IMPACT OF AGRICULTURAL PRACTICES ON ECOSYSTEM SERVICES

SEMINAR WRITE UP

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ABSTRACT

Agriculture produces much more than just crops. Agricultural practices have impact on a wide range of ecosystem services, including water quality, pollination, nutrient cycling, soil retention, carbon sequestration, and biodiversity conservation. In turn, ecosystem services affect agricultural productivity. (Dale and Polasky, 2007). Understanding the contribution of various agricultural practices to the range of ecosystem services would help inform choices about the most beneficial agricultural practices.

Agriculture is one of the main drivers of environmental change. It is the source of many changes in land use and the origin of a broad range of pollutants. The relationship between agricultural practices and impact on ecosystem services is complex (Sonak, 2004). Ecosystems deliver multiple types of services across widely varying spatial scales, so the patterns of agricultural use across many different scales also matter. Patterns of agricultural use affect the quantity and quality of services that they deliver. For example, one side Shifting cultivation, a primitive type of agriculture practiced in north-eastern India and another side, modern agriculture in so-called green revolution states of north-western India both have their devastating and far-reaching consequences in degrading the environment and ecosystem services. (Ranjan and Upadhyay, 1999; Singh, 2000). Increasing food demands for burgeoning population has restricted the agriculture itself as an ecosystem providing mainly provisioning services for human well being at the cost of degradation of other services. Millennium ecosystem assessment (2005) reports that water scarcity, nutrient overloading, biodiversity loss, ocean over exploitation, climate change and habitat change are the major interconnected trends linked with agricultural practices to affect global ecosystems.

Based on above-mentioned discussion, it can be concluded that in meeting demands and raising production, a significant number of ecosystems have been degraded. To co-create a sustainable future, we need to devise adequate means to value our natural assets and resources. This requires substantial changes in policy and practice of our agriculture.

INTRODUCTION

What is an ecosystem?

An **ecosystem** is a specific area of size in which climate, landscape, animals and plants are constantly interacting. An ecosystem is a community of animals and plants interacting with one another and with their physical environment. Ecosystems include physical and chemical components, such as soils, water, and nutrients that support the organisms living within them. These organisms may range from large animals and plants to microscopic bacteria. Ecosystems include the interactions among all organisms in a given habitat and flow of energy from one component to another. People are part of ecosystems. The health and wellbeing of human populations depends upon the services provided by ecosystems and their components - organisms, soil, water, and nutrients.

What are ecosystem services?

Ecosystem Services are the processes by which the environment produces resources that we often take for granted such as clean water, clean air, fresh food, timber for fuel and other purposes, habitat for fisheries and pollination of native and agricultural plants. Whether we find ourselves in the city or a rural area, the ecosystems in which humans live provide goods and services that are very familiar to us.

Agriculture and ecosystem services: a brief overview

The term "ecosystem services" denotes the economically valuable services generated by natural ecosystems as by-products of their normal functioning. The notion centres on natural ecosystems' capacity to process matter - their ability to alter the physical, chemical, or biological characteristics of the materials that pass through them. In an influential recent book, *Nature's Services: Societal Dependence on Natural Ecosystems* [Daily (1997)], Gretchen Daily organizes these services into fourteen categories:

- Purification of air and water
- Mitigation of droughts and floods
- Generation and preservation of soils and renewal of their fertility
- Detoxification and decomposition of wastes
- Pollination of crops and natural vegetation
- Dispersal of seeds
- Cycling and movement of nutrients
- Control of the vast majority of potential agricultural pests
- Maintenance of biodiversity
- Protection of coastal shores from erosion by waves
- Protection from the sun's harmful ultraviolet rays
- Stabilization of the climate
- Moderation of weather extremes and their impacts
- Provision of aesthetic beauty and intellectual stimulation that lift the human spirit.

Scanning down Gretchen Daily's list, one sees immediately that agriculture is a user of many types of ecosystem services. The natural environment provides essential inputs to agriculture, many of which are uncounted and unrecorded. Indeed, the essence of plant agriculture is the capture of public environmental goods - sunlight, wind, and rain - and their conversion into appropriable private goods such as crops. Amongst the ecosystem services used by agriculture are the following:

Pollination of crops and natural vegetation. About one-third by value of the crops, fruits, and vegetables produced in the world require pollination. Historically, "wild" populations of pollinators (bees, other insects, bats or birds) have carried out this function. Recently populations of many of these pollinators have declined sharply, to the point that replacements have been needed. Extensive use of pesticides, usually insecticides, is a significant cause of this decline [Nabhan and Buchmann (1997)]. There is now an active market in the rental of bees, the most widely used insect pollinator. Beekeepers can increase their income by renting hives of bees to farmers at pollination periods - apple growers and alfalfa growers make extensive use of these services.
Nutrient cycling. Natural ecosystems break down crop and animal wastes and release the nutrients in these to restore the fertility of farmlands. In so doing they maintain soil fertility and also avoid the runoff of wastes into water bodies, preserving their purity and value for humans and other animals.
Pest control. Control of pests is one of the main problems facing farmers. A significant fraction of crops, of the order of one-quarter to one-half, may be lost to pests without extensive intervention by the farmer. Pests are just insects or animals that eat a crop designated for human consumption, and are naturally attracted to huge concentrations of their foodstuffs. Most pests have natural enemies that control their populations in natural ecosystems. In agricultural systems, however, these predators may have been eliminated. For example, the predators of many insect pests may be insects that are eliminated by the very insecticides aimed to kill the pests. Or they may be birds, which have been driven away by the destruction of nesting sites or other cover.

