TEEBAgriFood Foundations Report
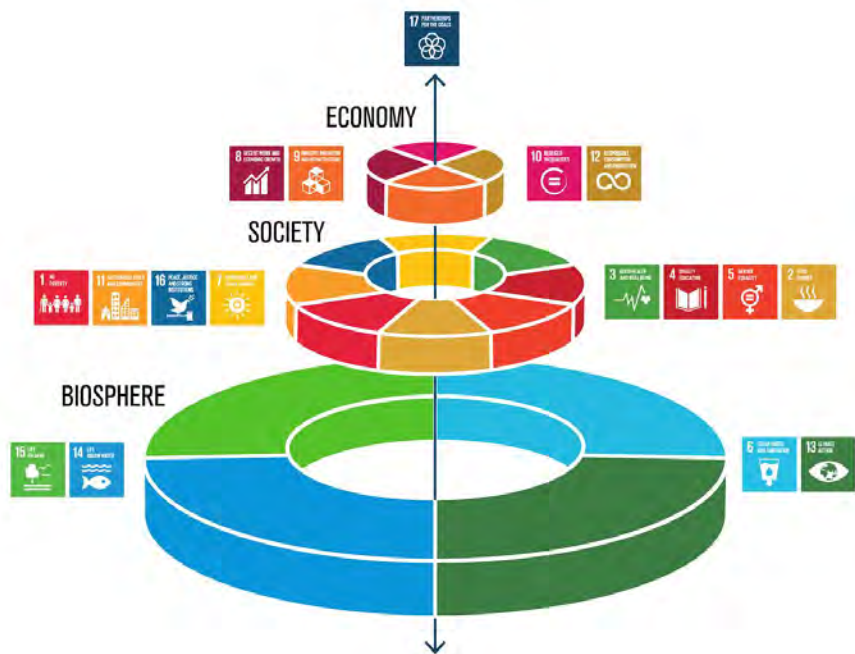# Full set of figures

The SDG 'wedding cake'

Figure 1.1
Source: EAT 2016

TEEB timeline and connected global events
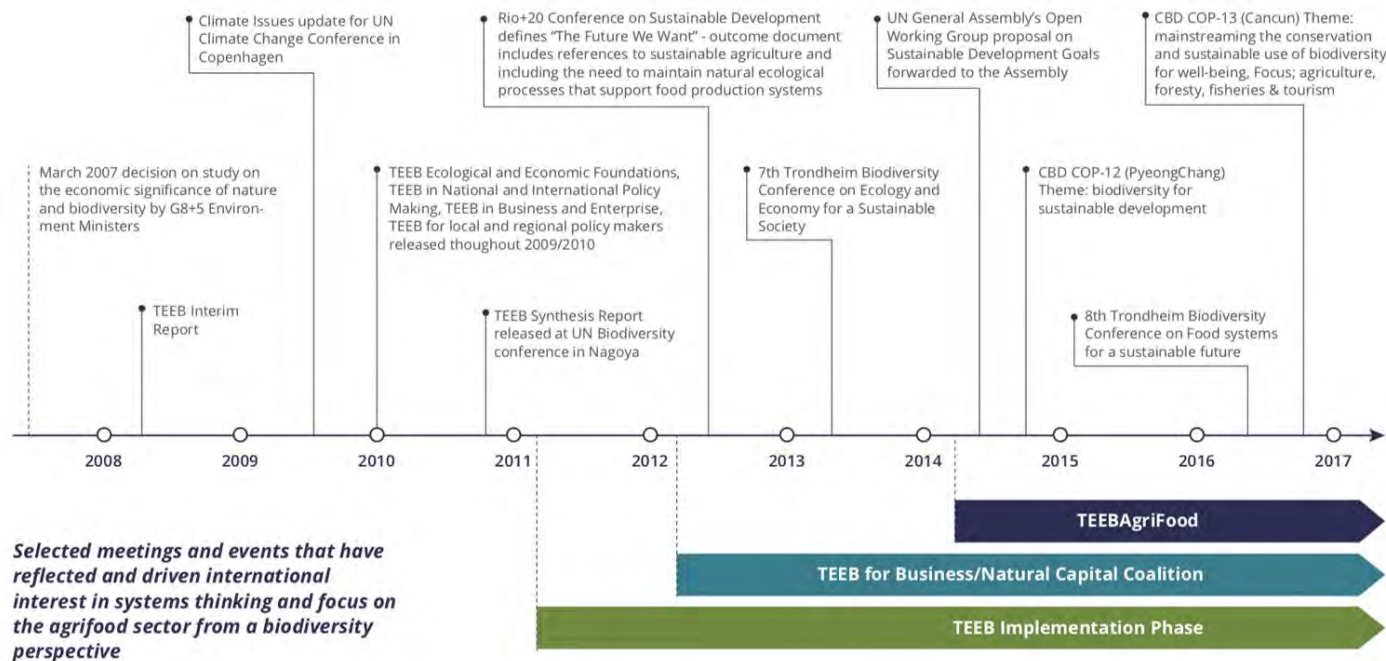
Figure 1.2
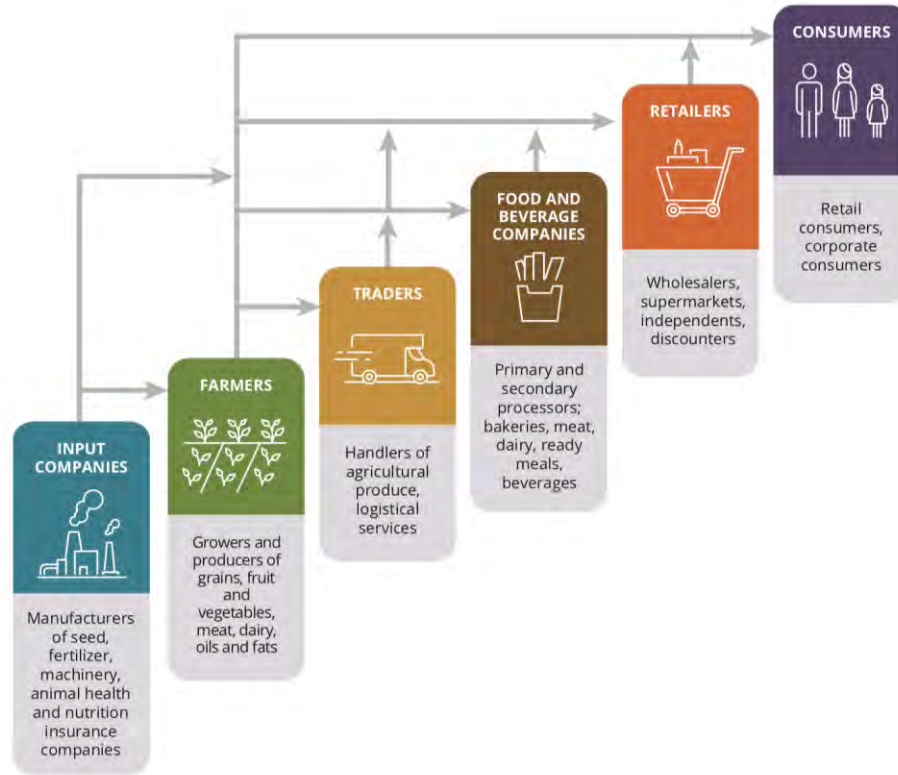Source: authors

The food and beverage value chain

INPUT COMPANIES
Manufacturers of seed, fertilizer, machinery, animal health and nutrition insurance companies

FARMERS
Growers and producers of grains, fruit and vegetables, meat, dairy, oils and fats

TRADERS
Handlers of agricultural produce, logistical services

FOOD AND BEVERAGE COMPANIES
Primary and secondary processors; bakeries, meat, dairy, ready meals, beverages

RETAILERS
Wholesalers, supermarkets, independents, discounters

CONSUMERS
Retail consumers, corporate consumers

Figure 1.3
Source: adapted from Trucost 2016

Capital stocks and value flows in eco-agri-food systems

HUMAN CAPITAL
- ► Labour
- ► Knowledge

- ► Wages
- ► Working conditions
- ► Nutritious food

SOCIAL CAPITAL
- ► Social networks
- ► Land access/tenure
- ► Cultural knowledge

- ► Food security
- ► Opportunities for co-operation and community activities

PRODUCED CAPITAL
- ► Machinery and infrastructure
- ► Energy, fuel, fertilizers and pesticides
- ► Research and Development; IT
- ► Finance

- ► Income
- ► Profits and rents
- ► Taxes

AGRICULTURE & FOOD VALUE CHAIN

Agricultural Production ⇒ Manufacturing and Processing ⇒ Distribution, Marketing and Retail ⇒ Household Consumption

- ► Biomass growth
- ► Fresh water
- ► Pollination
- ► Pest control
- ► Nutrient cycling

- ► Ecosystem restoration
- ► Deforesation and habitat loss
- ► Greenhouse Gas Emissions
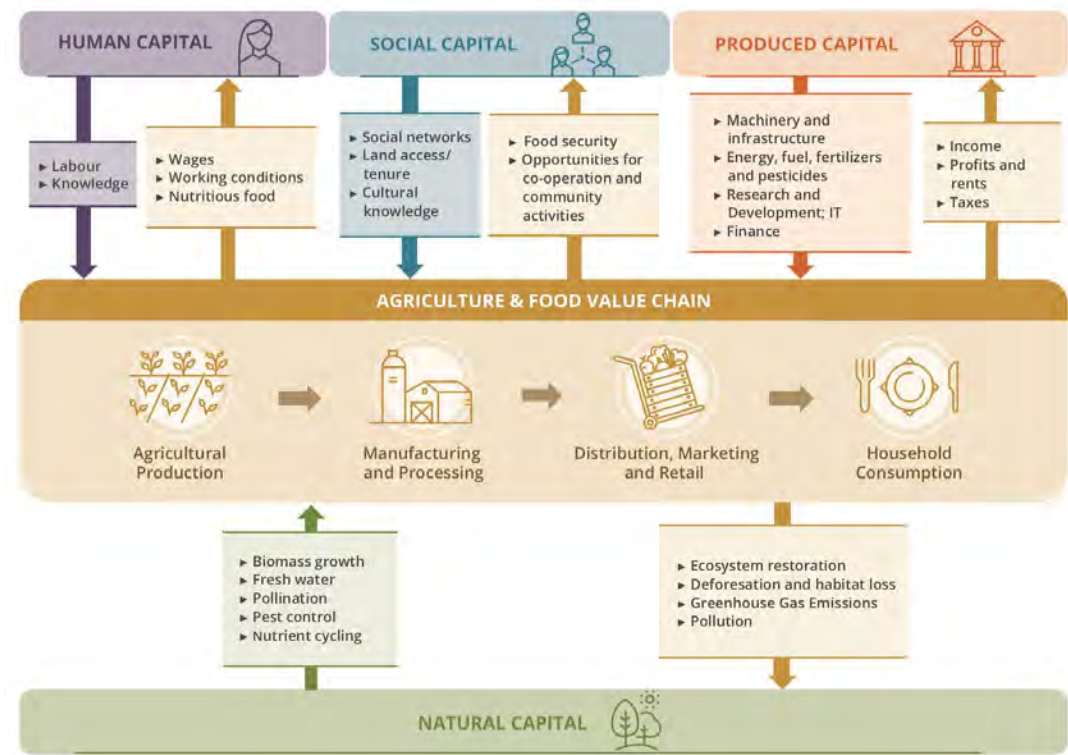- ► Pollution

NATURAL CAPITAL

Figure 1.4
Source: authors

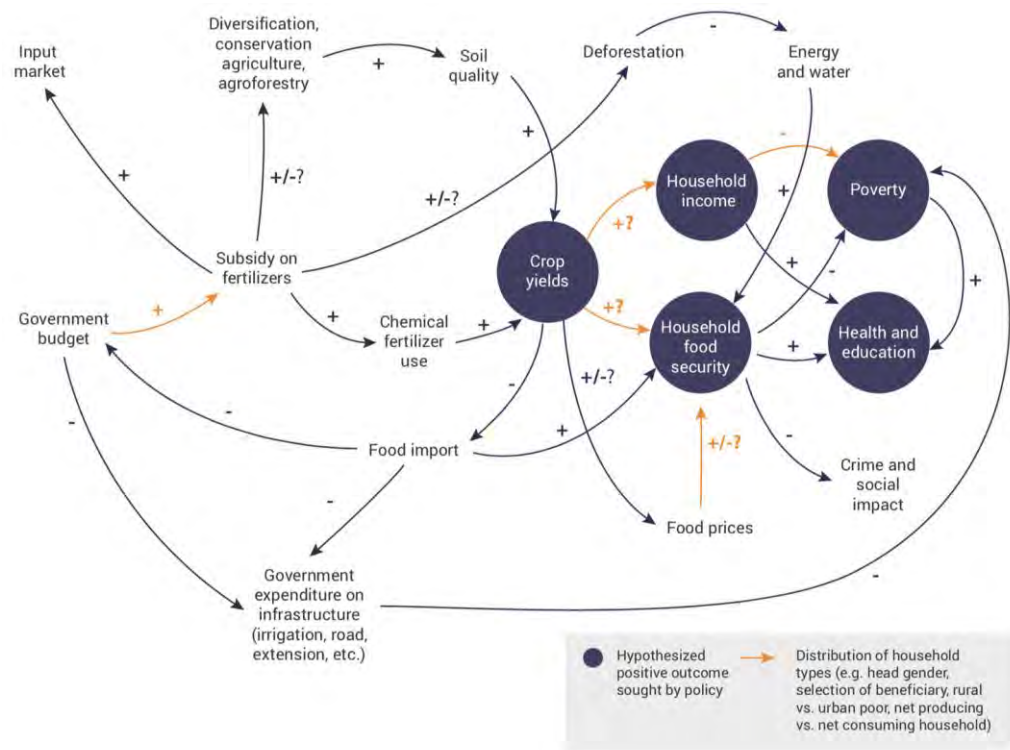# Mapping evidence of policy impact

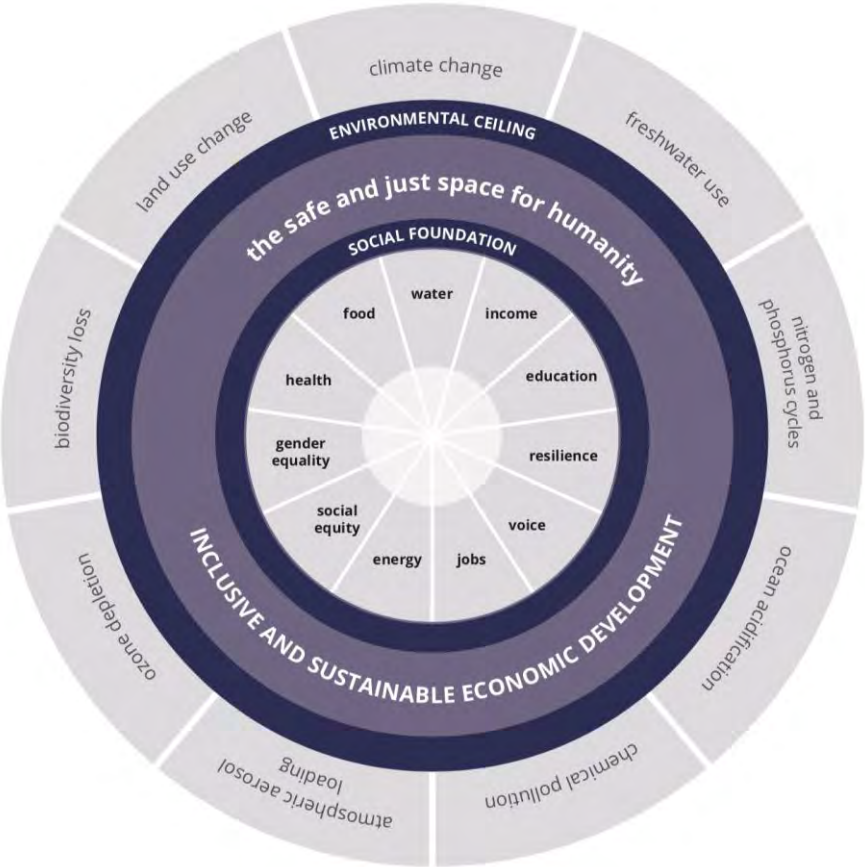Figure 2.1
Source: authors

The safe and just space for humanity

Figure 2.2
Source: adapted from Raworth 2012

Photo showing industrial monoculture alongside smallholder agriculture in Tanzania

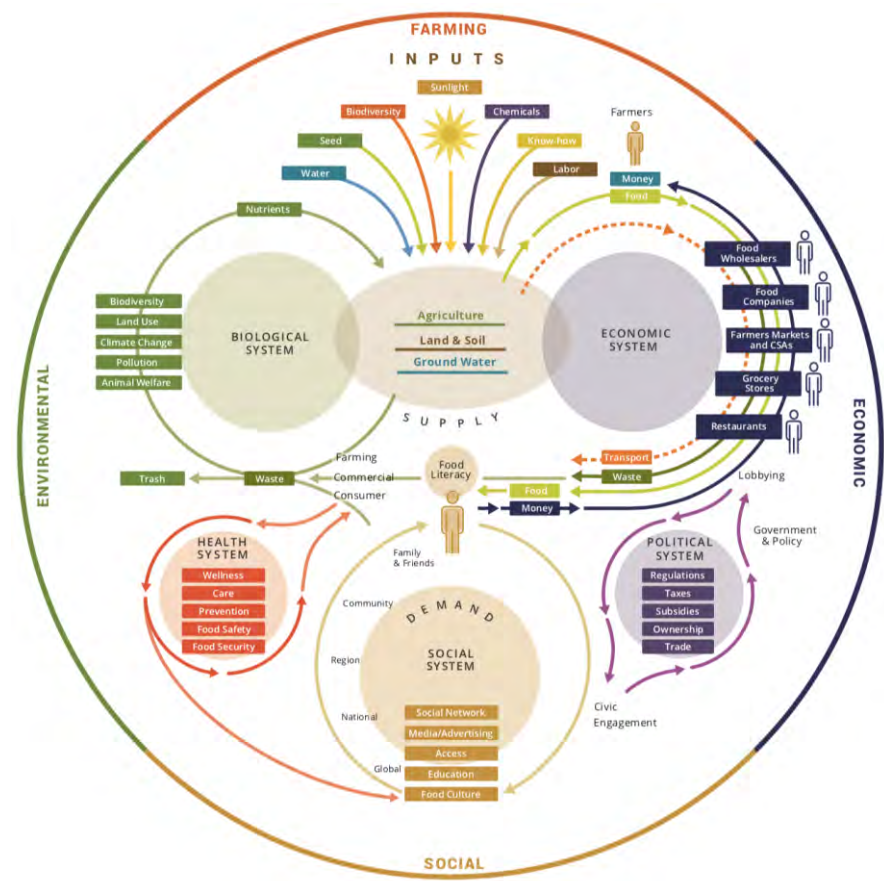# Food systems map that shows how multiple subsystems interact

Figure 2.4
Source: adapted from the Nourish initiative n.d.

Modified high-level 'systems' diagram of an archetypal eco-agri-food system
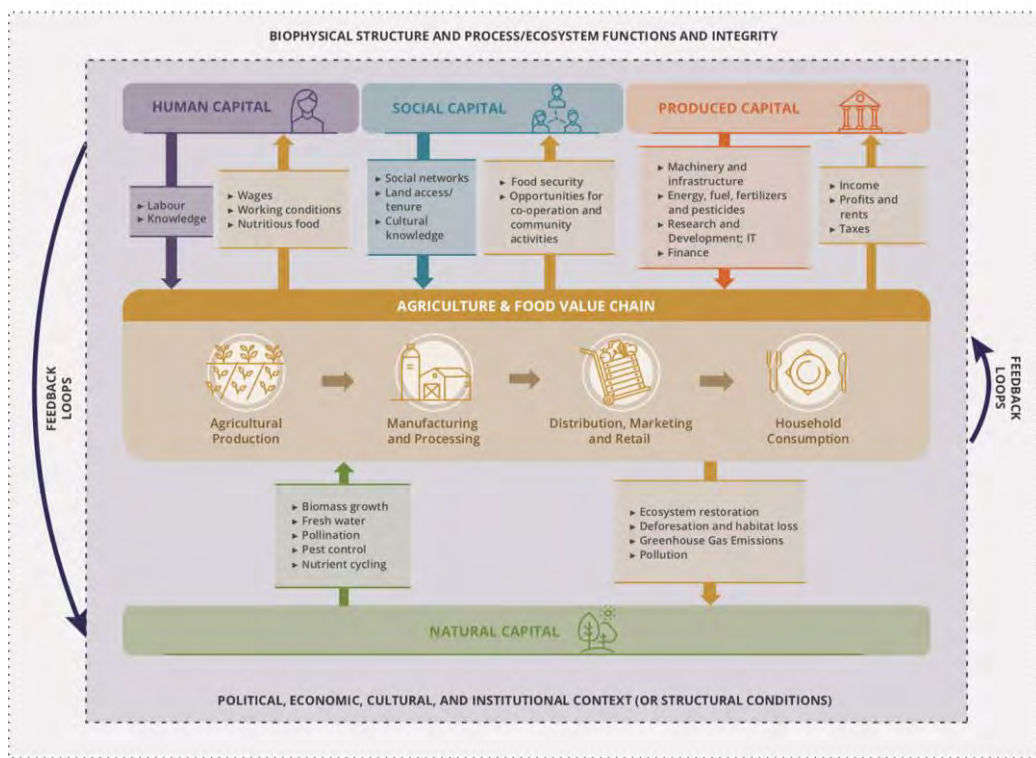

