5.2 – Terrestrial production systems and food choices

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The sustainability of terrestrial food production systems is influenced by factors such as scale; industrialization; mechanization; fossil fuel use; seed, crop and livestock choices; water use; fertilizers; pest control; pollinators; antibiotics; legislation; and levels of commercial versus subsistence food production.

There are many factors that affect food production. The post-war 'second agricultural revolution' in developed countries, and the 'green revolution' in developing nations in the mid-1960s transformed agricultural practices and raised crop yields dramatically, but the effect is levelling off and will not meet projected demand

At the same time, many other factors are having severe impacts on food production: water stress and desertification is reducing the amount of arable land; many pests are becoming resistant to insecticides, but many of the most effective chemical agents are now banned under environmental regulations; underdeveloped infrastructure means that losses increase further during transport and storage; consumption patterns are changing and developing nations such as India and China have an increased appetite for meat, and climate change is bringing new microbial diseases to food-growing regions along with more extreme and unpredictable weather patterns.

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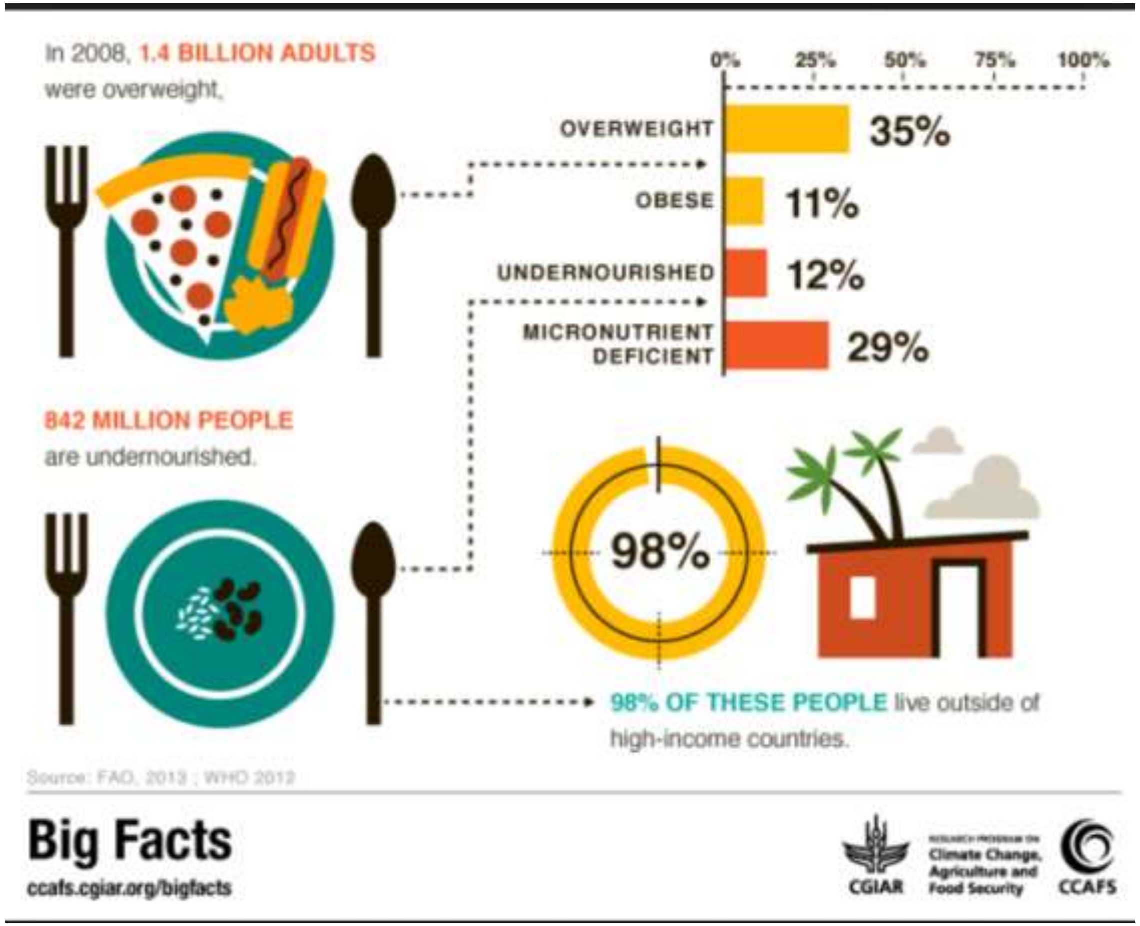
Inequalities exist in food production and distribution around the world

The United Nations Food and Agriculture Organization estimates that nearly 870 million people of the 7.1 billion people in the world, or one in eight, were suffering from chronic undernourishment in 2010-2012. Almost all the hungry people, 852 million, live in developing countries, representing 15 percent of the population of developing counties. There are 16 million people undernourished in developed countries. Chronic under-nourishment, during childhood leads to permanent damage: stunted growth, mental retardation, and social and developmental disorders. Many are also suffering from malnutrition (enough energy but not enough essential nutrients).

In many MEDCs, the cost of food is relatively cheap and people choose food based on preference not nutritional need. Seasonal foods have almost disappeared as foods are readily available all year round. Modern technology and transport systems mean that foreign foods can be bought in almost any market. In LEDCs, many populations struggle to produce enough food to sustain them. Arable land is scarce. There may also be political agendas as well as simple environmental limitations on food production. Crops that are grown are often exported for profit (cash cropping) and not for the local communities. Arable land is in finite supply.

There are large differences in food production in the world but distribution is the problem. Countries like USA, Canada, and Australia produce more food than they need but who should pay for it to be distributed to poorer countries in need such as Bangladesh, Sudan and Ethiopia. The political angle attached to this means that perhaps the receiving country maybe in the others debt, and prone to exploitation. Who decides who gets this food? These are issues that revolve around the topic of food distribution.



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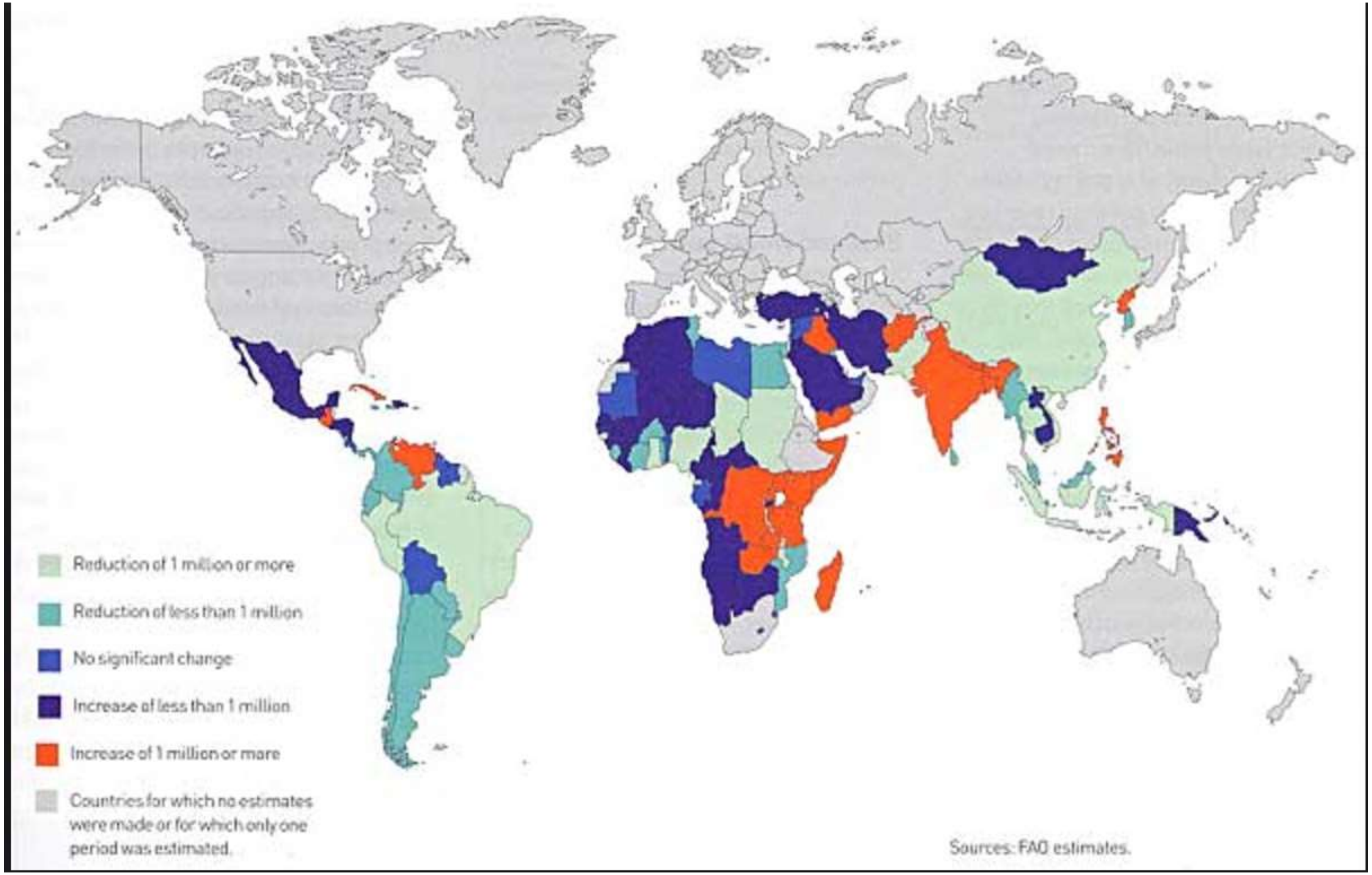
Changes in number of undernourished people



The diets of MEDCs and LEDCs, differ as well. MEDCs average calorie intake is about 3314 whereas LEDCs is only about 2666 per day. As we adapt more and more of the net primary productivity on Earth to human needs, use and degrade more land, demand more meat, we must be reaching our limits.

Agriculture in the LEDCs are in contrast and have low levels of technology, lack of capital and high levels of labour."

MEDC	LEDC
High food supplies for small population	Low food supply for large population
Cause problem such as obesity	Struggle to produce enough food and food price remain high
Low cost of food and all seasonal-supplies of food	In LEDC food production is used as a way to generate foreign currency however their farm produces are non-competitive.

