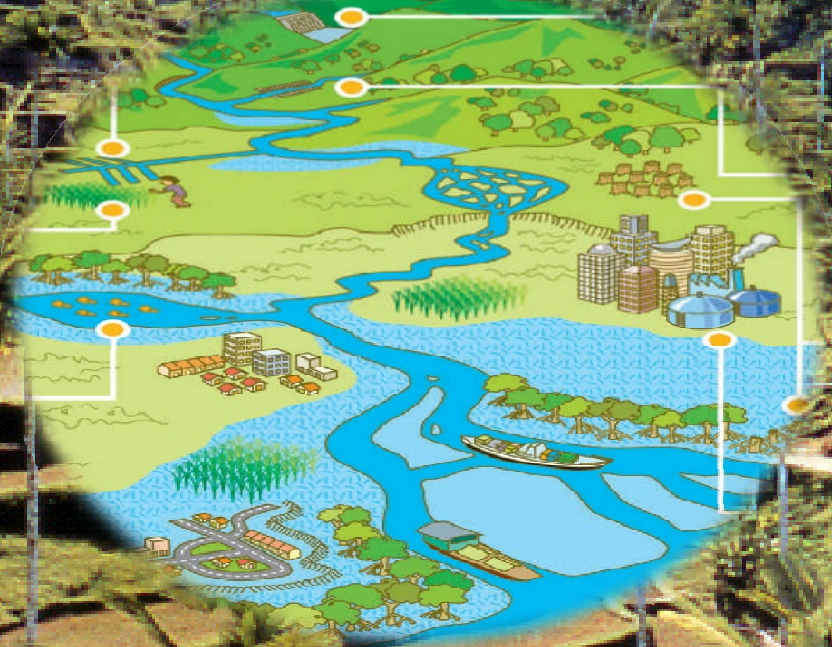
Impact of agricultural practices on ecosystem services



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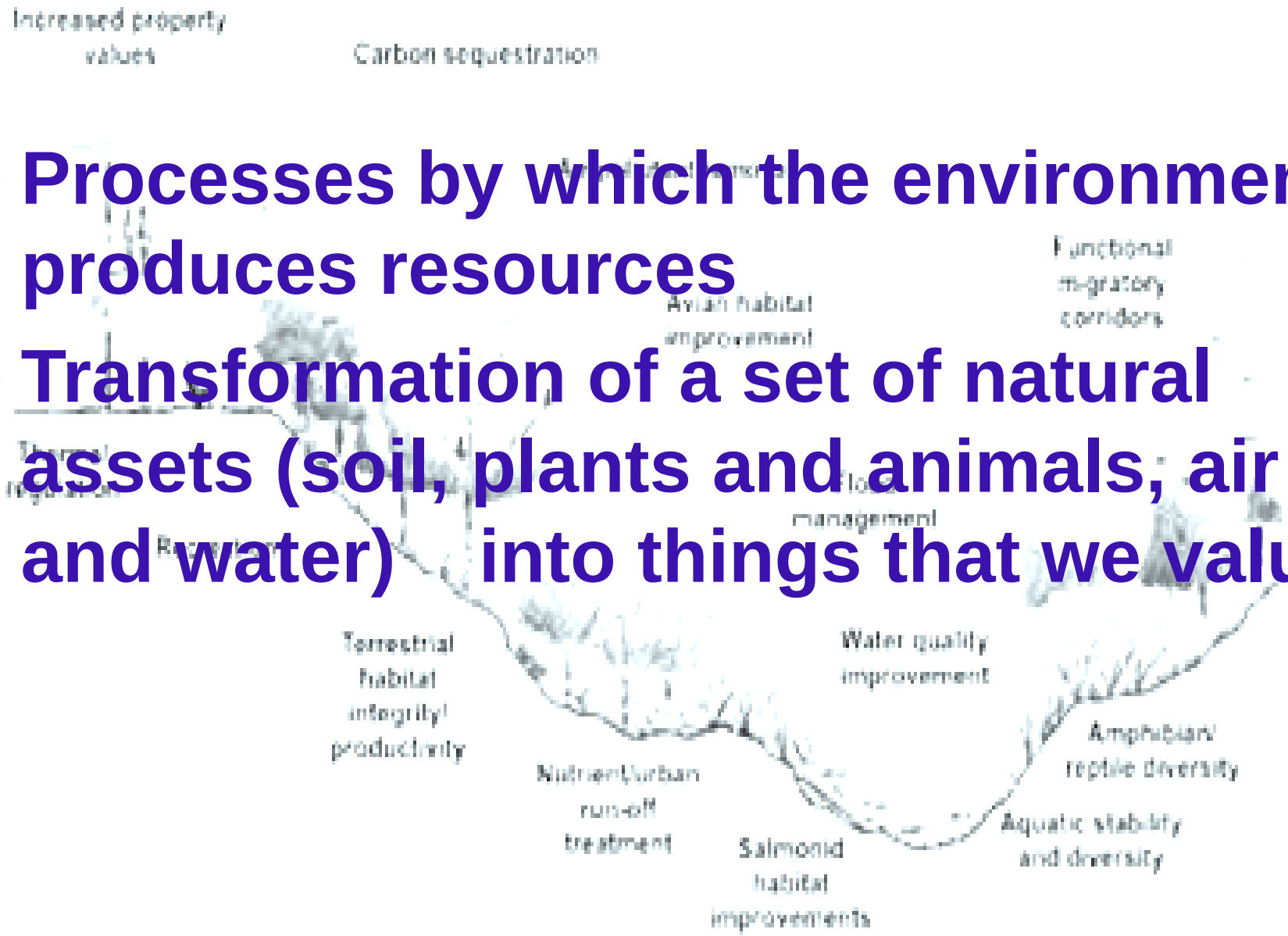
WHAT IS AN ECOSYSTEM?

- Community of living organisms
- Interaction
- Flow of energy
- Components –biotic and abiotic

What are ecosystem services?



- **Processes by which the environment produces resources**
- **Transformation of a set of natural assets (soil, plants and animals, air and water) into things that we value.**

To understand Ecosystem Services

Provisioning

Goods produced or provided by ecosystems

- food
- fresh water
- fuel wood
- fiber
- biochemicals
- genetic resources

Regulating

Benefits obtained from regulation of ecosystem processes

- climate regulation
- disease regulation
- flood regulation
- detoxification

Cultural

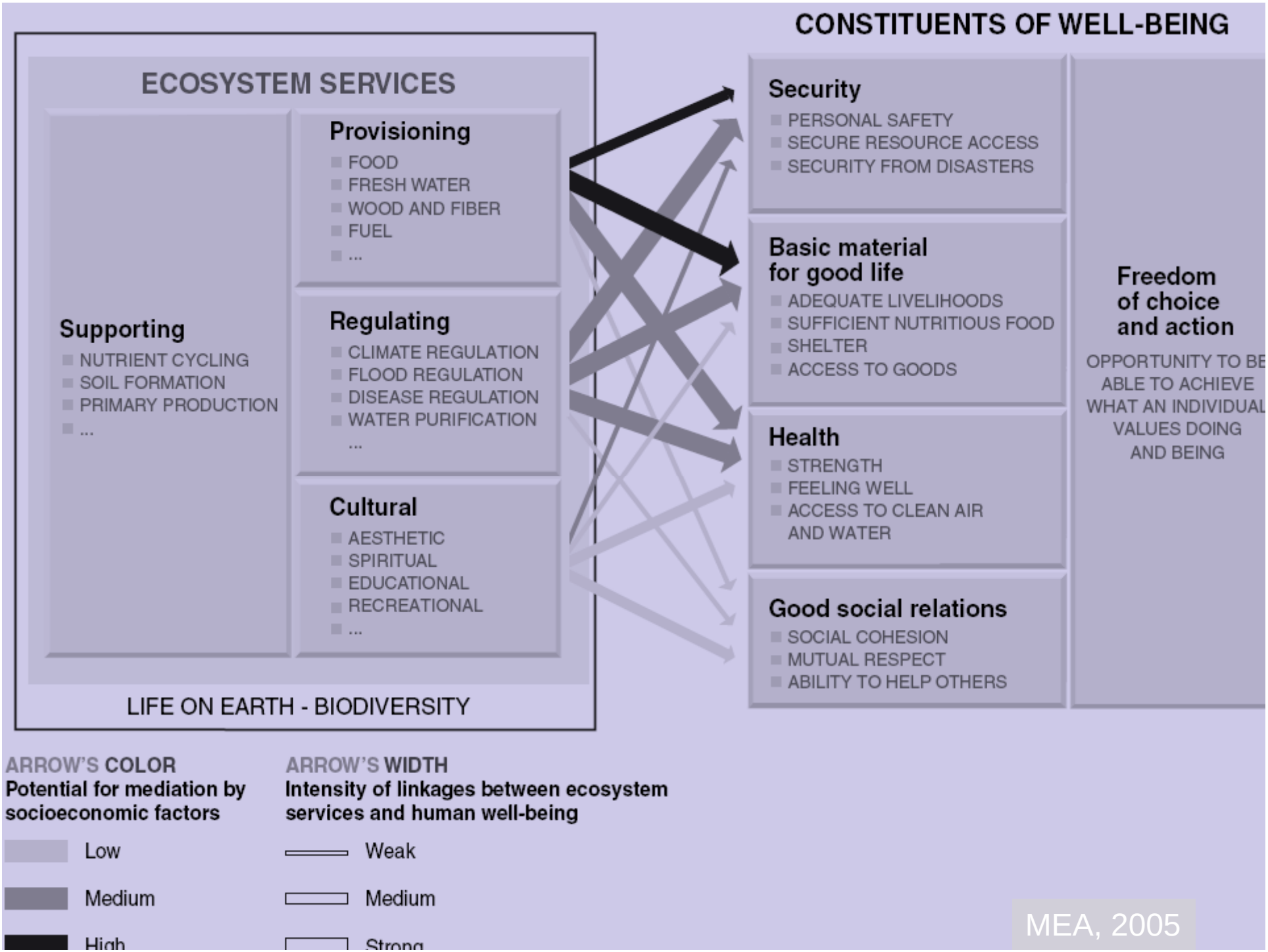
Non-material benefits obtained from ecosystems