Figure 2.5
Source: adapted from Figure 1.4

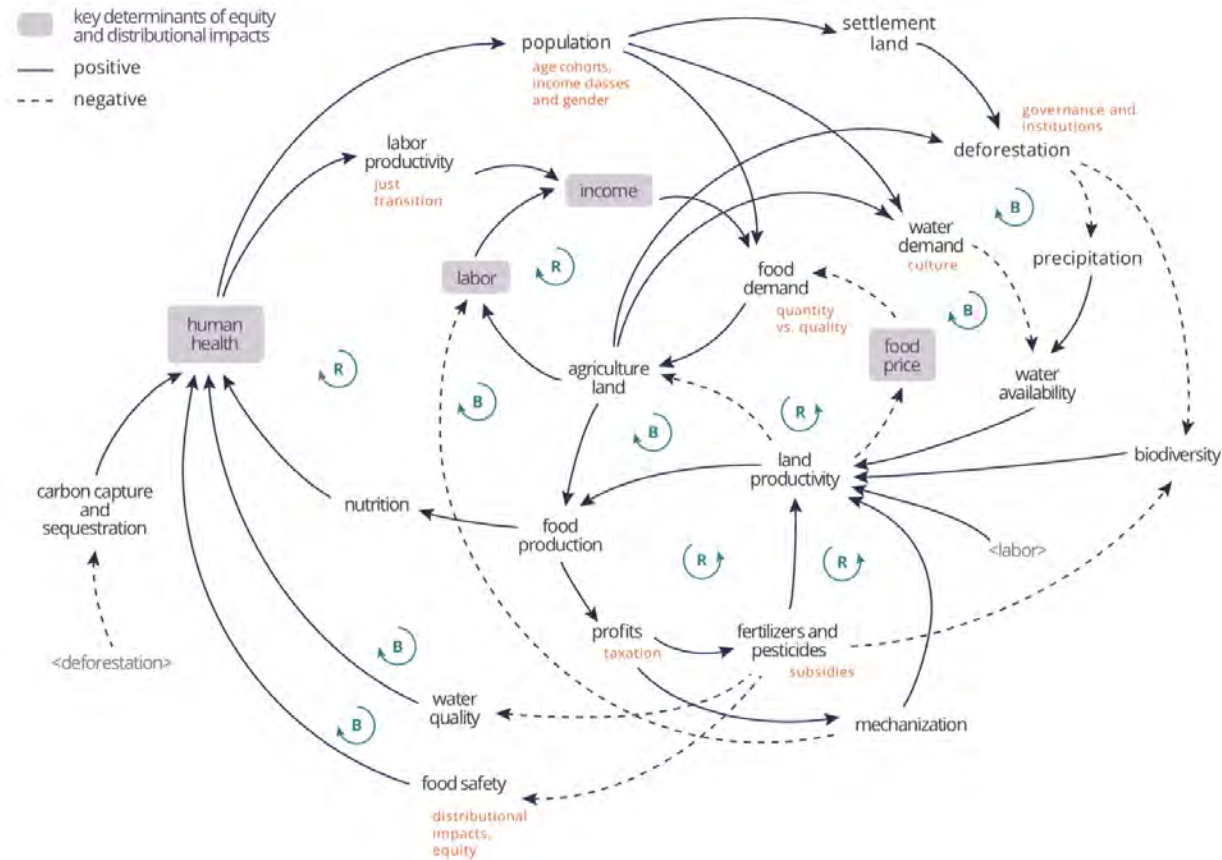# Illustrative Causal Loop Diagram of a generic eco-agri-food system

Figure 2.6
Source: authors
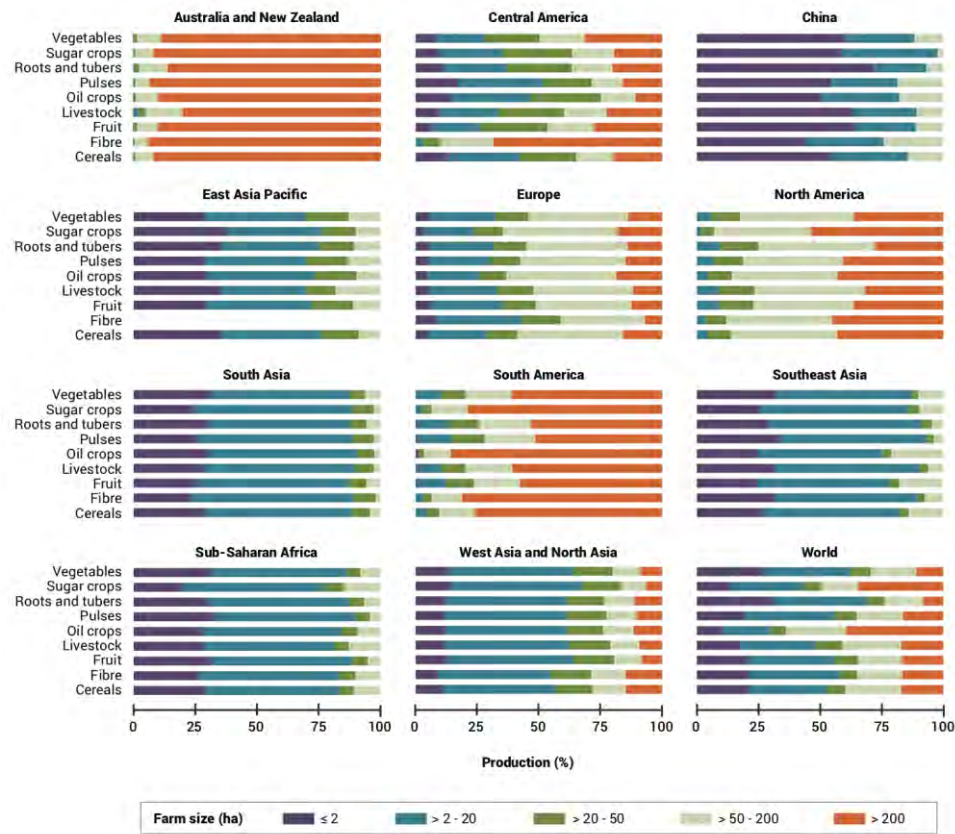
Production of key food groups by farm size

Australia and New Zealand
Central America
China
East Asia Pacific
Europe
North America
South Asia
South America
Southeast Asia
Sub-Saharan Africa
West Asia and North Asia
World

Vegetables
Sugar crops
Roots and tubers
Pulses
Oil crops
Livestock
Fruit
Fibre
Cereals

Production (%)

Farm size (ha)   ≤ 2   > 2 - 20   > 20 - 50   > 50 - 200   > 200

Figure 3.1
Source: adapted from Herrero *et al.* 2017
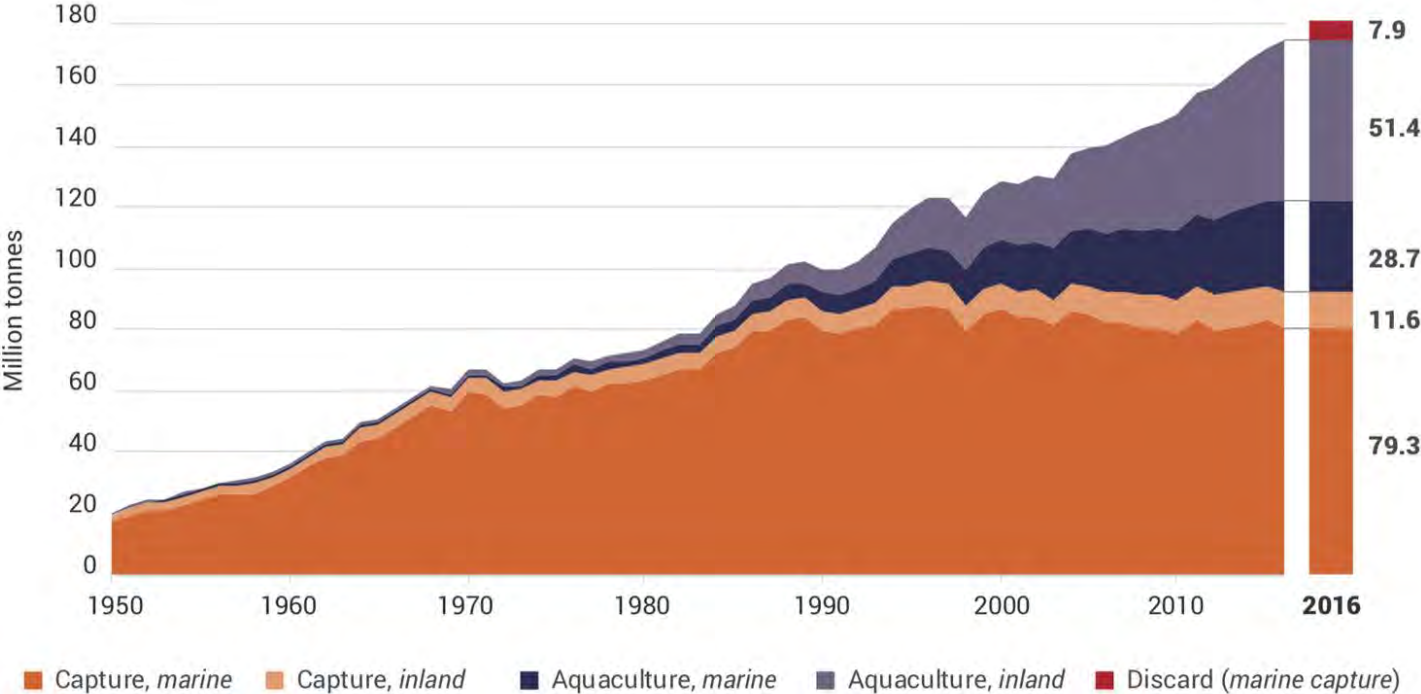
World fish production, 1950-2016

Figure 3.2
Source: adapted from HLPE 2014

Relationship between participation in agricultural sector and GDP per capita, 2015
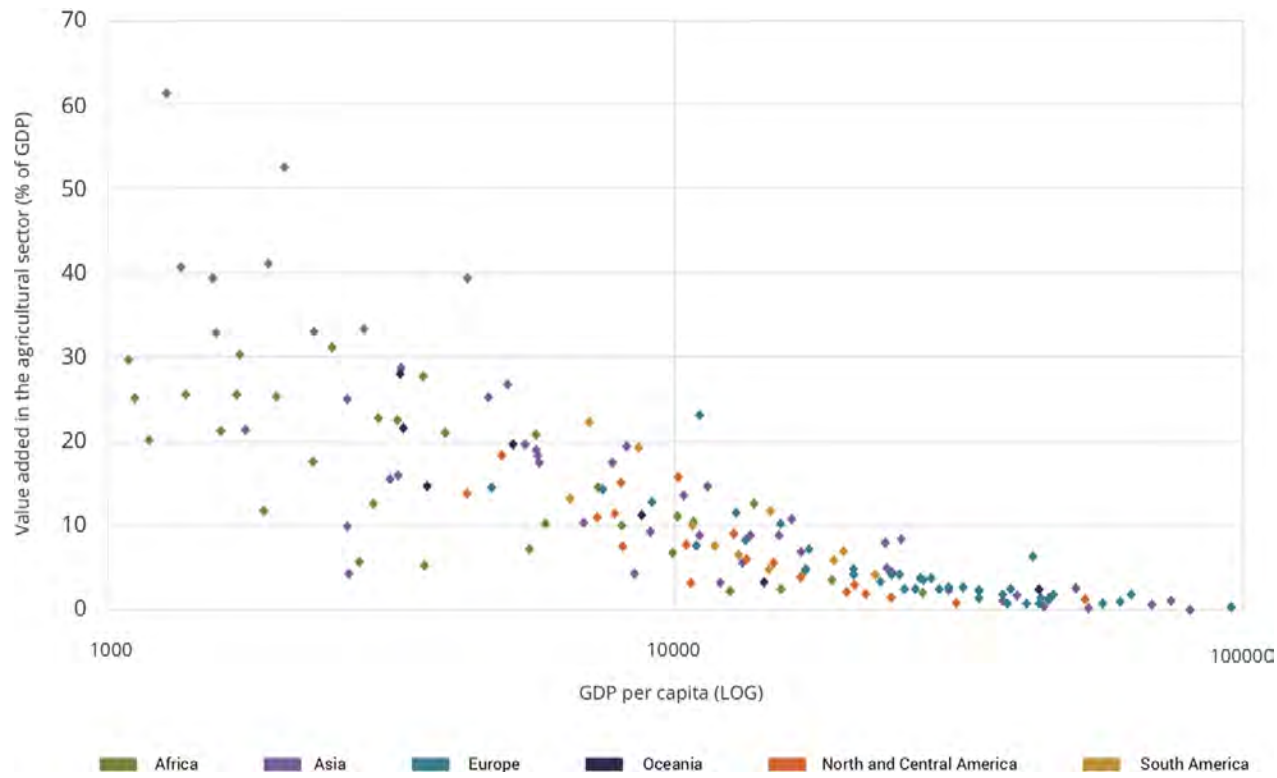
Figure 3.3
Source: adapted from Roser 2018

The status of the nine planetary boundaries overlaid with an estimate of agriculture's role in that status
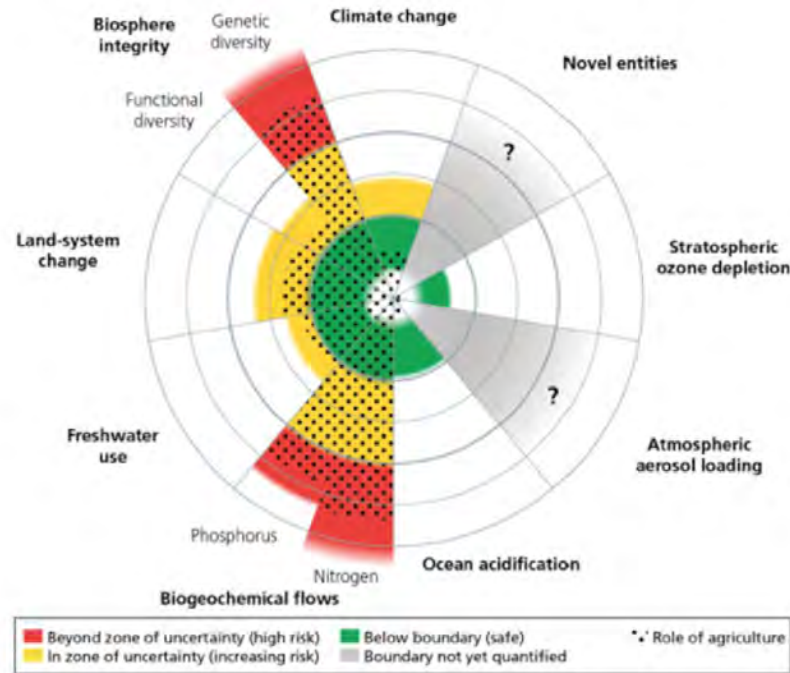

Figure 3.4
Source: Campbell *et al.* 2017

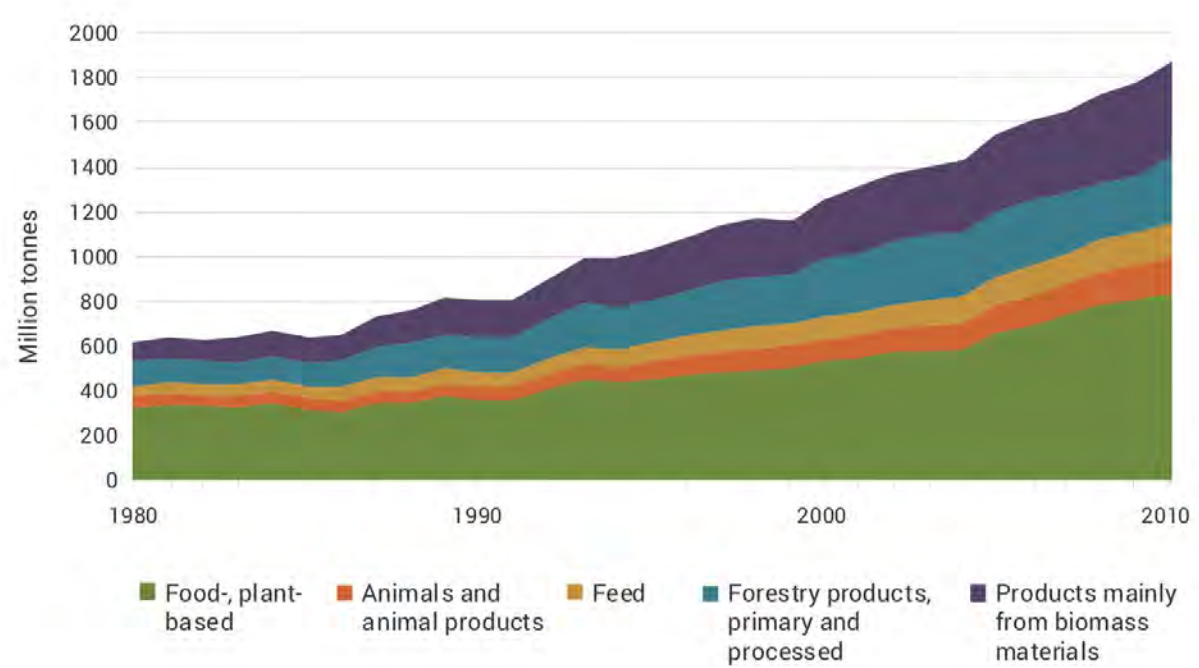**Trade in biomass by main sub-category, 1980-2010**

Figure 3.5
Source: adapted from Dittrich 2012
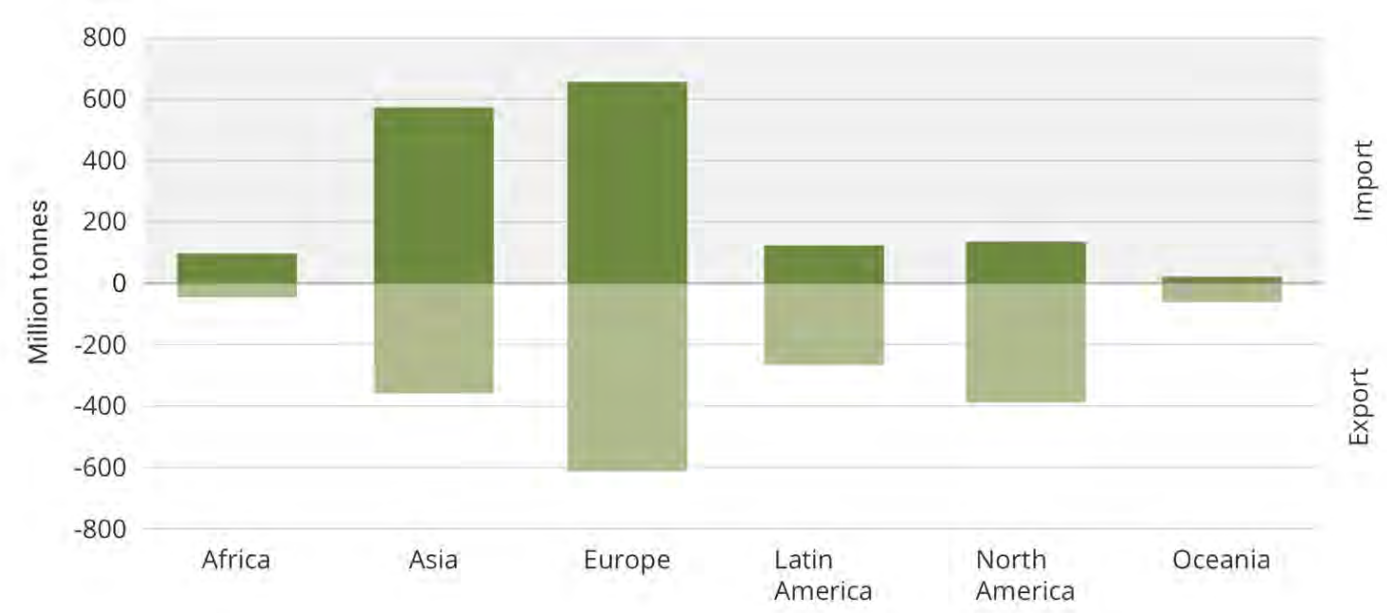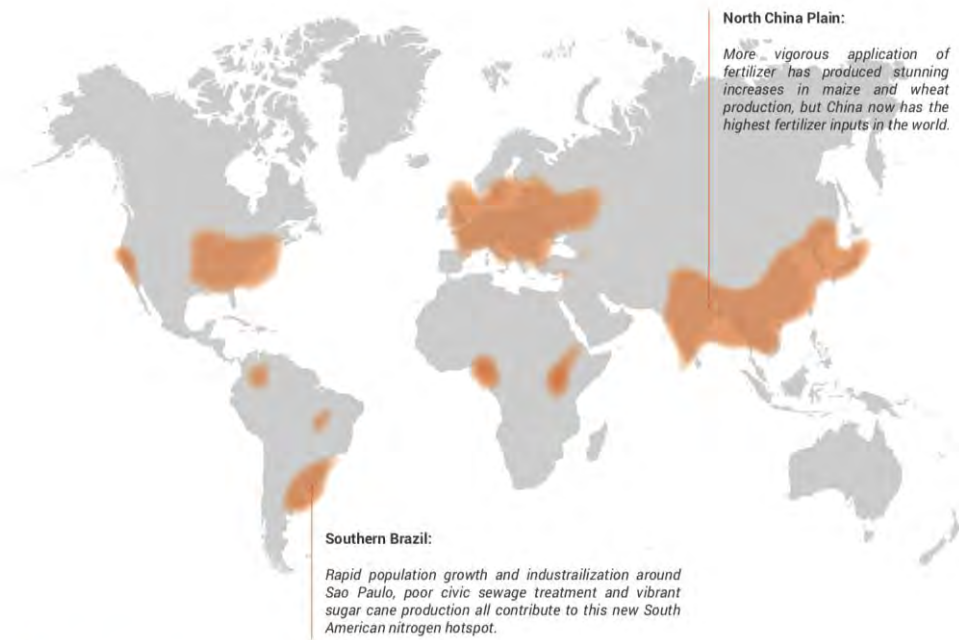
Biomass-based commodity trade between countries

Figure 3.6
Source: adapted from Dittrich 2012

Regions of greatest nitrogen use in the world

North China Plain:

More vigorous application of fertilizer has produced stunning increases in maize and wheat production, but China now has the highest fertilizer inputs in the world.

Southern Brazil:

Rapid population growth and industrailization around Sao Paulo, poor civic sewage treatment and vibrant sugar cane production all contribute to this new South American nitrogen hotspot.

Shifting hotspots

Regions of greatest nitrogen use (red) were once limited mainly to Europe and North America. But as new economies develop and agricultural trends shift, patterns in the distribution of nitrogen are changing rapidly. Recent growth rates in nitrogen use are now much higher in Asia and in Latin America, whereas other regions -including much of Africa- suffer from fertilizer shortages.