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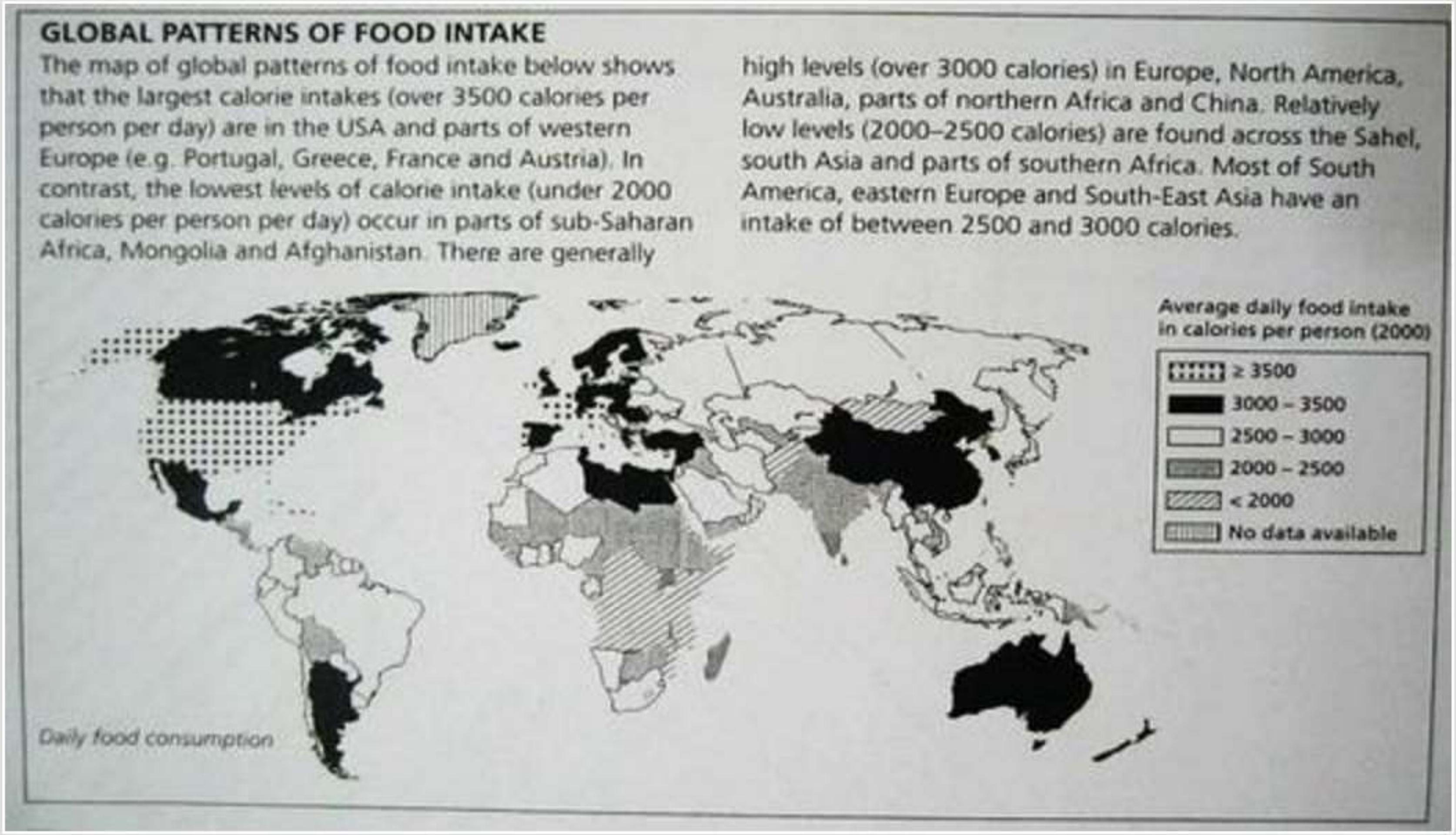
Cause in imbalance food distribution

- Ecological: some climate and soils are better for food production
- Economic: advance technology and money can overcome ecological limitation (transportation of water)
- Socio-political: underinvestment in rural area and rapid area in LEDC; poor human health weaken available labor force



GLOBAL PATTERNS OF FOOD INTAKE

The map of global patterns of food intake below shows that the largest calorie intakes (over 3500 calories per person per day) are in the USA and parts of western Europe (e.g. Portugal, Greece, France and Austria). In contrast, the lowest levels of calorie intake (under 2000 calories per person per day) occur in parts of sub-Saharan Africa, Mongolia and Afghanistan. There are generally high levels (over 3000 calories) in Europe, North America, Australia, parts of northern Africa and China. Relatively low levels (2000–2500 calories) are found across the Sahel, south Asia and parts of southern Africa. Most of South America, eastern Europe and South-East Asia have an intake of between 2500 and 3000 calories.

Food waste is prevalent in both LEDCs and more economically developed countries (MEDCs), but for different reasons.

As countries develop and consumption increases so does the amount of waste per capita, and pollution becomes a greater problem. There are global, national and local strategies in place to reduce levels of waste and minimise impact on the environment.
Global waste production

The amount and type of waste produced varies between countries. MEDCs have higher levels of consumption, so many produce more waste than LEDCs. Ireland and the USA produce over 700 kg of waste per person per year. In LEDCs the figure is around 150 kg per person per year. This difference is due to different levels of consumption; it is also more common to reuse items in LEDCs.

As a country becomes more wealthy, the demand for consumer items increases. This means that items are replaced more frequently - leading to larger quantities of waste. For example, mobile phones and computers that still work may be discarded for a newer version.

In LEDCs waste production is lower because:

- Less is bought because people are typically on lower incomes
- Less packaging is used on products
- Disposable items (eg razors, plastic plates and nappies) are used less
- Lower literacy levels means there is less production of written material

Into the Trash It Goes

A federal study found that 96.4 billion pounds of edible food was wasted by U.S. retailers, food service businesses and consumers in 1995 — about **1 pound of waste per day** for every adult and child in the nation at that time. That doesn't count food lost on farms and by processors and wholesalers.

For a family of four people, that amounted to about **122 pounds of food thrown out each month** in grocery stores, restaurants, cafeterias and homes. Here is a depiction of that family's monthly share, the sum of waste in eight different food groups as detailed in the study.

Source: United States Department of Agriculture; Census Bureau

BILL MARSH AND KARI HASKELL/THE NEW YORK TIMES; PHOTOGRAPH BY TONY CENICOLA/THE NEW YORK TIMES

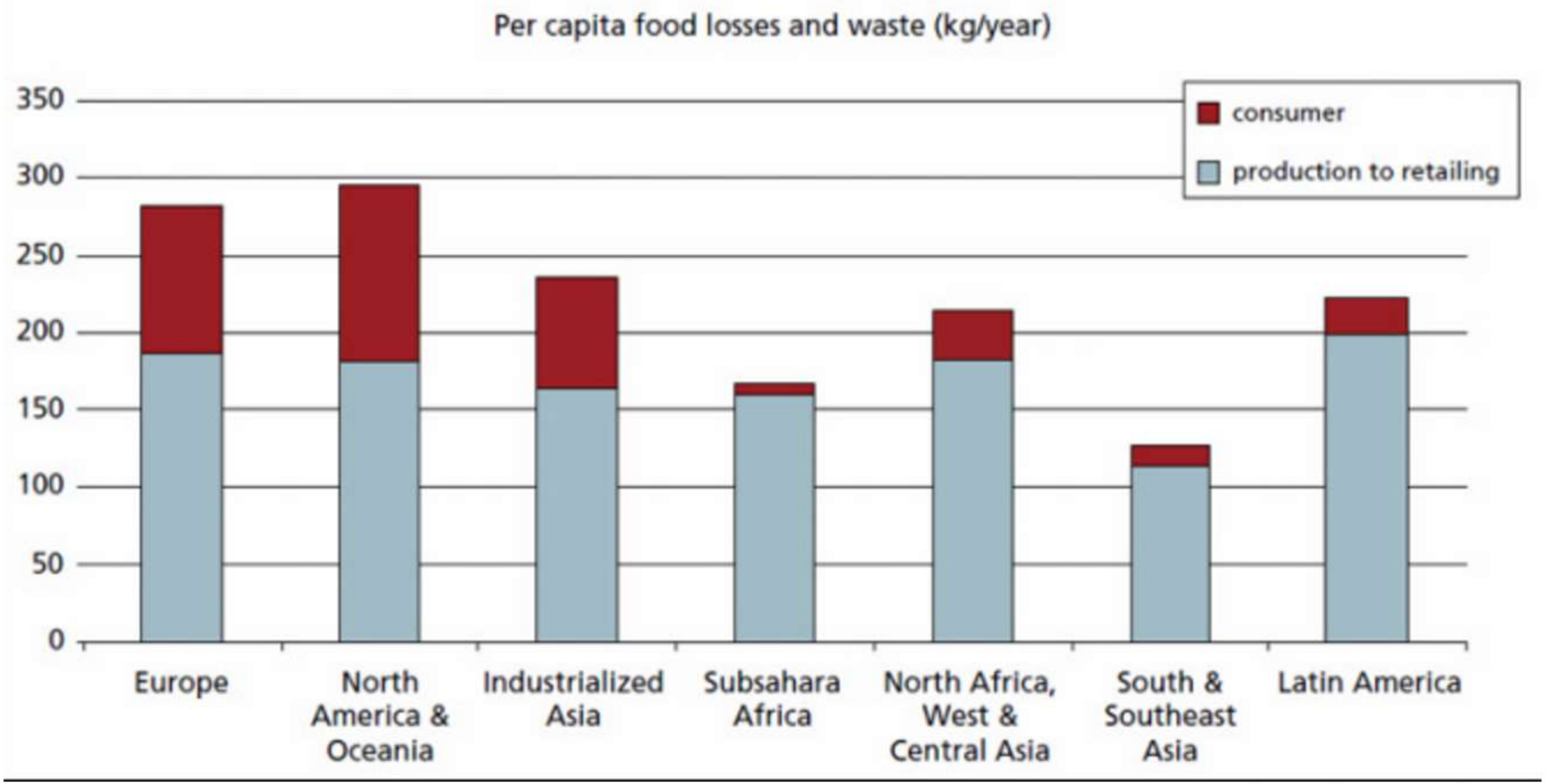


image from www.fao.org

Socio-economic, cultural, ecological, political and economic factors can be seen to influence societies in their choices of food production systems


image from www.eufic.org

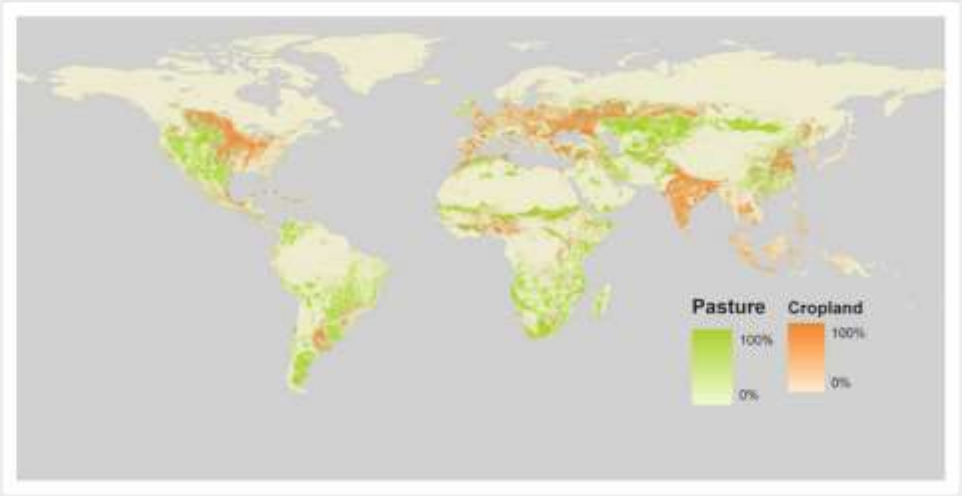
Social influences on food intake refer to the impact that one or more persons has on the eating behaviour of others, either direct or indirect, either conscious or subconscious. The relationship between low socio-economic status and poor health is complicated and is influenced by gender, age, culture, environment, social and community networks, individual lifestyle factors and health behaviours.

There are clear differences in social classes with regard to food and nutrient intakes. Low-income groups in particular, have a greater tendency to consume unbalanced diets and have low intakes of fruit and vegetables.