Agriculture is a producer of ecosystem services, as well as a consumer. Indeed, agricultural systems are themselves ecosystems, a form of human-dominated ecosystem. The distinction between cultivated lands and undisturbed areas is always a matter of degree, rather than of kind: farms lie on a spectrum between lands completely free of human impact (an essentially hypothetical state, on today's Earth) and completely built environments. The services that agriculture could in principle produce include the following:
Carbon sequestration and stabilization of the climate. Trees and other growing vegetation sequester carbon, as does soil. Decay of vegetable matter releases carbon, as does tilling soil. So farming practices can affect the carbon cycle both positively and negatively. This is now the focus of much political negotiation concerning the future of the Kyoto Protocol and the various flexibility mechanisms that have been proposed to lessen the costs of implementation to industrial countries. Agricultural management is central to this debate.
Beauty and tourism. Tourism is the world's largest industry in terms of employment, and also rapidly growing. Management of the landscape affects its attractions to tourists, and farmers are the principal landscape managers in the U.S. Many farm landscapes are unattractive, but some can retain their natural beauty, as have those in Tuscany and the Swiss Alps.
Habitat for endangered species and other wildlife, especially in wetlands. Farms that retain or restore some measure of the original vegetation provide habitats for indigenous species that are otherwise likely to become endangered. These farms may also help themselves because original vegetation may provide habitat for predators of pests and for pollinators.

Purification of air and water; detoxification and decomposition of wastes. It is now increasingly recognized that wetlands can play a major role in removing a range of pollutants from stream water and so in preventing eutrophication by nitrates and phosphates. Retention or restoration of wetlands is therefore a mechanism through which farms may contribute to the resolution of some of the environmental problems they create.

Mitigation of droughts and floods. We are increasingly recognizing that many floods are caused by human alterations to the landscape that have reduced the ability of natural ecosystems to buffer irregular rainfalls. Forests, wetlands, and floodplains have traditionally preformed this function, and the destruction of the former two and the canalization of rivers have destroyed natural flood control systems. Land management practices by farmers can to some degree restore these functions.

Figure: 1. Ecosystem services and dis-services to and from agriculture. Solid arrows indicate services, whereas dashed arrows indicate dis-services (**Zhang *et al* 2007)**