Figure 3.7
Source: adapted from Townsend and Howarth 2010

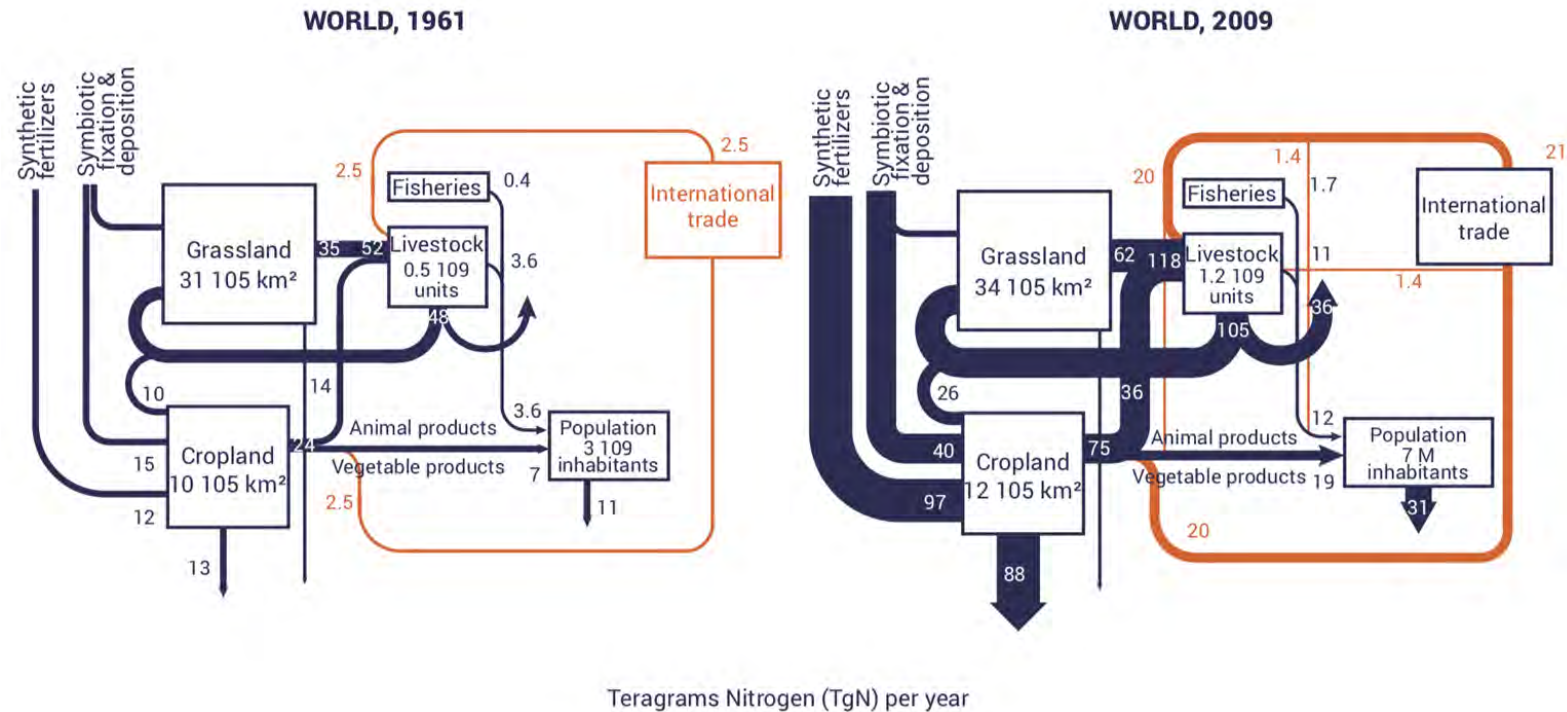**Generalized representation of Nitrogen transfers through the world agro-food system, 1961 and 2009**

WORLD, 1961

Synthetic fertilizers
Symbiotic fixation & deposition

2.5

Fisheries   0.4

Grassland
31 105 km²   35 52 Livestock
0.5 109 units   3.6

48

10

14

Cropland
10 105 km²   24   Animal products   3.6   Population
3 109 inhabitants

15

Vegetable products   7

12

2.5   11

13

International trade   2.5

WORLD, 2009

Synthetic fertilizers
Symbiotic fixation & deposition

20   1.4

Fisheries   1.7

Grassland
34 105 km²   62 118 Livestock
1.2 109 units   11

105   36   1.4

26

36

40   Cropland
12 105 km²   75   Animal products   12   Population
7 M inhabitants

97   Vegetable products   19

88   20   31

International trade   21

Teragrams Nitrogen (TgN) per year

Figure 3.8
Source: adapted from Lassaletta *et al.* 2016

Virtual water flows between the six world regions
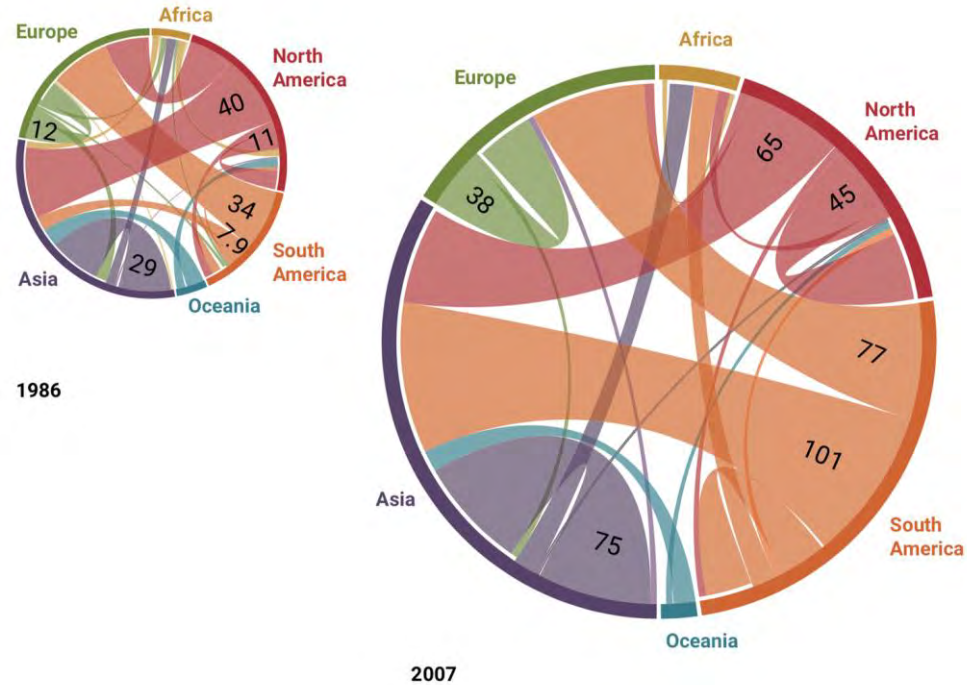
Figure 3.9
Source: adapted from Dalin *et al.* 2012
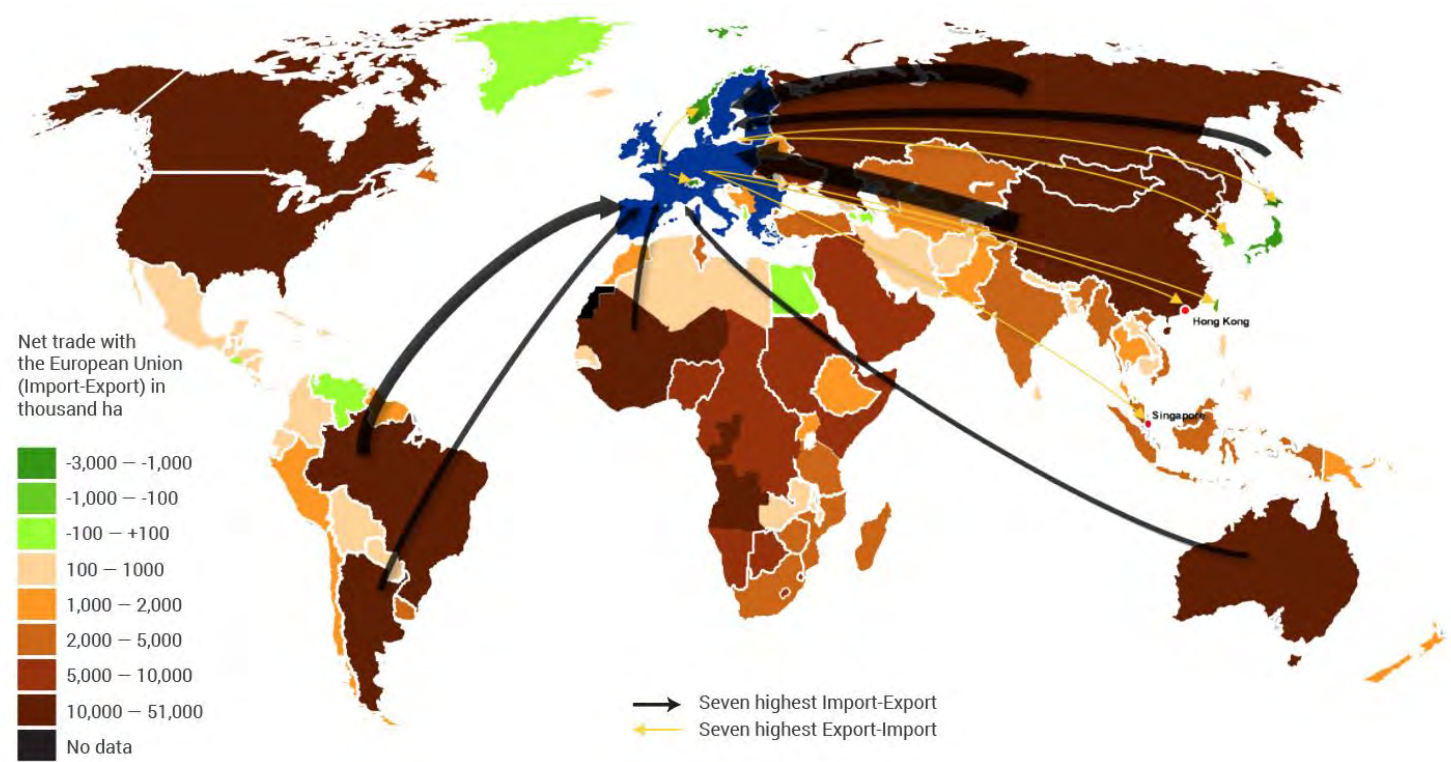
Trade balances of virtual land for the EU-27

Net trade with
the European Union
(Import-Export) in
thousand ha

- -3,000 — -1,000
- -1,000 — -100
- -100 — +100
- 100 — 1000
- 1,000 — 2,000
- 2,000 — 5,000
- 5,000 — 10,000
- 10,000 — 51,000
- No data

Hong Kong

Singapore

→ Seven highest Import-Export
→ Seven highest Export-Import

Nutrients exported in soybean products from Argentina, 2007-2017

NORTH AMERICA 0.2

EUROPE 7.7

AFRICA 2.1

ASIA 14.8

SOUTH AMERICA 1.0

OCEANIA 0.6

> 2 million tons
1.3 - 2 million tons
0.3 - 1.3 million tons
< 0.3 million tons
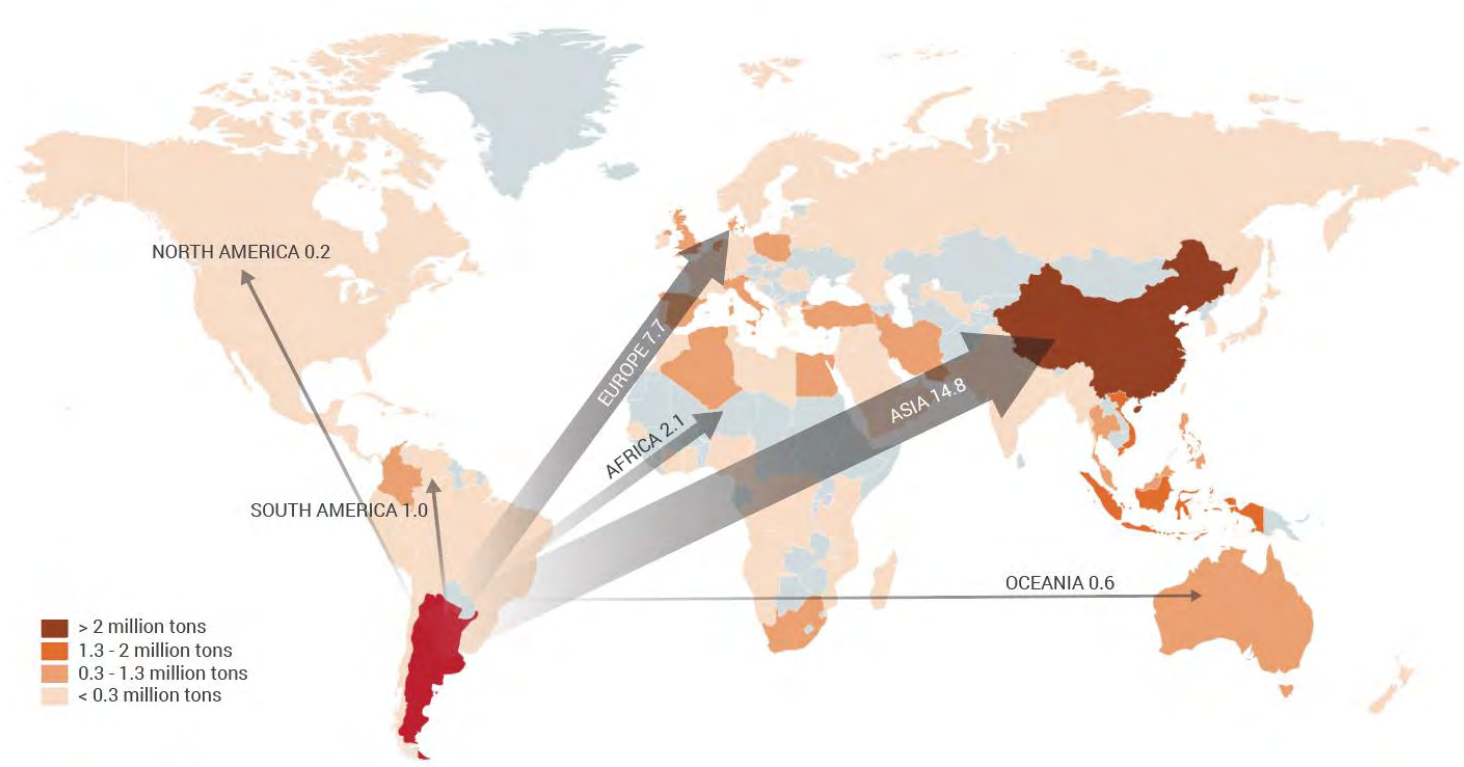
Figure 3.11
Source: adapted from Diaz de Astarloa and Pengue 2016

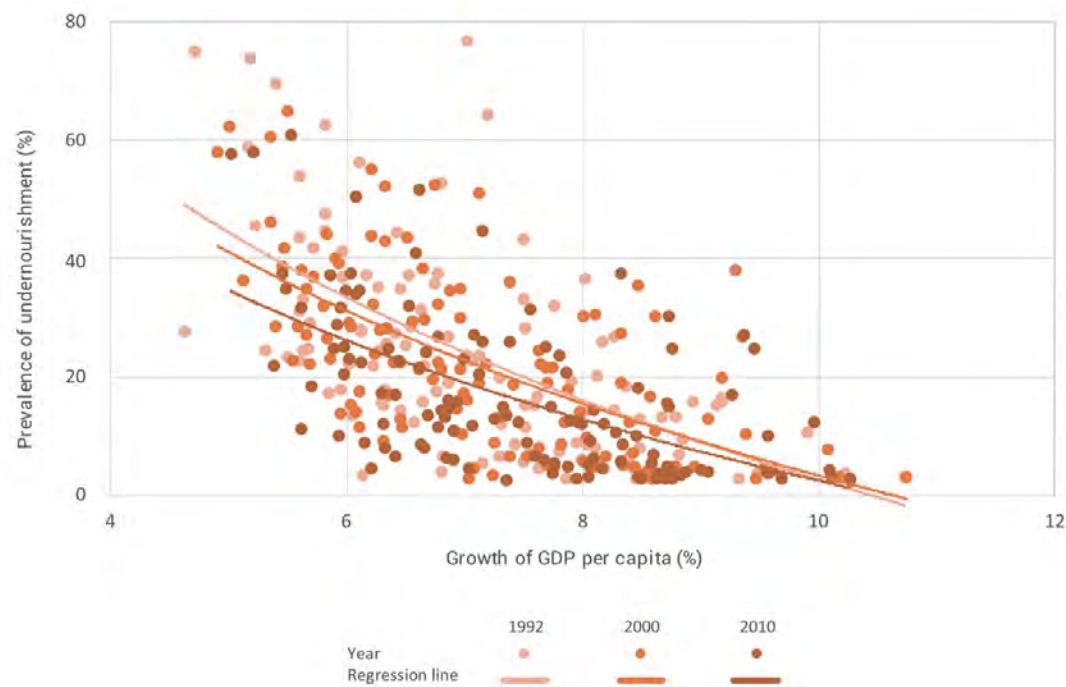**Economic growth and prevalence of undernourishment, 1992, 2000 and 2010**

Figure 3.12
Source: adapted from FAO 2015a

Mapping of value generation in smallholder Asian rice production systems to the Sustainable Development Goals

SDG 13 - Climate regulation
Micro, regional and global climate regulation are influenced by greenhouse gas concentrations due to land use change (eg. deforestation). Alternative wetting and drying of rice fields can reduce methane emissions by 45 percent.

SDG 2,4,6,13 - Freshwater
(Hydrological cycle and water flow maintenance)
Based on indigenous knowledge, the communally-managed forestry areas and upstream terraces serve as a rainwater retention and filtration system.

SDG 1,8.5,9.3 - Employment and income
Labour intensive rice farming in Asia *provides livelihoods* to around 140 million rice farming households.

SDG 11.4, 4.7, 12.8 - Cultural heritage
Physical, intellectual, symbolic and other interactions arise in rice production landscapes; Social cohesion is built around *indigenous agricultural innovations*, communal decision-making and respecting local customs.

SDG 1, 2, 3 - Food
Nutritional value for rice farming households and landless members of the community. Combined rice-and-fish farming provides *nutritional diversity* from aquatic habitat.

SDG 15 - Habitat for species
Habitat for species for birds and vertebrate wildlife.

SDG 2.5, 3 - Genetic diversity
Exchange of seeds with neighboring farms to avoid pest problems.

SDG 15 - Erosion control
Vegetation cover and terrace structure protect/stabilise terrestrial ecosystems (erosion landslide, gravity flow protection.

SDG 3, 12.4, 15 - Pest and disease control
Eliminate negative health externalities** from fertilisers and pesticide use through natural pest control and integrated pest management.

Figure 3.13
Source: authors
Image source: Wikimedia

Per capita consumption of meat in selected countries or regions
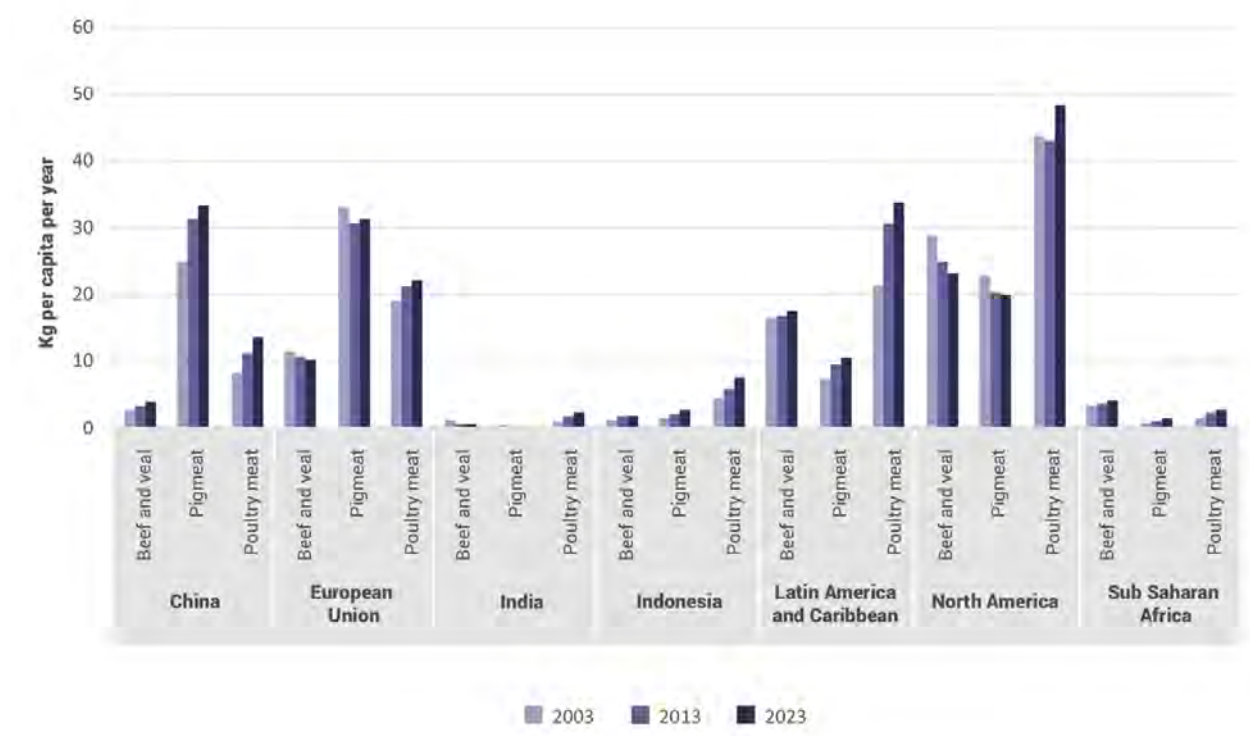
Effect of diets on GHG emissions and cropland
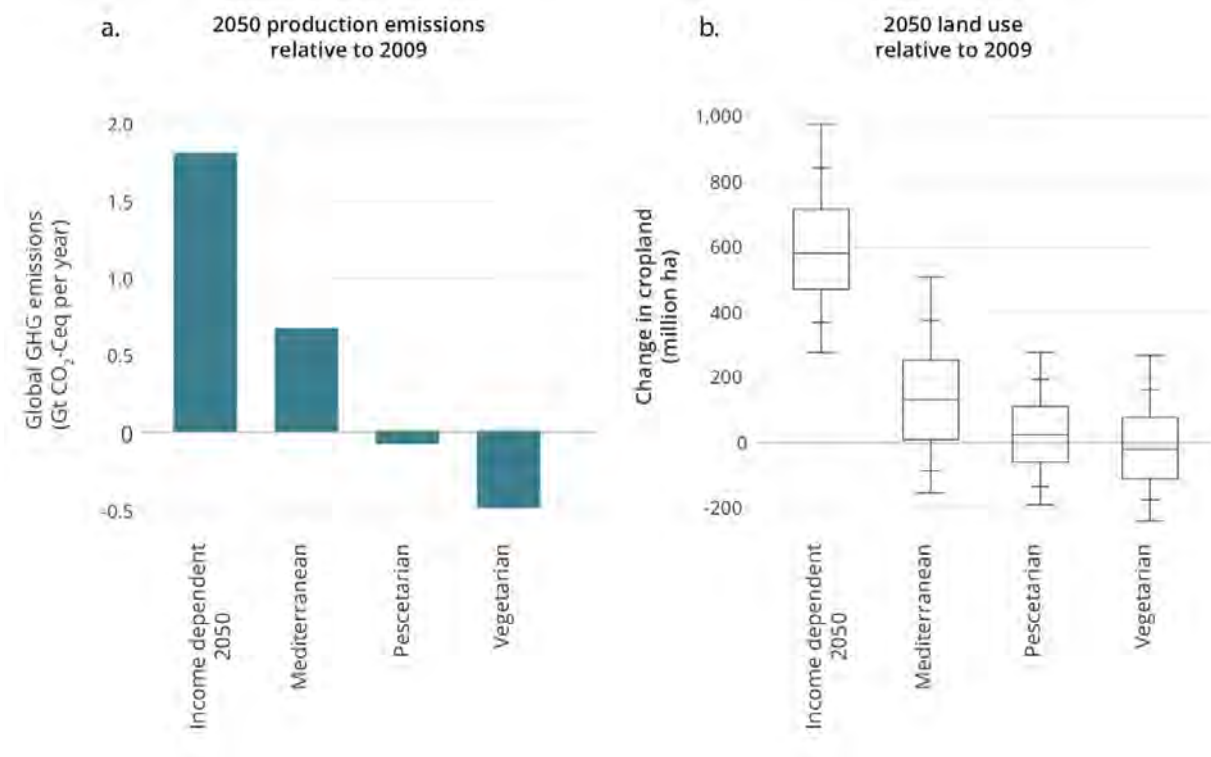
Figure 3.15
Source: adapted from Tilman and Clark 2014
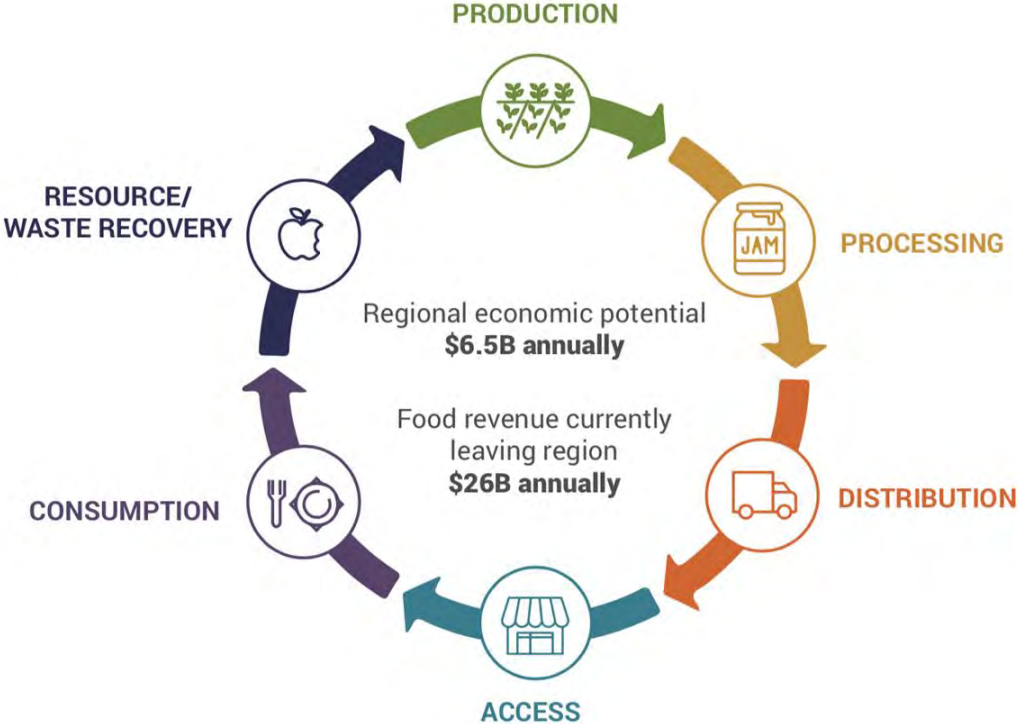
Sustainable local food system in Chicago

PRODUCTION

RESOURCE/
WASTE RECOVERY

PROCESSING

Regional economic potential
$6.5B annually

Food revenue currently
leaving region
$26B annually

DISTRIBUTION

CONSUMPTION

ACCESS

Figure 3.16
Source: adapted from CMAP n.d.

