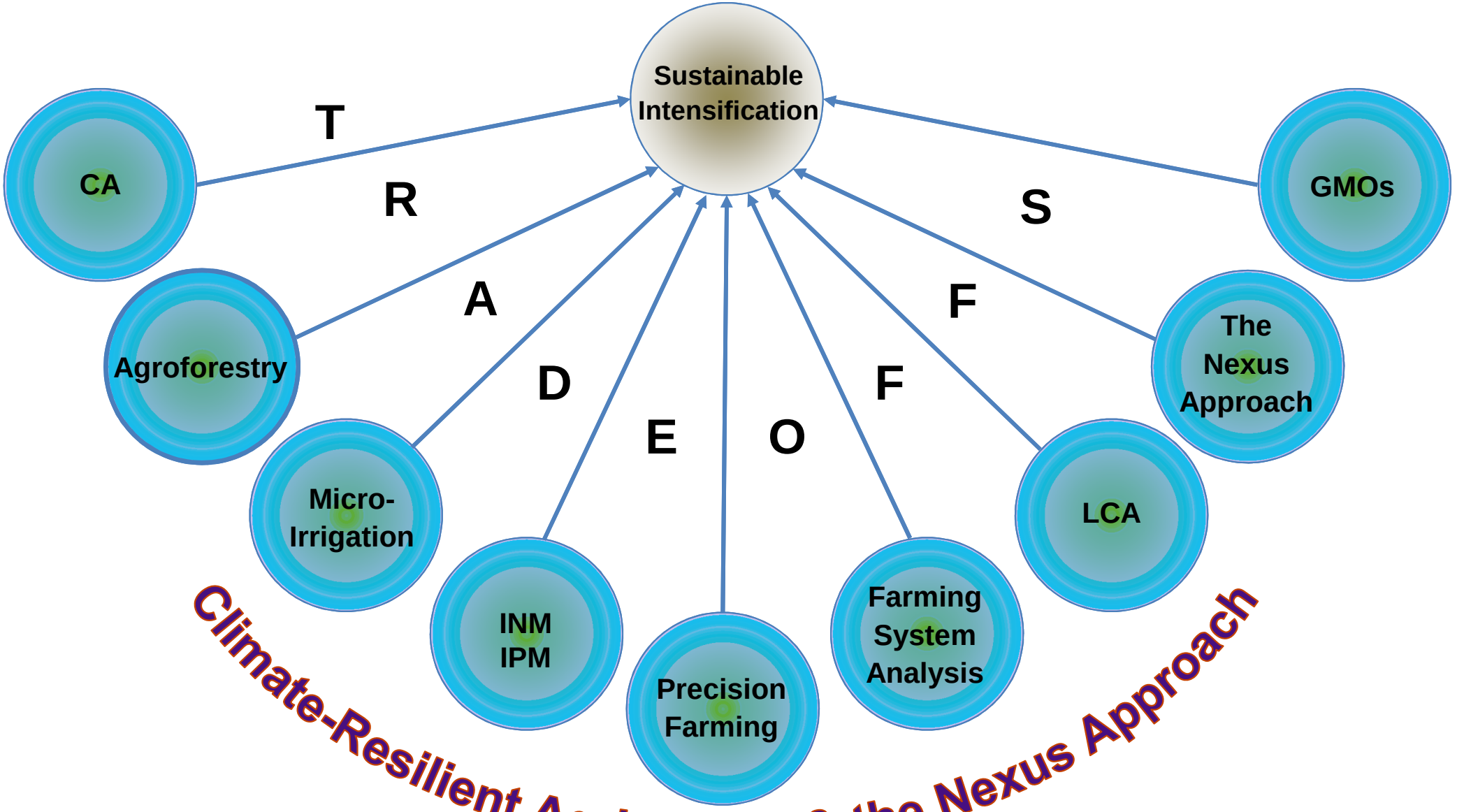
Yet, **1 in 7** are food insecure.