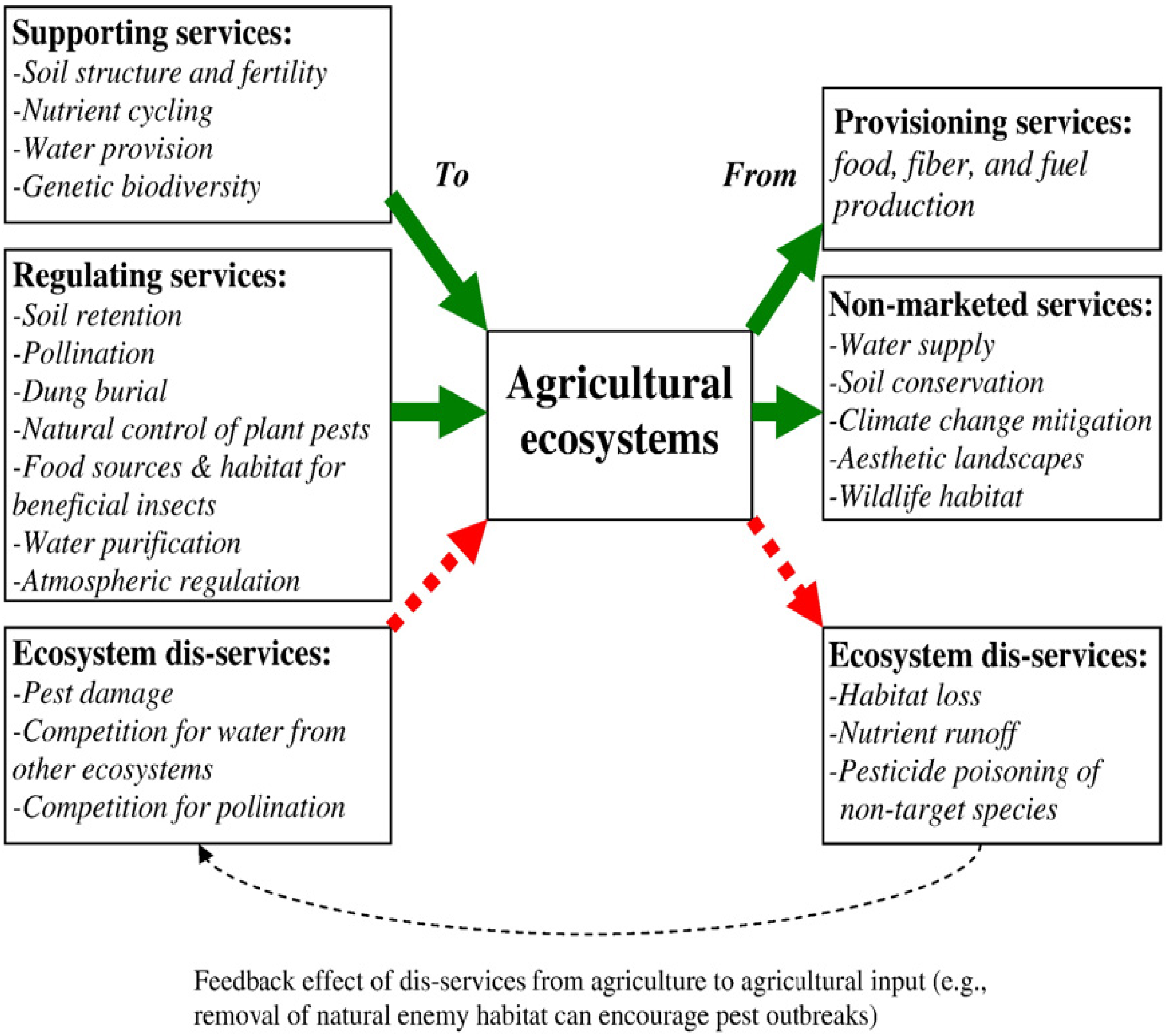
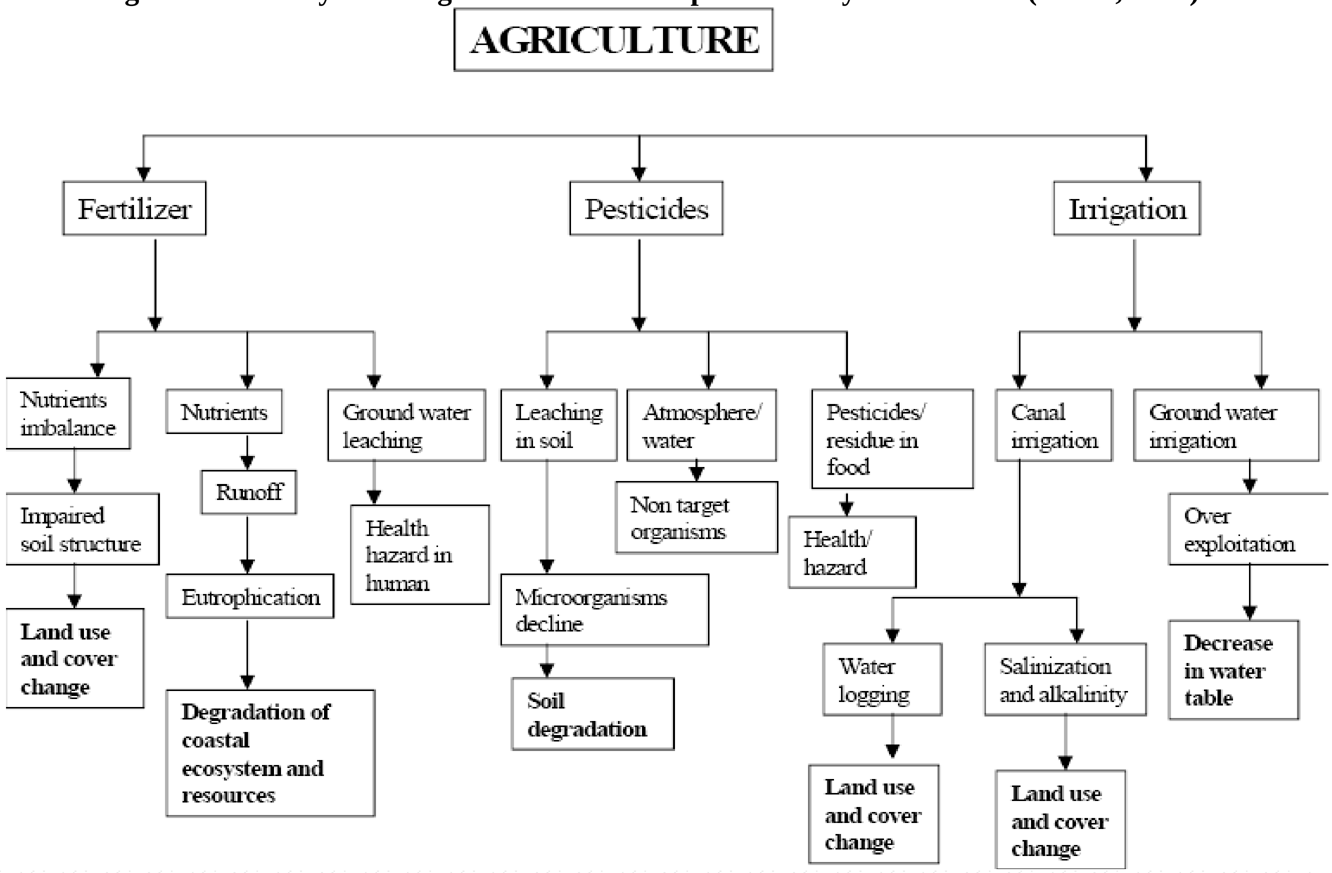