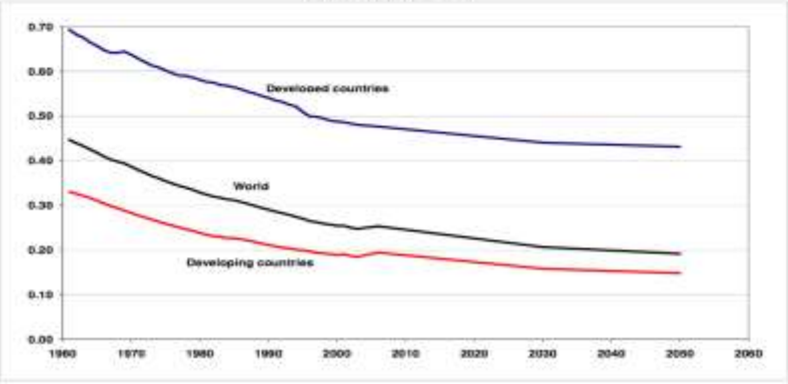
Education level and income determine food choices and behaviours that can ultimately lead to diet-related diseases. The origins of many of the problems faced by people on low incomes emphasises the need for a multidisciplinary approach to targeting social needs and improving health inequalities.

As the human population grows, along with urbanization and degradation of soil resources, the availability of land for food production per capita decreases.

As the world population continues to grow in almost all continents, great pressure is being placed on arable land, water, energy, and biological resources to provide an adequate supply of food while maintaining the integrity of our ecosystem. As the world population grows, the food problem will become increasingly severe. The most venerable will be population in developing countries. The per capita availability of world grains, which make up 80 per cent of the world's food, has been declining for the past 25 years. Certainly with a quarter million people being added to the world population each day, the need for grains and all other food will reach unprecedented levels.



Arable land per capita (ha in use per person) (1961-2050) – Jelle Bruinsma (2009) [FAO][3]



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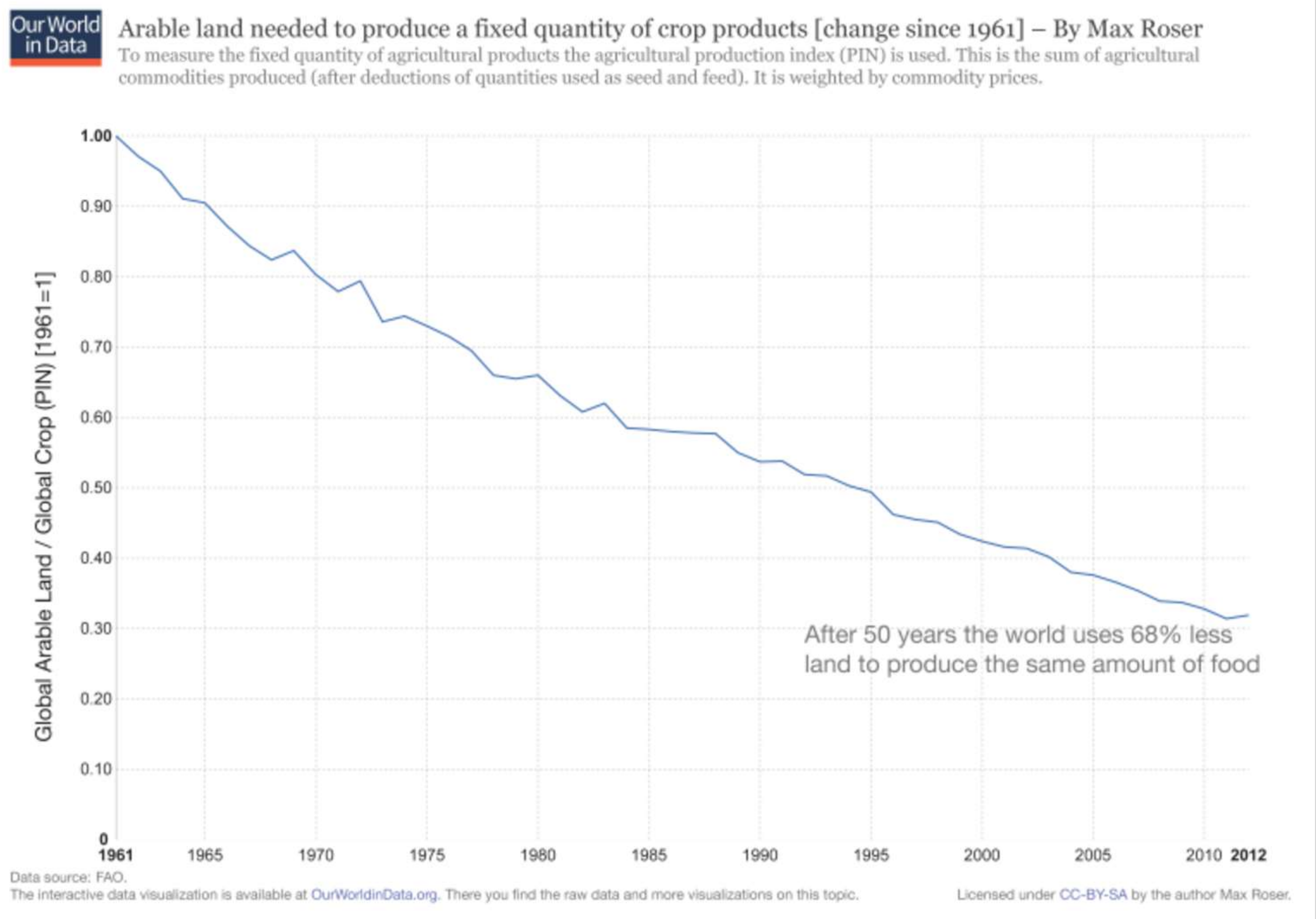
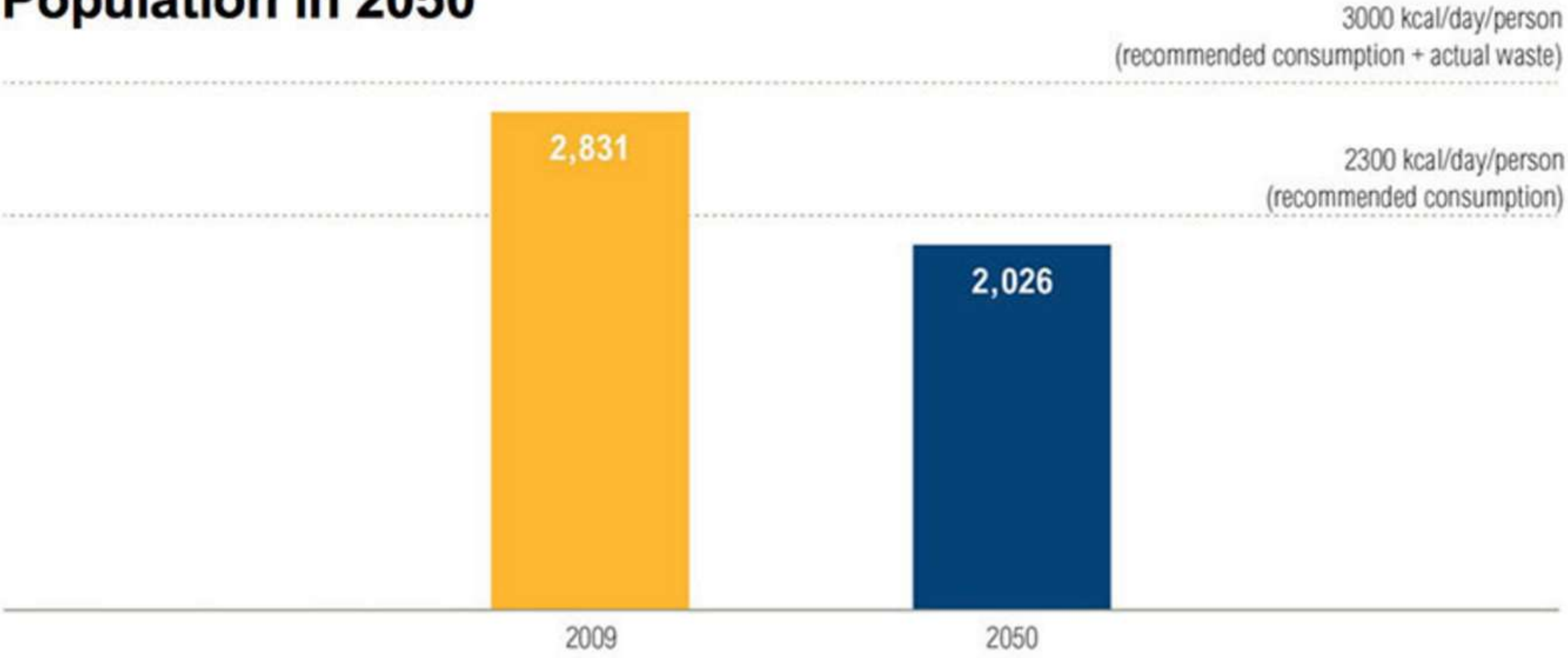

Our World in Data
Arable land needed to produce a fixed quantity of crop products [change since 1961] – By Max Roser
To measure the fixed quantity of agricultural products the agricultural production index (PIN) is used. This is the sum of agricultural commodities produced (after deductions of quantities used as seed and feed). It is weighted by commodity prices.
Global Arable Land / Global Crop (PIN) [1961=1]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
1961
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2012
After 50 years the world uses 68% less land to produce the same amount of food
Data source: FAO.
The interactive data visualization is available at OurWorldinData.org. There you find the raw data and more visualizations on this topic.
Licensed under CC-BY-SA by the author Max Roser.

Even Distribution of All Food Produced in 2009 to World Population in 2050



Note: Data reflects food for direct human consumption. It excludes food crops grown for animal feed and biofuels. See endnotes for assumptions used to generate the global average daily energy requirement per person.

WORLD RESOURCES INSTITUTE

Sources: http://ow.ly/rpfMN

The yield of food per unit area from lower trophic levels is greater in quantity, lower in cost and may require fewer resources

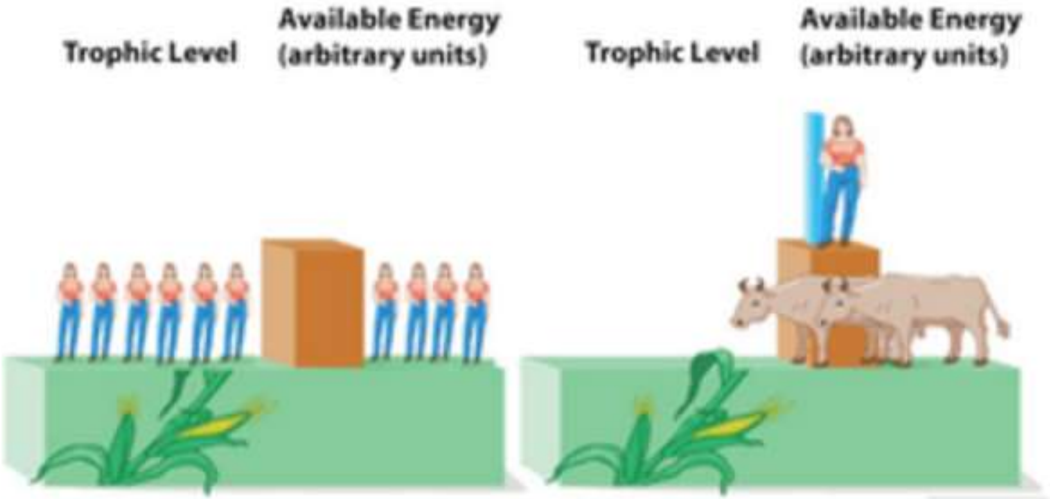


image from www.sciencemusicvideos.com

Most food chains do not have a fourth or fifth trophic level, because energy is not sufficient to sustain fourth or fifth trophic level. As you progress a trophic level only a percentage is passed on to the next organism (approximately 10%- as a result of the energy required to maintain homeostasis), so it would not be efficient to eat an animal that would give you a small biomass.