Global urban population growth is propelled by the growth of cities of all sizes
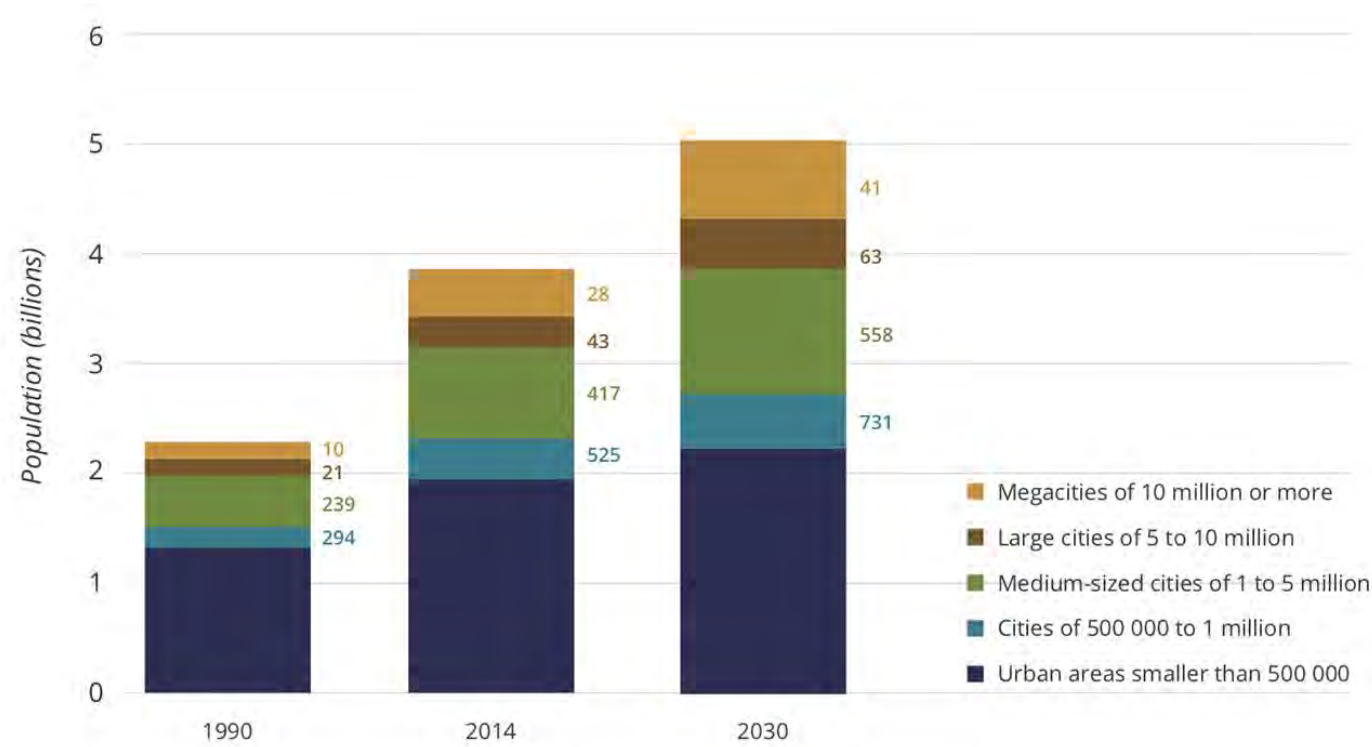
Figure 4.1
Source: adapted from UNDESA 2015

Development of meat supply over time
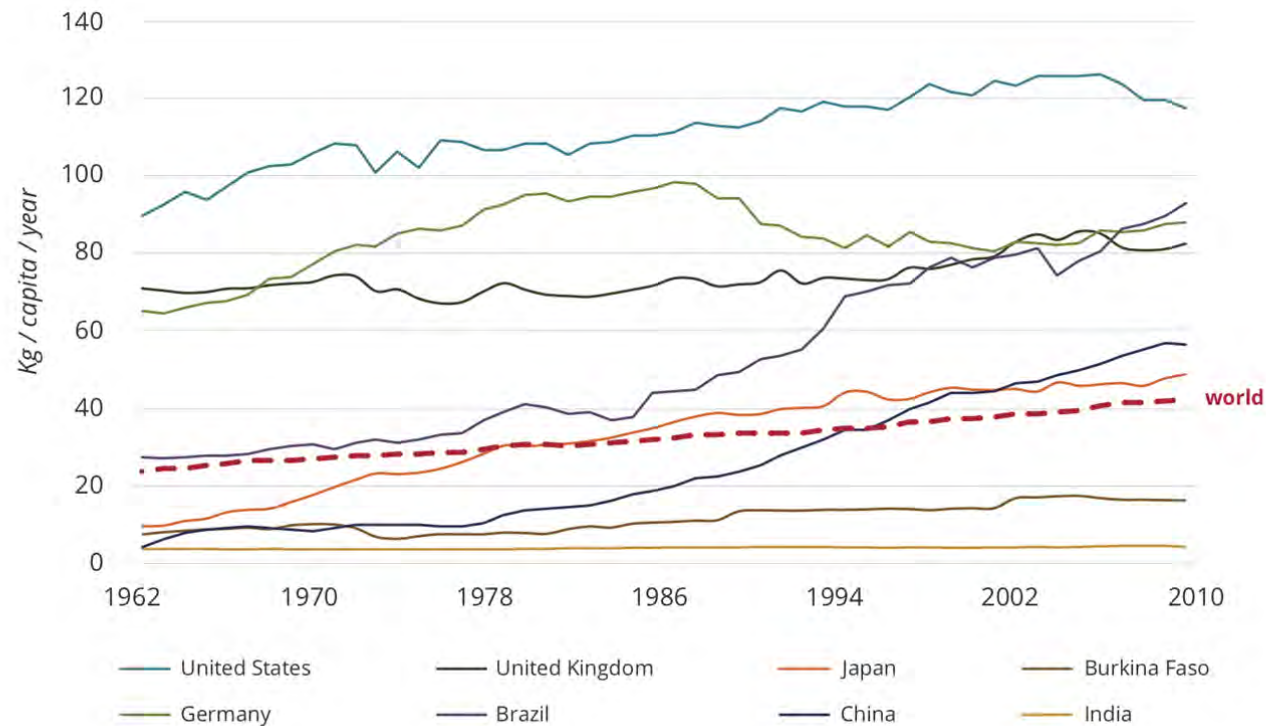
Figure 4.2
Source: adapted from Stoll-Kleemann and O'Riordan 2015

Understanding health impacts in a food systems context
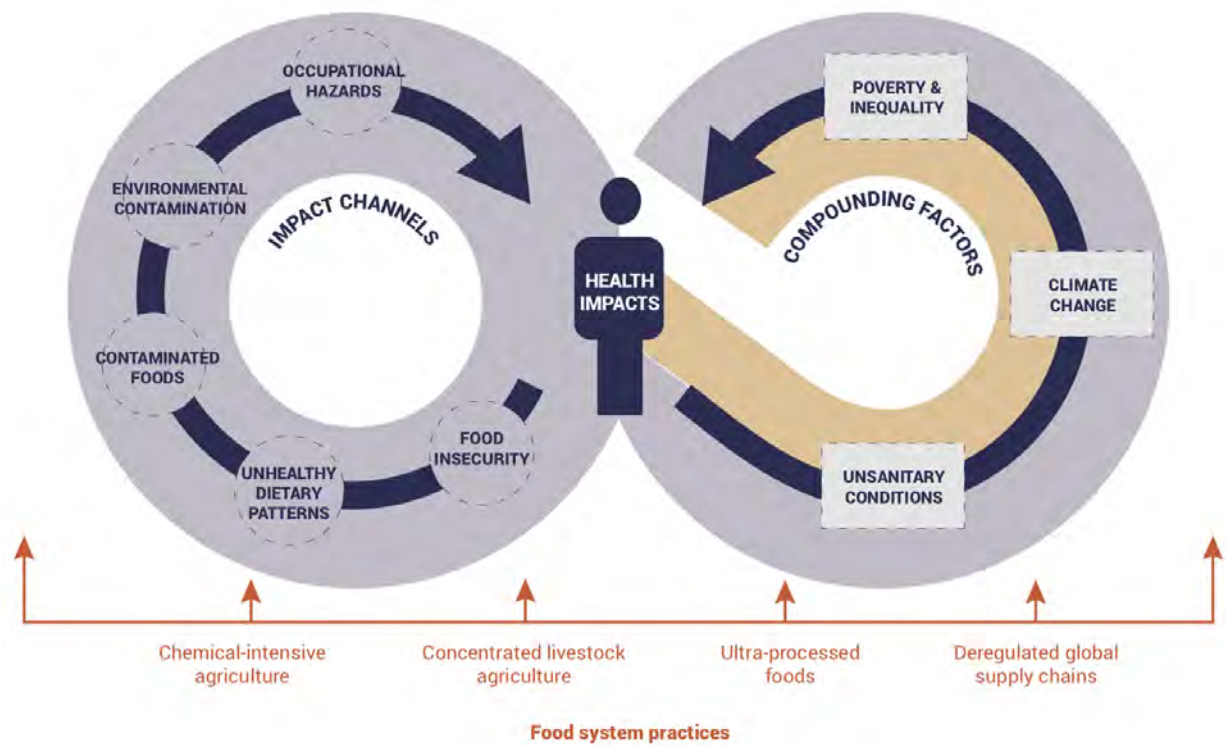
Figure 4.3
Source: adapted from IPES-Food 2017

Annual costs resulting from endocrine-disrupting chemical (EDC) exposure

$217 BILLION
EU - 1.28% of GDP

$340 BILLION
USA - 2.33% of GDP

$42 BILLION
USA - Pesticides alone

Time changes in the dietary share of ultra-processed products in the average household food basket in Canada and Brazil

Global prevalence of anaemia in children of preschool age 0-5 years

Anaemia prevalence
- Mild (5.0−19.9%)
- Moderate (20.0−39.9%)
- Severe (≥40.0%)
- Regression-based estimate
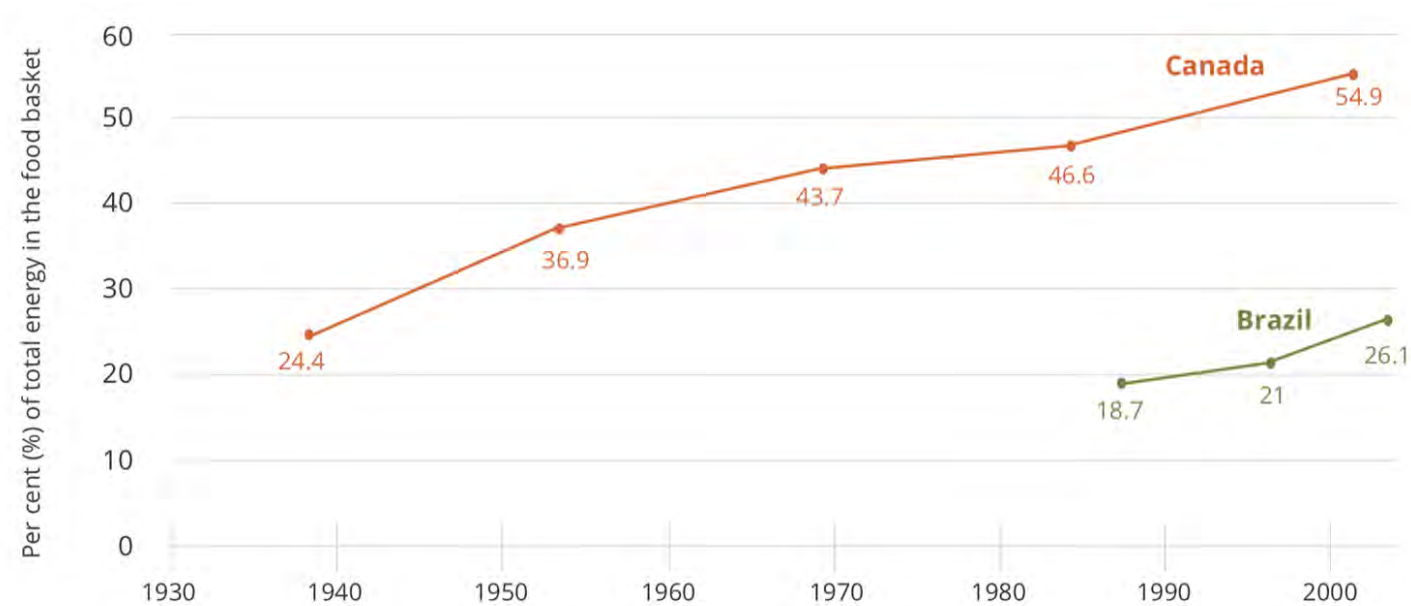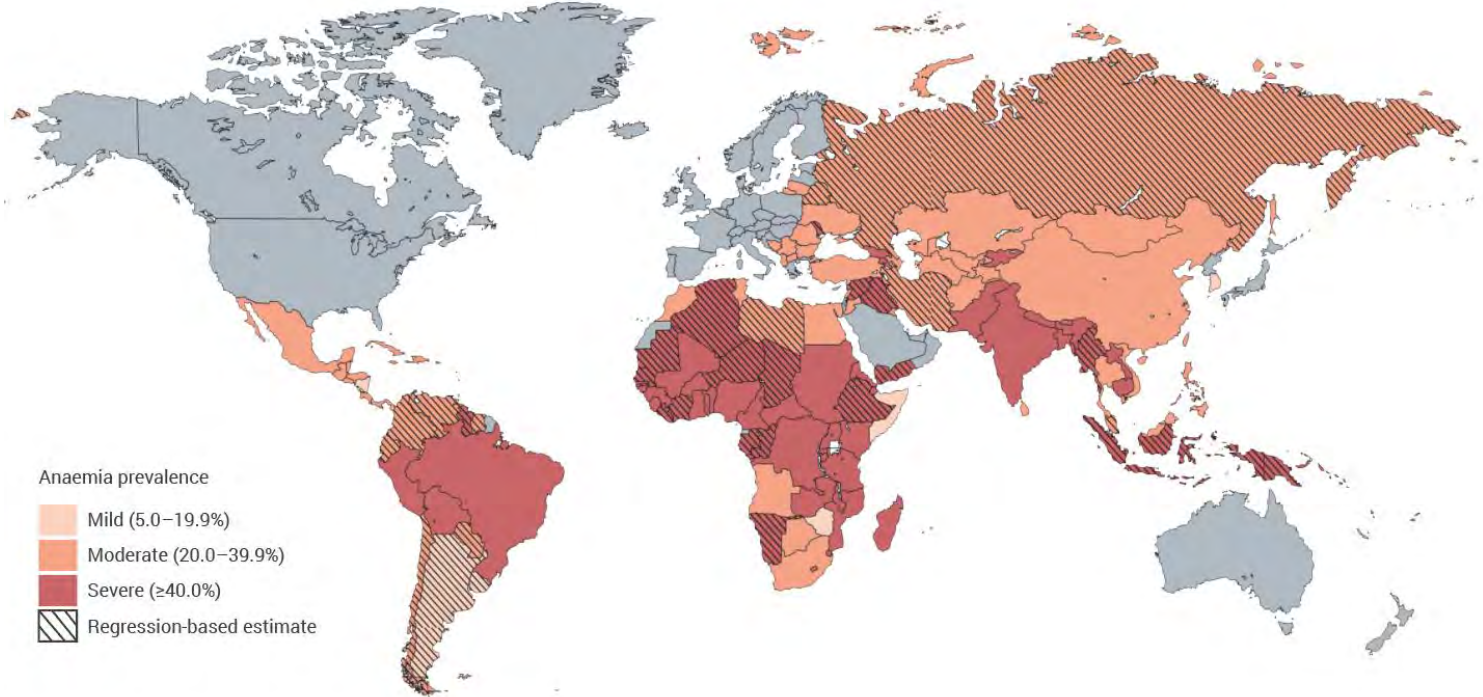
Figure 4.6
Source: adapted from Monteiro *et al.* 2013

Estimated country-specific prevalence of inadequate zinc intake

Legend:
- >25%
- 15% — 25%
- <15%
- Unknown
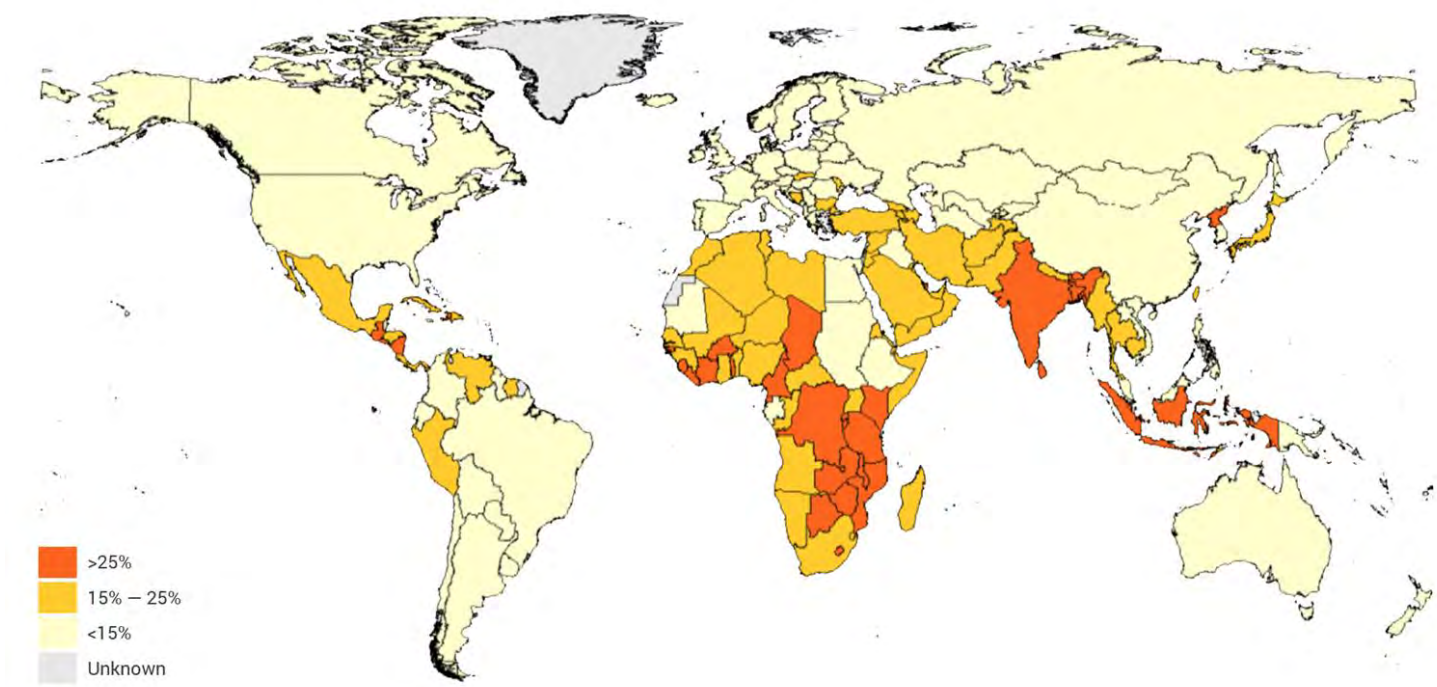
Main types of food losses and wastage

Field losses (e.g. pests, diseases, rodents)

Pre-Processing (e.g. inefficient harvesting, drying, milling)

Transport (e.g. spillage, leakage)

Storage (e.g. technical deficiencies)

Processing & Packaging (e.g. excessive peeling, washing)

Marketing (e.g. spoilage, rotting in stores)

Wastage by Consumer (e.g. overeating, food wastage)

Producer

Consumer

Field

Fork

High Income Countries

Moderate at first stages of food chain depending on type of food

Losses and wastage relatively high in latter part of food chain

Low Income Countries

Relatively high at first stages of food chain especially for perishable food items

Losses and wastage relatively low in latter part of food chain; food not consumed in households and other consumption units is often used for feed and/or distributed in society