Fig. 2 Processes by which agriculture has an impact on ecosystem services (Sonak, 2004)



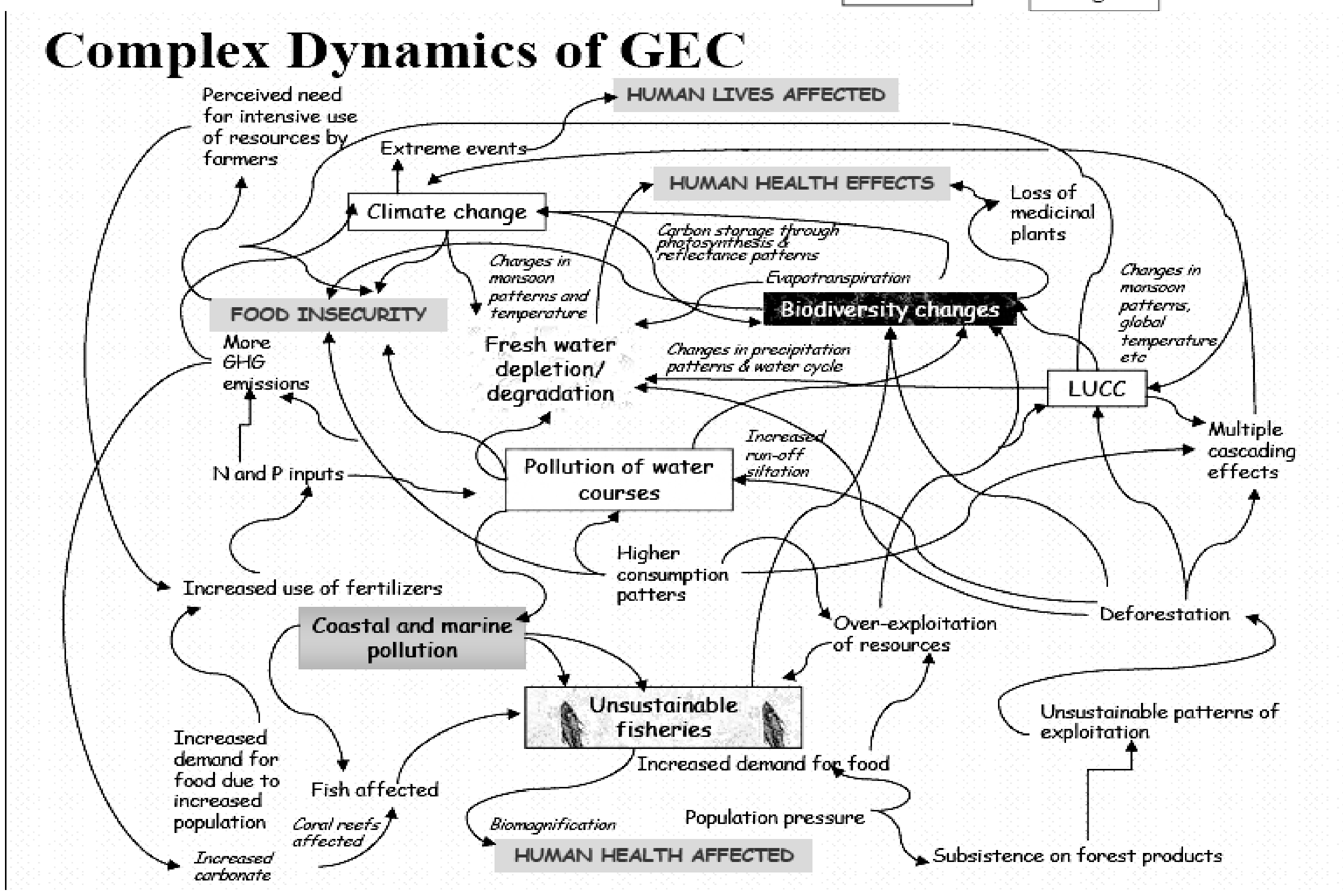


Figure: 4. Changes from agriculture that affect and are affected by several ecosystem services (Dale and Polasky, 2007)