More people on Earth could be supported for a given area of land farmed if individuals eat lower on the food chain. Eating primary producers instead of eating herbivores could support the same number of people as at present, but with less land degradation because we wouldn't need to have so much land in production. These consequences of a change in our diets result from the basic thermodynamic principles outlined above.

The UN's Food and Agriculture Organization (FAO) estimates that ~ 30% of the ice-free land surface area of Earth is directly or indirectly involved in livestock production!

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The Second Law of Thermodynamics states that energy goes from a concentrated form (like the sun) to a dispersed form (like heat), the availability of energy to do work therefore diminishes on the system becomes increasingly disorder. It explains how energy transformations in living systems can lead to loss of energy from the system. The order in living systems is only maintained by constant input of new energy from the sun.

We get to see from the second law of thermodynamics that energy conversion through food chains is inefficient and that energy is lost by respiration and waste production at each level within the food web.

Energy in sunlight -> producer (90% energy lost) -> primary consumer (9% energy lost) -> secondary consumer (0.9% energy lost)

100% -> 10% -> 1% -> 0.1%

Comparing Food Production

Terrestrial	Aquatic
• Food is harvested from low trophic levels. • More efficient fixing of solar energy by photosynthesis.	• Food is harvested from higher trophic levels mostly because of human taste. • Energy conversions are more efficient along the food chain.

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Eating lower on the food chain, one or more of the following benefits would be likely:

- Not as much land and other resources raising grain to feed to animals.
- Overgrazing on public and private range lands could decrease.
- Would not have to farm or graze marginal lands as intensively
- More people in the world could receive an adequate diet
- Less fossil fuel energy (and associated emissions of CO2) would be required to produce our food.

Terrestrial	Aquatic
Consume from lower tropic level (cow/rice) due to taste and cultural demand	Consume from higher trophic level (salmon) due to taste and cultural demand
Less efficient	Higher efficiency, however, the initial available solar energy is slower due to reflection and absorption of light by water

TERRESTRIAL VS. AQUATIC BIOMASS PYRAMIDS

image from www.arctic.uoguelph.ca

Compare and contrast these in terms of their trophic levels and efficiency of energy conversion. There is no need to consider individual production systems in detail. In terrestrial systems, most food is harvested from relatively low trophic levels (producers and herbivores).

In aquatic systems, perhaps largely due to human tastes, most food is harvested from higher trophic levels where the total storages are much smaller. Although energy conversions along the food chain may be more efficient in aquatic systems, the initial fixing of available solar energy by primary producers tends to be less efficient due to the absorption and reflection of light by water.

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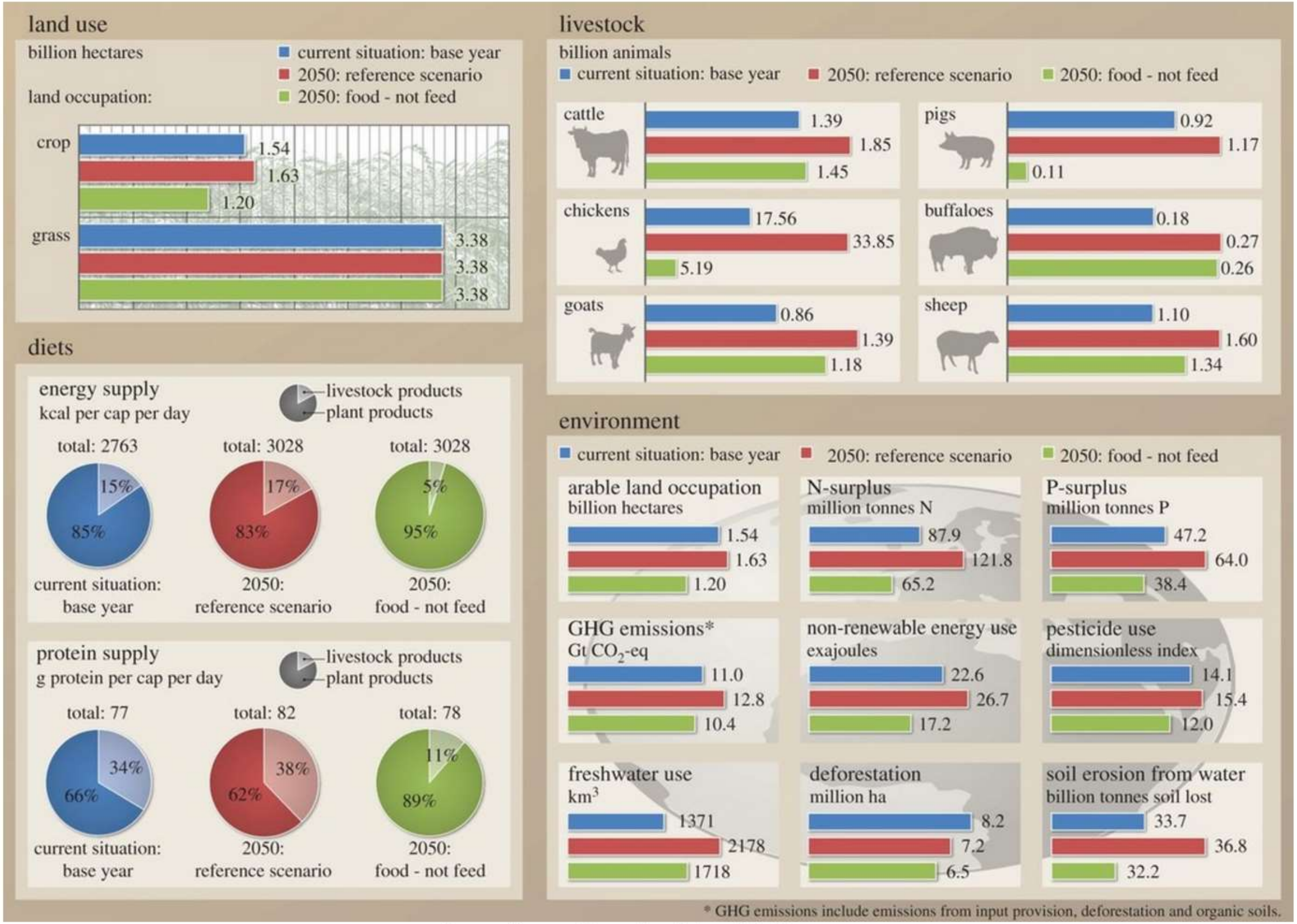
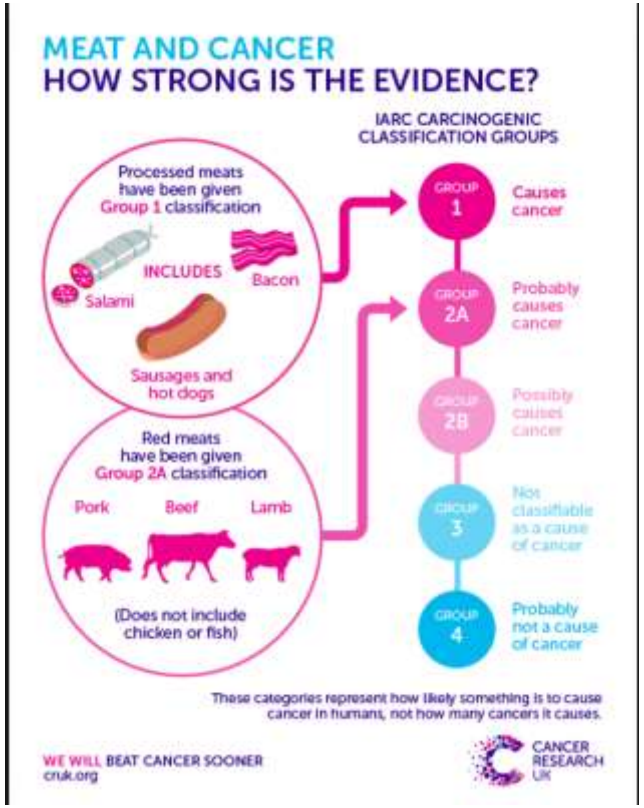


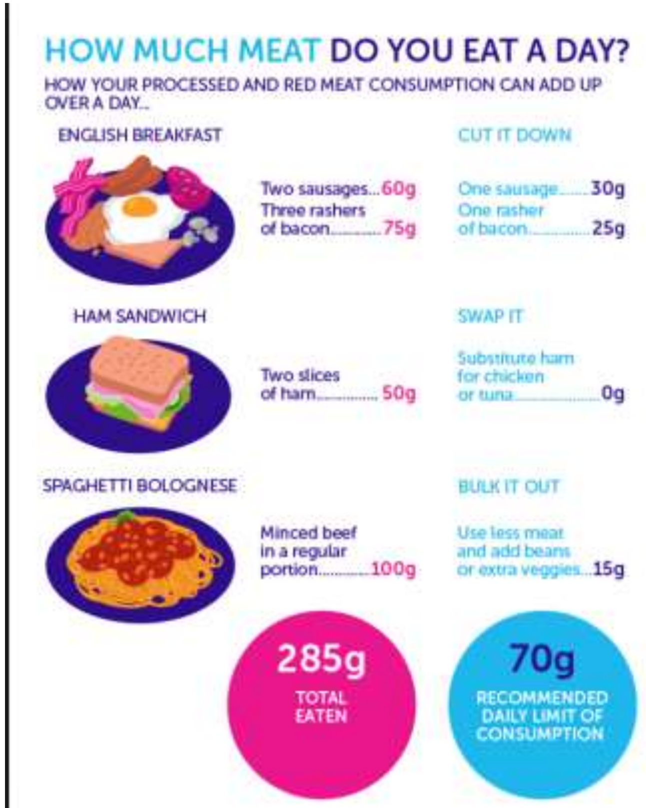
image from rsif.royalsocietypublishing.org

Cultural choices may influence societies to harvest food from higher trophic levels.

image .sustainablecitiesinstitute.org

Most food is harvested from low trophic levels (producers and herbivores). Systems that produce crops are more energy efficient then those which produce livestock. This is because energy is greater in proportion in the low trophic levels. Even though it is efficient to use arable systems, many cultures still use livestock as part of their farming system. Taste and cultural demand play a major role in this and the animals also provide a source protein which is essential for the human diet. Animals are also used as working animals in some cultures.