Figure 4.8
Source: adapted from Lundqvist 2008

Fresh fruit and vegetable market share of modern and traditional market retail sales
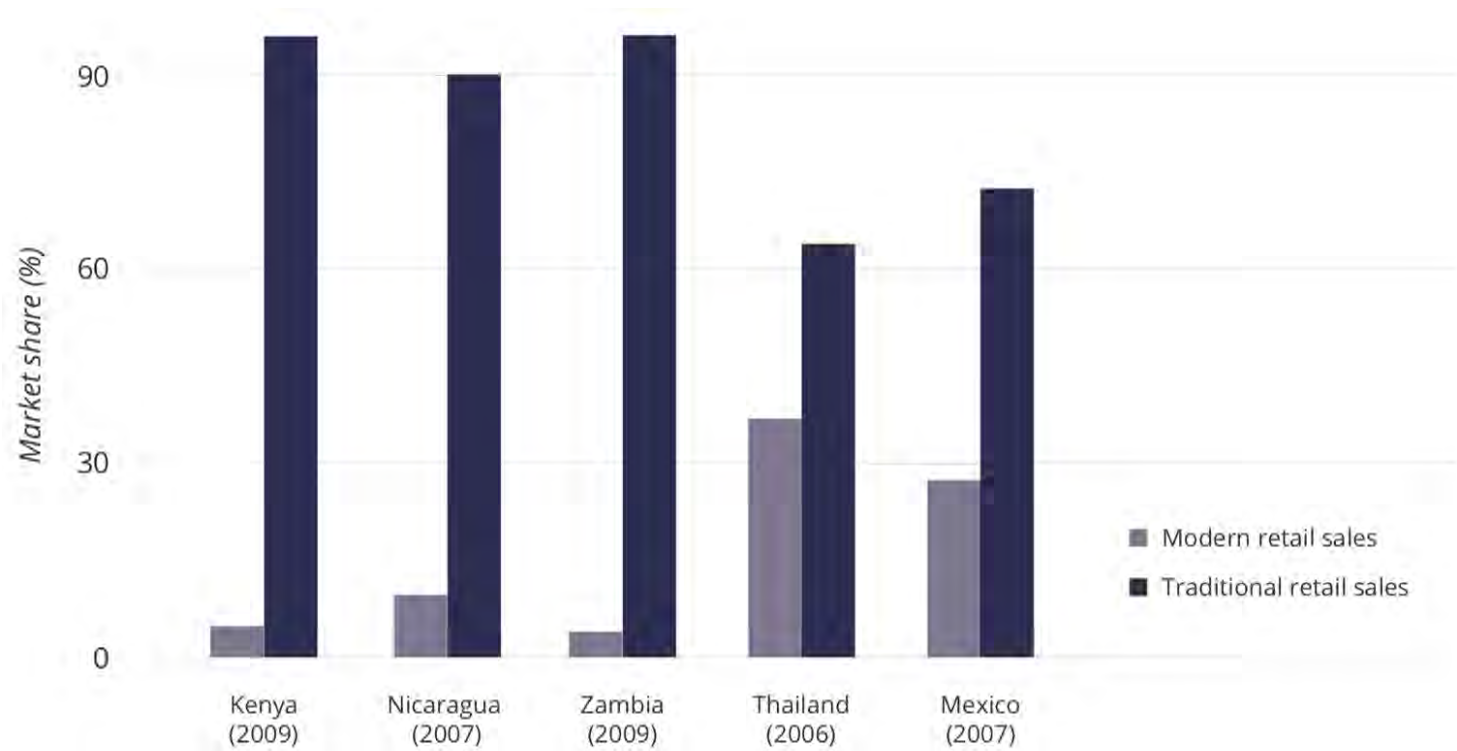
Figure 4.9
Source: adapted from Gomez and Ricketts 2013

Structure of food marketing system, East and Southern Africa, 2010
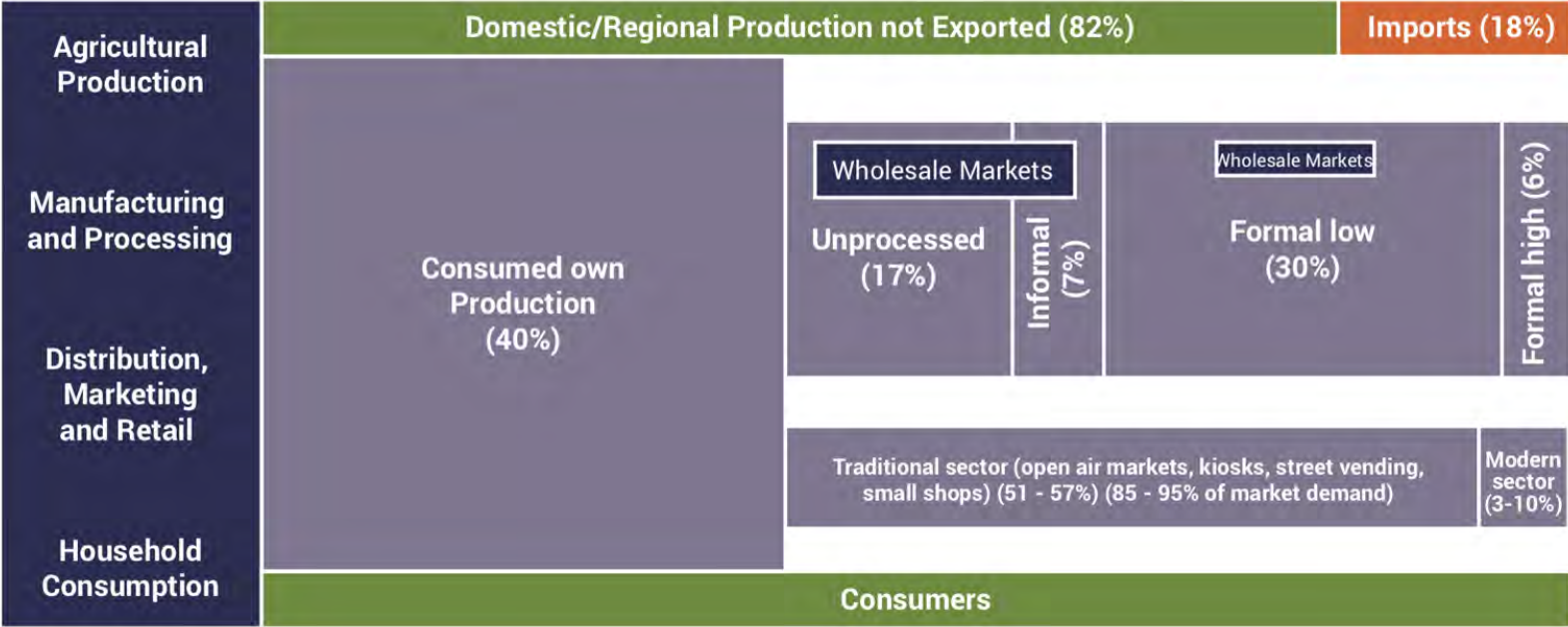
Figure 4.10
Source: adapted from Tschirley *et al.* 2014

Projected structure of food marketing system, East and Southern Africa, 2040
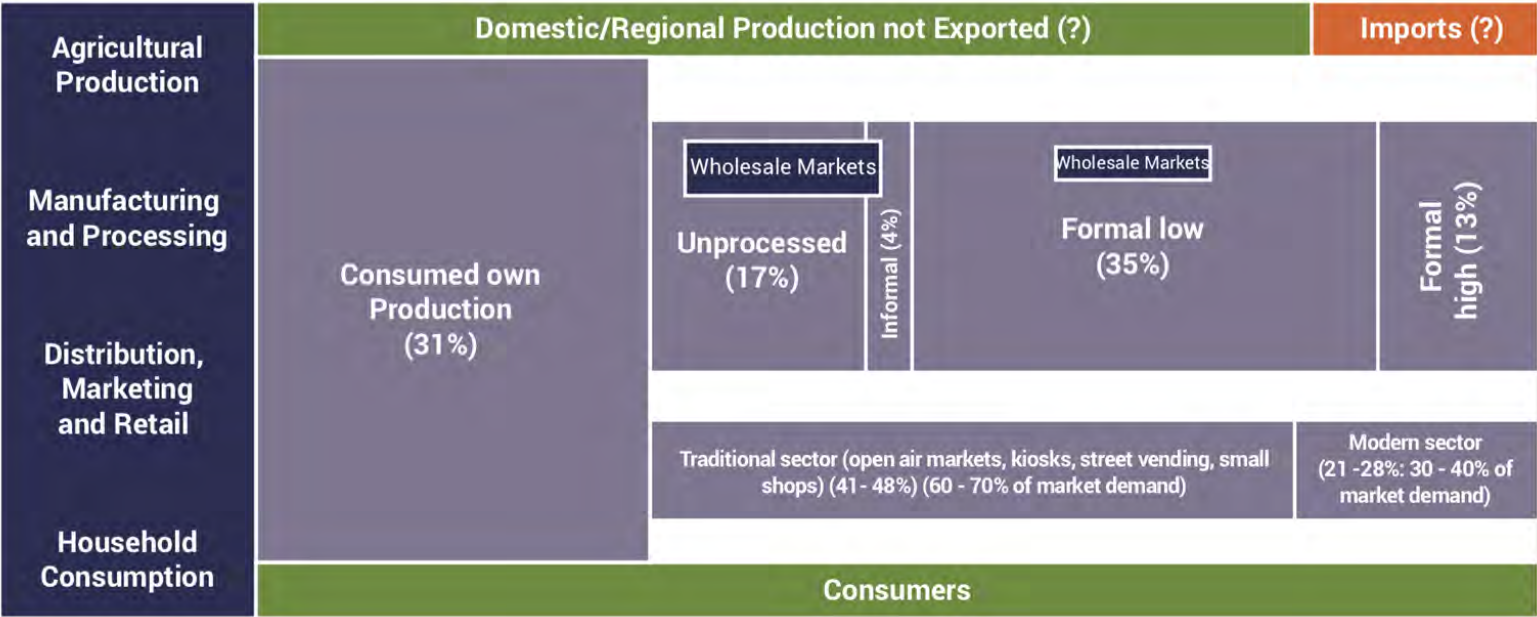
Figure 4.11
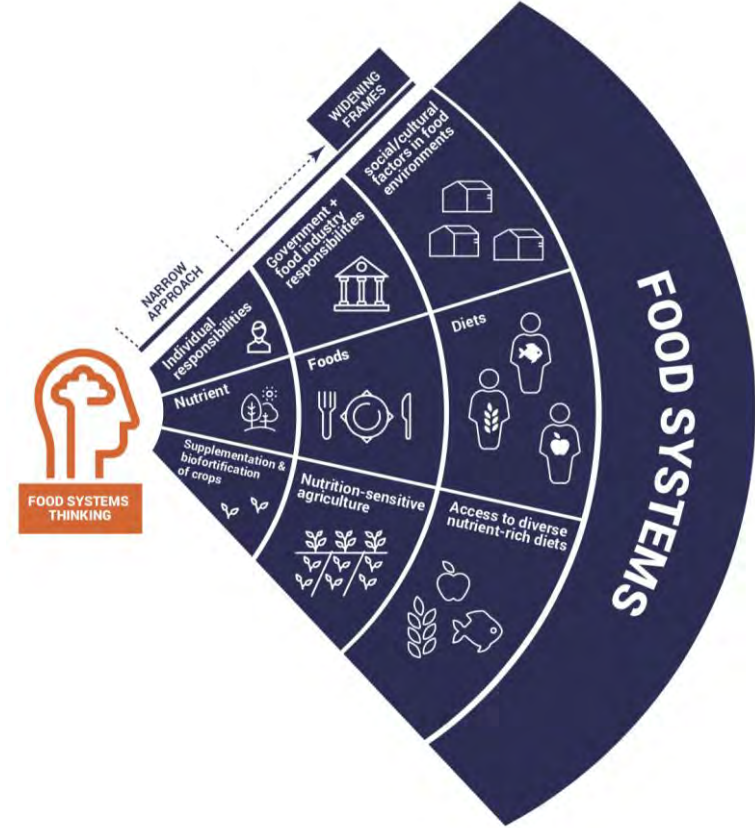Source: adapted from Tschirley *et al.* 2014

A food systems thinking lens

Figure 4.12
Source: adapted from IPES-Food 2017

The food system and related social equity, justice and ethics issues

Barriers to land, credit, resources

Environmental contamination

Wages and working conditions

Child & forced labor, slavery

Ethical issues

Animal Welfare

Concentration of food exports in a few countries can create stress on inequity

Trade projected to increase mostly low income countries become importers

FOOD PRODUCTION PROCESSING

FOOD TRADE RETAIL

FOOD WASTE

FOOD ACCESS CONSUMPTION

Impact sustainability of food systems and Climate Change

Jeopardize capacity to ensure good quality and adequate food for this & future generations

Food and nutrition insecurity

Lack of access to healthy food

Unsustainable meat consumption

Disproportionate obesity rates & diet related non-communicable diseases

Figure 5.1
Source: authors

Climate change is projected to reduce crop yields in regions where food demand is projected to increase most

No data

Percentage change in yields between present and 2050

-50% Change   +100% Change
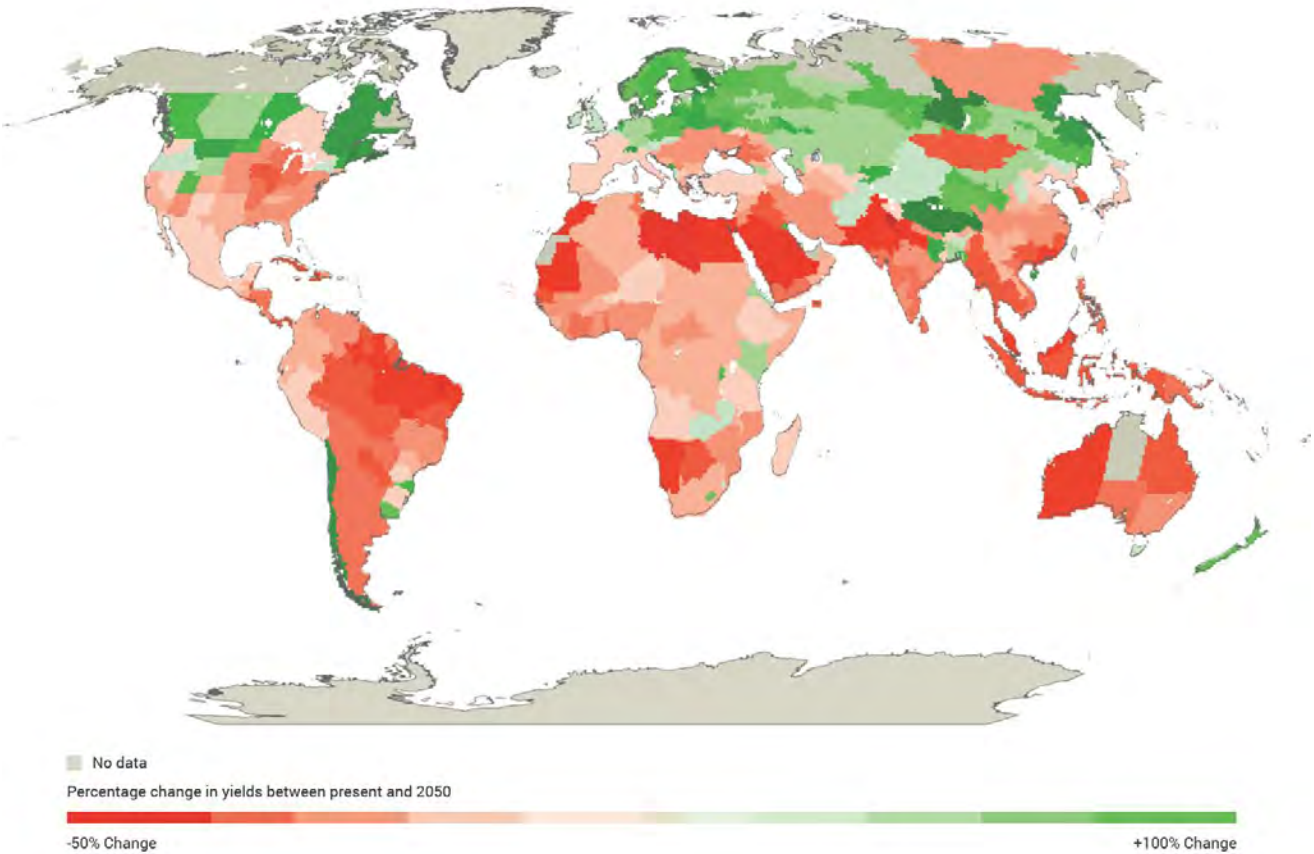
Trends in rural and urban extreme poverty by region
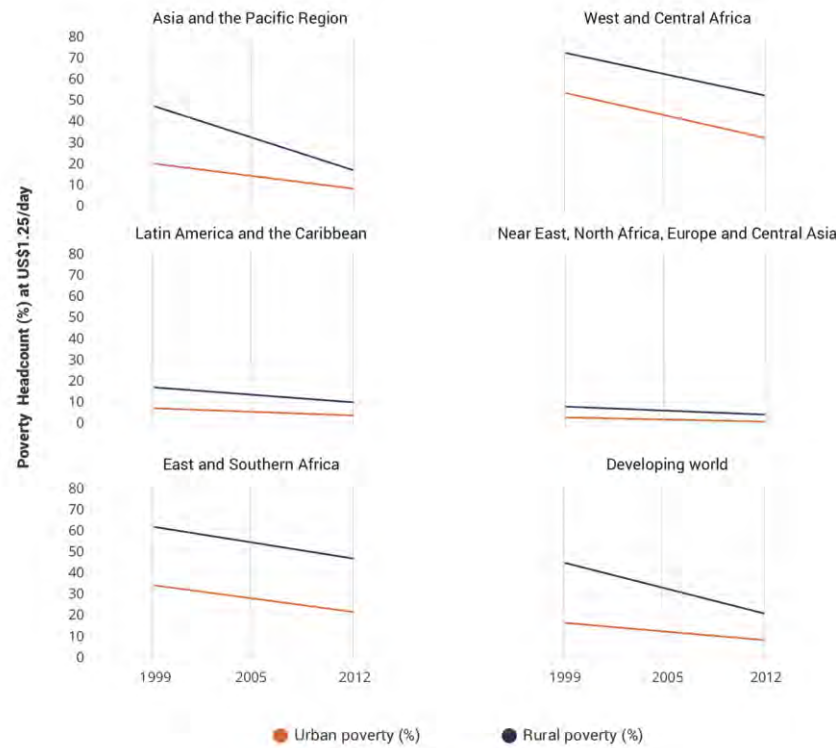
Figure 5.3
Source: adapted from IFAD 2016

Stunting prevalence by subnational region
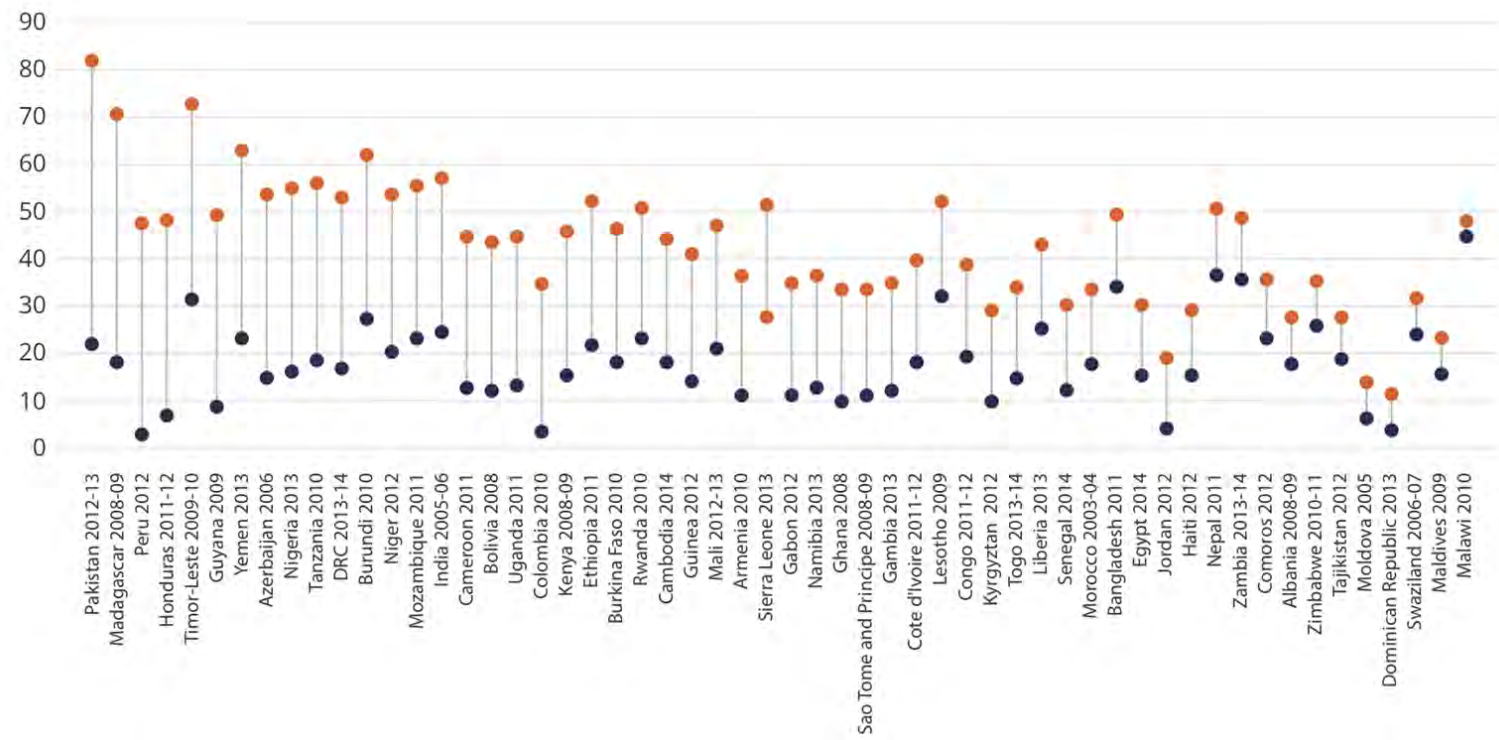
Figure 5.4
Source: adapted from IFPRI 2016