THE PATH FORWARD

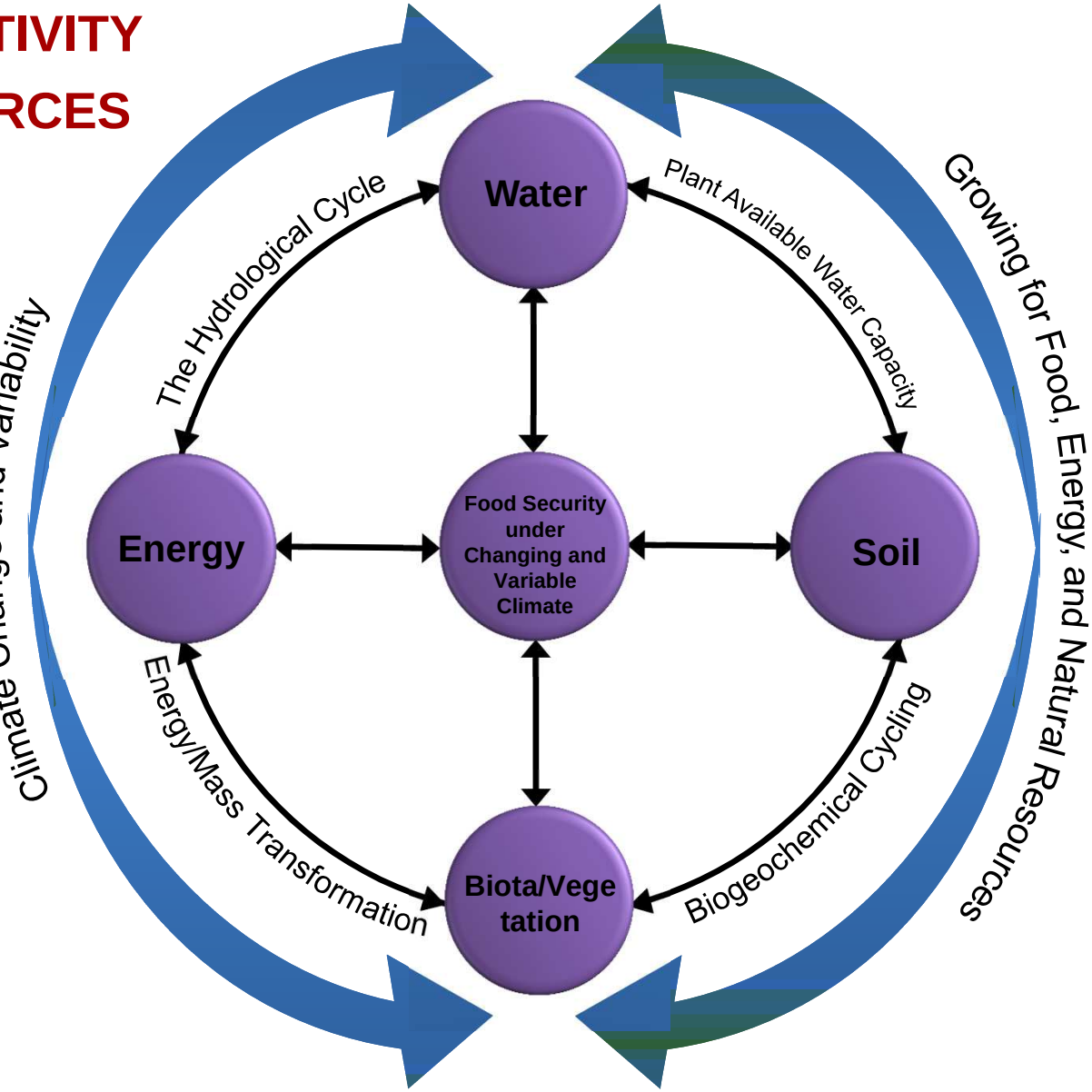
Rather than a silver bullet or a panacea, we must look for multiple paths. We cannot afford to be myopic and locked into a specific strategy whether organic farming, no-till agriculture, biotechnology, and others.