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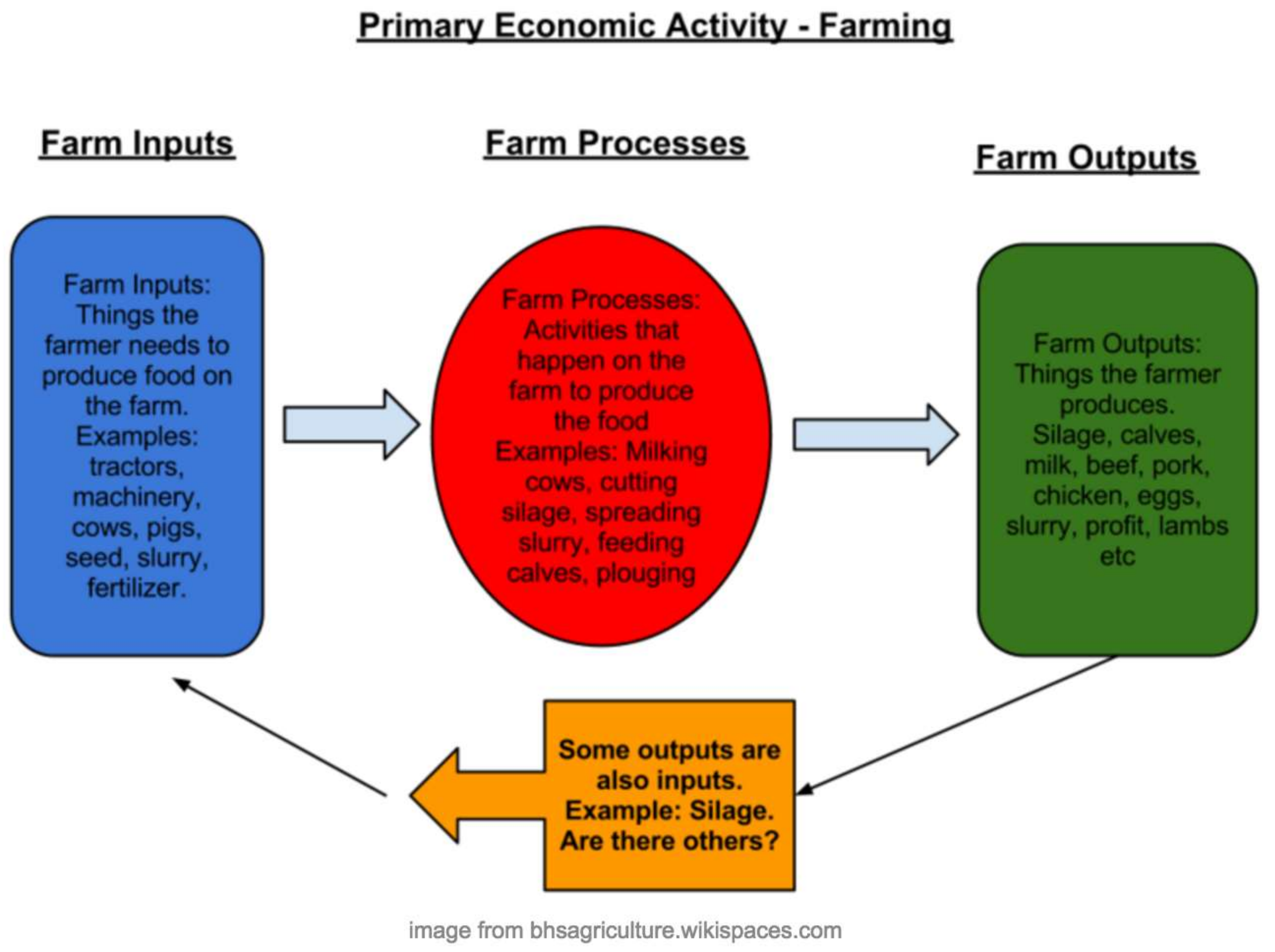
Analyse tables and graphs that illustrate the differences in inputs and outputs associated with food production systems



Term		Definition
Subsistence farming		Form of farming in which nearly all the crops or livestock raised are used to maintain the farmer and his family, leaving little surplus for sale or trade
Cash cropping		A crop grown for the purpose of selling it, rather than using or consuming it personally.
Extensive farming		Uses a lot of land and with a lower density of stocking or planting and lower inputs and corresponding outputs
Intensive farming		Uses land and to sustain a high density of stocking or planting with high levels of inputs and output per area
Pastoral farming		Raising animals, usually on grass or land not suitable for crops
Arable farming		Sowing crops on good soils to eat directly or feed to animals
Mixed farming		Uses both crops and animals and is a system in itself where animal waste is used to fertilize the crops and improve soil structure. Some of the crops are fed to the animals.
Shifting cultivation		A form of agriculture, used especially in tropical Africa, in which an area of ground is cleared of vegetation and cultivated for a few years and then abandoned for a new area until its fertility has been naturally restored.
Slash and burn		A method of agriculture in which existing vegetation is cut down and burned off before new seeds are sown, typically used as a method for clearing forest land for farming.

Farming system flowchart

INPUTS ***What goes in to make it?***
Physical
Rainfall
Length of growing season
Temperature
Relief
Soils and drainage
Human
Labour
Rent
Transport cost
Machinery
Fertilisers/pesticides
Government control
Seeds/livestock
Farm buildings
Energy
Market demand

→

PROCESSES ***Activities carried out to transform inputs to outputs***
Ploughing
Weeding
Watering
Harvesting
Milking
Fertilizing
Pest control
Grazing

↑

POSSIBLE CHANGES TO THE SYSTEM
Physical Food, disease **Human** Change in demand, market price, Government policy

→

LEDC – output usually consumed by family *Subsistence farming*

↑

OUTPUTS ***Products from the farm***
Crops
Animal products

↓

MEDC – output profit will be reinvested into farm *Commercial farming*

Terrestrial farming systems are divided into two types:

- Commercial farming: for profit, often monoculture
- Subsistence farmer: produces only enough to feed their family with no sell for profit

Both commercial and subsistence can be intensive or extensive farms

- Intensive farms: take a small area of land for a high input
- Extensive farms: large in comparison to the money and labour put into it

Subsistence Farming	Commercial Framing
This type of farming is practiced to meet the needs of the farmer's family.	In commercial farming crops are grown and animals are reared for sale in market.
Traditionally, low levels of technology and household labour were used to produce on small output.	The area cultivated and the amount of capital used is large. Most of the work is done by machines. Chemical fertilizers, pesticides, insecticides and high yielding variety of seeds are used in order to get maximum output.
Subsistence farming can be further classified as intensive subsistence and primitive subsistence farming.	Commercial farming includes commercial grain farming, mixed farming and plantation agriculture.

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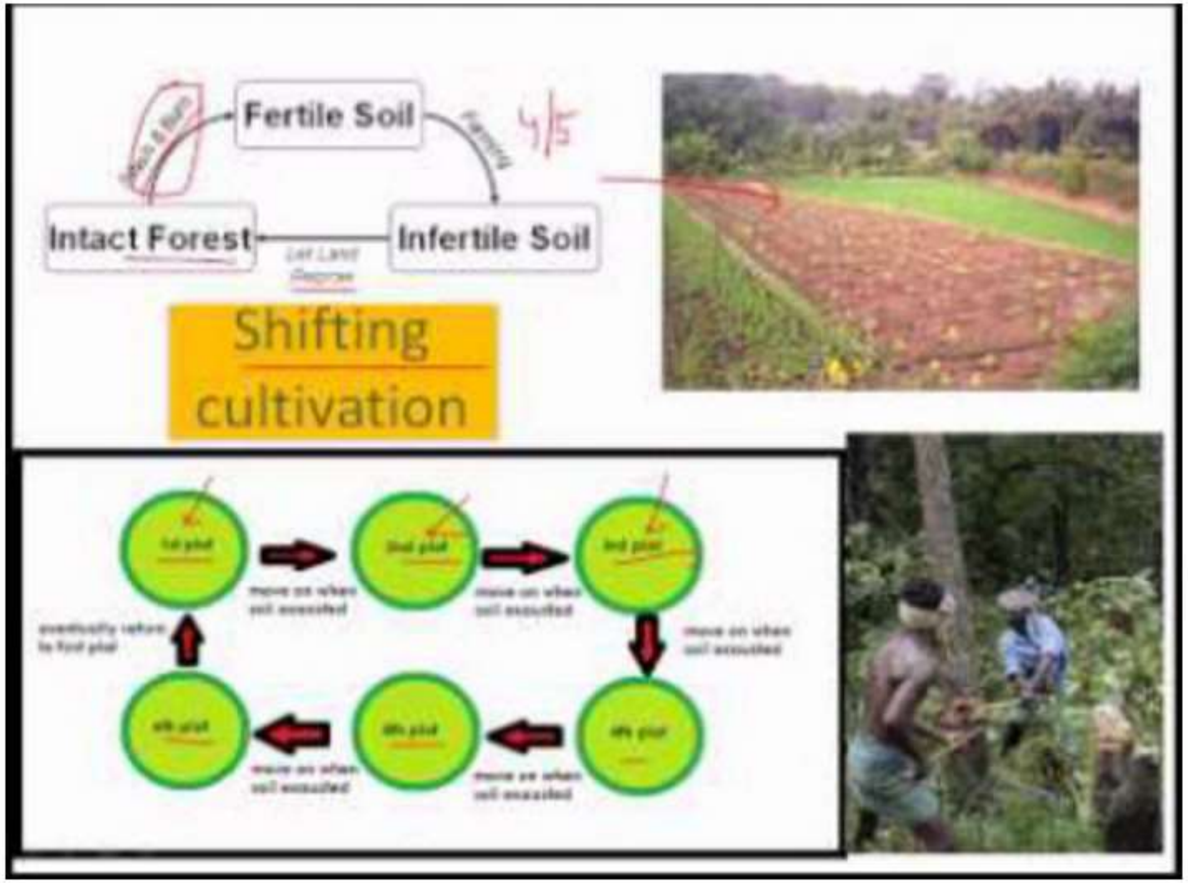
Practice	Purpose	Labor force	Machinery	Farm size	Off farm contact
Subsistence agriculture LDCs	Personal consumption	On average 55% of workforce engaged in farming	Human and animal powered tools	Very small	Occasional surplus sold
Commercial agriculture MDCs	Grow crops and raise animals primarily for sale off the farm for profit	On average 5% of workforce engaged in farming	Mechanized farm machines, computer technology and science	Large [US average in 2008 = 418 acres]	*agribusiness* – farms one part of a large food production industry including food processing, packaging, sorting, distributing, and retailing

DIFFERENCES BETWEEN SUBSISTENCE & COMMERCIAL FARMERS

	TRADITIONAL/SUBSISTENCE	MODERN/COMMERCIAL
Proportion of output sold off the farm	Low	High
Destination of foods	Local direct consumption & some processed locally	High proportion processed & to food manufacturers
Origin of inputs		
i. Power	Draught animals	Petroleum, electricity
ii. Plant nutrients	Legumes, ash, bones, manure	Chemical fertilisers
iii. Pest control	Crop rotations, intercropping	Insecticides, fungicides, break crops
		Herbicides
i. Weed control	Rotations, hoeing, use of plough	
	Hoe, plough, sickle, scythe	Machinery, often self-propelled
i. Implements & tools	From own harvest	combine harvesters
ii. Seed		Purchased from seed merchants
		Purchased from compound feed mixers
	Grass & fodder crops grown on	
i. Livestock feeds	farm/common land	

Discuss the links that exist between sociocultural systems and food production systems.



This could be illustrated through the use of examples, such as: the way in which the low population densities and belief systems of shifting cultivators links with the ecosystem of “slash and burn” agriculture; the relationship between high population densities, culture, soil fertility and the wetrice ecosystem of South-East Asia; the link between the political economy of modern urban society, corporate capitalism and agro-ecosystems.

There are many factors that come into consideration as to the method and level of sustainability of food production methods. Population density/size, culture, soil fertility, and method of agriculture are some of these factors.

Shifting cultivation is an agricultural system in which plots of land are cultivated temporarily, then abandoned and allowed to revert to their natural vegetation while the cultivator moves on to another plot. The period of cultivation is usually terminated when the soil shows signs of exhaustion or, more commonly, when the field is overrun by weeds. The length of time that a field is cultivated is usually shorter than the period over which the land is allowed to regenerate by lying fallow.

Of these cultivators, many use a practice of slash-and-burn as one element of their farming cycle. Others employ land clearing without any burning, and some cultivators are purely migratory and do not use any cyclical method on a given plot. Sometimes no slashing at all is needed where regrowth is purely of grasses, an outcome not uncommon when soils are near exhaustion and need to lie fallow.

One land-clearing system of shifting agriculture is the slash-and-burn method, which leaves only stumps and large trees in the field after the standing vegetation has been cut down and burned, its ashes enriching the soil. Cultivation of the earth after clearing is usually accomplished by hoe or digging stick and not by plough.