Food Price Index

Food Commodity Price Indices
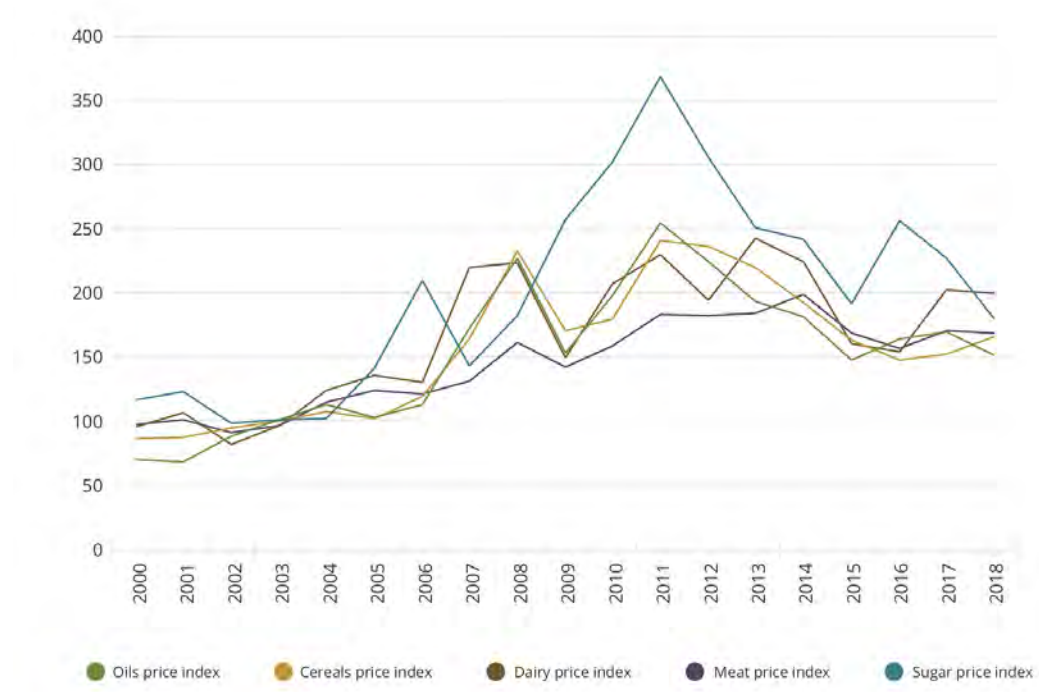
Figure 5.6
Source: FAO 2018a

Cost of living in Asian cities
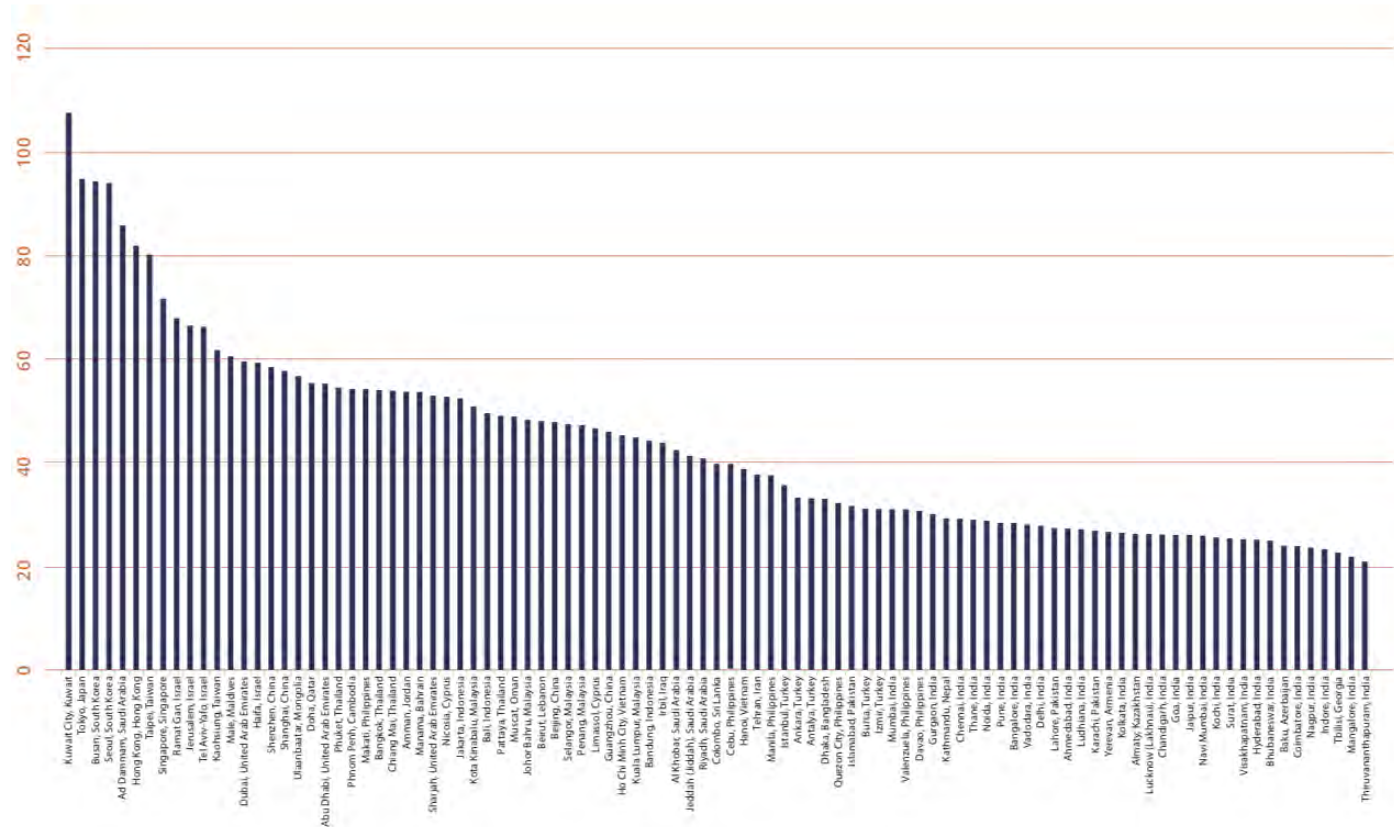
Figure 5.7
Source: Numbeo 2018

Basic Food Basket and minimum wage in a sample of countries in Latin America
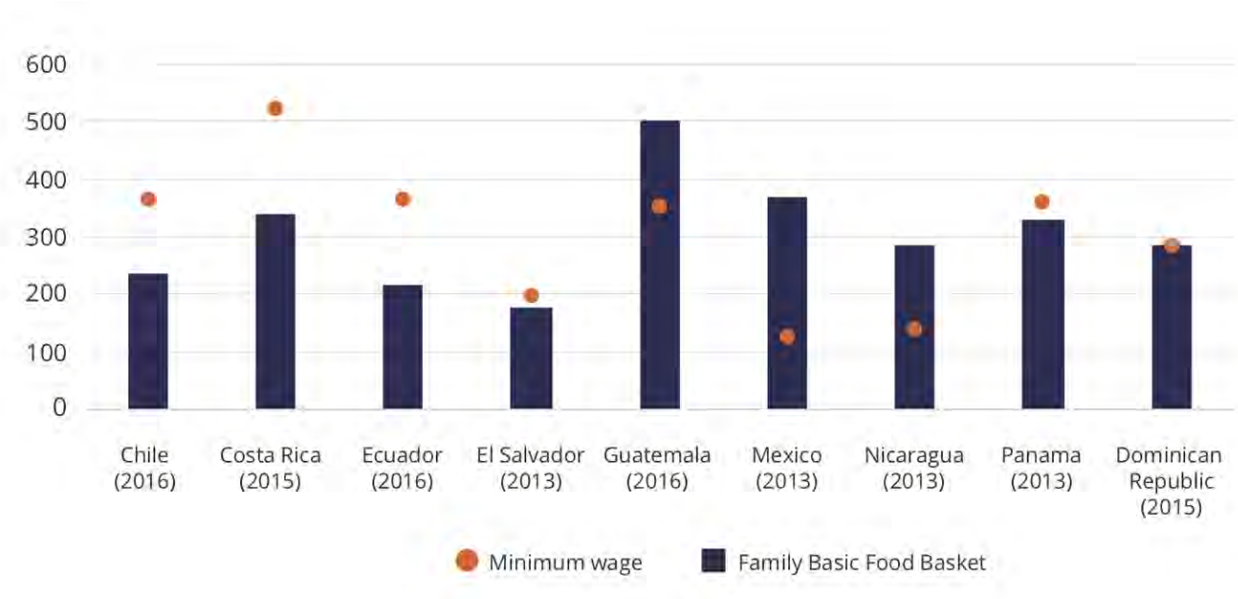
Figure 5.8
Source: personal communication, FAO Regional Office for Latin America and the Caribbean, based on country data and ILOSTAT

Undernourishment and obesity rates vary significantly by region
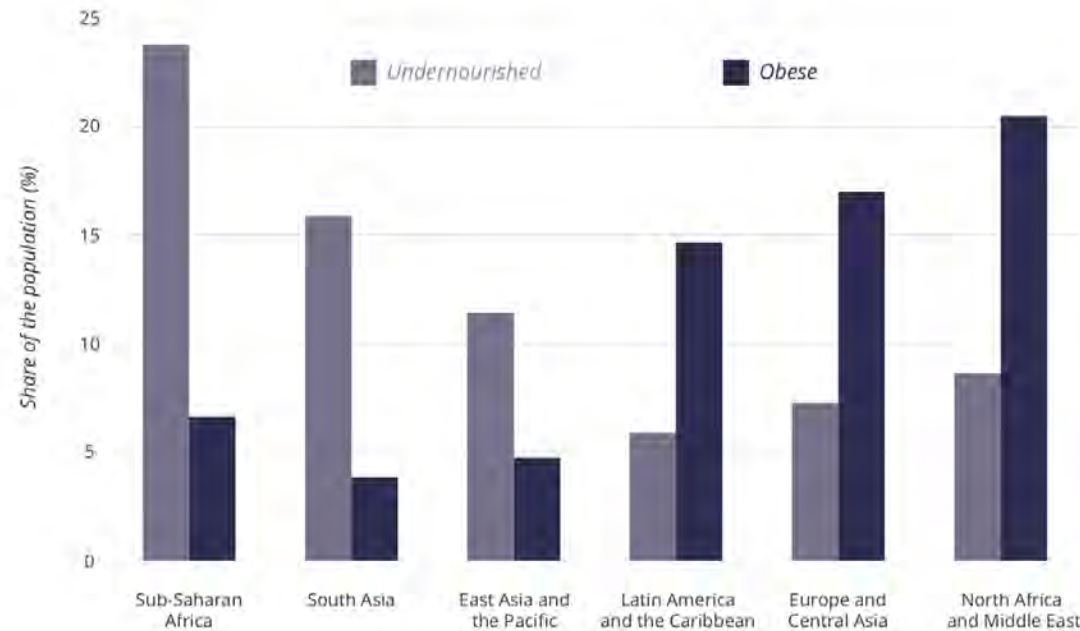
Figure 5.9
Source: adapted from World Bank 2015

Rates of disease burden of diabetes, all ages
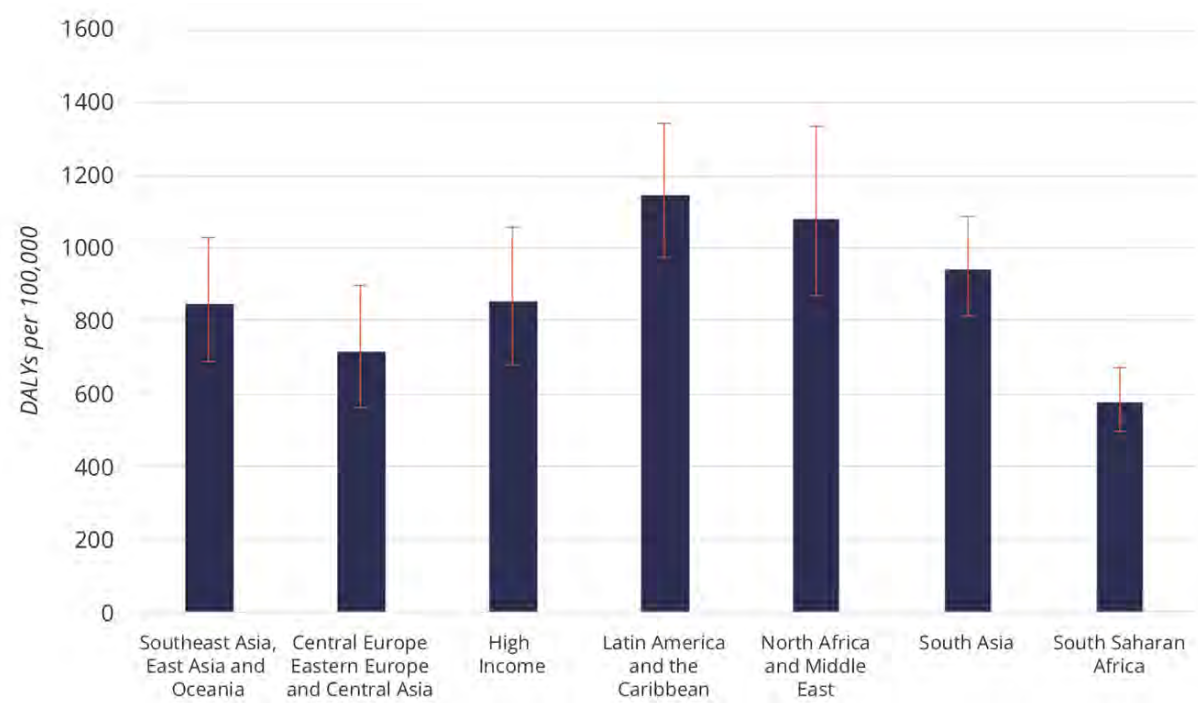
Figure 5.10
Source: adapted from IHME 2015

Rates of disease burden of cardiovascular disease (CVD), all ages
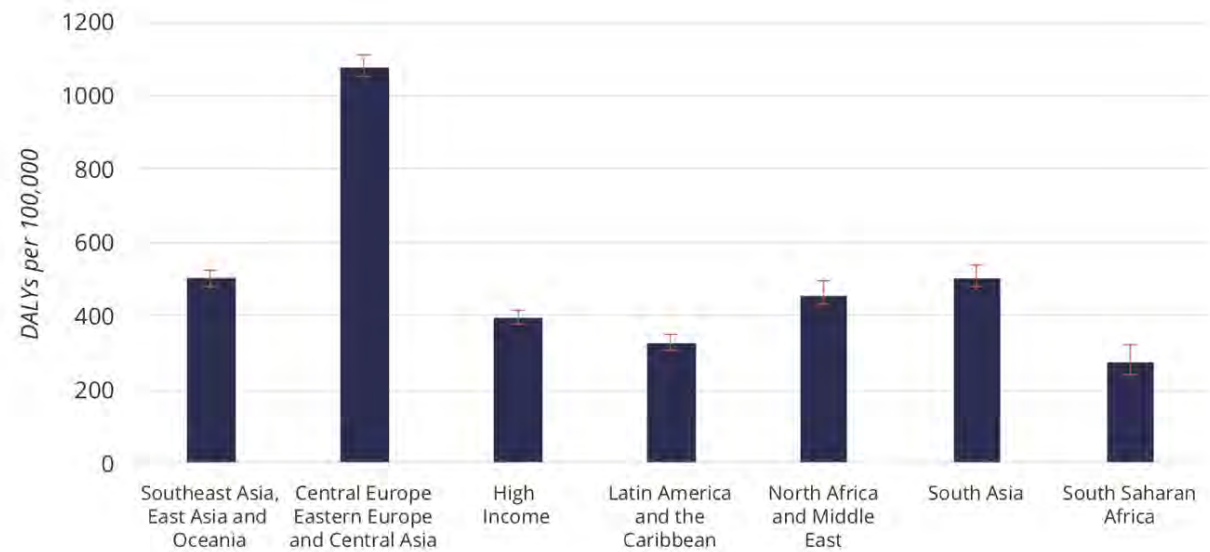
Figure 5.11
Source: adapted from IHME 2015

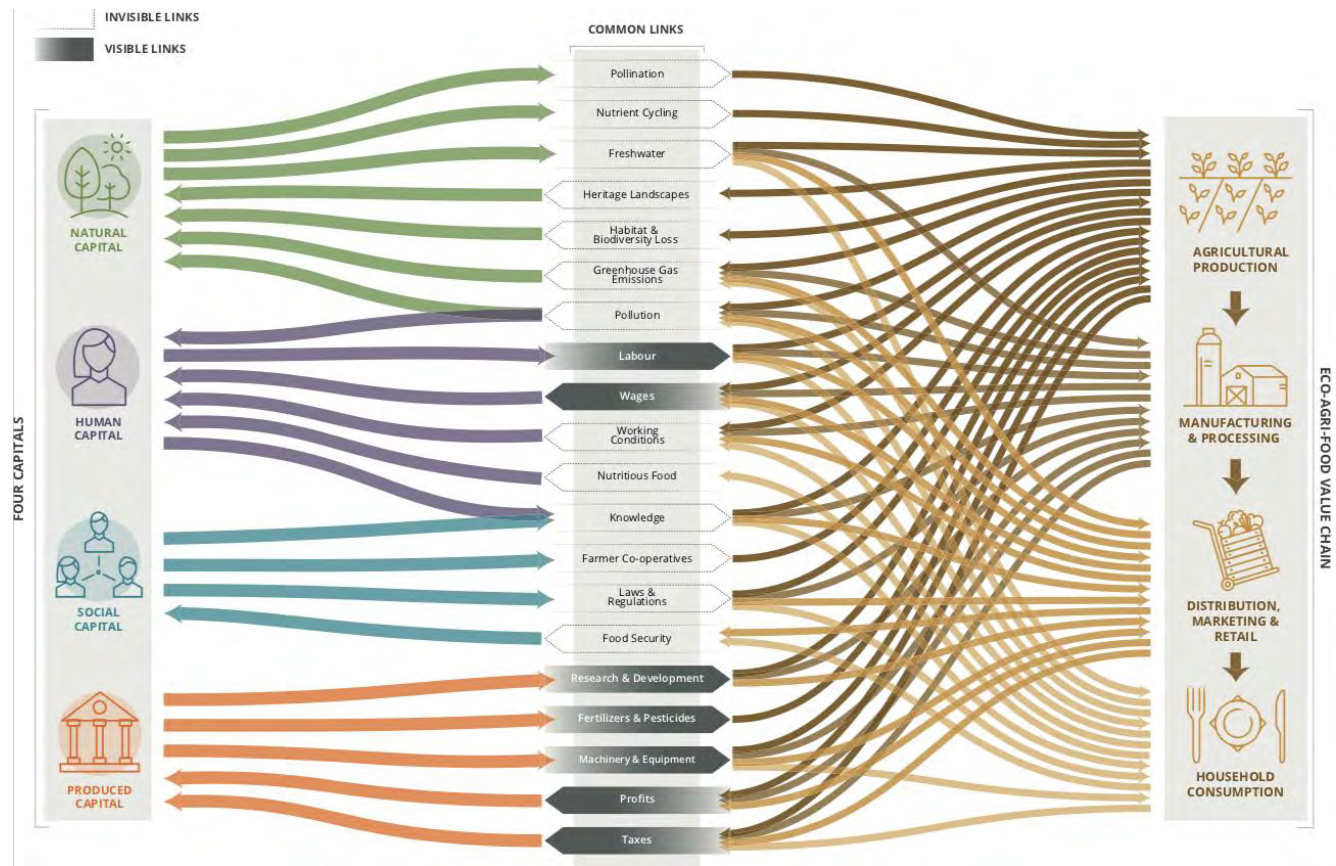# Food losses and waste at consumption and pre-consumption stages by region
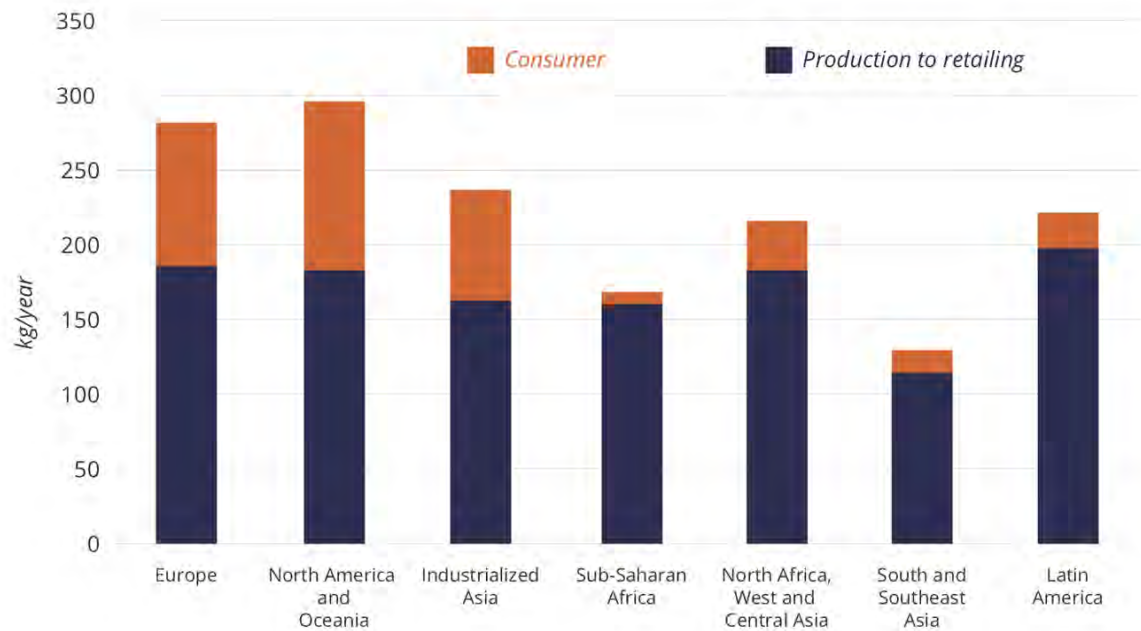
Figure 5.12
Source: adapted from Gustavsson *et al.* 2011