- spiritual
- recreational
- aesthetic
- inspirational
- educational
- communal
- symbolic

Supporting

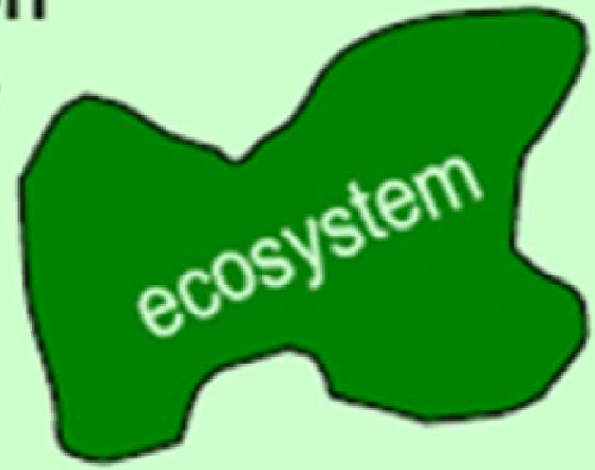
Services necessary for production of other ecosystem services

- Soil formation
- Nutrient cycling
- Primary production


CONSTITUENTS OF WELL-BEING
ECOSYSTEM SERVICES
Supporting
NUTRIENT CYCLING
SOIL FORMATION
PRIMARY PRODUCTION
...
Provisioning
FOOD
FRESH WATER
WOOD AND FIBER
FUEL
...
Regulating
CLIMATE REGULATION
FLOOD REGULATION
DISEASE REGULATION
WATER PURIFICATION
...
Cultural
AESTHETIC
SPIRITUAL
EDUCATIONAL
RECREATIONAL
...
LIFE ON EARTH - BIODIVERSITY
Security
PERSONAL SAFETY
SECURE RESOURCE ACCESS
SECURITY FROM DISASTERS
Basic material for good life
ADEQUATE LIVELIHOODS
SUFFICIENT NUTRITIOUS FOOD
SHELTER
ACCESS TO GOODS
Health
STRENGTH
FEELING WELL
ACCESS TO CLEAN AIR AND WATER
Good social relations
SOCIAL COHESION
MUTUAL RESPECT
ABILITY TO HELP OTHERS
Freedom of choice and action
OPPORTUNITY TO BE ABLE TO ACHIEVE WHAT AN INDIVIDUAL VALUES DOING AND BEING
ARROW'S COLOR
Potential for mediation by socioeconomic factors
Low
Medium
High
ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being
Weak
Medium
Strong

MEA, 2005

Ecosystem Services



Stabilisation of climate

Decomposition of wastes

Hydrological cycle

Water purification

Pollination

Nutrient cycling

Priority ecosystem services and agriculture

Freshwater. Agriculture highly depends upon this ecosystem service for watering crops—on rain-fed and irrigated farms—and for generating electricity to run some irrigation systems. At the same time, farmers can impact freshwater quantity (through irrigation) and quality (through fertilizer and agrochemical runoff).

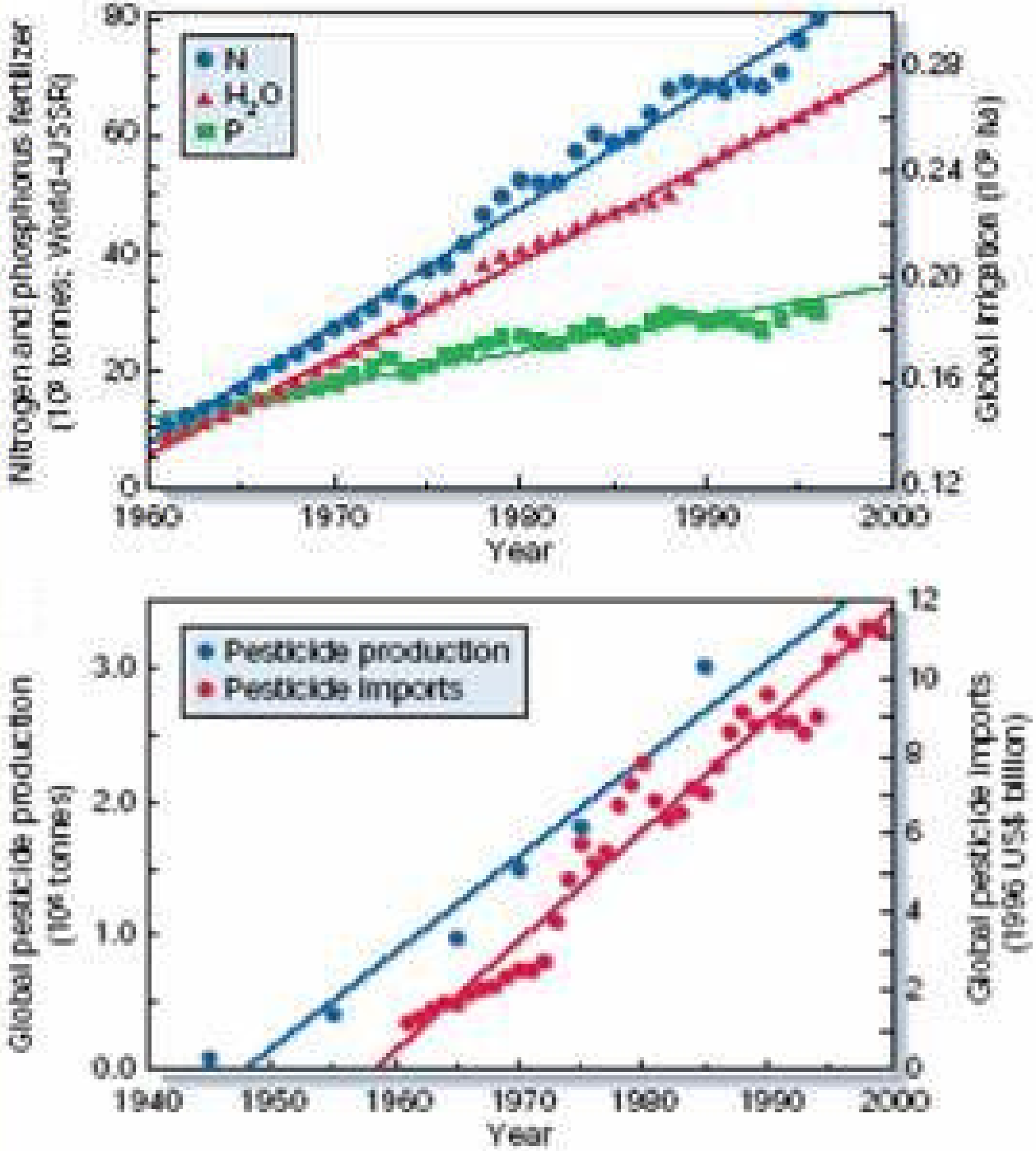
Water regulation. Farmers are dependent on the role that wetlands and other ecosystems play in managing the timing and magnitude of water runoff during the monsoon season and in recharging aquifers.

Erosion regulation. Farmers depend on vegetation to retain topsoil. Poor agricultural practices are having some localized negative effects, but other practices such as living fences and minimum tillage are improving erosion control.

Pest regulation. Farmers rely on some native organisms to help control crop pests in integrated crop management systems. But farming practices such as growing monocultures, fragmenting natural habitats, and inappropriately using agrochemicals are eroding nature's ability to manage pests.