We need some revolutionary approaches

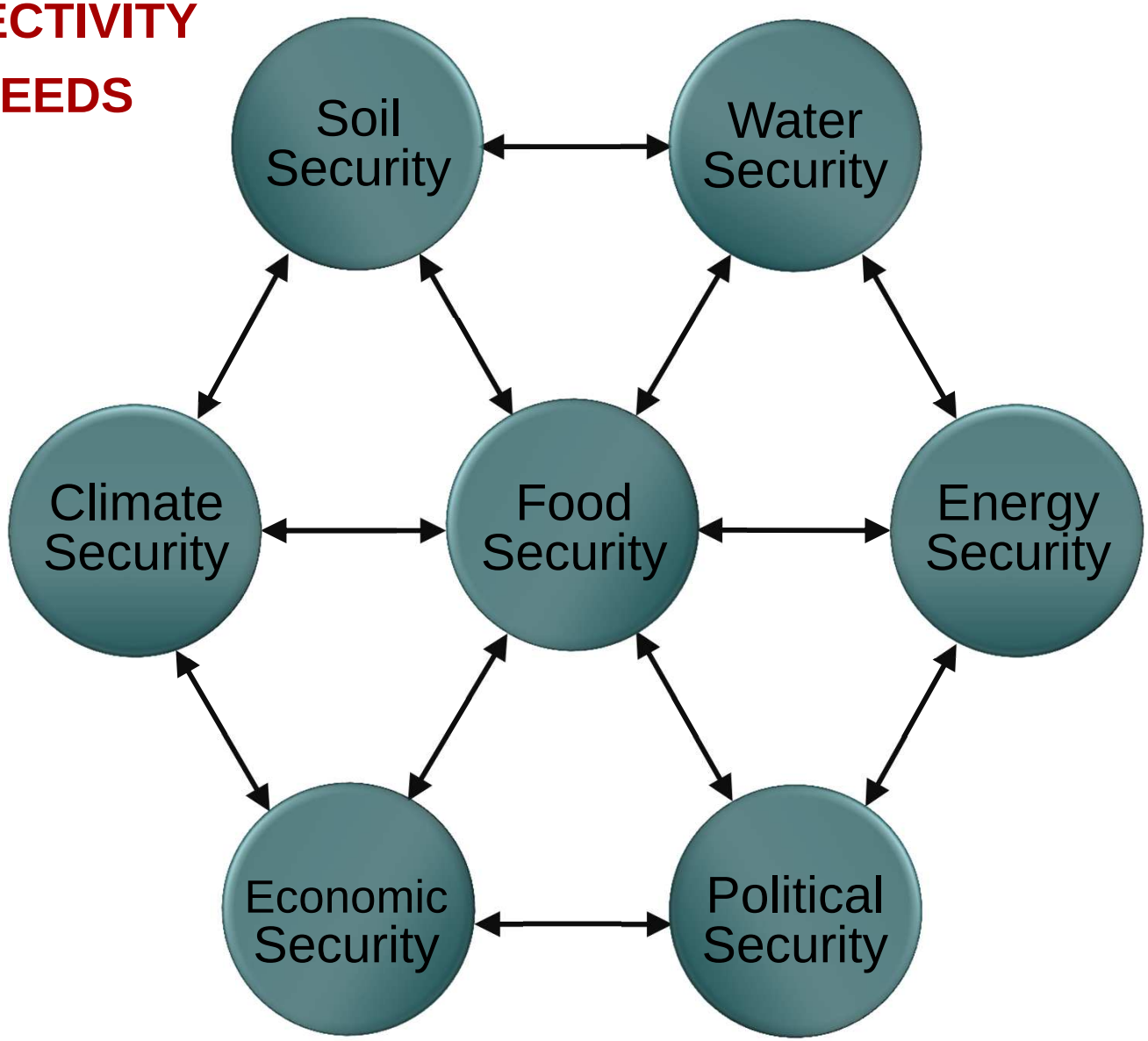
NO PANACEA NOR A SILVER BULLET

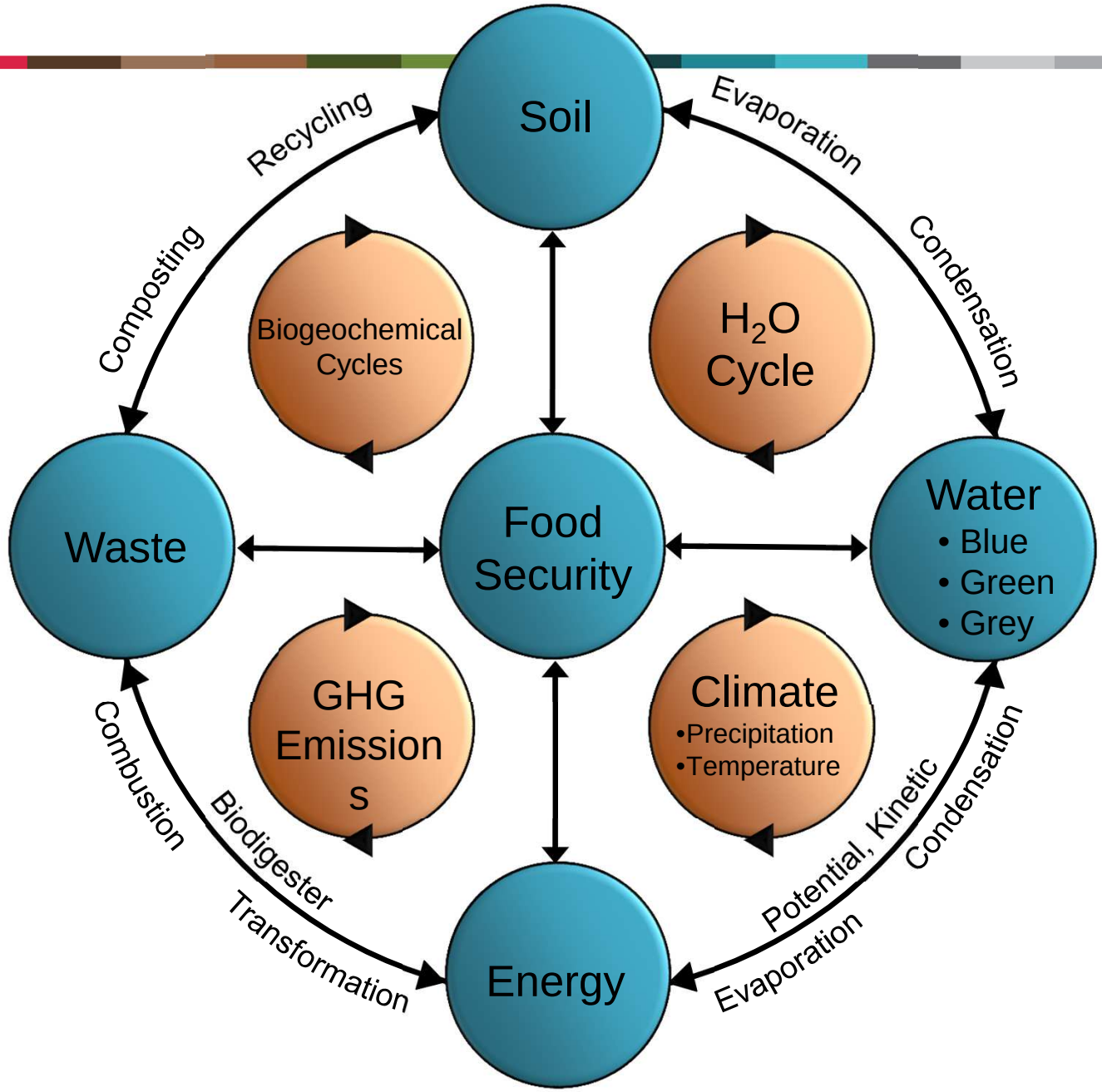


INTER-CONNECTIVITY AMONG RESOURCES

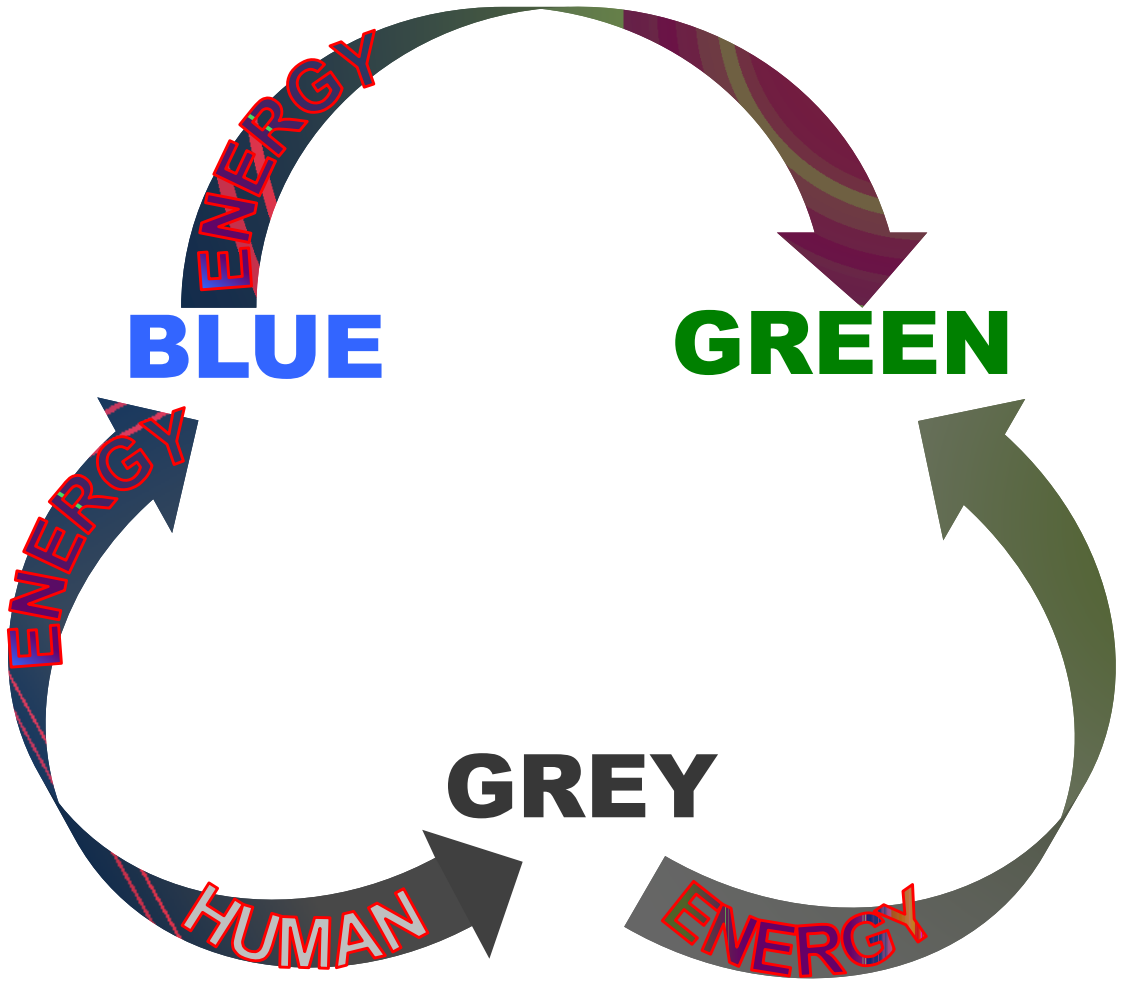


INTER-CONNECTIVITY OF HUMAN NEEDS




Soil
Recycling
Evaporation
Composting
Condensation
Biogeochemical Cycles
H_2O Cycle
Waste
Food Security
Water
• Blue
• Green
• Grey
GHG Emissions
Climate
•Precipitation
•Temperature
Combustion
Biodigester
Transformation