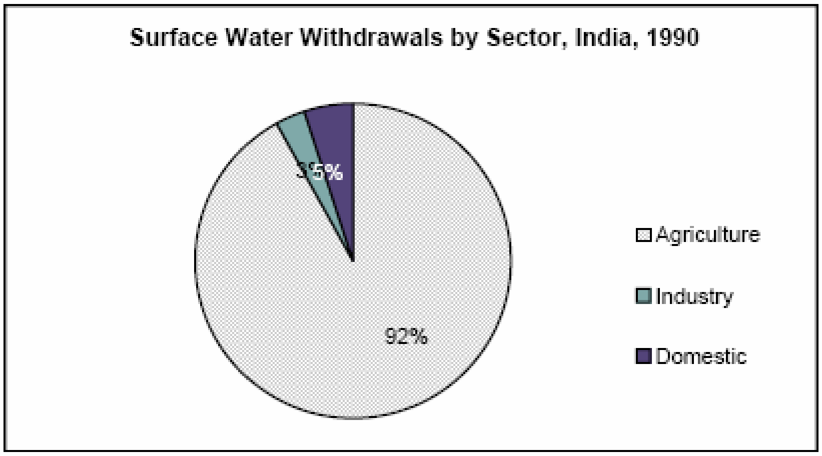
Agent of change →	Ecological services
Land cover	<u>**Production services**</u>
Erosion	**-Food and materials for human consumption**
Chemical use	**- Energy**
	<u>**Regulation services**</u>
	-Water quality and quantity
	-Soil quality
	-Air quality
	-Pollination
	-Seed dispersal
	-Biodiversity
	-Pest mitigation
	-Protection from disturbances
	<u>**Habitat services**</u>
	-habitat

The changes to the environment associated with agriculture affect a wide range of ecosystem services including food and materials for human consumption, water quality and quantity, soil quality, air quality, carbon sequestration, pollination services, seed dispersal, pest mitigation, biodiversity, habitat change and habitat degradation, and protection from disturbances (Fig. 4). Food and materials for human consumption constitute a prime category of ecological indicators since this is the main purpose of agriculture. The service provided is usually measured as productivity (calculated as the weight of material per area in cultivation). In addition to food, crops are grown for energy, fiber, oils, fabrics, rope, and other such goods. Because the business of farming depends on productivity, we have exceptionally good records of this.

Water quality and quantity are important services that can be enhanced or degraded by agriculture. Agriculture has both a direct and indirect effect on water consumption and quality. Indian agriculture consumes about 92% of total surface water **(figure: 5)**. Furthermore, chemical use and erosion significantly affect water quality in many areas. The most common causes of water body impairment are sediments, pathogens, nutrients, metals, dissolved oxygen, and other habitat alteration. Agricultural practices are contributors to all of these metrics, and in some cases are the dominant contributors in many water bodies.

Soil quality is also directly and indirectly affected by agricultural practices. Because soil properties are so variable over space and time, there is great interest in means to rapidly and remotely characterize soil quality. Non-invasive geophysical measurements of apparent soil electrical conductivity are proving effective (Jung et al., 2005).

Figure: 5. Surface water withdrawal by sector, India (Earthtrends, 2008)



Agricultural effects on air pollution include pesticides, odors, smoke, dust, allergenic pollens, and trash. Nitrogen compounds emitted from agricultural sources can affect air quality in two ways: ammonia (NH_3) emissions result from fertilizers and livestock, and nitrogen oxides (NOx) from fuel combustion in farm equipment. Agricultural practices also affect net greenhouse gas emissions both through the burning of fossil fuels and through the release or storage of greenhouse gases in plant material and soils. The move toward no-till cropping provides some energy use efficiency. Though there is some support in the literature that notill also increases carbon sequestration (Lal et al., 2007). Agricultural practices can also result in emissions of N_2O, which is a powerful greenhouse gas, and methane. Its contribution to global greenhouse gas emissions is shown in the pie chart below.

Figure: 6. Global greenhouse gas emissions in 2004 from different sectors (IPCC, 2007).