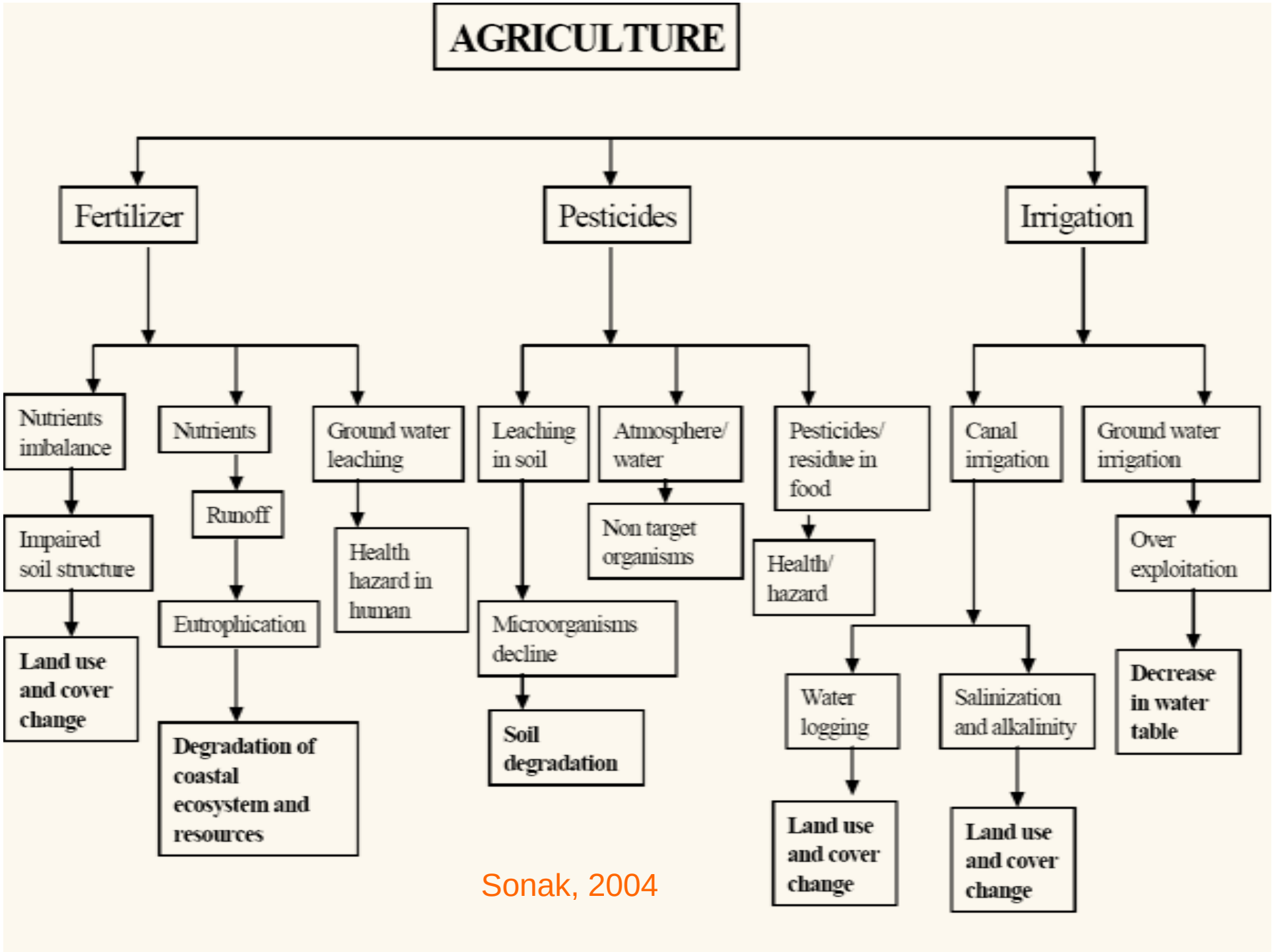
Pollination. Many crops benefit from pollination by bees and other animals, although a substitute practice—pollination by human hand—is used especially for plant breeding. Agriculture has a negative impact on natural pollination due to conversion of pollinator habitat.

Nutrient cycling. Crops depend on nature's processing of nutrients such as nitrogen and phosphorus, but synthetic substitutes exist. Poor farming practices sometimes inhibit this natural process, requiring more man-made inputs to replace lost nutrients.



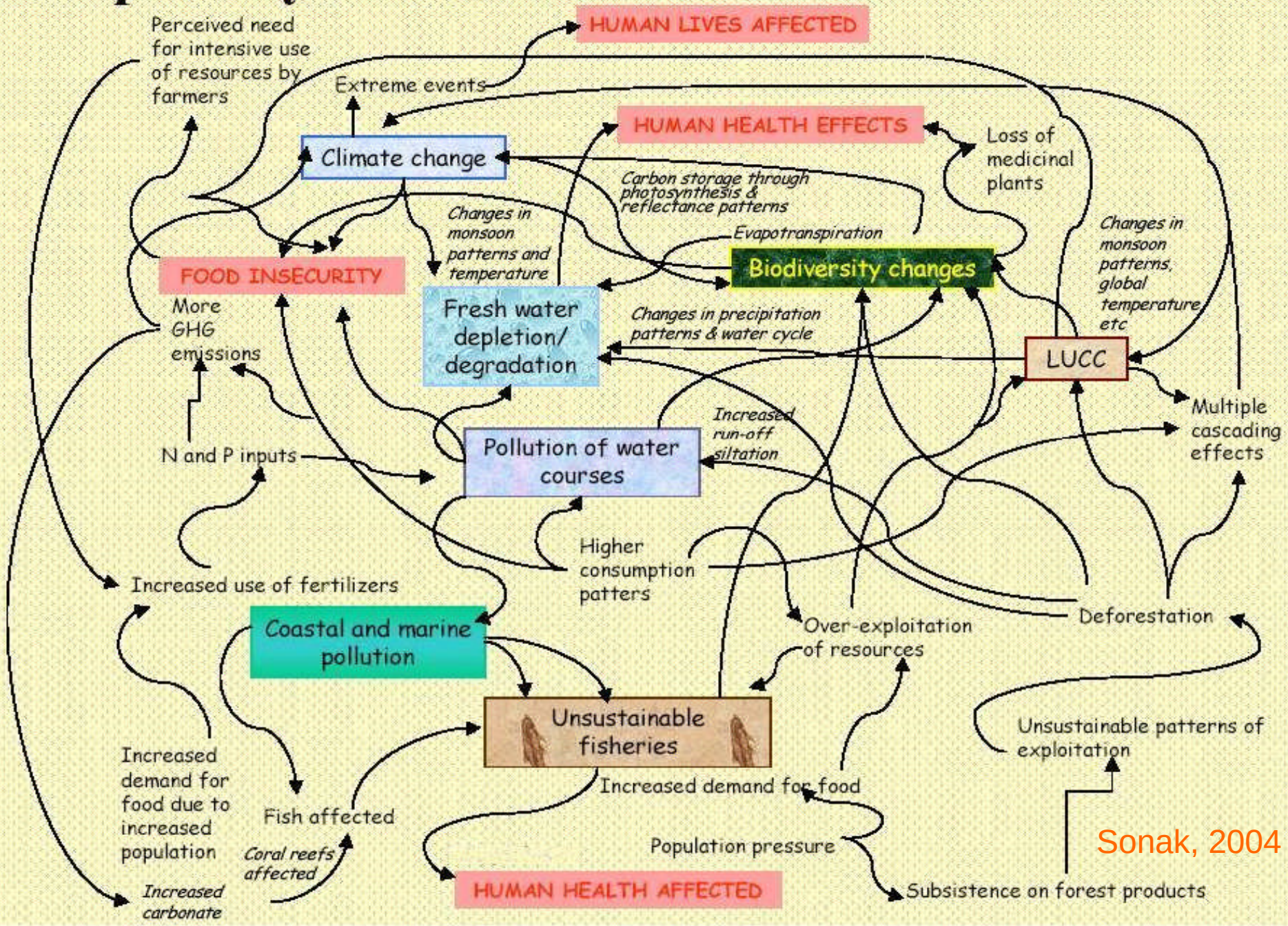
Agricultural trends over the past 40 years.