Food losses and waste at consumption and pre-consumption stages by region

Figure 6.1
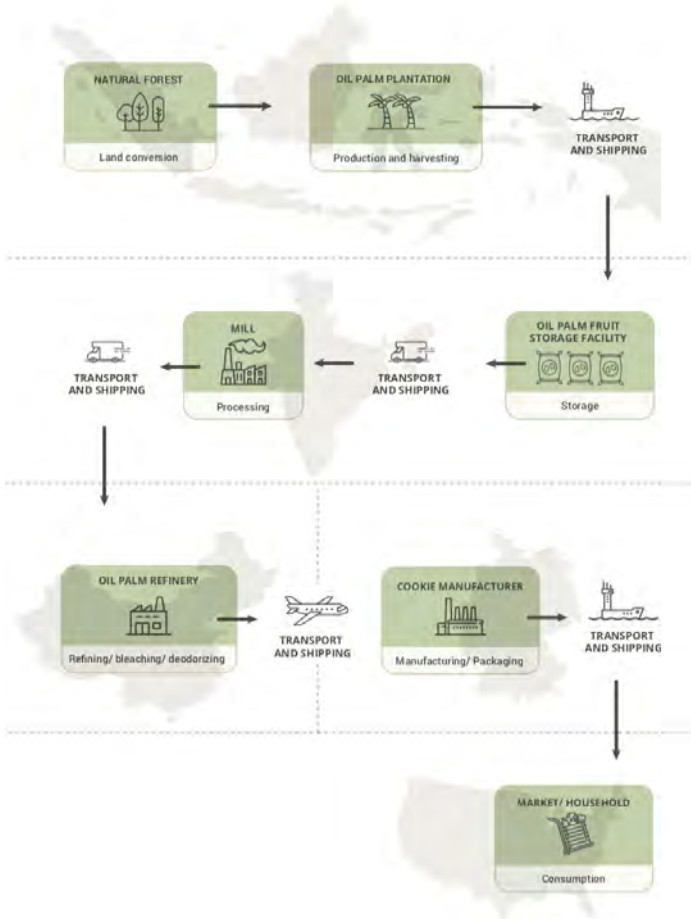Source: authors

Palm oil value chain

Figure 6.2
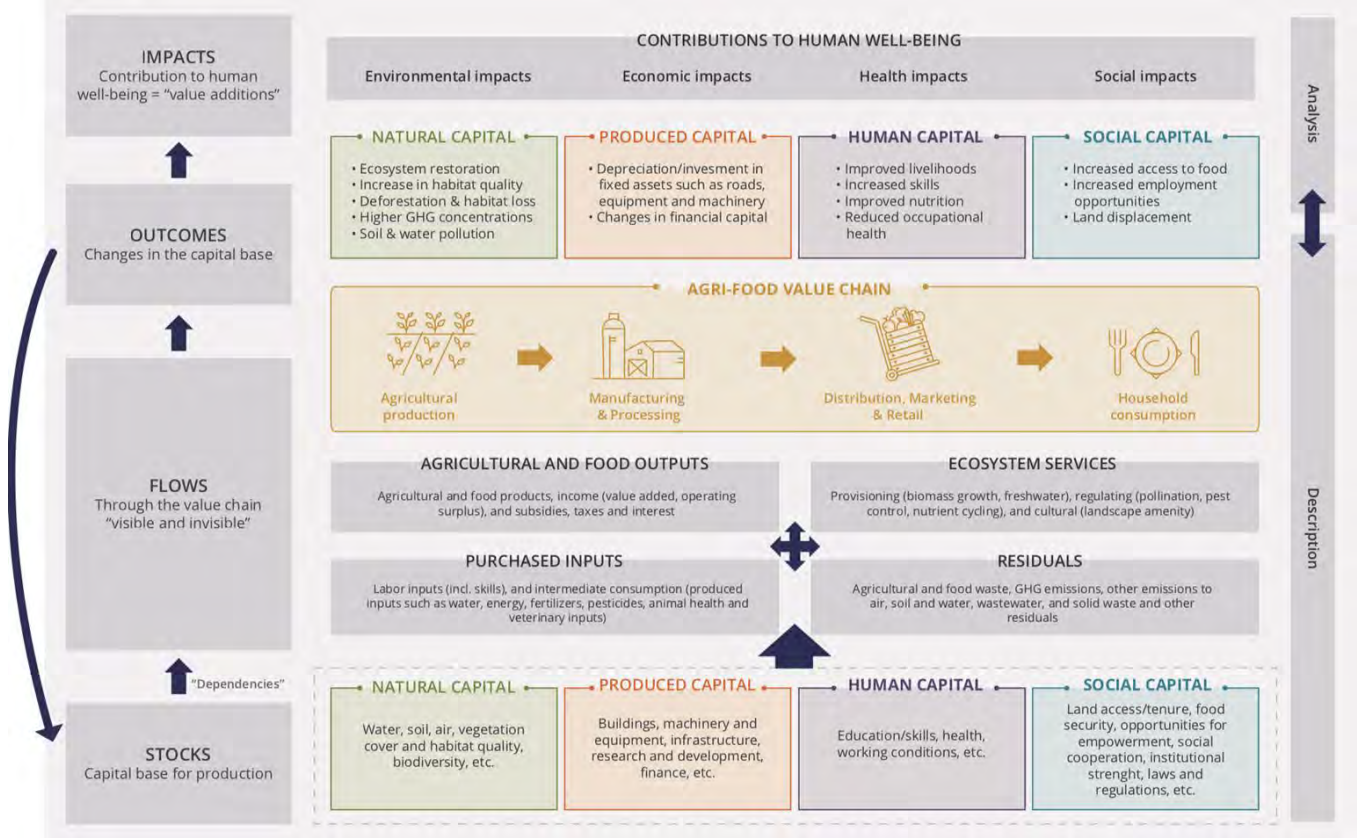Source: authors

Elements of the TEEBAgriFood Evaluation Framework

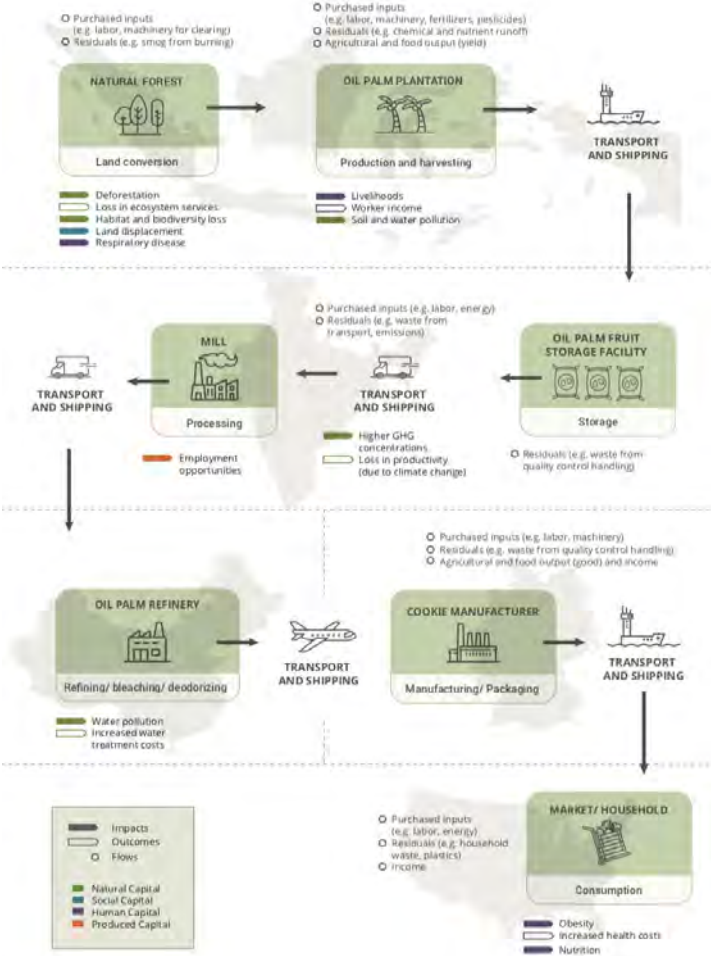Figure 6.3
Source: authors

Palm oil value chain revisited

NATURAL FOREST
Land conversion

○ Purchased inputs
(e.g. labor, machinery for clearing)
○ Residuals (e.g. smog from burning)

OIL PALM PLANTATION
Production and harvesting

○ Purchased inputs
(e.g. labor, machinery, fertilizers, pesticides)
○ Residuals (e.g. chemical and nutrient runoff)
○ Agricultural and food output (yield)

TRANSPORT AND SHIPPING

Deforestation
Loss in ecosystem services
Habitat and biodiversity loss
Land displacement
Respiratory disease

Livelihoods
Worker income
Soil and water pollution

OIL PALM FRUIT STORAGE FACILITY
Storage

○ Purchased inputs (e.g. labor, energy)
○ Residuals (e.g. waste from transport, emissions)

○ Residuals (e.g. waste from quality control handling)

TRANSPORT AND SHIPPING

MILL
Processing

TRANSPORT AND SHIPPING

Employment opportunities

Higher GHG concentrations
Loss in productivity (due to climate change)

OIL PALM REFINERY
Refining/ bleaching/ deodorizing

TRANSPORT AND SHIPPING

COOKIE MANUFACTURER
Manufacturing/ Packaging

TRANSPORT AND SHIPPING

○ Purchased inputs (e.g. labor, machinery)
○ Residuals (e.g. waste from quality control handling)
○ Agricultural and food output (good) and income

Water pollution
Increased water treatment costs

Impacts
Outcomes
○ Flows

Natural Capital
Social Capital
Human Capital
Produced Capital

MARKET/ HOUSEHOLD
Consumption

○ Purchased inputs
(e.g. labor, energy)
○ Residuals (e.g. household waste, plastics)
○ Income

Obesity
Increased health costs
Nutrition

Figure 6.4
Source: authors

Four types of capital

PRODUCED CAPITAL

SOCIAL CAPITAL

HUMAN CAPITAL

NATURAL CAPITAL
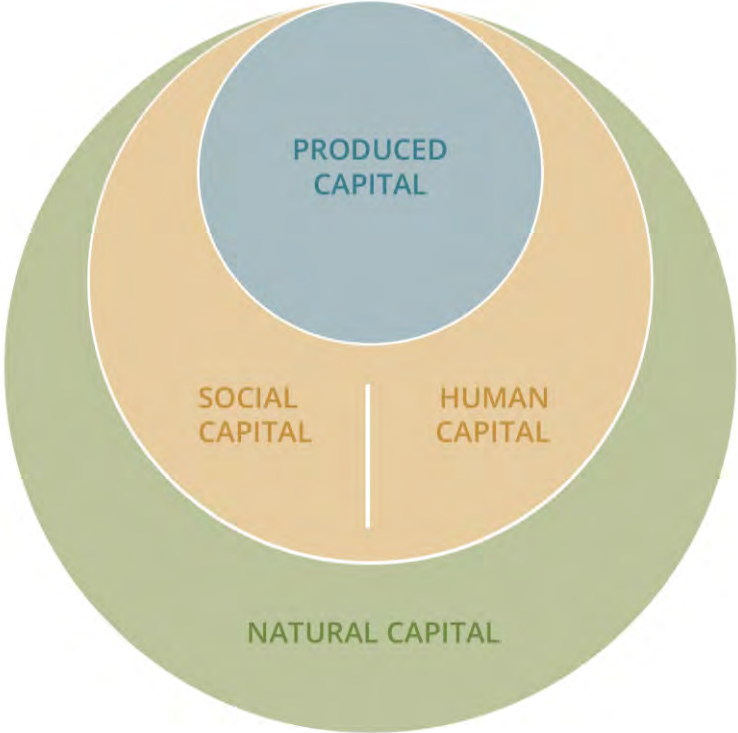
Applications of a universal evaluation framework
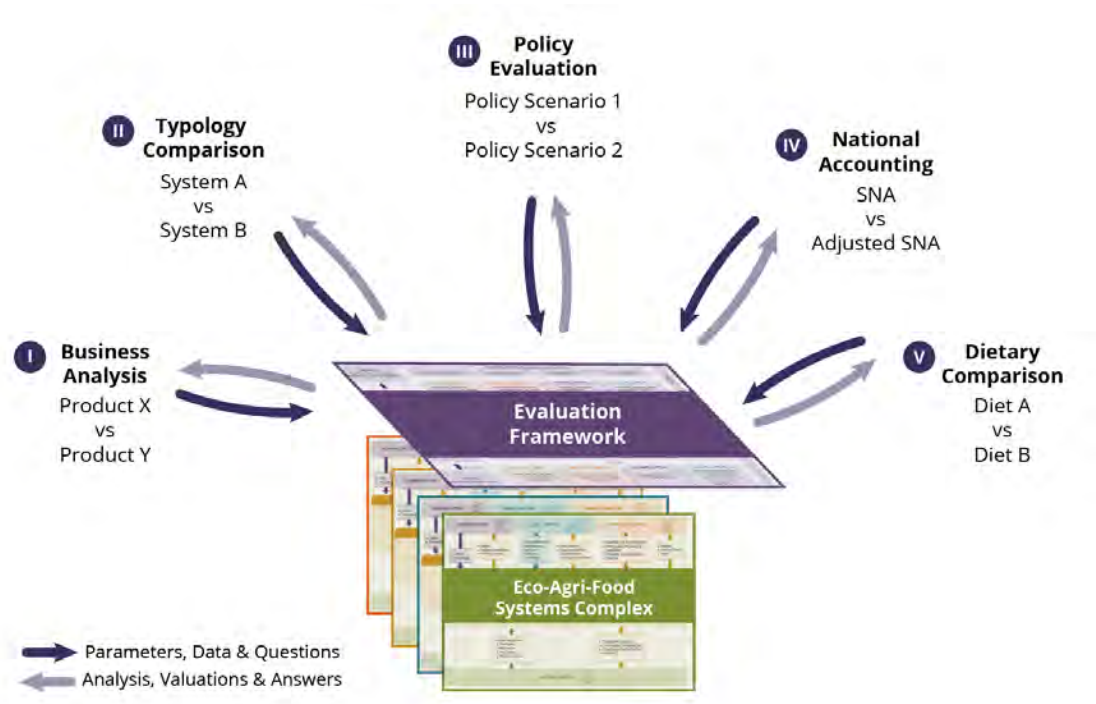
Figure 6.6
Source: authors
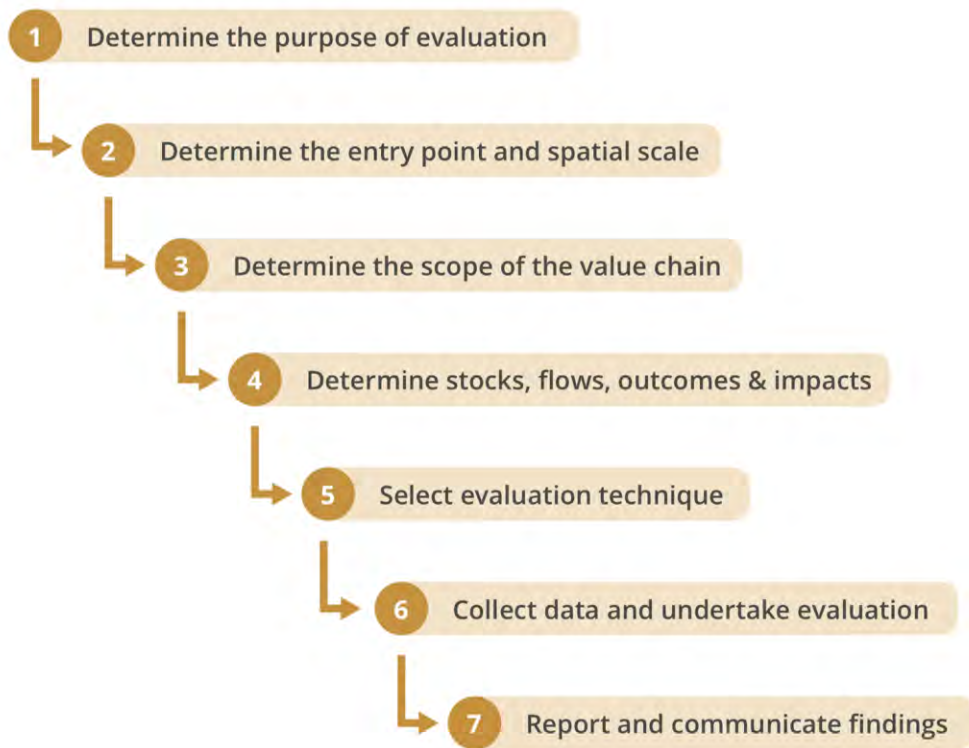
Steps in applying the TEEBAgriFood Evaluation Framework

1. Determine the purpose of evaluation
2. Determine the entry point and spatial scale
3. Determine the scope of the value chain
4. Determine stocks, flows, outcomes & impacts
5. Select evaluation technique
6. Collect data and undertake evaluation
7. Report and communicate findings

Figure 6.7
Source: authors

Drivers and constraints that affect farmers' decisions
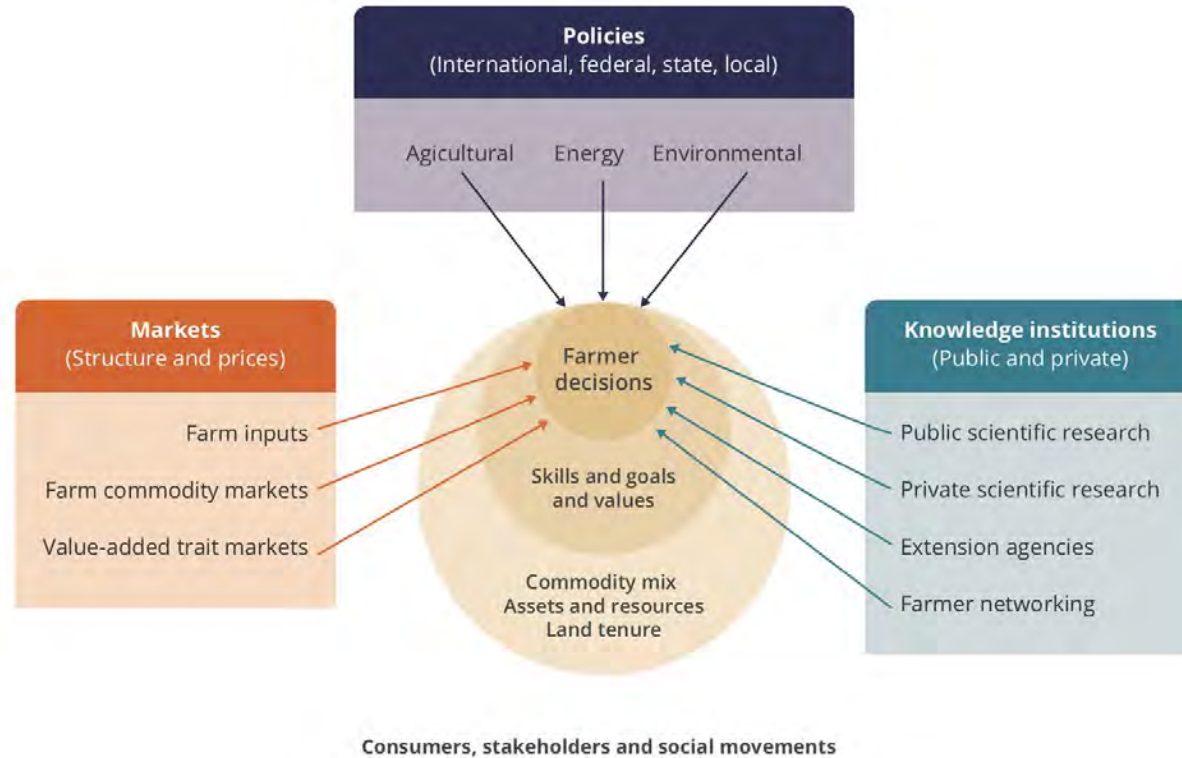
Figure 7.1

Source: adapted from Reganold 2011

Poster of Sugar-Sweetened Beverage Tax in Boulder, Colorado, US

Figure 7.2
Source: bouldercolorado.gov

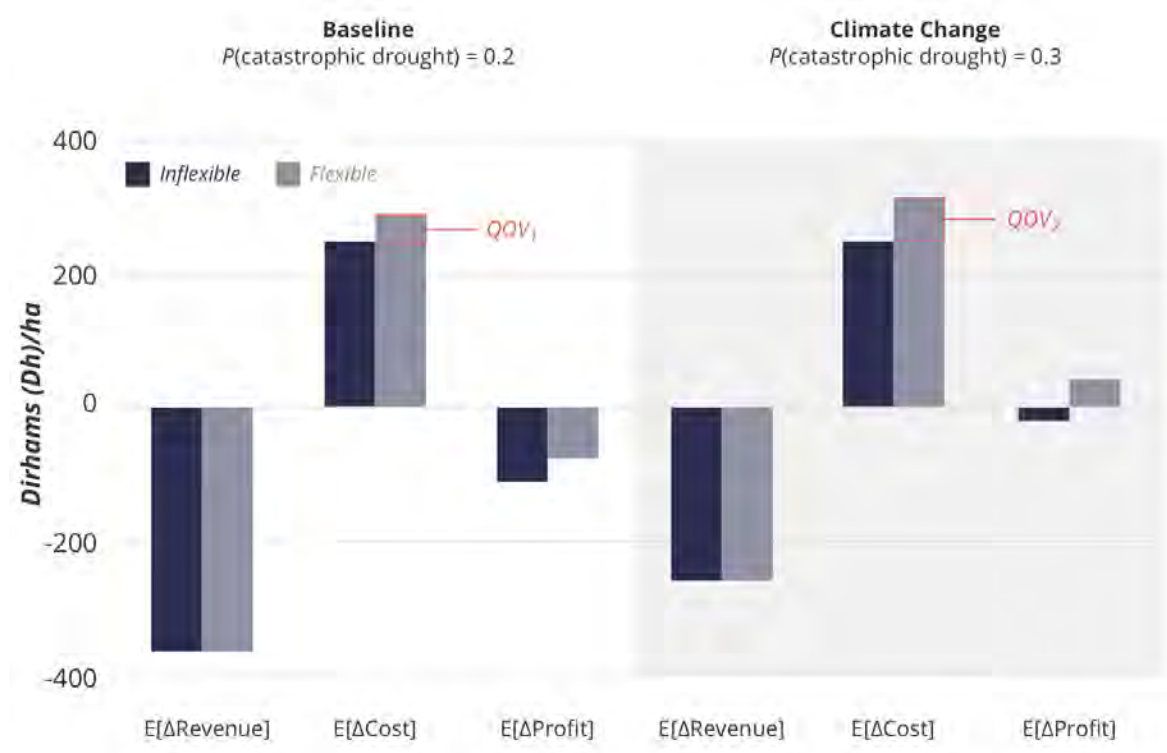# Changes in expected revenues, costs and profits from adopting no-tillage

Figure 7.3
Source: adapted from Magnan *et al.* 2011
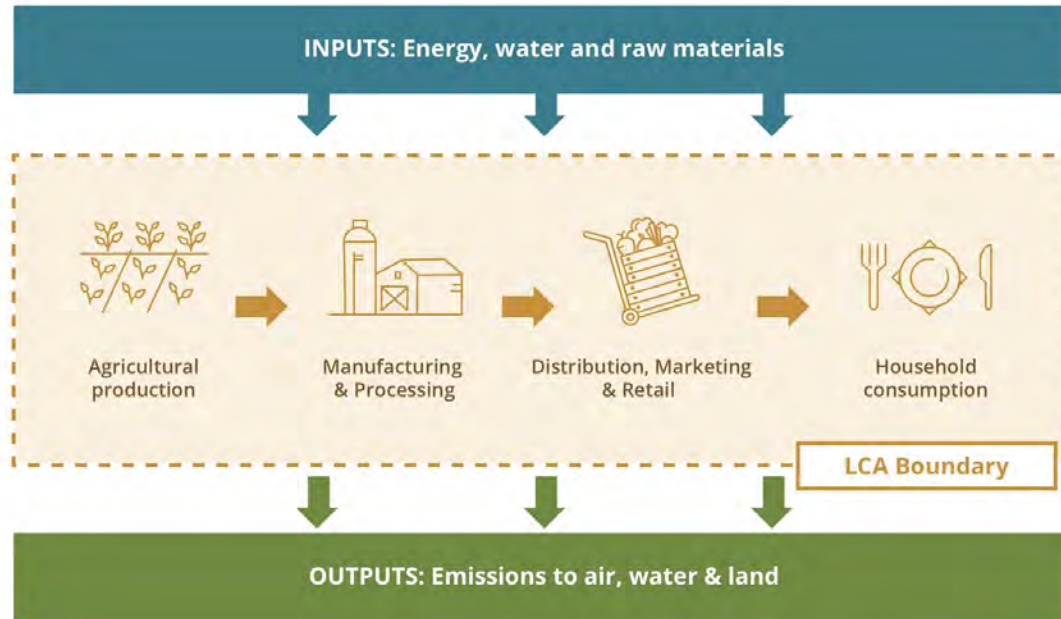
Life Cycle Assessment (LCA) boundaries