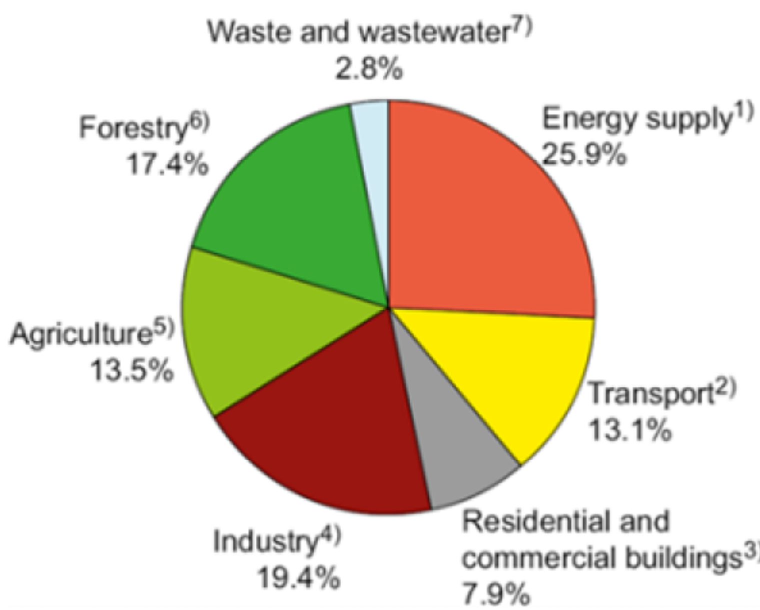


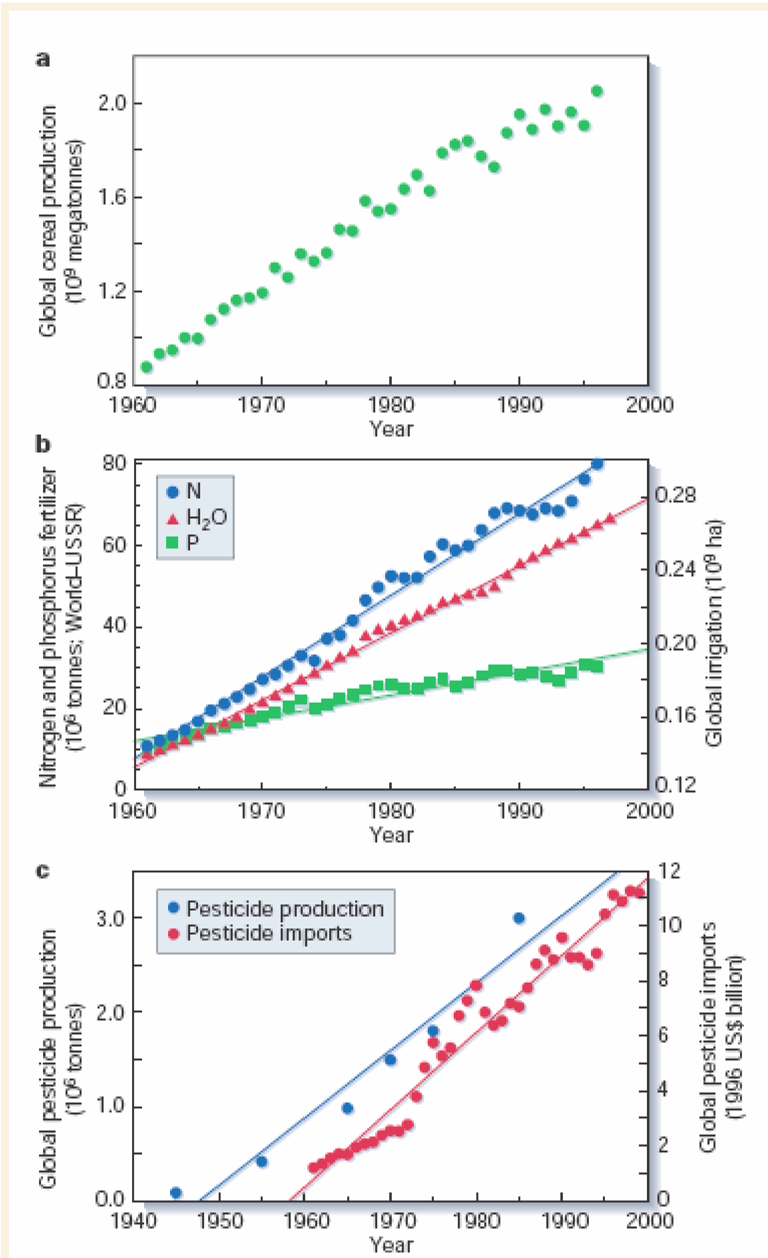
Table: 1. Major gases emissions from agriculture systems (MEA, 2005)

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

Effect of green revolution on ecosystem services

Global cereal production has doubled in the past 40 years (Fig. 7a), mainly from the increased yields resulting from greater inputs of fertilizer, water and pesticides (Figure 7b &c), new crop strains, and other technologies of the 'Green Revolution'. This has increased the global per capita food supply, reducing hunger, improving nutrition (and thus the ability of people to better reach their mental and physical potential) and sparing natural ecosystems from conversion to agriculture. But slowly yields have been stagnant for 15–20 years in those rice producing regions of Japan, Korea, and China where farmers were early adopters of green-revolution technologies; average yields are currently about 80% of the climate-adjusted genetic yield potential ceiling. Lack of a larger exploitable 'yield gap' highlights the need for efforts to steadily increase the yield potential ceiling. The large yield gap for rice in many parts of south and southeast Asia, and for maize in developed and developing countries, indicates that these regions could have significant yield increases with use of appropriate technologies. (MEA, 2005).

Figure 7 Agricultural trends over the past 40 years. (a)Total global cereal production; (b) Total global use of nitrogen and phosphorus fertilizer (except former USSR not included) and area of global irrigated land and (c) Total global pesticide production and global pesticide imports (Tilman, 2002)



Singh (2000) reported that the Green Revolution in India has achieved self-sufficiency in food production. However, in the state of Haryana this has resulted in continuous environmental degradation, particularly of soil, vegetation and water resources. Soil organic matter levels are declining and the use of chemical inputs is intensifying. Newly introduced crop varieties have been responsive to inputs but this has necessitated both increased fertiliser application and use of irrigation resulting in water contamination by nitrate and phosphate and changes in the ground water table. With 82% of the geographic area already under cultivation, the scope for increased productivity lies in further intensification which is crucially dependent on more energy-intensive inputs. Declining nutrient-use efficiency, physical and chemical degradation of soil, and inefficient water use have been limiting crop productivity, whilst the use of monocultures, mechanisation and an excessive reliance on chemical plant protection have reduced crop, plant and animal diversity in recent years. About 60% of the geographical area faces soil degradation (water logging, salinity and alkalinity) which threatens the region's food security in the future. Since 1985, the water table has risen more than 1 m annually, and patches of salinity have started to appear at the farm level. The situation is worse in higher rainfall areas where water logging follows shortly after the rains. Apart from affecting agricultural crops, a high water table causes floods even following slight rains due to the reduced storage capacity of the soil. Such ecological impacts have led to the physical, hydrological, chemical and biological constraints relating to soil and water resources for ecosystem sustainability.