Tilman et al, 2002


AGRICULTURE
Fertilizer
Pesticides
Irrigation
Nutrients imbalance
Nutrients
Ground water leaching
Leaching in soil
Atmosphere/ water
Pesticides/ residue in food
Canal irrigation
Ground water irrigation
Impaired soil structure
Runoff
Health hazard in human
Non target organisms
Health/ hazard
Over exploitation
Land use and cover change
Eutrophication
Microorganisms decline
Water logging
Salinization and alkalinity
Decrease in water table
Degradation of coastal ecosystem and resources
Soil degradation
Land use and cover change
Land use and cover change

Sonak, 2004

Complex Dynamics of GEC



Sonak, 2004

Changes from agriculture that affect and are affected by several ecosystem services

Agent of change → **Ecological services**

Land cover

Erosion

Chemical use

<u>Production services</u>

-Food and materials for human consumption
- Energy

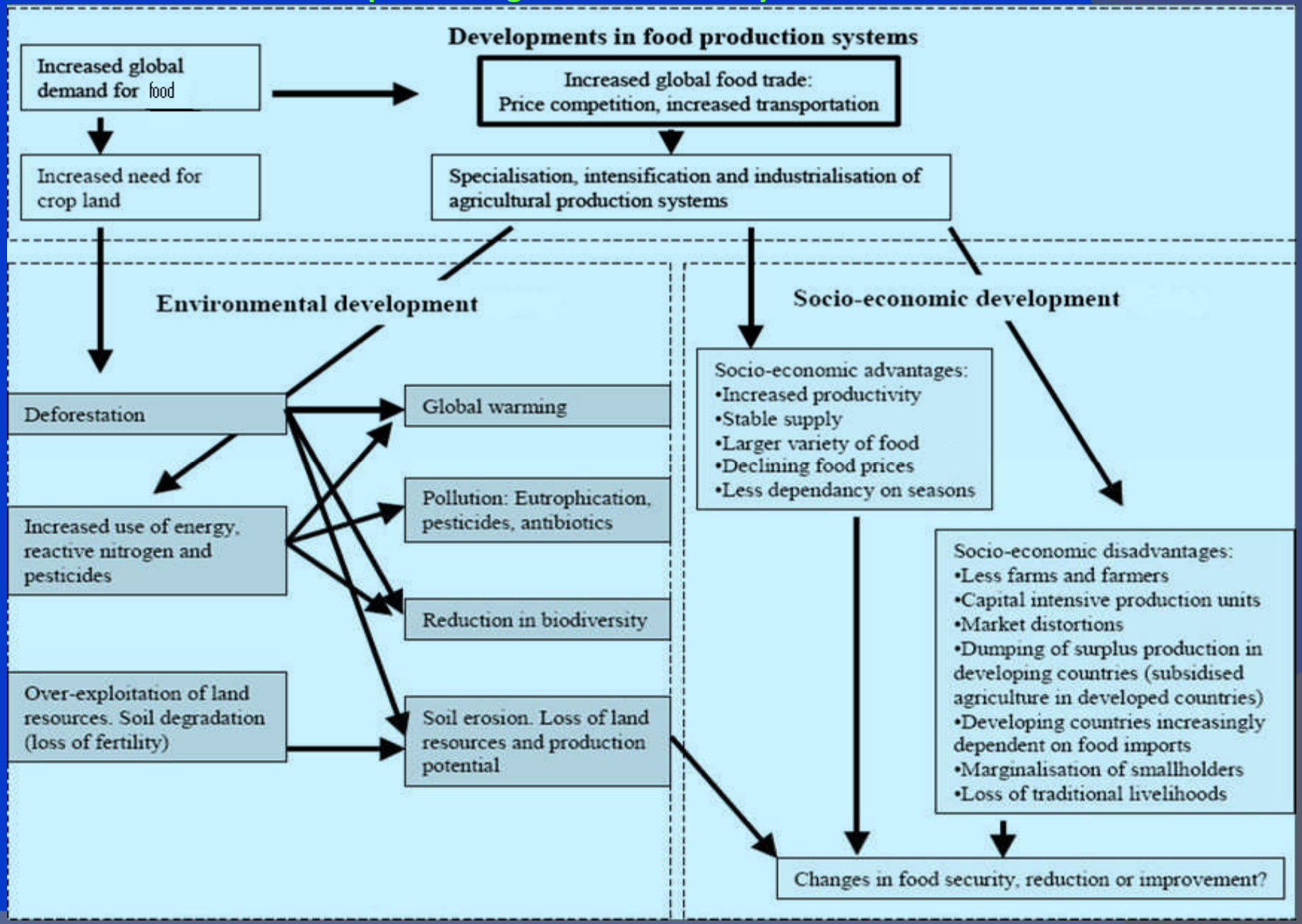
<u>Regulation services</u>

-Water quality and quantity
-Soil quality
-Air quality
-Pollination
-Seed dispersal
-Biodiversity
-Pest mitigation
-Protection from disturbances