Potential, Kinetic
Condensation
Evaporation
Energy

SHADES OF WATER



WATER FOOTPRINT OF BIOFUELS

	m^3 H_2O/GJ			
Crop	**Brazil**	**The Netherlands**	**USA**	**Zimbabwe**
Cassava	30	-	-	205
Groundnuts	51	-	58	254
Maize	39	9	18	200
Miscanthus	49	20	37	64
Palm Oil	75	-	-	-
Poplar	55	22	42	72
Sugarcane	25	-	30	31
Rapeseed	214	67	113	-
AVERAGE	62	24	57	142

… Adapted from Gerben-Leenes et al., 2009)

WATER FOOTPRINT OF FOOD

Food	Liters of water per kg	Relative
Vegetables	322	1
Starchy roots	387	1-20
Cereals	1644	5-11
Pulses	4055	12-56
Chicken meat	4325	13-43
Bovine meat	**15,415**	**47-87**

… Adapted from Mekonnen and Hoekstra, 2012

POVERTY ENVIRONMENT NEXUS

- "Love and business and family and religion and art and patriotism are nothing but shadows of words when a man is starving."

… O'Henry (1907)

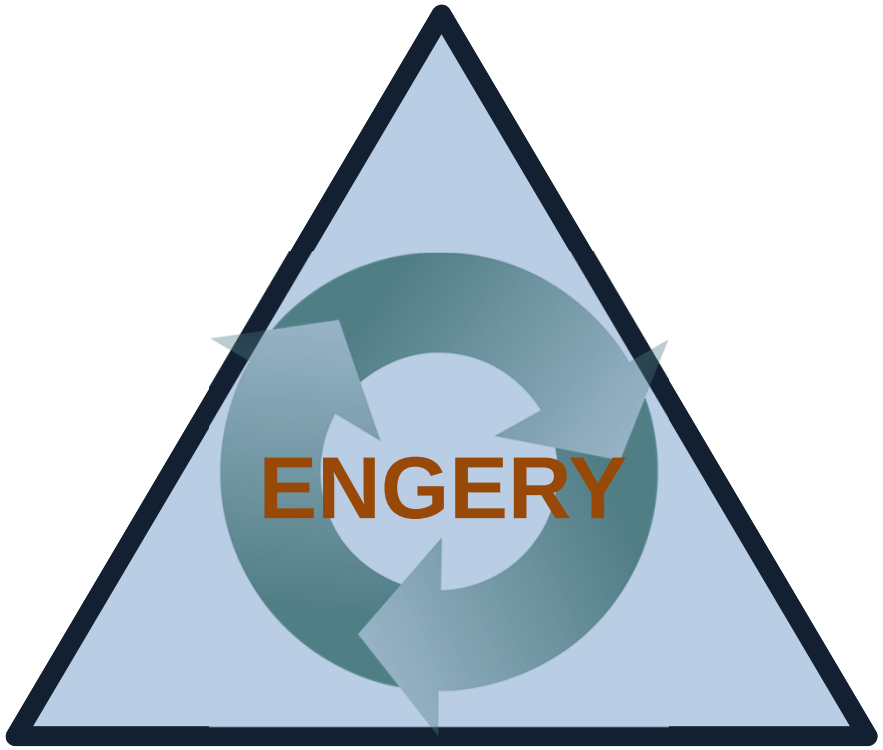
- There are not many troubles in the world more alarming than those caused by the fire in the pit of an empty stomach.