Shifting Cultivation	Extensive Subsistence Farming	Agribusiness
• Slash and burn and its widely used by those who can't afford other methods of land clearance. • Fertilizers in the soil will last for a while and people are forces to move after it has be depleted. • Low population allows it and affected by cultural beliefs e.g. choice of site for land clearance.	• High demand for food due to high population which in turn allow for high labor inputs and it requires low technology • High rainfall and warm temperatures support it • Intensive subsistence farming	• After WWII concern of self-sufficiency raise and smaller farms were combined to create large areas of the same crops • Intensive farming to produce food for commercial use. • Maximum productivity and profit to compete in a global market • High impacts on the environment

Compare and contrast the inputs, outputs and system characteristics for two given food production systems.

The systems selected should be both terrestrial or both aquatic. In addition, the inputs and outputs of the two systems should differ qualitatively and quantitatively (not all systems will be different in all aspects).

The pair of examples could be North American cereal farming and subsistence farming in some parts of South-East Asia, intensive beef production in the developed world and the Maasai tribal use of livestock, or commercial salmon farming in Norway/Scotland and rice-fish farming in Thailand. Other local or global examples are equally valid.

Factors to be considered should include:

- inputs, such as fertilizers (artificial or organic); water (irrigation or rainfall); pest control (pesticides or natural predators); labour (mechanized and fossil-fuel dependent or physical labour); seed (genetically modified organisms—GMOs—or conventional); breeding stock (domestic or wild); livestock growth promoters (antibiotics or hormones vs organic or none)
- outputs - outputs, such as food quality, food quantity, pollutants (air, soil, water), consumer health, soil quality (erosion, degradation, fertility); common pollutants released from food production systems include fertilizers, pesticides, fungicides, antibiotics, hormones and gases from the use of fossil fuels; transportation, processing and packaging of food may also lead to further pollution from fossil fuels system characteristics—selective breeding, genetically engineered organisms, monoculture versus polyculture, sustainability,

- system characteristics - such as diversity (monoculture versus polyculture); sustainability; indigenous versus introduced crop speciessocio-cultural—the Maasai cattle equals wealth and quantity is more important than quality;
- environmental impact—pollution (air, soil, water); habitat loss; biodiversity loss; soil erosion or degradation; desertification; disease epidemics from high-density livestock farming
- socio-economic factors - arming for profit or subsistence, for export or local consumption, for quantity or quality; traditional or commercial farming.

STEPS TO A HEALTHY, ENDURING AGRICULTURE:	INDUSTRIAL AGRICULTURE	SUSTAINABLE AGRICULTURE
1 Create and conserve healthy soil	■ Soil quality declining– soil erosion a chronic problem, organic matter not replenished, microbial activity damaged by farm chemicals, soil compacted by farming practices ■ Conventional tillage, conservation tillage combined with heavy chemical use	■ Soil quality a central concern– soil protected from erosion by cover crops, residue, low-impact tillage, and conservation measures such as windbreaks; organic matter continually added, farming methods and smaller sized machinery keep soil loose and friable ■ Conservation tillage techniques combined with biofriendly management to cut use of chemicals
2 Conserve water and protect its quality	■ Water is mined from dropping aquifers, agricultural chemicals degrade water supplies and threaten aquatic life ■ Conservation structures and areas take a back seat to more production	■ Farming methods conserve water and soil moisture and protect surface and ground water from pollutants and sediment ■ Conservation is a top priority: terraces, buffer strips, riparian buffers and other conservation structures, practices, and areas incorporated into the farm
3 Manage organic wastes so they don't pollute	■ CAFOs concentrate large amounts of animal wastes in one place, overloading the ability of the area to utilize it and also increasing chances of spills and water pollution	■ Animal wastes provide nutrients for growing crops without polluting watersheds; smaller numbers of animals are raised on integrated farms where they are part of a diversified system

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Terrestrial Systems:

Intensive Charolais beef production in France:

In Western Europe the Charolais beef is one of the beef brands chosen. Through selective breeding and genetic engineering bloodlines that puts weight on exist but has a low fat cover. Charolais lives under controlled conditions, they are fed with high proteins and treated with antibiotics to make sure they are healthy. Lots of energy is used in transporting and processing the finished meat.

Cattle raised outdoors however grown on single monoculture (cultivation of a single crop on a farm or in a region or country) grass land in large fields with a high stock rate. To keep the productivity of these fields going, large amounts of fertilizer are used.

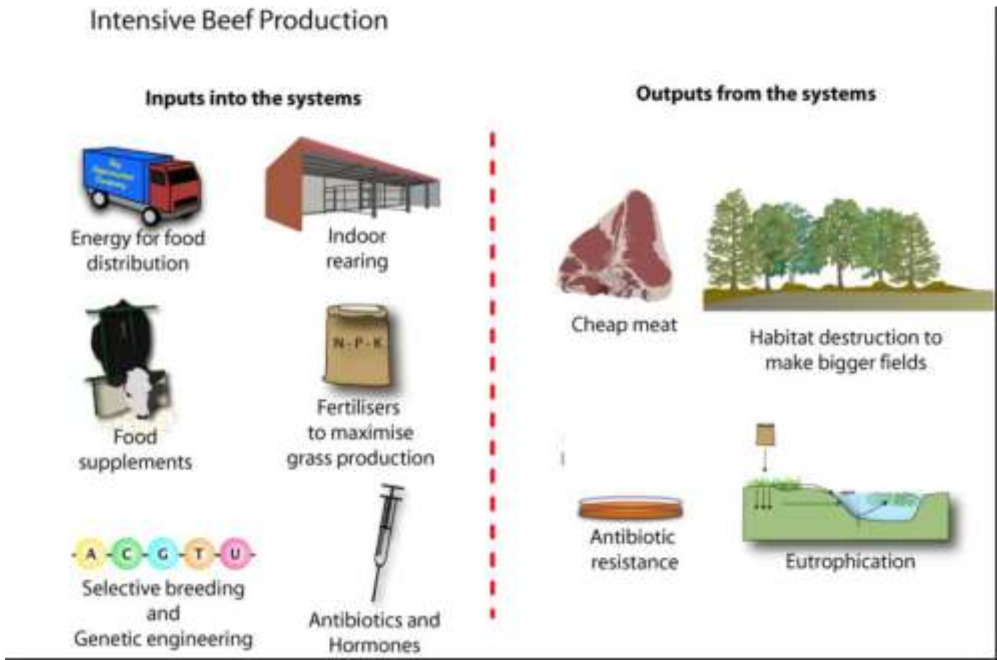
This intensified farming e the 1940's with the aim of producing cheaper meat has led to habitat loss as they have been removed to make bigger fields and cases of Eutrophication have increased as excess use of fertilizers and large amounts of slurry produced in the system enter water courses. Fear of causing antibiotic resistance in human bacteria through bioaccumulation.

Inputs:

- *energy for food distribution*
- *food supplements*
- *selective breeding and genetic engineering (system characteristics)*
- *indoor rearing*
- *fertilizers to maximize grass production*
- *antibiotics and hormones*

Outputs:

- *cheap meat (socio-cultural)*
- *habitat destruction to make bigger fields (environmental impact)*
- *antibiotic resistance*
- *Eutrophication*



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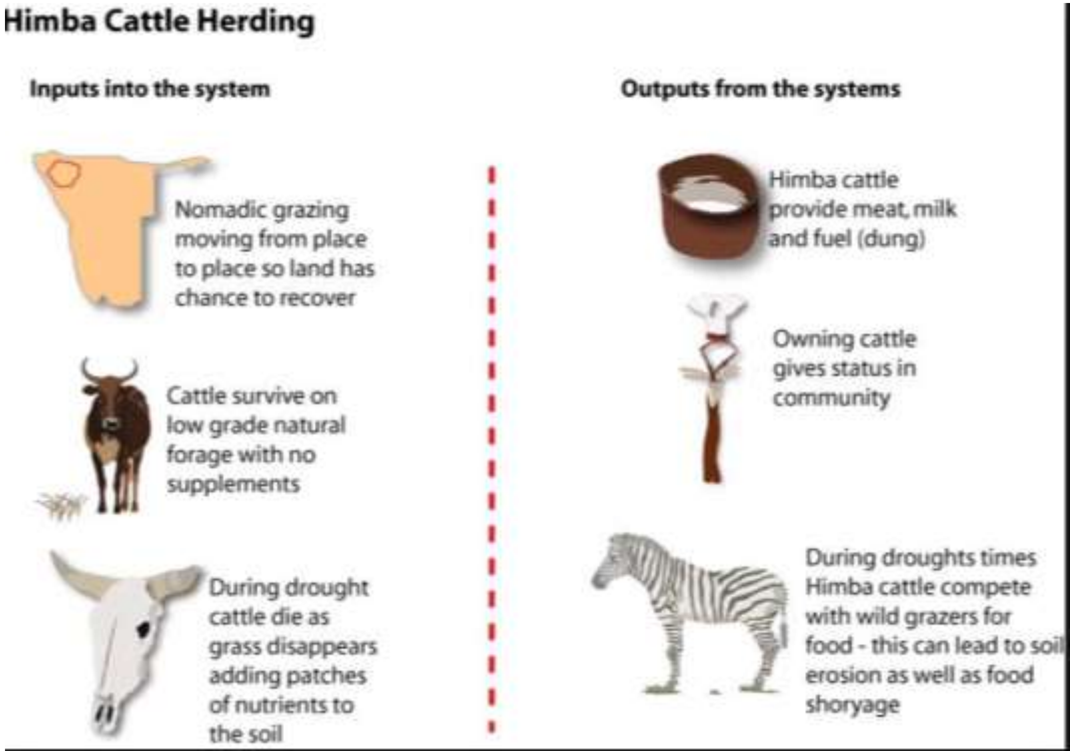
Nomadic cattle grazing of the Himba:

The Charolais beef production can be contrasted with the Nomadic cattle grazing of the Himba. The Himba people are from North West Namibia, they survive by being Nomadic hunters/grazers. They also have a tight bond with the cattle they graze. During the dry seasons the Himba move their cattle from area to area until the grass is used up until the raining season, they go to better pastures. Cattle to the Himba are very important as they provide; meat, milk, skins and even dung for fires. Prestige between the Himba is seen by how many cattle they have, not the size of the cattle. The cattle during the dry season may start competing with herbivores. This has increased especially with global warming drought periods. This can lead to soil erosion as extra grazing pressure removes the grasses that hold the top soil together.



Input:

- *nomadic grazing moving from place to place so land has a chance to recover*
- *cattle survive on low grade natural forage with no supplements*
- *during drought cattle die as grass disappears adding patches of nutrients to the soil (environmental impact)*

Outputs:

- *Himba cattle provide meat, milk and fuel (dung)*
- *owning cattle gives status in community (socio-cultural)*
- *during drought times Himba cattle compete with wild grazers for food this can lead to soil erosion as well as food shortage (environmental impact)"*

http://www.mrgscience.com/

Deserts and Desertification

Causes of Desertification

- **Overgrazing** –
  - too many animals grazing on the land
  - animals eat all the vegetation
  - vegetation fails to grow
  - soil is exposed to rain and wind
  - soil is washed or blown away.

Read about desertification in Namibia here http://allafrica.com/stories/201504160877.html

Evaluate the relative environmental impacts of two given food production systems.