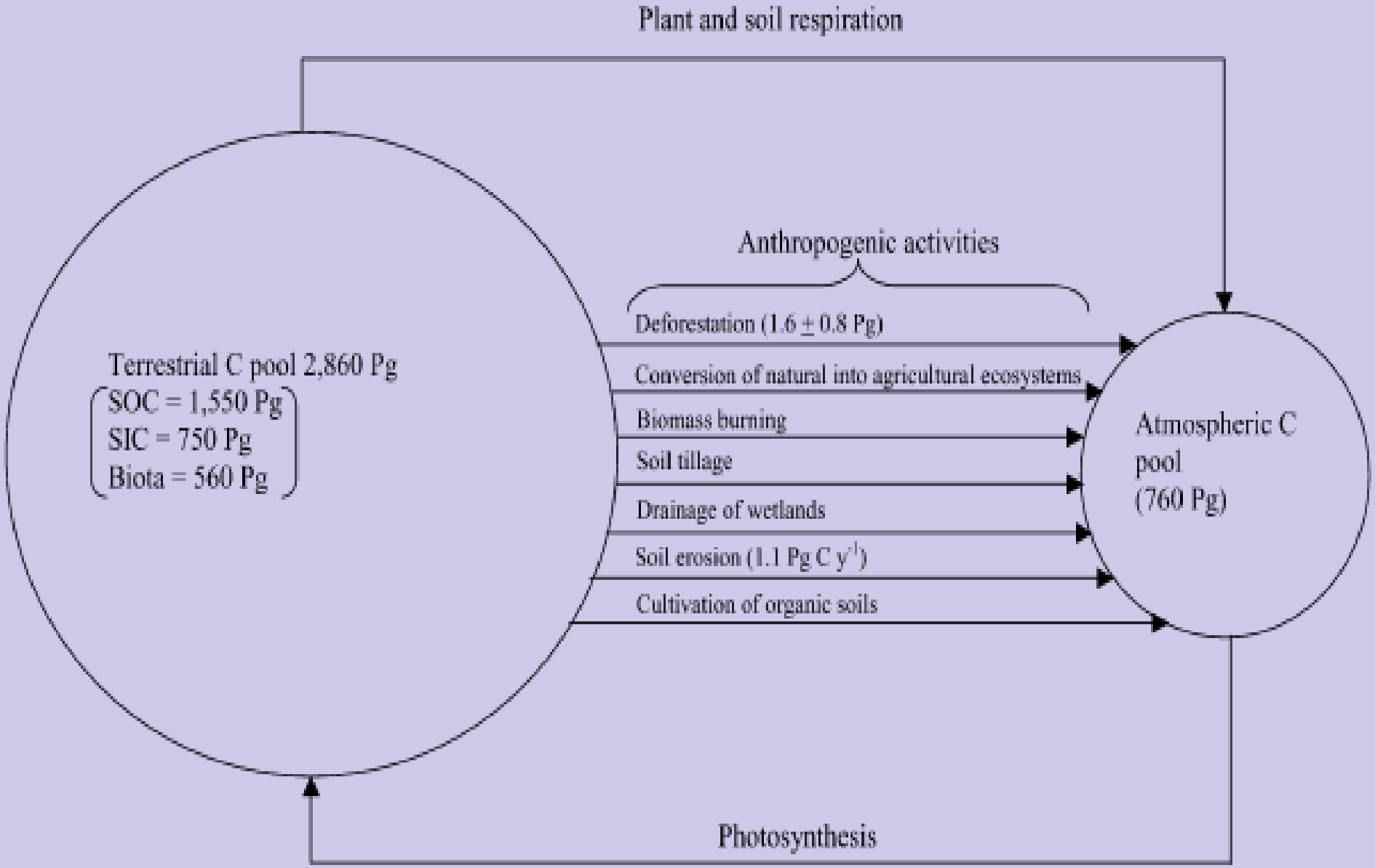
<u>Habitat services</u>
-habitat

Dale and Polasky, 2007

Impacts of Agriculture on ecosystem services

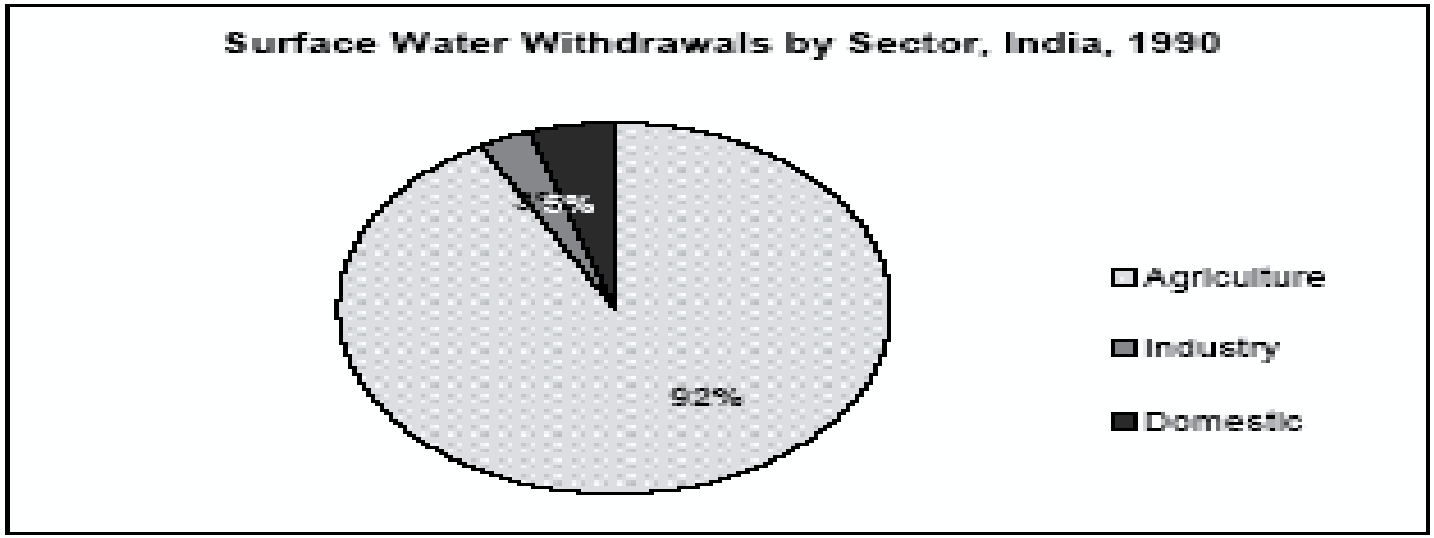


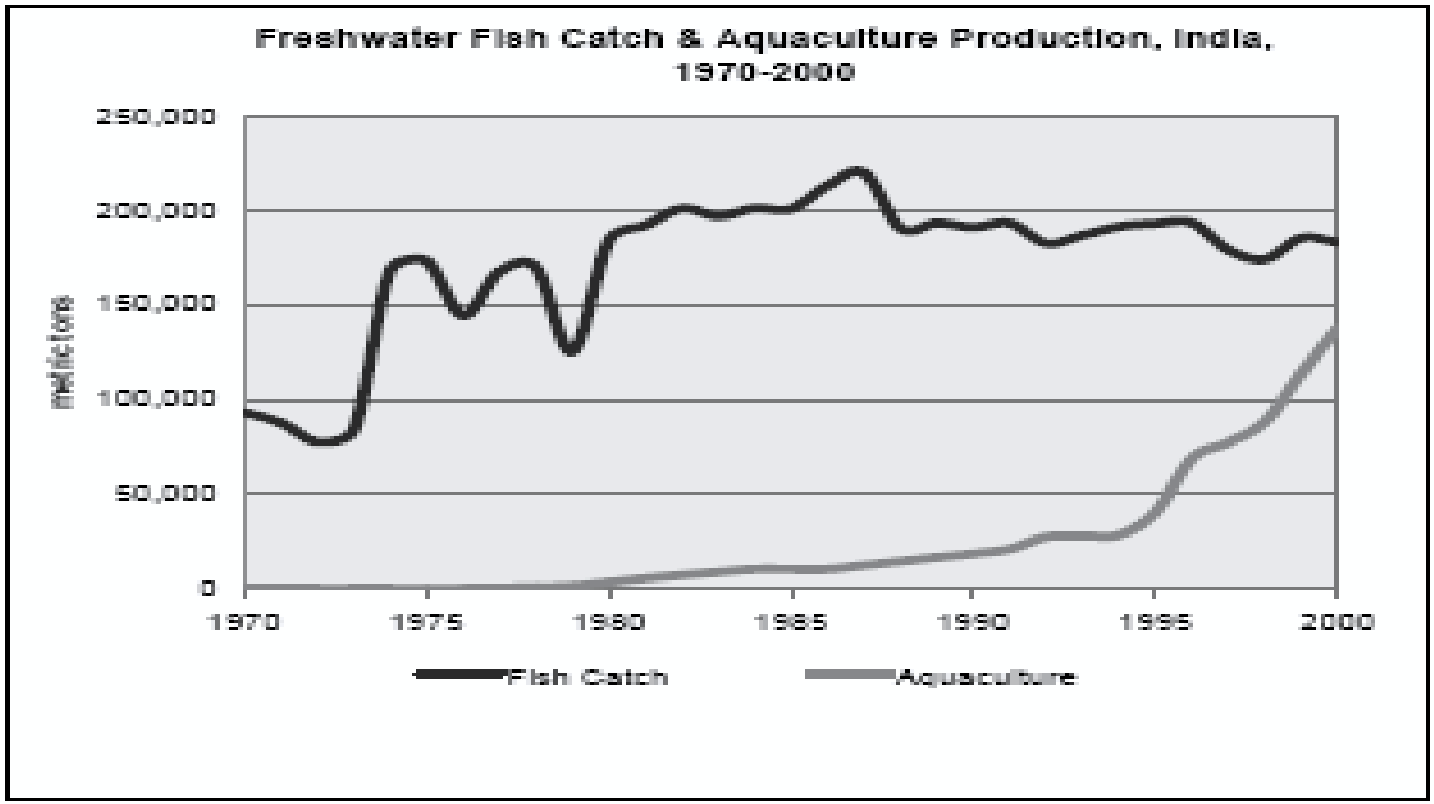
Knudsen et al, 2005



Anthropogenic activities affecting C emission from the terrestrial to the atmospheric pool.

Lal, 2004





at http://earthtrends.wri.org

Impact of Shifting cultivation on ecology

Clear forest vegetation (Dec-Jan)

↓

Burning of vegetation (Feb-March)

↓

Dibbling (April-May)

↓

Few years cultivation

↓

Shifting

↓

Returning back

- **Recovery of soil fertility and Nutrient conservation**
- **Barren hills**

Ranjan and Upadhyay, 1999

Loss in forest cover in north-eastern states (sq Km)

States	1993-95	1995-97
Arunachal Pradesh	169	75
Assam	224	257
Manipur	65	603
Meghalaya	218	75
Mizoram	792	292
Nagaland	58	573
Tripura	-	-
Total	1526	1875

- **2.7 million ha of land has already been affected**
- **Each year 0.45 ha of land fall under shifting cultivation in northeastern India**
- **Jhum cycle has been reduced from 20-30 years to 2-3 years**

Ranjan and Upadhyay, 1999

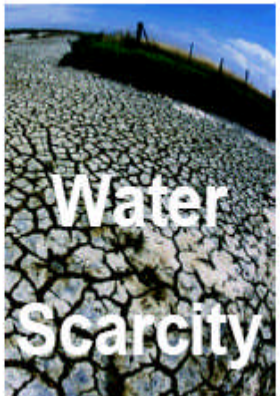
Impacts of intensive agricultural practices on ecosystem services

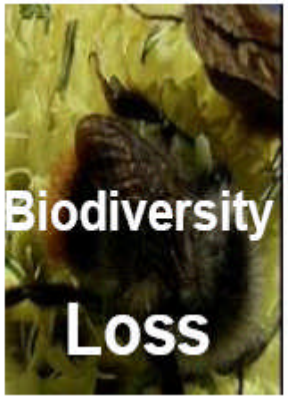
- 60% of geographical area faces soil degradation, water logging, salinity and alkalinity- threatens food security
- Water table decline in the range of 3-10 m
- The use of agro-chemicals in Haryana is the highest in India
- Fertilizer consumption increased from 3 to 30 kg/ha in the last 30 years.
- Rice-wheat CS (5.8 lakh ha)- ⇩N, P, Zn
- Residue burning-C emission

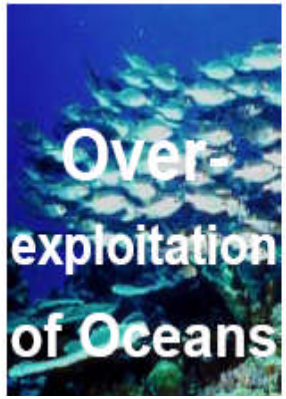
Singh, 2000

2005: Millennium Ecosystem Assessment

- Many of the world's ecosystems are in serious decline;
- Continuing supply of critical ecosystem services like water purification, pollination and climate regulation are in jeopardy;
- 6 interconnected trends affecting global ecosystems:





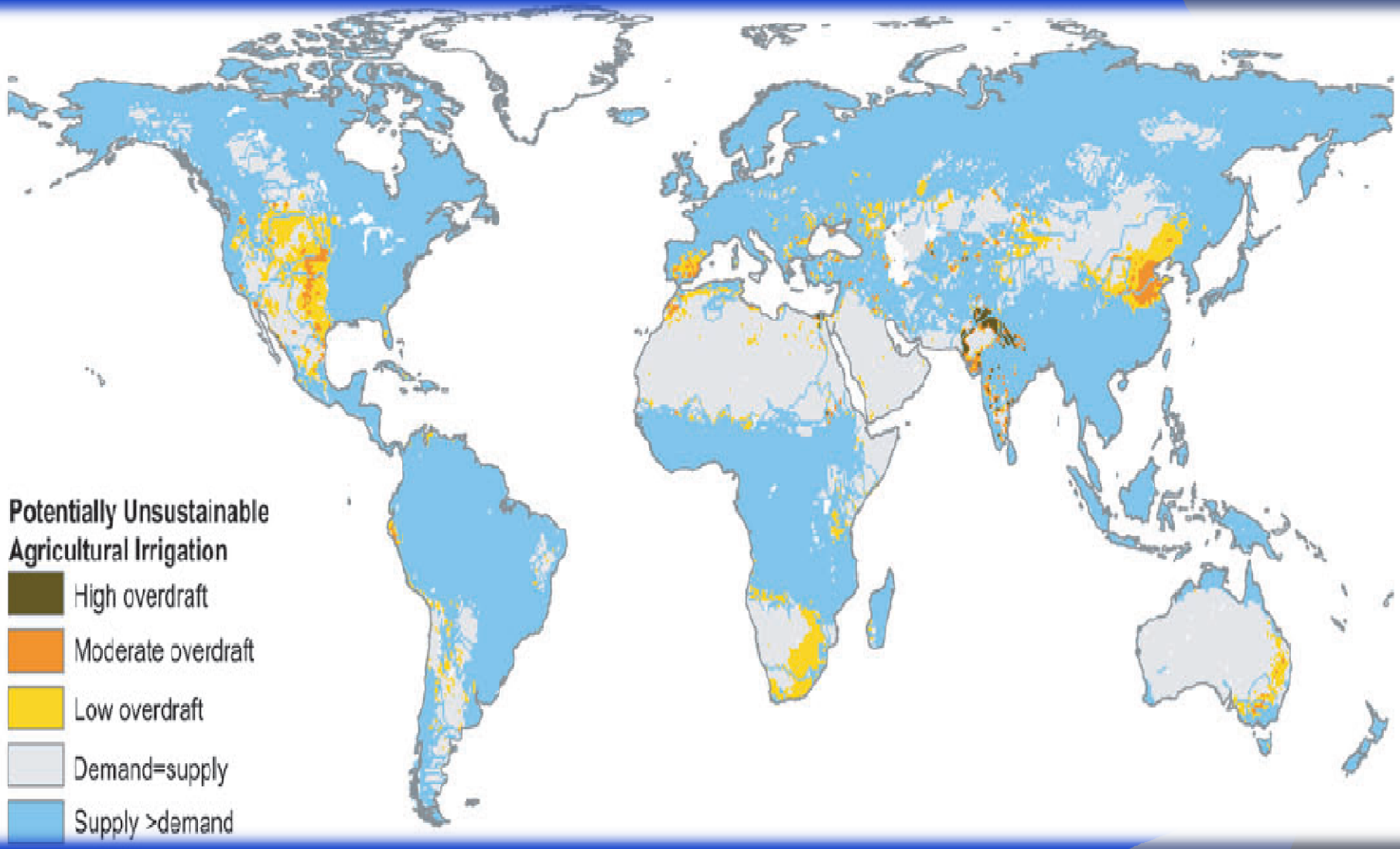


Water Scarcity – Challenges

Worldwide, some 1.7 million people die annually as a result of inadequate water, sanitation and hygiene.

- Half the urban populations in Africa, Asia, Latin America and the Caribbean suffer from diseases associated with inadequate water and sanitation;
- 5 – 20% of global freshwater use exceeds long-term sustainable supply;
- Most water is consumed by agriculture and industry, with agriculture accounting for more than 70% of total consumption
- Projections indicate that between 2000 and 2010, global water use will expand by 10%.

Contemporary Geography of Non-sustainable Withdrawals for Irrigation.



The following divisions are based on calculated consumptive use by crops : High overdraft: 1 km3/yr; Moderate: 0.1–1 km3/yr; Low: 0–0.1 km3/yr. The map indicates where there is insufficient fresh water to fully satisfy irrigated crop demands. The imbalance in long-term water budgets necessitates diversion of surface water or the tapping of groundwater resources. The areas shown with moderate to-high levels of non-sustainable use occur over each continent and are known to be areas of aquifer mining and/or major water transfer schemes. (MEA, 2005)

Climate Change – Challenges

Climate cycles are influenced by emitting **greenhouse gases** such as **carbon dioxide (CO_2)** – from land use changes, primarily deforestation; **methane (CH_4)** – from natural processes in wetlands and agriculture; and **nitrous oxide (N_2O)** – from farm systems, e.g. manure and fertilizer use.

- Over the next 50 years, **climate change** will affect ecosystems through: global mean surface temperature, changing productivity and growing zones of vegetation, causing sea level rise, expanding the prevalence of pests and diseases such as malaria, dengue fever and cholera, etc.

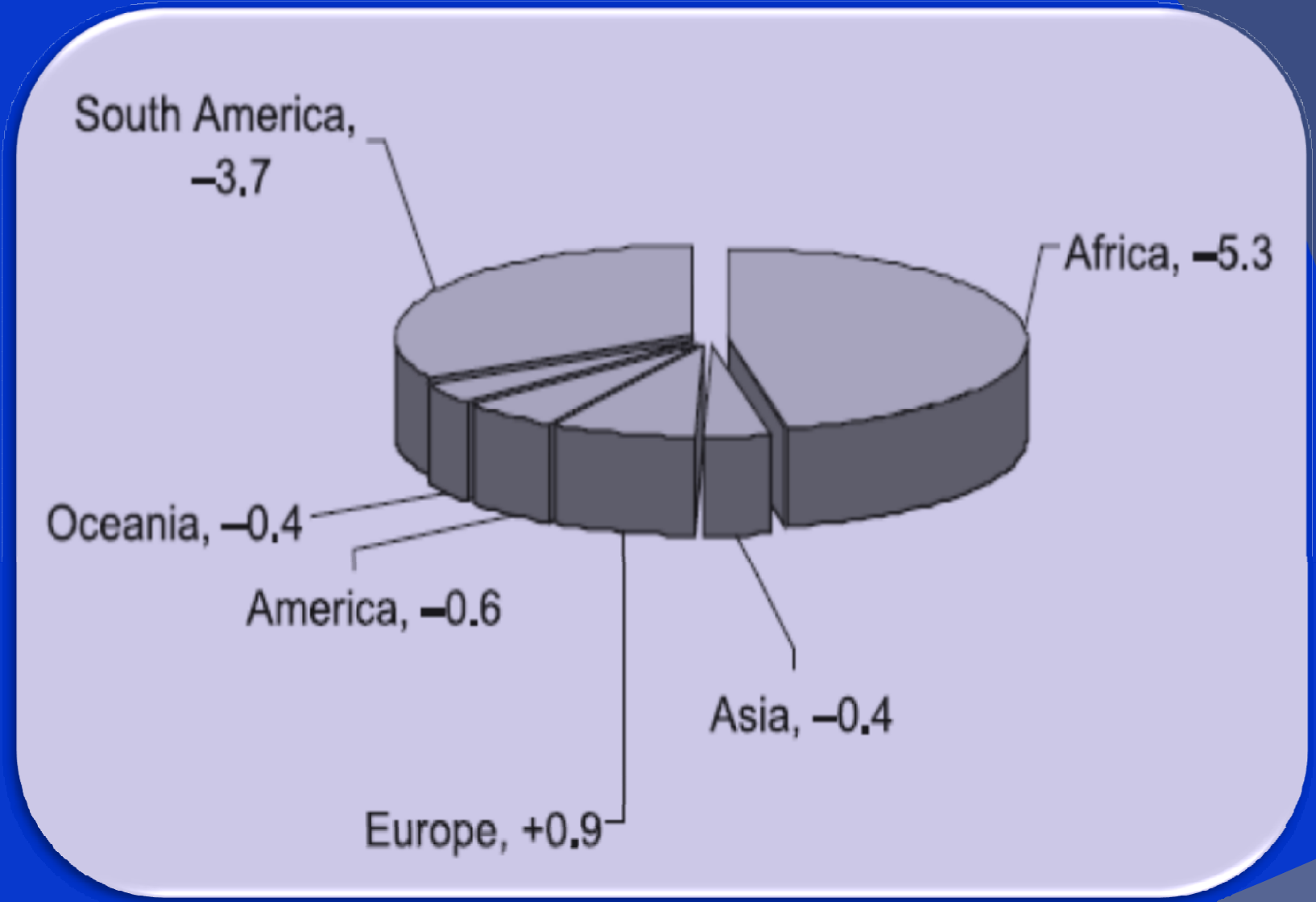
Agriculture and air quality

Biome	Major Biochemical Impacts	Major Biophysical Impacts
Cultivated systems	CO_2 source: conversion to cropland, management sink: management (e.g., low tillage) CH_4 source: rice paddies, ruminant animals, termites sink: upland soils N_2O source: soils, cattle/feedlots, fertilizer use NO_x source: soils NH_3 source: cattle, feedlots, fertilizer, plants, soils VOCs source: oxygenated VOCs (e.g., methanol, ethanol, acetone) dust source: disturbed soil surfaces and reduced vegetation cover	albedo: increase when forest conversion to cropland, decrease in case of irrigation, decrease where leaf area index higher than natural vegetation transpiration: decrease in case of forest conversion to cropland, increase for irrigated systems
Dryland systems (including savannas and grasslands)	CO_2 source: biomass burning, devegetation, sink: woody encroachment CH_4 source: biomass burning, ruminants, termites sink: upland soils CO source: biomass burning N_2O source: soils NO_x source: soils NH_3 source: plants, animal waste, soils VOCs source: plants, biomass burning S source: biomass burning particulates source: biomass burning tropospheric O_3 source: biomass burning CO source: biomass burning dust source: devegetation, degradation, and erosion	albedo: increase in case of desertification surface runoff: increase in case of desertification

Habitat Change – Challenges

Today 1/4 of the Earth's terrestrial surface is covered by cultivated and modified systems.