INPUTS: Energy, water and raw materials

Agricultural production → Manufacturing & Processing → Distribution, Marketing & Retail → Household consumption

LCA Boundary

OUTPUTS: Emissions to air, water & land

Causal Loop Diagram (CLD) of the study area, emphasizing the impacts of implementing the SAGCOT agriculture intensification plan

Figure 7.5
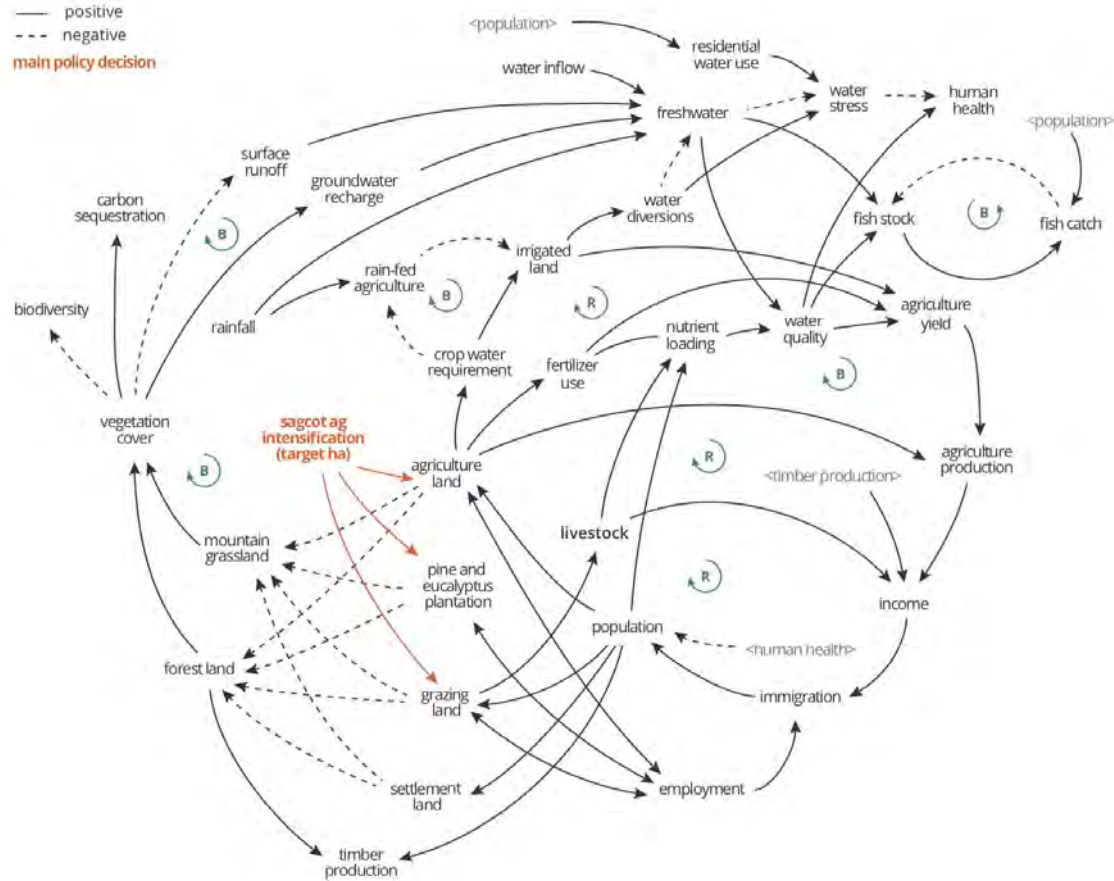Source: authors
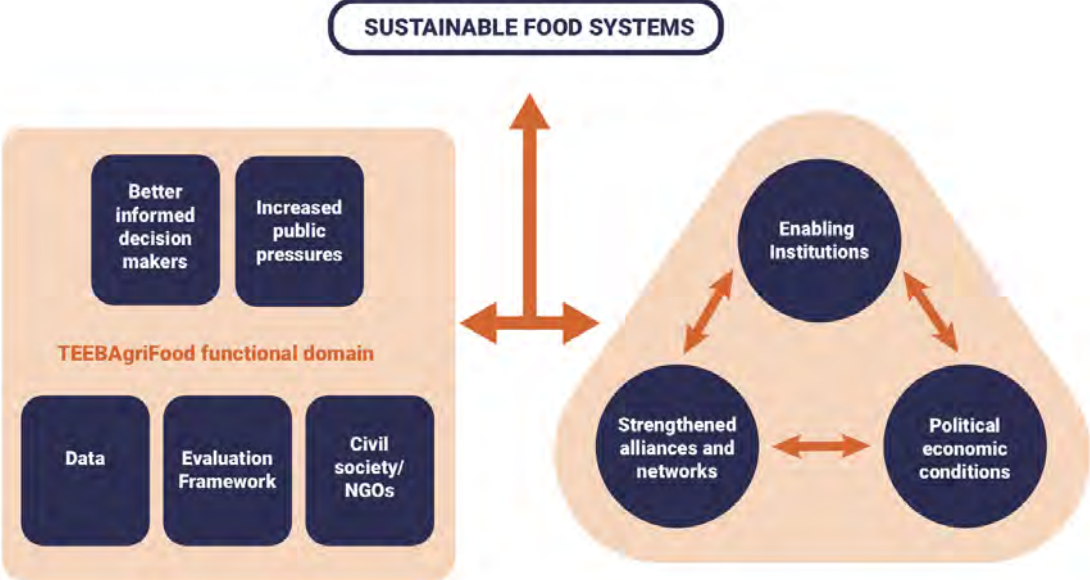
TEEBAgriFood Theory of Change functional domain

Figure 9.1
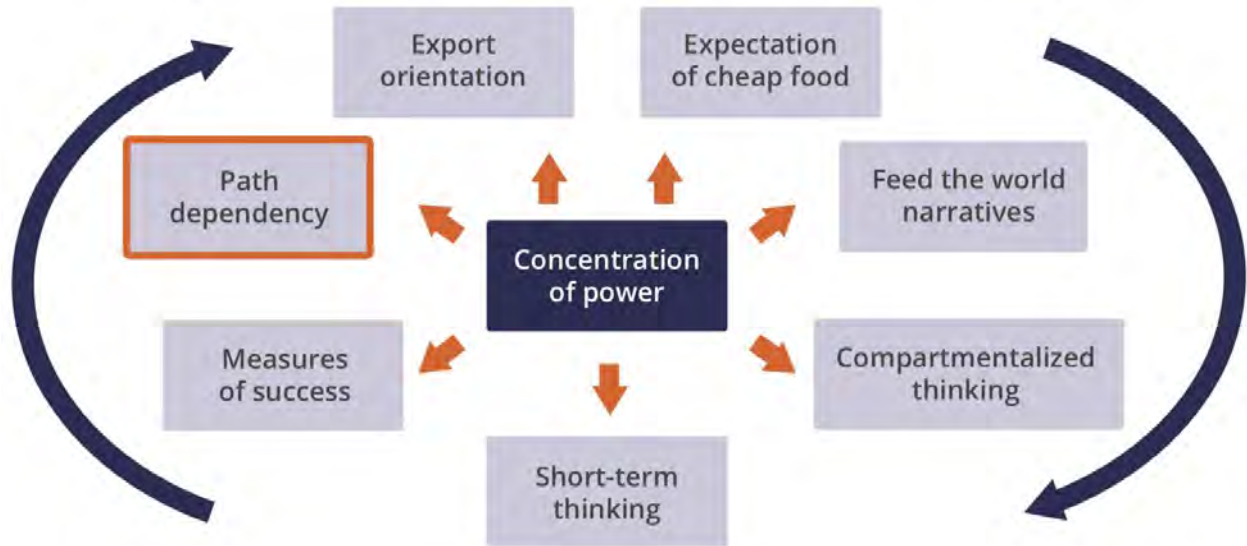**Source: authors**

Eight key lock-ins of industrial agriculture

Figure 9.2
Source: authors

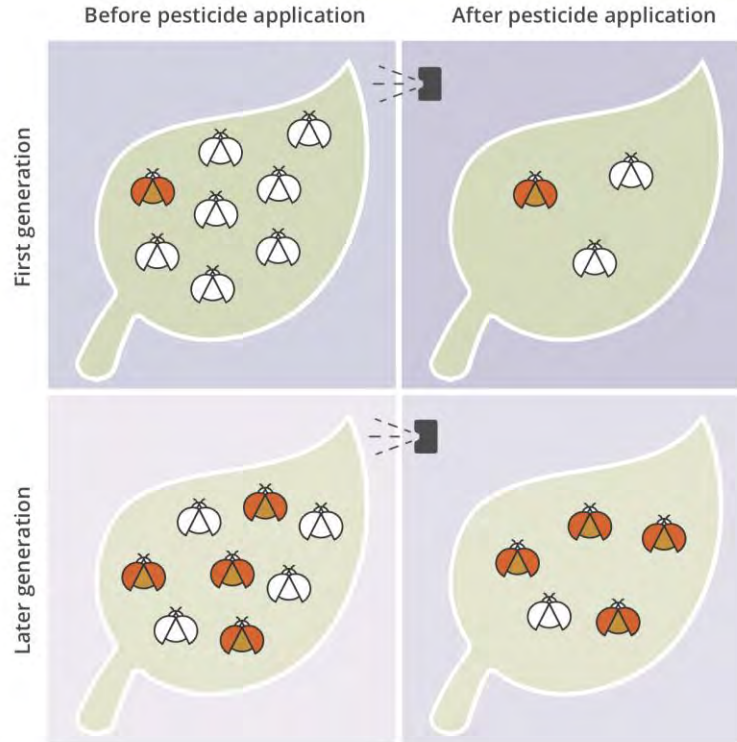**Time sequence of pesticide resistance in pest populations**

Figure 9.3
Source: adapted from https://commons.wikimedia.org/w/index.php?curid=3965987

Transformational change through strengthening the connections in the value chain, indicating key pressure points (arrows)

Primary Inputs → Agricultural Production → Manufacturing & Processing → Distribution, Marketing & Retail → Household Consumption

Land
Advocates for sustainable use
Environmental NGOs
Local watchdog groups

Labor
Unions
Human right groups

Capital
Shareholders
Consumer advocates

Producers
Sustainable certification

Living wage
Fair trade groups

Pressure from food wholesalers and producers

Shareholder pressure on managers

Information exchange between shareholders and consumers

Consumer advocacy groups
Boycotts
Demands for sustainability certification

Taxpayers
Demands for elimination of agricultural subsidies to corporate agriculture
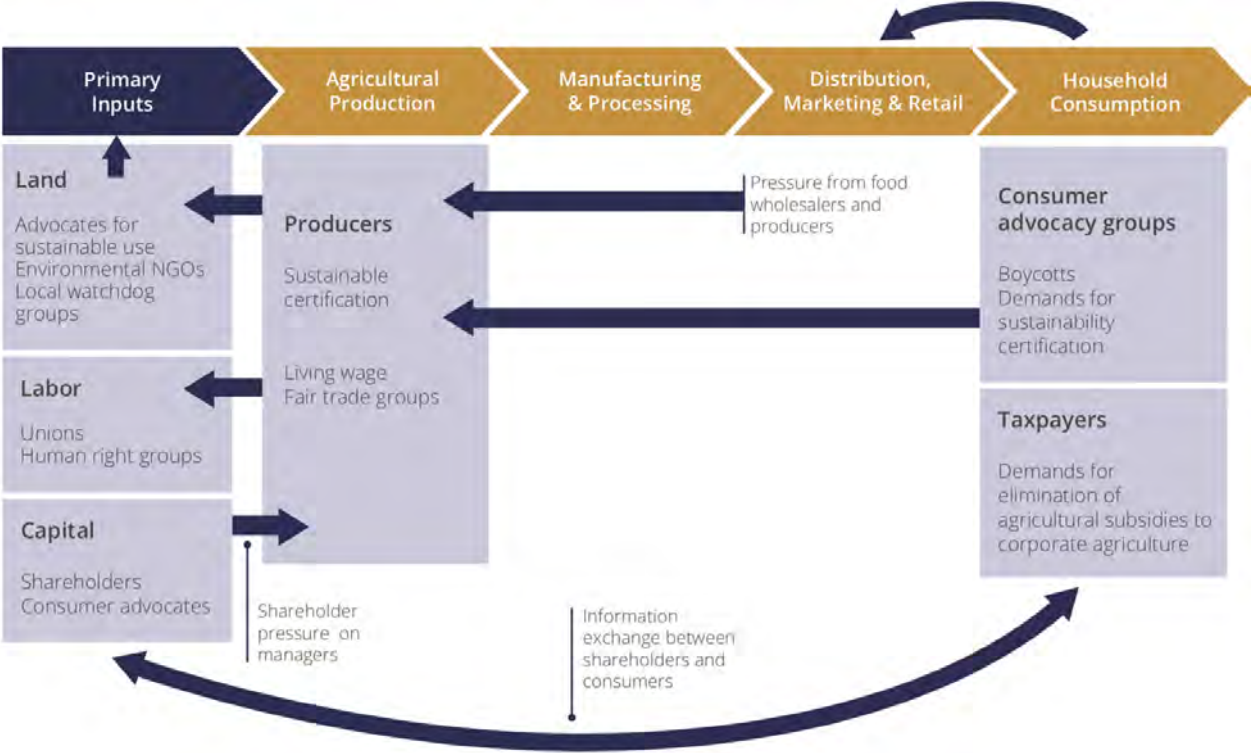
Figure 9.4
Source: authors

Location of sugarcane processing units in Brazil (a) and agro-environmental zoning of sugarcane industry in São Paulo (b)
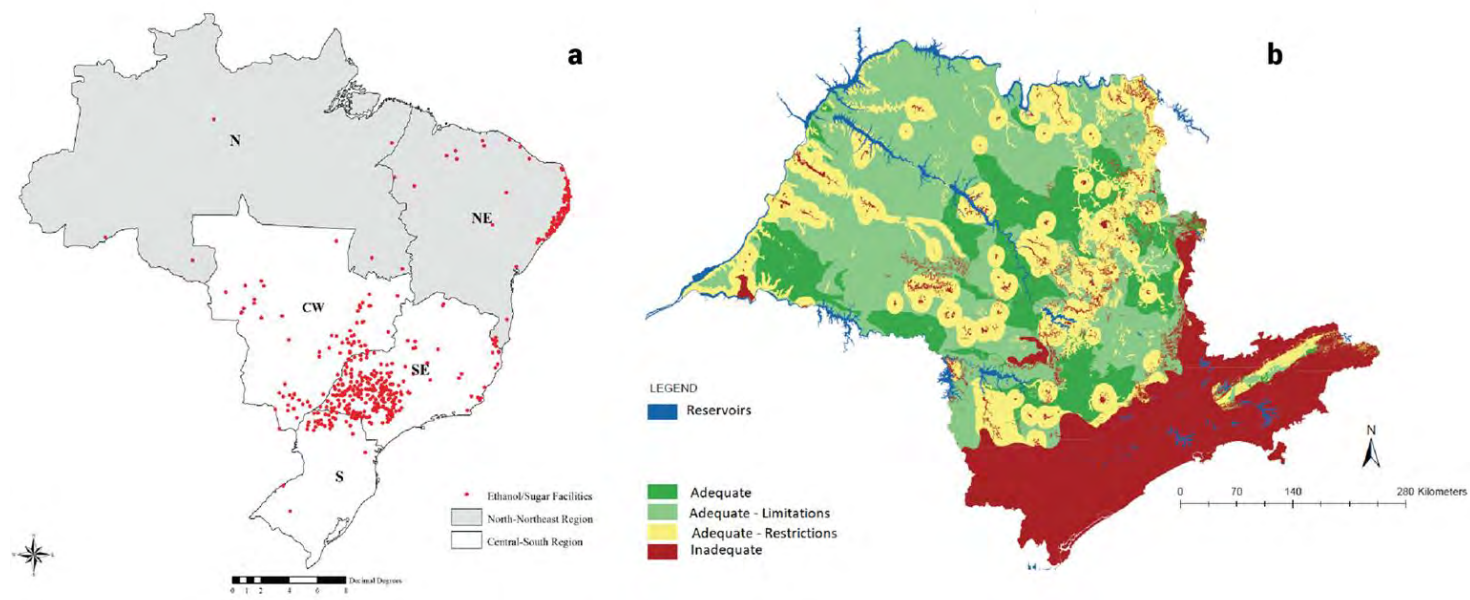

Figure 9.5
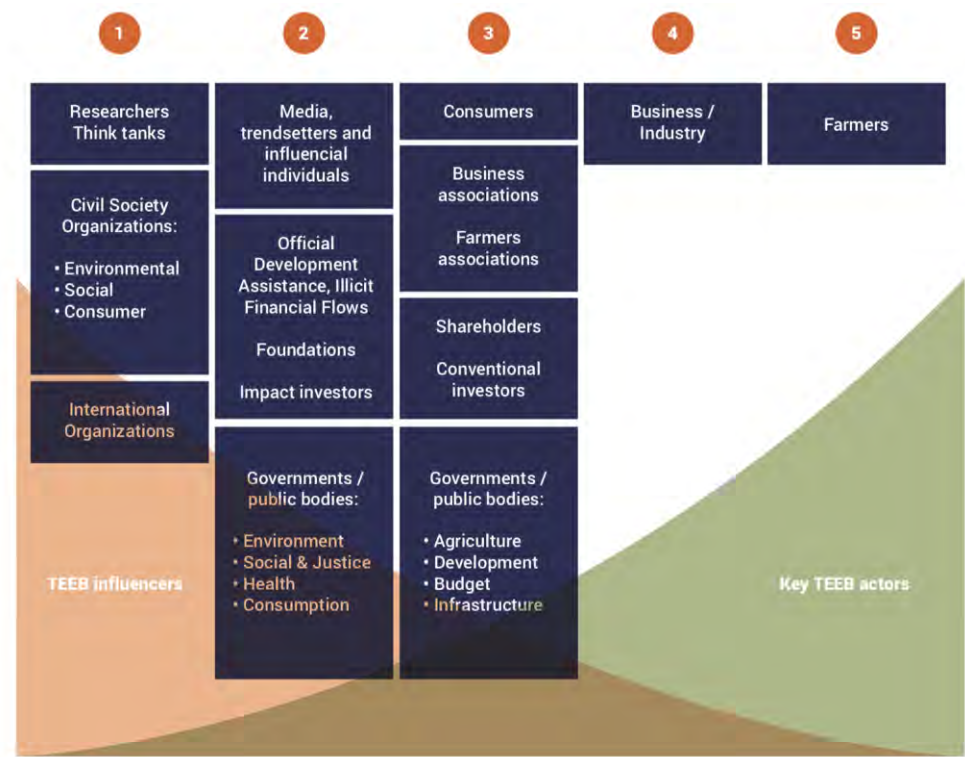Source: SMA 2009; Walter *et al.* 2014

Agri-food actor group continuum

Figure 9.6
Source: authors

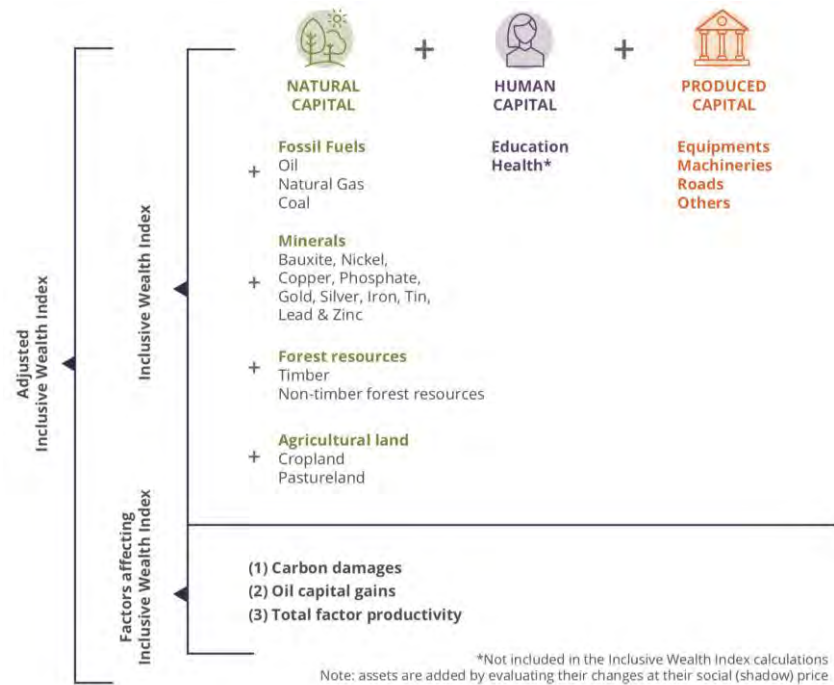**Schematic representation of the Inclusive Wealth Index and the Adjusted Wealth Index**

Figure 10.1
Source: adapted from UNU-IHDP and UNEP 2014
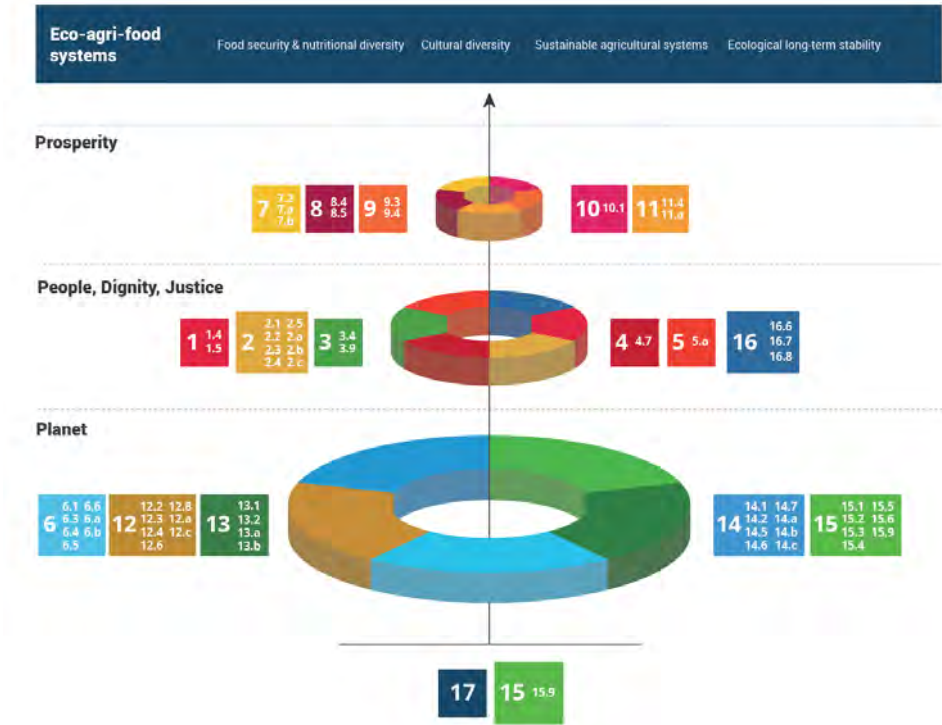
SDG's three-tiered structure and links to eco-agri-food systems

Figure 10.2
Source: authors, adapted from EAT 2016