Effect of primitive agriculture i.e. shifting cultivation on ecosystem services

Ranjan and Upadhyay (1999) reported that the current practice of shifting cultivation in eastern and north eastern of India is an extravagant and unscientific form of land use. The evil effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of these regions. The earlier 15-20 year cycle of shifting cultivation on a particular land has reduced to 2-3 years now. This has resulted in large-scale deforestation, soil and nutrient loss and invasion by weeds and other species. Now a stage has come that it has already affected 2.7 million hectares of land and each year 0.45 of land fall under shifting cultivation resulting from deforestation in northeast India.

Table: 2. 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

(Ranjan and Upadhyay, 1999)

Expansion and intensification of cultivation are among the predominant global changes of this century. Intensification of agriculture by use of high-yielding crop varieties, fertilization, irrigation, and pesticides has contributed substantially to the tremendous increases in food production over the past 50 years. Land conversion and intensification, however, also alter the biotic interactions and patterns of resource availability in ecosystems and can have serious local, regional, and global environmental consequences. The use of ecologically based management strategies can increase the sustainability of agricultural production while reducing off-site consequences. The summary of impact of agriculture practices on ecosystem services can be tabulated here:

Table: 3. Ecosystem services and impact of agriculture practices

Ecosystem services	Impact of agricultural practices
FOOD PROVISIONING SERVICE	1. Food production increased by 160% from 1961 to 2003, as a result of intensification and expansion. 2. Gains in food services have come at the expense of other services, such as disease regulation.
WATER PROVISIONING AND SUPPORTING SERVICES	3. Human use of freshwater runoff has increased dramatically at a mean rate of 20% per decade between 1960 and 2000, with 70% worldwide used for agriculture. 4. Inorganic nitrogen pollution of inland waters has increased more than twofold globally since 1960. 5. More than 1 billion people live in areas without appreciable supplies of renewable fresh water to meet their needs.
TIMBER, FIBER, FUEL PROVISIONING SERVICES	6. Global timber harvests increased by 60% since 1960. 7. Fuelwood is the primary source of energy for heating and cooking for some 2.6 billion people, although they account for less then 7% of world energy use. 8. Among agricultural fibres, global cotton production has doubled and silk has tripled since 1961.
CLIMATE REGULATION	9. About 40% of historical emissions (over the last 2 centuries) and about 20% of CO_2 emissions (1990s) originated from land use changes, mostly deforestation. 10. Terrestrial ecosystems become a source of carbon dioxide (CO_2) and other greenhouse gases when they are broken down, but they become a net sink during regrowth (afforestation and reforestation for example). Terrestrial ecosystems were on average a net source of CO_2 during the 19th and early 20th centuries.
DISEASE REGULATION	11. Intensive livestock production that uses subtherapeutic doses of antibiotics has led to the emergence of antibiotic-resistant strands of Salmonella, Campylobacter and Escherichia coli bacteria. 12. Deforestation has increased the risk of malaria in Africa and South America by increasing habitat suitable for malaria-transmitting mosquitoes. 13. Natural systems with preserved structure and characteristics, such as the Amazon forest, generally resist the introduction of invasive human pathogens brought by migration.

Source : www.cbd.int/doc/bioday/2008/ibd-2008-factsheet-01-en.pdf

In 2005, the Millennium Ecosystem Assessment appraised the state of 24 key ecosystem services, and found that 15 were being degraded or used unsustainably (figure: 8). Many of these services--such as climate regulation, water provision, and soil protection--are both impacted by and support agricultural production, yet most farmers have little to no financial incentive to protect them. As a consequence, agriculture is a leading driver of soil erosion, water pollution, biodiversity loss, and greenhouse gas emissions from land use change.

Figure: 8. 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

Important findings of Millennium Ecosystem Assessment 2005 that:

- 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:

1. Water Scarcity
2. Climate Chang
3. Biodiversity Loss
4. Habitat Change
5. Overexploitation of Oceans
6. Nutrient Overloading

1. 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 in six out of eight regions;
- Projections indicate that between 2000 and 2010, global water use will expand by 10%.

2. 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.

3. 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.

4. 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.

5. 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.