- "When people are poverty stricken, desperate and hungry, they pass on their sufferings to the land."

… Lal (2008)

SOIL – WATER NEXUS

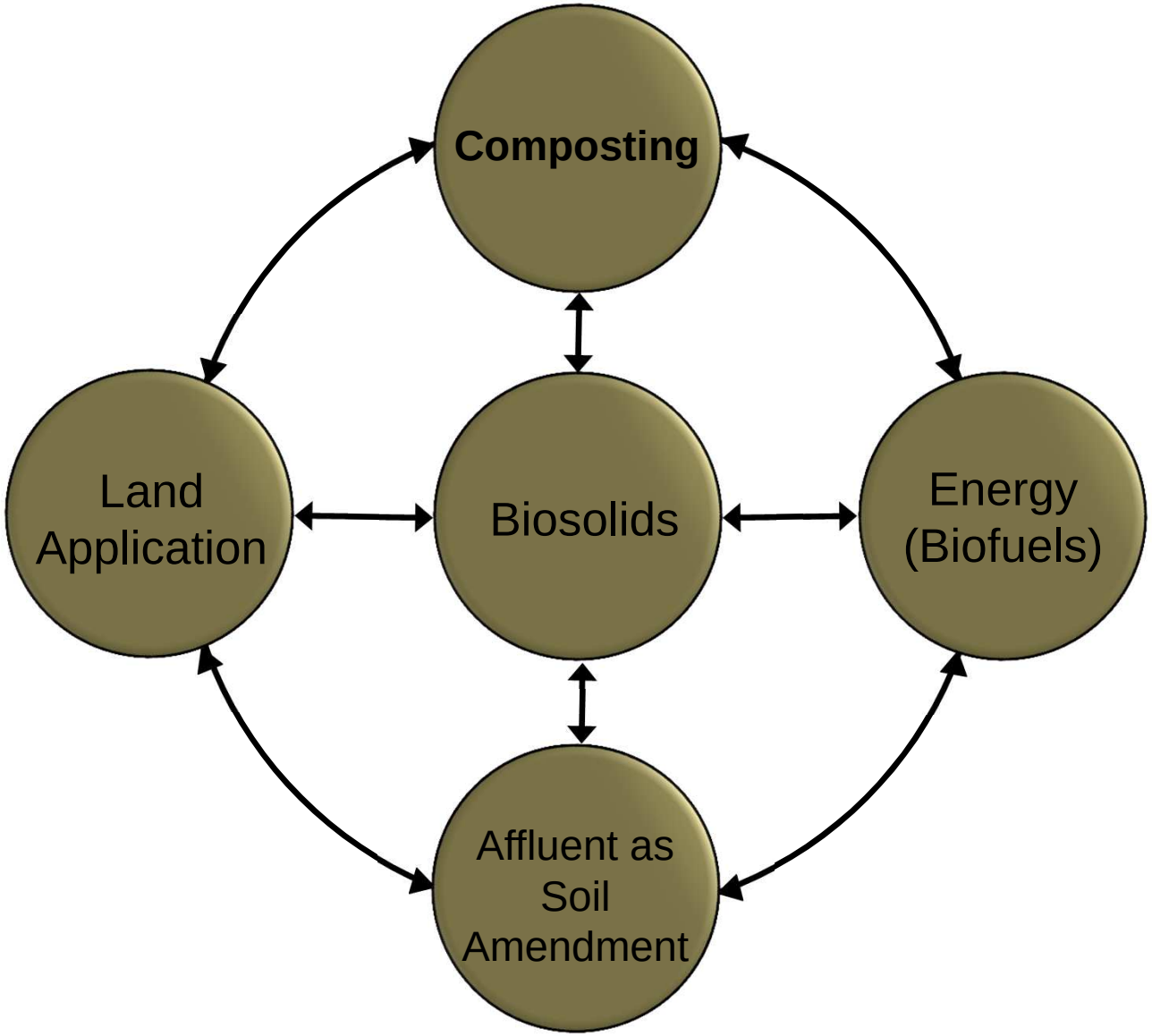
Food
(Availability, Access, Quality)