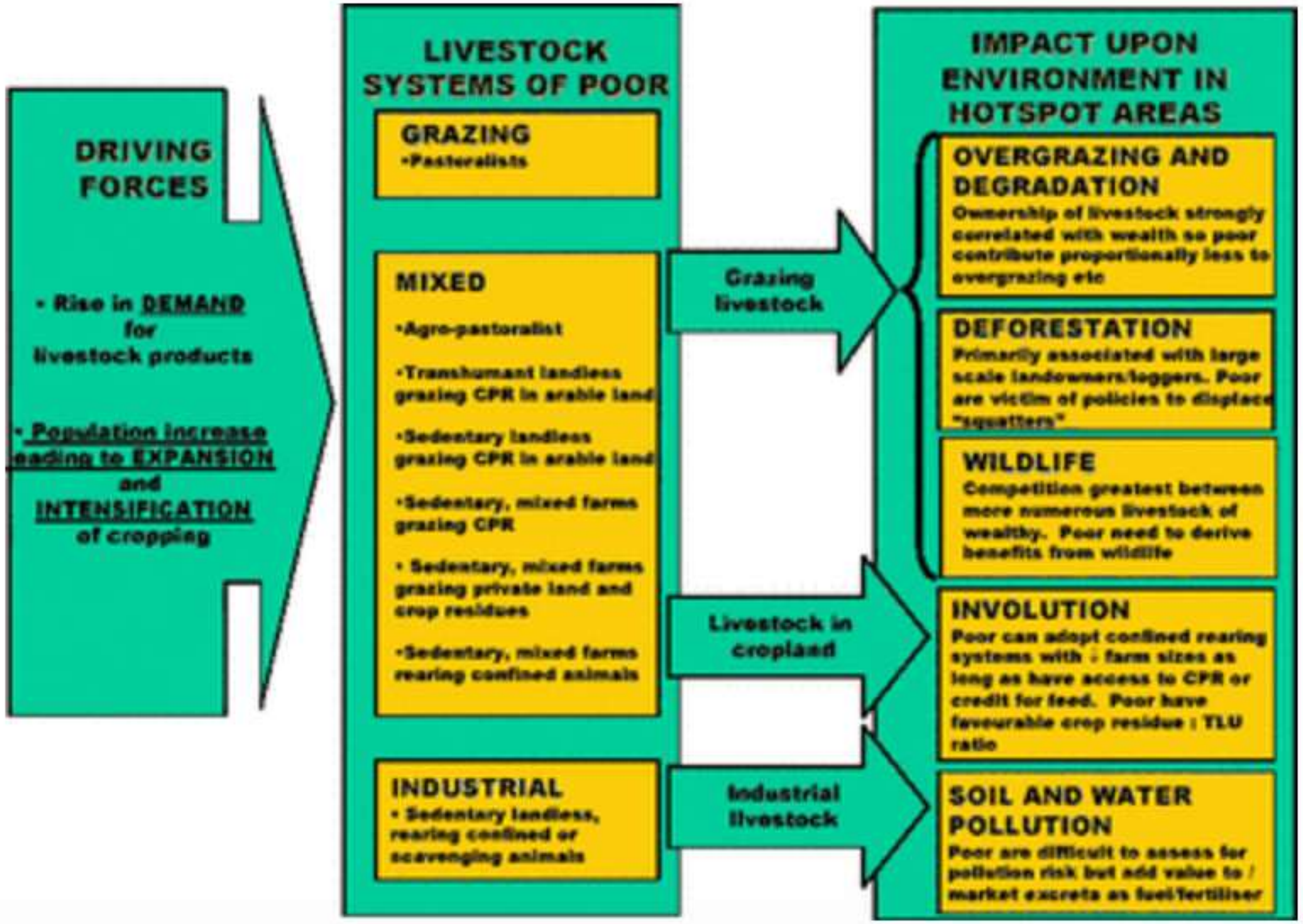
Food production and the supply chain can have wide-ranging positive and negative impacts on the environment. Negative impacts include escalating water and land use, soil erosion and degradation through loss of fertility or desertification, loss of biodiversity, and intensive use of energy (for production, notably for fertiliser manufacture, and for supply, especially in transport and refrigeration) with associated greenhouse gas emissions

Factory farming reduces the amount of land needed for meat production, however, these farms are a serious air and water pollutant. The waste of these animals ends up in the nature and poses a constant risk of drinking water contamination and seriously affects the air quality of the nearby areas. One solution for the problem with animal waste lays in its use for production of biofuel which can then be used for production of electricity but this practice is the exception rather than the rule.

Mass meat production has shown main contributors to carbon dioxide emissions which in turn are the main cause of the climate change. The meat industry is estimated to be responsible for about 9 percent of total carbon dioxide emissions which are a result of emissions of various gases from the farms as well as from the microbial activities after application of animal waste as fertilizers.

http://www.mrgscience.com/

Animal husbandry poses a serious threat to the local ecosystems and biodiversity due to the use of the land for grazing and animal feed production. As much as one quarter of the Earth's surface is used for grazing and about one third of arable land is used to produce animal feed. As a result, the wildlife species struggle with lack of habitat, while some are even threatened with extinction.



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Increased sustainability may be achieved through: altering human activity to reduce meat consumption and increase consumption of organically grown and locally produced terrestrial food products, improving the accuracy of food labels to assist consumers in making informed food choices, monitoring and control of the standards and practices of multinational and national food corporations by governmental and intergovernmental bodies, planting of buffer zones around land suitable for food production to absorb nutrient runoff.

Farming must feed more people more sustainably. Advances in agricultural science and technology have contributed to remarkable increases in food production since the mid-twentieth century. Global agriculture has grown 2.5–3 times over the last 50 years. This has let food production keep pace with human population growth so that, overall, there are enough calories produced per capita. However, progress toward reducing hunger is variable across the world

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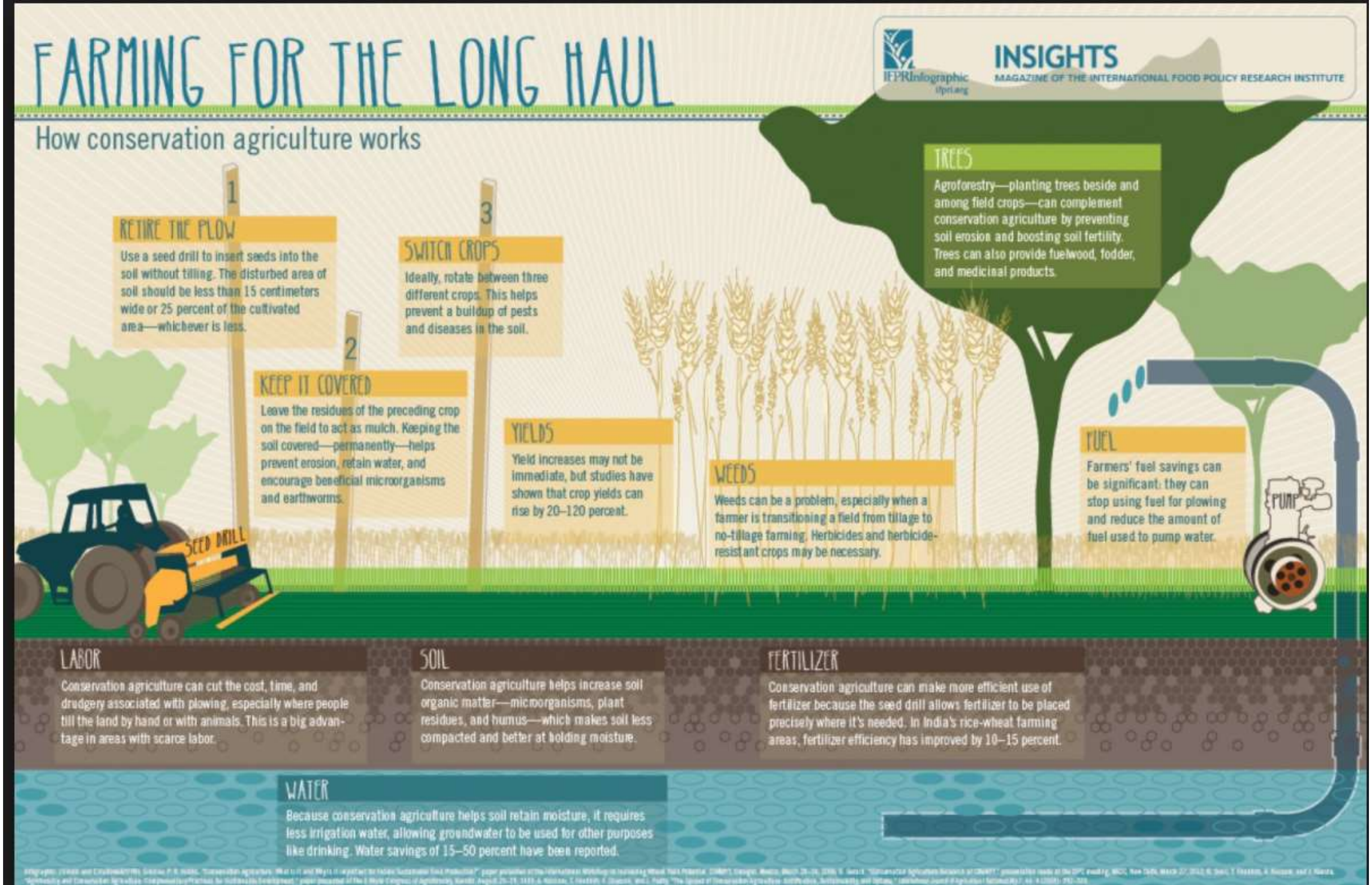

FARMING FOR THE LONG HAUL
INSIGHTS
MAGAZINE OF THE INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI infographic
ifpri.org
How conservation agriculture works
1
RETIRE THE PLOW
Use a seed drill to insert seeds into the soil without tilling. The disturbed area of soil should be less than 15 centimeters wide or 25 percent of the cultivated area—whichever is less.
2
KEEP IT COVERED
Leave the residues of the preceding crop on the field to act as mulch. Keeping the soil covered—permanently—helps prevent erosion, retain water, and encourage beneficial microorganisms and earthworms.
3
SWITCH CROPS
Ideally, rotate between three different crops. This helps prevent a buildup of pests and diseases in the soil.
YIELDS
Yield increases may not be immediate, but studies have shown that crop yields can rise by 20–120 percent.
WEEDS
Weeds can be a problem, especially when a farmer is transitioning a field from tillage to no-tillage farming. Herbicides and herbicide-resistant crops may be necessary.
TREES
Agroforestry—planting trees beside and among field crops—can complement conservation agriculture by preventing soil erosion and boosting soil fertility. Trees can also provide fuelwood, fodder, and medicinal products.
FUEL
Farmers' fuel savings can be significant: they can stop using fuel for plowing and reduce the amount of fuel used to pump water.
PUMP
SEED DRILL
LABOR
Conservation agriculture can cut the cost, time, and drudgery associated with plowing, especially where people till the land by hand or with animals. This is a big advantage in areas with scarce labor.
SOIL
Conservation agriculture helps increase soil organic matter—microorganisms, plant residues, and humus—which makes soil less compacted and better at holding moisture.
FERTILIZER
Conservation agriculture can make more efficient use of fertilizer because the seed drill allows fertilizer to be placed precisely where it's needed. In India's rice-wheat farming areas, fertilizer efficiency has improved by 10–15 percent.
WATER
Because conservation agriculture helps soil retain moisture, it requires less irrigation water, allowing groundwater to be used for other purposes like drinking. Water savings of 15–50 percent have been reported.