6. Nutrient Overloading – Challenges

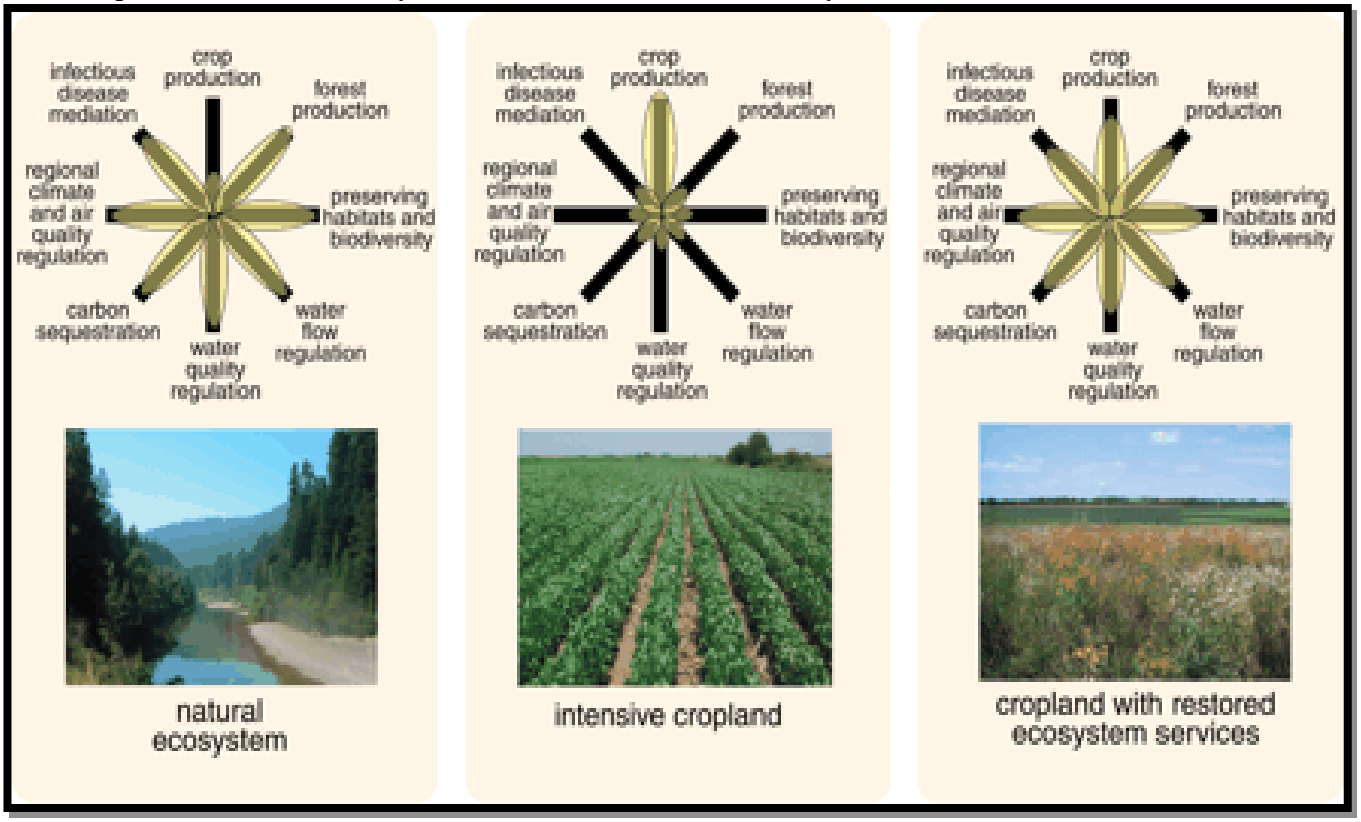
- Nutrient cycling is essential for the supply of farmed and wild products. Human activities (i.e. agriculture) have significantly changed nutrient balances.
- Main nutrients include nitrogen, phosphorus, sulfur, carbon and potassium
- Over half of the nitrogen fertilizer ever used has been applied since 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.

Therefore, providing the right incentives should help maximize the total return to society of the net benefits of agricultural production. However, many environmental problems and ecosystem services are difficult to monitor and quantify. The pursuit of sustainable agriculture will also require substantial increases in knowledge-intensive technologies that enhance scientifically sound decision making at the field level to reduce detrimental effect on other ecosystem services. Some of the best practices which can help in maintaining ecosystem services are:

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. Reducing applications of pesticides
6. Practicing conservation agriculture

Figure: 9 (1^{st} from left) showed that we can not produce as much as our requirement in natural ecosystem but the balanced use (fig.9, 3^{rd} from left) of natural resources will certainly lead to sustainable development not the monoculture i.e. intensive cultivation (fig.9, 2^{nd} from left) at the cost of resources for other production system.

Figure: 9. Production systems at different costs of ecosystem services



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

Discussion

"Agriculturalists are the de-facto managers of the most productive lands on Earth" (Tilman, 2002). The main environmental impacts of agriculture come from the conversion of natural ecosystems to agriculture. In the face of an expanding world population and rapid economic growth, global agriculture has kept apace via incredible growth in scale and intensity. Increasing the extent and intensity of agriculture (more fertilizers, more pesticides and irrigation water) has placed more strain on already stressed ecosystems. Agriculture currently consumes more land and water than any other human activity, with crops and pasture occupying 40% of the world's total land area and accounting for 70% of total water use (MEA, 2005). Agricultural ecosystems both provide and rely upon important ecosystem services (Zhang *et al*., 2007). Managing agricultural landscapes to provide sufficient supporting and regulating ecosystem services and fewer dis-services will require research that is policy-relevant, multidisciplinary and collaborative.

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 assets and 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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