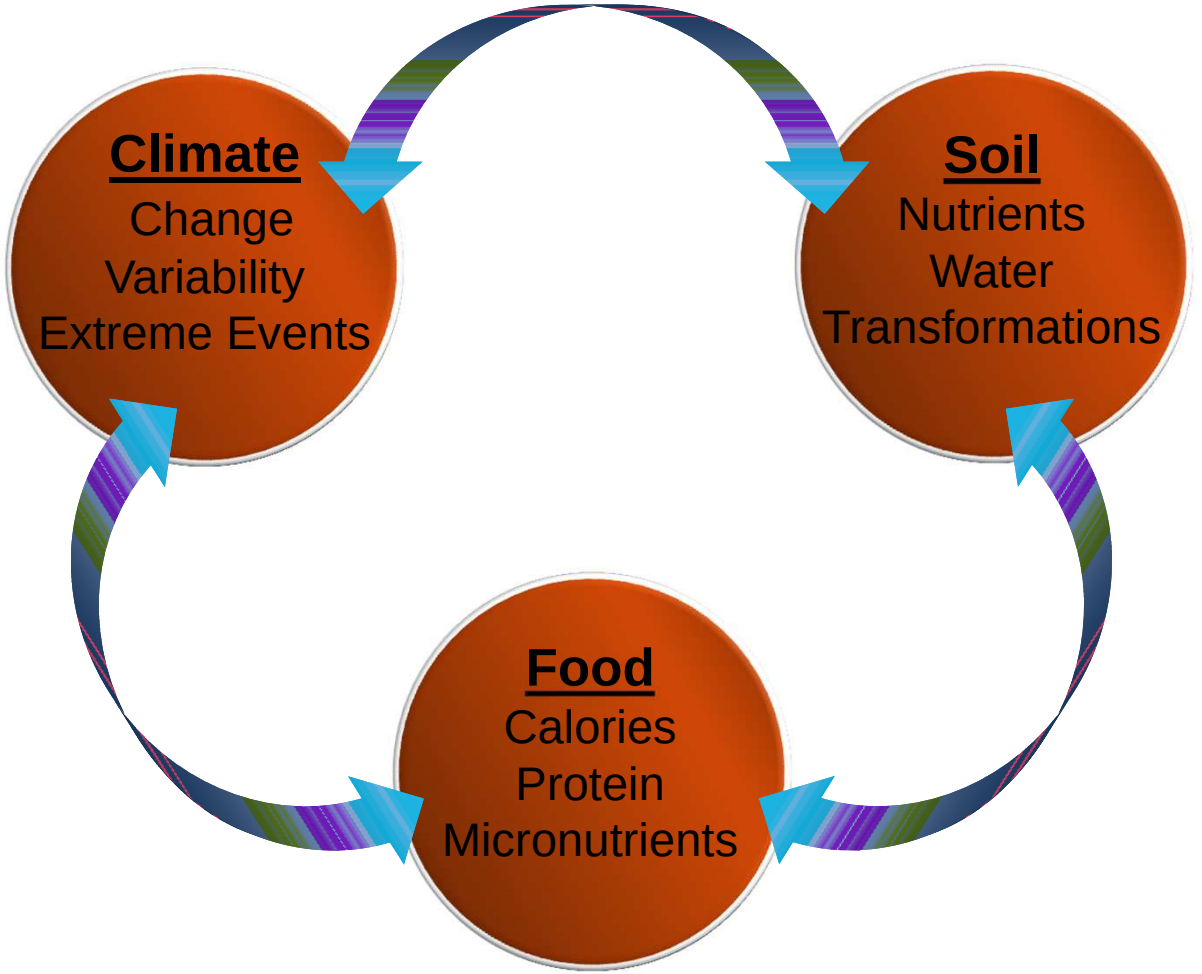
Soil
(Quality, Degradation)

Water
(Scarcity, Quality)