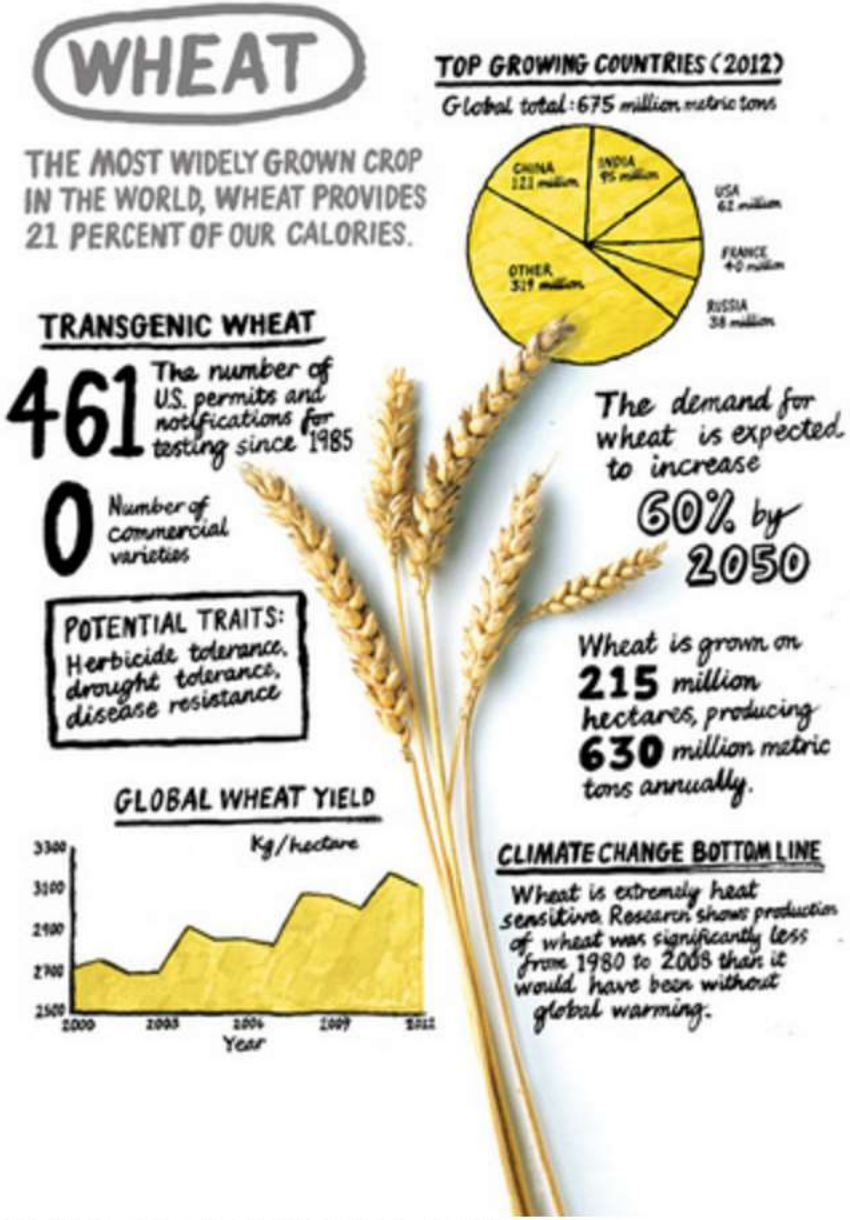
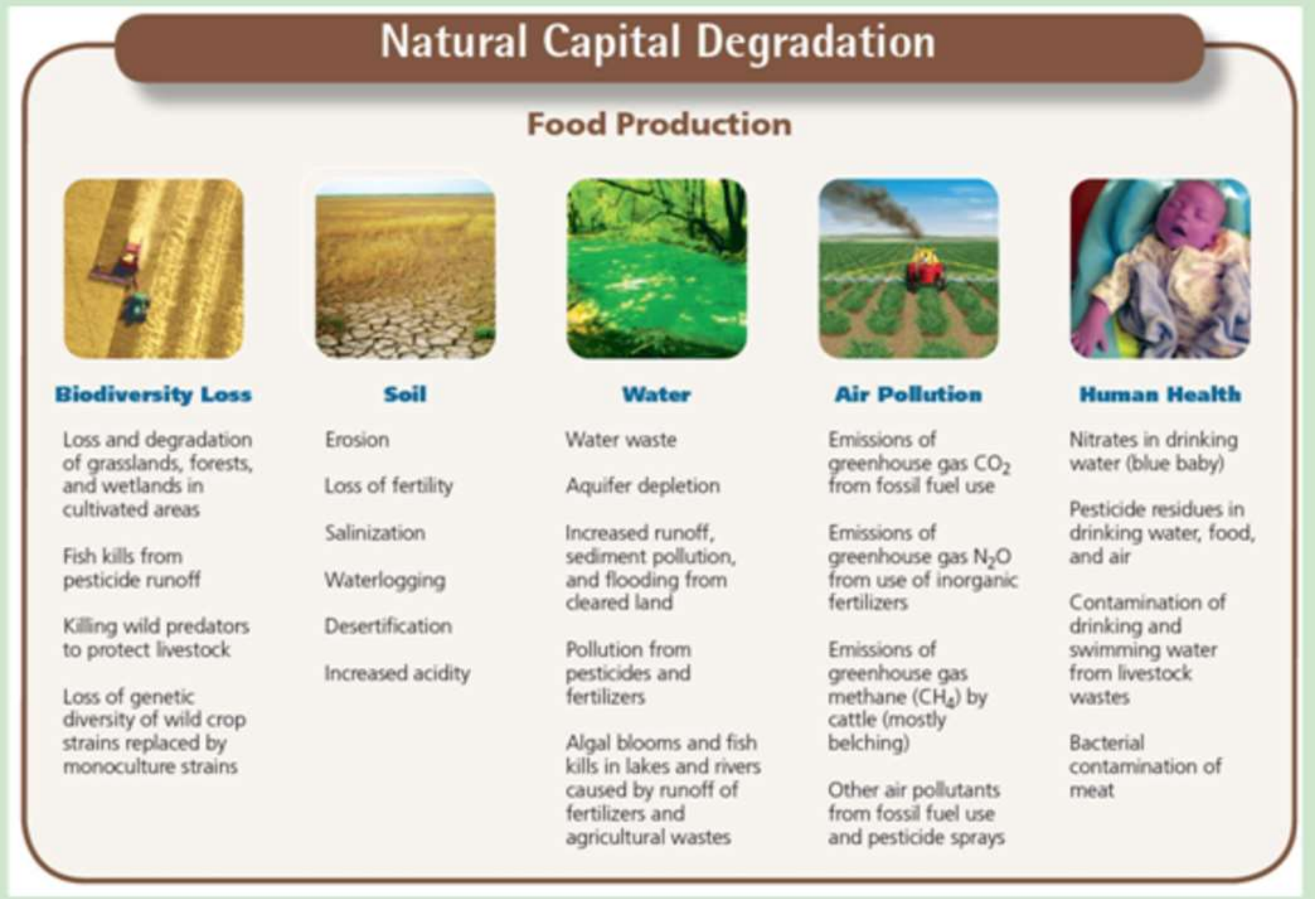


image from www.technologyreview.com

Evaluate strategies to increase sustainability in terrestrial food production systems.

Altering human activity
Local produce
Food Labels
Monitoring multi-nationals
Buffer zones (nutrient run-off)



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- Five major strategies to help farmers and consumers make the transition to more sustainable agriculture:
    1. Greatly increase research on more sustainable organic farming and perennial polyculture, and on improving human nutrition.
    2. Establish education and training programs in more sustainable agriculture for students, farmers, and government agricultural officials.
    3. Set up an international fund to give farmers in poor countries access to various types of more sustainable agriculture.

4. Replace government subsidies for environmentally harmful forms of industrialized agriculture with subsidies that encourage more sustainable agriculture.
5. Mount a massive program to educate consumers about the true environmental and health costs of the food they buy. This would help them understand why the current system is unsustainable, and it would help build political support for including the harmful costs of food production in the market prices of food.

Trade-Offs

Genetically Modified Crops and Foods

Advantages	Disadvantages
Need less fertilizer	Unpredictable genetic and ecological effects
Need less water	Harmful toxins and new allergens in food
More resistant to insects, disease, frost, and drought	No increase in yields
Grow faster	More pesticide-resistant insects and herbicide-resistant weeds
May need less pesticides or tolerate higher levels of herbicides	Could disrupt seed market
May reduce energy needs	Lower genetic diversity

Trade-Offs

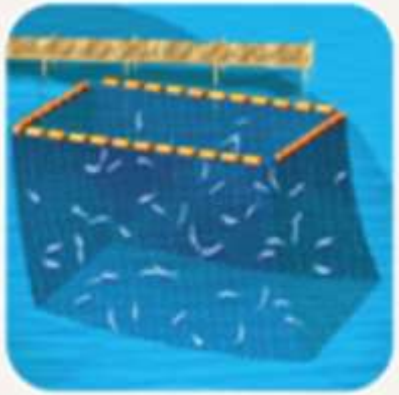
Animal Feedlots

Advantages	Disadvantages
Increased meat production	Large inputs of grain, fish meal, water, and fossil fuels
Higher profits	Greenhouse gas (CO_2 and CH_4) emissions
Less land use	Concentration of animal wastes that can pollute water
Reduced overgrazing	Use of antibiotics can increase genetic resistance to microbes in humans
Reduced soil erosion	
Protection of biodiversity	

Trade-Offs

Aquaculture

Advantages	Disadvantages
High efficiency	Large inputs of land, feed, and water
High yield	Large waste output
Reduced over-harvesting of fisheries	Loss of mangrove forests and estuaries
Low fuel use	Some species fed with grain, fish meal, or fish oil
High profits	Dense populations vulnerable to disease



Trade-Offs

Conventional Chemical Pesticides

Advantages	Disadvantages
Save lives	Promote genetic resistance
Increase food supplies	Kill natural pest enemies
Profitable	Pollute the environment
Work fast	Can harm wildlife and people
Safe if used properly	Are expensive for farmers

Solutions

Soil Salinization

Prevention	Cleanup
Reduce irrigation	Flush soil (expensive and wastes water)
Use more efficient irrigation methods	Stop growing crops for 2–5 years
Switch to salt-tolerant crops	Install underground drainage systems (expensive)

Solutions

More Sustainable Aquaculture

- Protect mangrove forests and estuaries
- Improve management of wastes
- Reduce escape of aquaculture species into the wild
- Raise some species in deeply submerged cages
- Set up self-sustaining aquaculture systems that combine aquatic plants, fish, and shellfish
- Certify and label sustainable forms of aquaculture

Solutions

More Sustainable Agriculture

More

- High-yield polyculture
- Organic fertilizers
- Biological pest control
- Integrated pest management
- Efficient irrigation
- Perennial crops
- Crop rotation
- Water-efficient crops
- Soil conservation
- Subsidies for sustainable farming

Less

- Soil erosion
- Soil salinization
- Water pollution
- Aquifer depletion
- Overgrazing
- Overfishing
- Loss of biodiversity and agrobiodiversity
- Fossil fuel use
- Greenhouse gas emissions
- Subsidies for unsustainable farming

Solutions

Organic Farming

- Improves soil fertility
- Reduces soil erosion
- Retains more water in soil during drought years
- Uses about 30% less energy per unit of yield
- Lowers CO_2 emissions
- Reduces water pollution by recycling livestock wastes
- Eliminates pollution from pesticides
- Increases biodiversity above and below ground
- Benefits wildlife such as birds and bats

Food system outcomes:

- Food and nutrition security for all
- Rural and urban livelihoods

SOURCES & CONTACT

This document highlights findings from the report on "Food Systems and Natural Resources" and should be read in conjunction with the full report.

▶ References to research on which this infographic is based are listed in the full report: UNEP (2016): Food Systems and Natural Resources.

The International Resource Panel was established in 2007 to provideindependent, scientific assessment on the sustainable use of natural resources and the impacts of resource use over the full life cycle.

www.unep.org/resourcepanel

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