- Projections for the next 50 years estimate that:
  - ✓ Demand for food crops will grow by 70-85%;
  - ✓ Land conversion will be mainly in poor countries and dry regions;
  - ✓ Land use change will continue to degrade terrestrial and freshwater ecosystems.



Net Change in Forest Area by Continent (in million hectares per year)

FRA, 2000

Biodiversity Loss – Challenges

Over the past few hundred years, species extinction rates have increased by 1,000 times over background rates.

- The main causes of current and future biodiversity loss are human induced and include:
  - ✓ Habitat change, particularly conversion of natural systems to agriculture;
  - ✓ Climate change, which may become the dominant driver in the coming decades;
  - ✓ Invasive species, particularly on islands and in estuaries and freshwater ecosystems;
  - ✓ Overexploitation, particularly of fish stocks.

Overexploitation of Oceans – Challenges

Oceans cover more than 70% of the Earth, playing key roles in climate regulation, the freshwater cycle, food provisioning, energy and cultural services.

- Demands on coastal space are increasing in terms of shipping, waste disposal, military and security uses, recreation and fish farming;

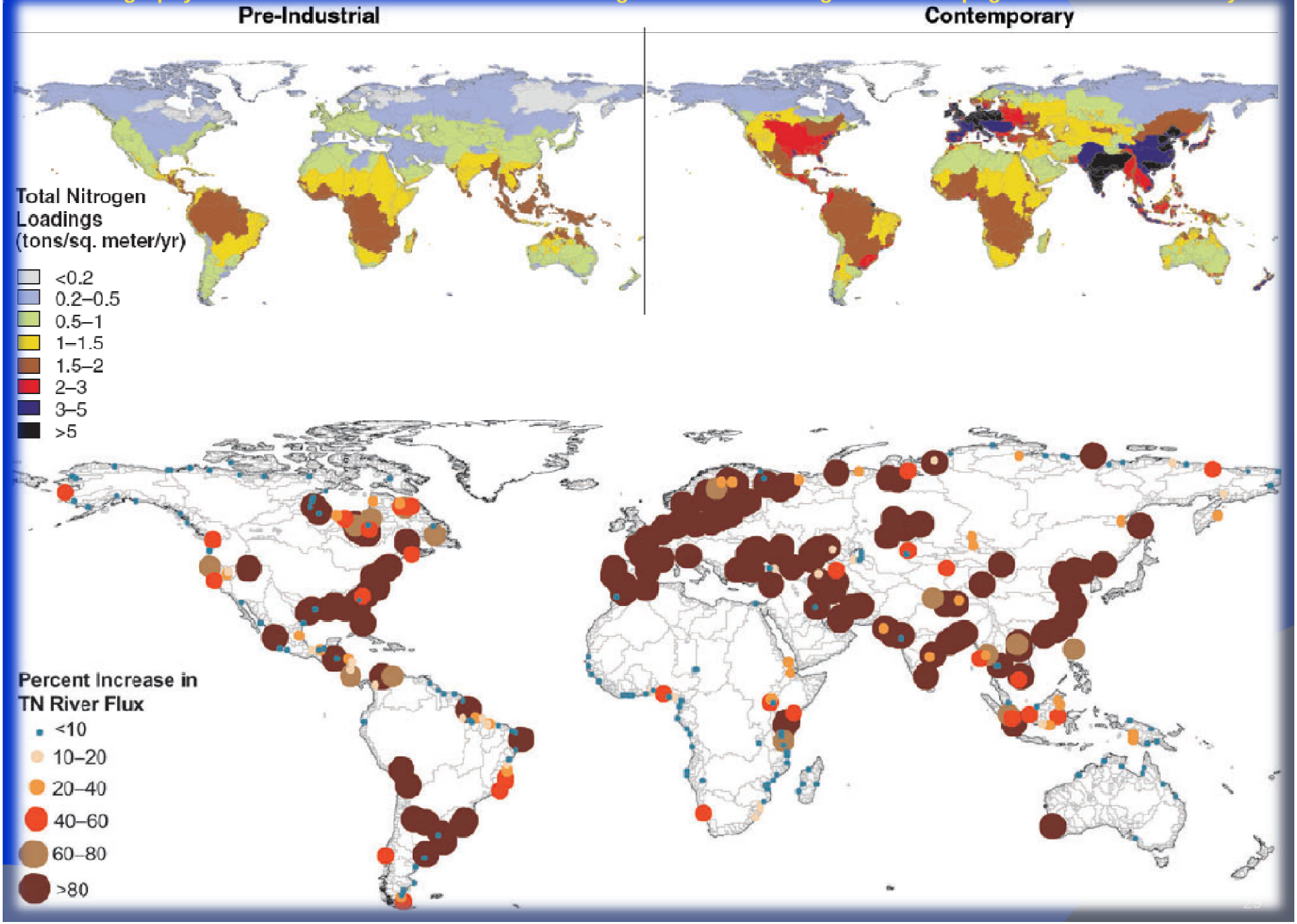
- A quarter of fish stocks are overexploited or significantly depleted.

Nutrient Overloading – Challenges

Nutrient cycling is essential for the supply of farmed and wild products. Human activities have significantly changed nutrient balances.

- Main nutrients include nitrogen, phosphorus, sulfur, carbon and potassium
  - ✓ Over half of the nitrogen fertilizer ever used has been applied since 1985;
  - ✓ Phosphorus is accumulating in ecosystems due to the use of mined phosphorus in agriculture and industrial products;
  - ✓ Sulfur emissions have been reduced in Europe and North America, but are still rising in countries like China, India and South Africa and South America;
  - ✓ Soil nutrient depletion affects more than 85% of agricultural lands in Africa.

Contrast between Contemporary and Preindustrial Loadings of Easily Transported Nitrogen onto Land Mass of Earth and Geography of Relative Increases in Riverborne Nitrogen Fluxes Resulting from Anthropogenic Acceleration of Cycle.