SOIL – WASTE NEXUS



FOOD – NATURAL RESOURCES NEXUS

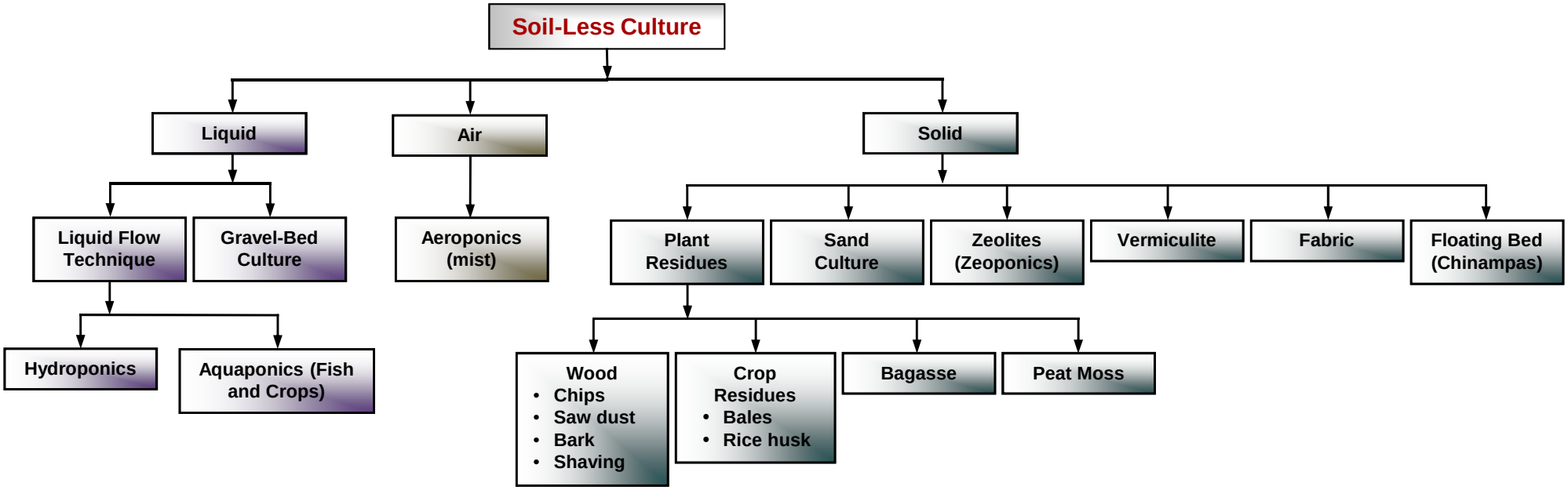


IMPORTANCE OF URBAN AGRICULTURE

	Population (10^6)		
City	1950	2025	Growth Factor
New Delhi	1.4	28.6	20.4
Calcutta	4.5	20.1	4.5
Bombay	2.9	25.8	8.9
Pune	0.6	6.6	11.0
Hyderabad	1.1	8.9	8.1
Bangalore	0.7	9.5	13.6
Madras	1.5	9.6	6.4
% of population living in cities of > 1 million	3.1	15.6	5.0

(Adapted from Kazmin, 2011)

SOIL-LESS CULTURE



BIOREGENERATING SOIL-BASED SPACE AGRICULTURE

Multiple life support functions of plants:

- Removing CO_2 through photosynthesis,
- Generating O_2,
- Producing food,
- Purifying waste water applied to roots through transpiration,
- Composting inedible biomass,
- Denaturing pollutants by soil and filtering H_2O,
- Increasing harvest index from 50% to 70% to reduce per capita food production area from 40 to 28m2, with edible biomass productivity of 16 to 22g $^{m\text{-}1d\text{-}1}$

…Wheeler, 2003; Silverstone et al., 2003)

GRAVITY EFFECTS ON SOIL PROCESSES

Physical	:	Soil buoyancy, hydrologic properties, advection, soil permeability, water infiltration rate, low water residence time,
Chemical	:	Nutrient dispersion & transport rate, low solute residence time,
Biological	:	Nutrient transformation,
Plant	:	Biomass dynamics

Coupled dynamics of soil hydrologic and biogeochemistry

Gravity :	Earth	1g = 9.806m s^{-2}
	Mars	= 0.38g
	Moon	= 0.16g
	Orbiting Space Station	= 0g

TRILEMMA OF OF SOIL DEGRADATION
(Rates Per Minute)

Causes

- Population increase : 150 people (births 250, deaths 100)
- CO_2 carbon increase : 6150 ton
- Tropical deforestation : 25 ha
- Urban encroachment : 5.5 ha

Effects

- Soil degradation : 10 ha
- Deaths from hunger : 16 people (incl. 12 children)

Consequences

- Political instability
- Civil strife

THE FUTURE AGRICULTURE

- This is an exciting era, especially for agriculture and systems of food production
  - More change will happen between now and 2050 than during the past 10-12 millennia since the onset of agriculture
- With automation and full integration with the industrial sector, the global farmer population will decrease to < 1% of the 9.6 billion by 2050 or 11 billion by 2100
- The high tech 3-dimensional vertical farms can efficiently produce clean organic food within the urban centers

THE WAY FORWARD

- With projected population population expected to be 9.6 billion by 2050, we have to be innovative and resourceful.
- The BAU approach will jeopardize the natural resources already under great stress.
- The losses must be minimized and efficiency enhanced by 3Rs:
  - **Reduce,**
  - **Reuse, and**
  - **Recycle**