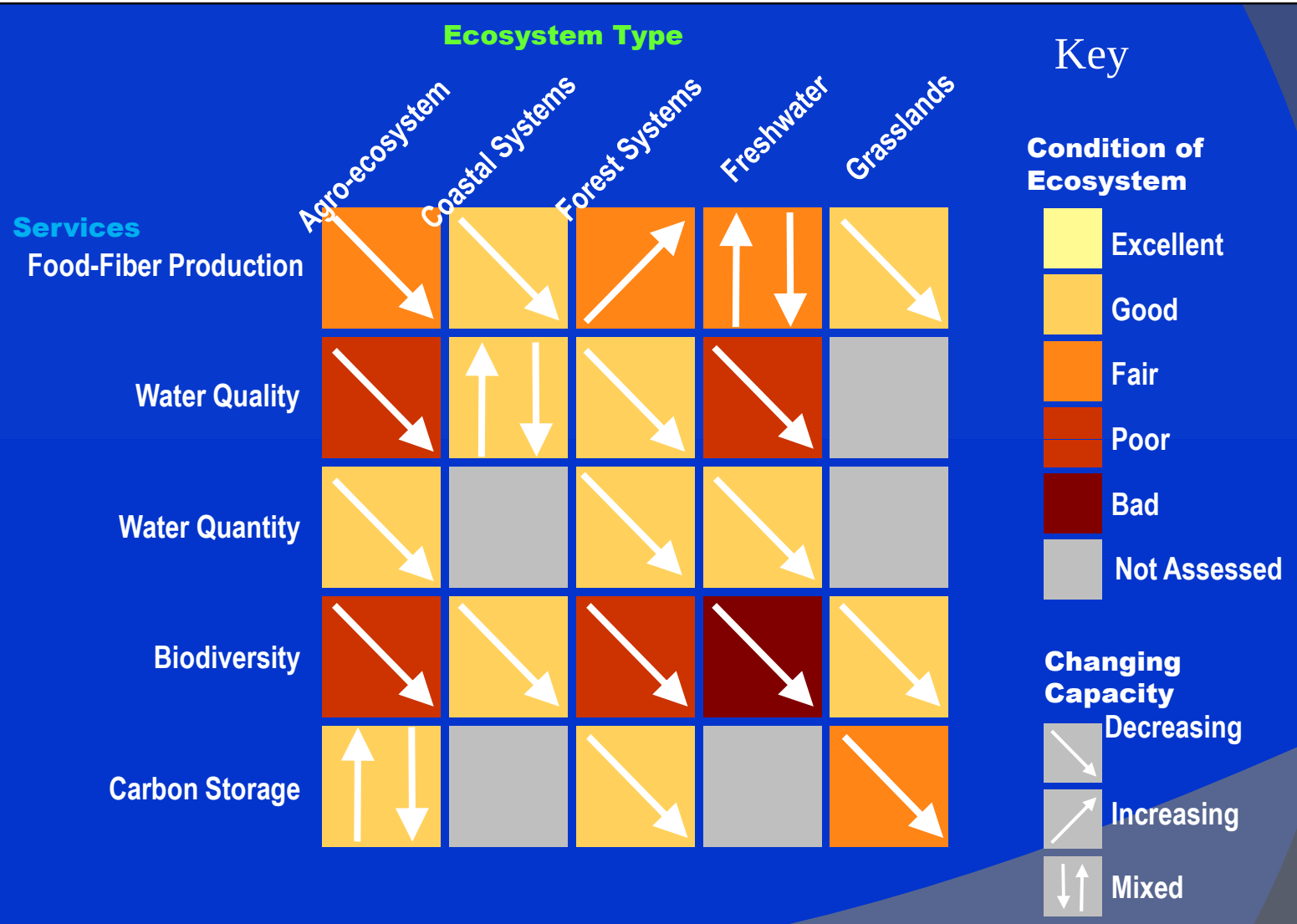
Balance Sheet – Ecosystems Services

Provisioning services		
Food	crops	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fiber	timber	+/-
	cotton, silk	+/-
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Water	freshwater	↓

Regulating services	
Air quality regulation	↓
Climate regulation – global	↑
Climate regulation – regional and local	↓
Water regulation	+/-
Erosion regulation	↓
Water purification and waste treatment	↓
Disease regulation	+/-
Pest regulation	↓
Pollination	↓
Natural hazard regulation	↓
Cultural services	
Spiritual and religious values	↓
Aesthetic values	↓
Recreation and ecotourism	+/-

↑ globally enhanced
↓ globally degraded

ISSUE: *The capacity of many ecosystems to provide certain services has been declining...*



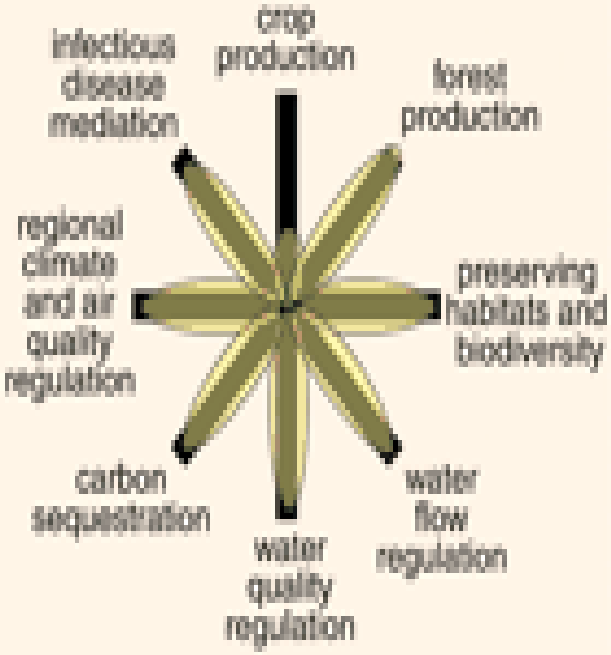
*Source: Pilot Assessment of Global Ecosystems. WRI, 2000.

www.**wri**.org/

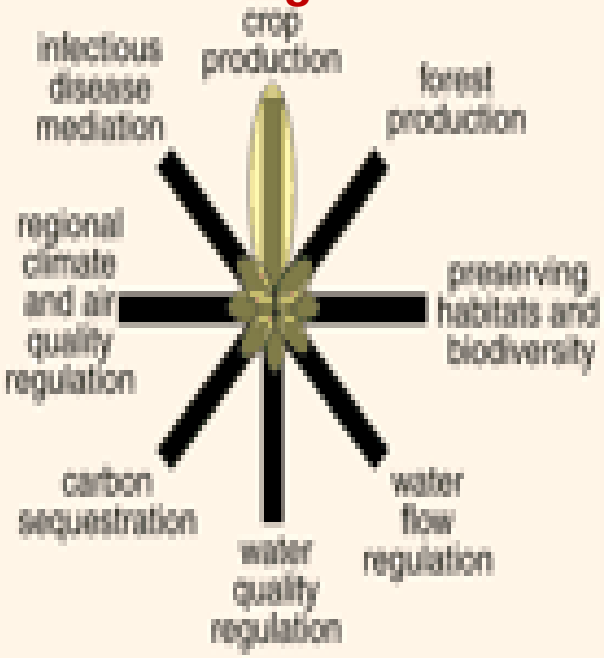
BEST PRACTICES

1. Promoting a diversified farm landscape, including crop rotations and intercropping within the fields, but also diversification on the edges and outside of the farm, for example, in crop-field boundaries with windbreaks, shelterbelts, and living fences, which can improve habitat for wildlife and beneficial insects, provide sources of wood, organic matter, resources for pollinating bees, and in addition, modify wind speed and the microclimate.
2. Integrated Soil Fertility Management (ISFM) i.e. the judicious use of both organic and inorganic sources of nutrients rather than either alone;
3. The use of conservation tillage rather than continuous deep ploughing;
4. Using nutrient recycling mechanisms through the use of crop rotations, crop/livestock mixed systems,agroforestry and intercropping systems based on legumes, and so forth.
5. Reduce applications of pesticides
6. Practice conservation agriculture

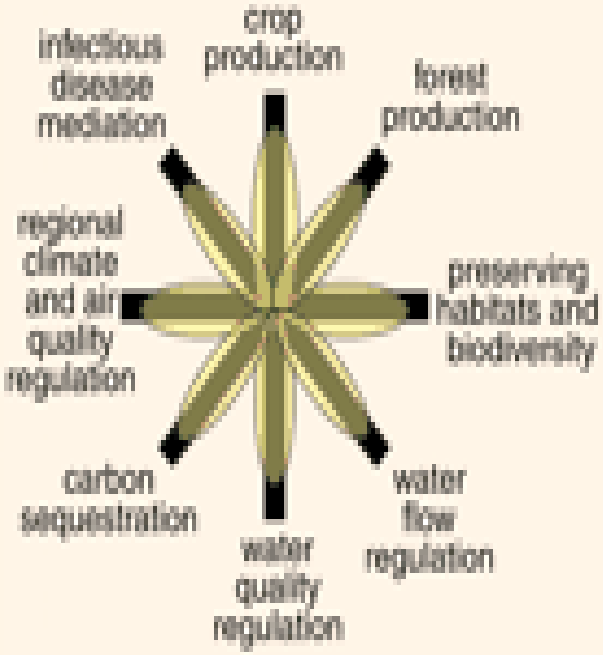
Maintaining Balance

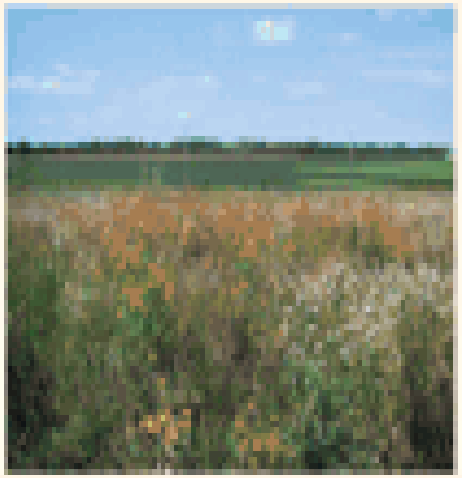


natural ecosystem



intensive cropland





cropland with restored ecosystem services

http://rs.resalliance.org/category/tools/millennium-ecosystem-assessment/

Conclusion

- **We all rely on Ecosystems**
- **Ecosystems provide a wide range of goods and services – provisioning, regulating, cultural and supporting**
- **In meeting demands and raising production a significant number of the worlds ecosystems have been degraded**
- **To co-create a sustainable future, we need to devise adequate means to value our natural capital and human resources**
- **It is possible to do something about the ecological problem. This requires substantial changes in policy and practice and the conceptualization of a new paradigm in our agriculture for sustainable development**
- ***The future depends on wise eco choices of today.* The choices we make today in how we use land and water resources will have enormous consequences on the future sustainability of earth's ecosystems and the services they provide**

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THANK YOU