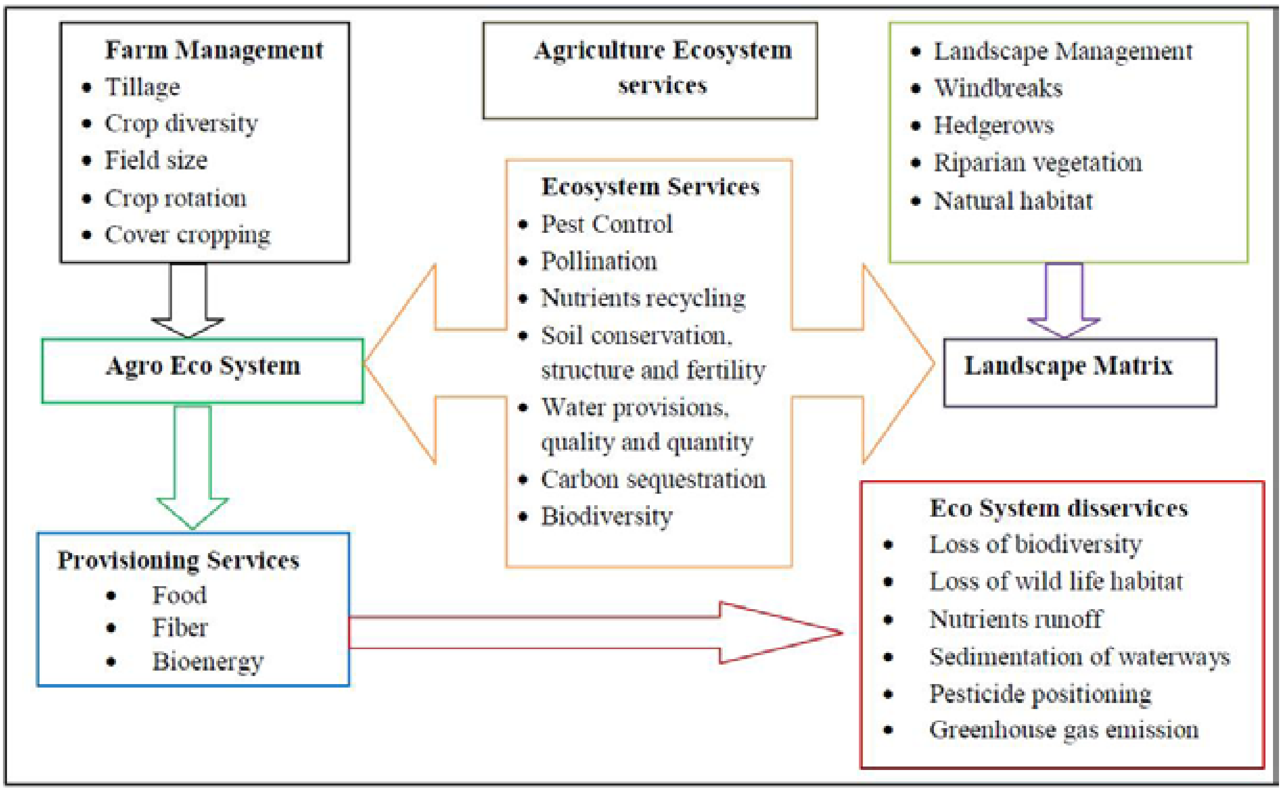
An Introduction to Ecosystem Services

Introduction

Agriculture is the dominant form of land management globally, and agricultural ecosystems cover nearly 40 per cent of the terrestrial surface of the Earth (FAO 2009). An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. Ecosystem services can be defined as the benefits that humans obtain from ecosystems. Agroecosystem services in particular support agricultural activity and are based on living and nonliving components and their interactions.



According to the Millennium Ecosystem Assessment (MEA 2005), ecosystem services are divided into four basic types:

1. Provisioning services (production of food, fuelwood, water supply, fiber and genetic resources);
2. Regulating services (climate regulation, water regulation, disease & pest regulation, pollination);
3. Supporting services (soil formation, nutrient cycling, primary production);
4. Cultural services (recreational, aesthetic, cultural, and educational functions).

A broad range of factors lead directly and indirectly to changes in ecosystems, ecosystem services, and human well-being.

Biodiversity and ecosystems are closely related concepts. Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". Ecosystems with high biological diversity provide many (and more stable) ecosystem services that concern, among others, provision of food, maintenance of pollination, and biological control of pests. Pollination is an ecosystem services of special importance for agricultural production and humans. Pollination is an important ecosystem service for 87 of the 115 most important arable crops in the world, and 35% of global food production volume (Klein et al. 2007).

Ecosystem service flows to Agriculture

1. **Natural pest control**

   Pest species destroy 25%–50% of the world's crops, either before or after those crops are harvested. Natural pest control is one of most important functions of agroecosystem services which relies on the conservation of natural enemies of insect pests in agroecosystems. The non-agricultural habitats within and nearby agricultural fields provide habitat and diverse food resources for arthropod predators, parasites and parasitoids, and microbial pathogens that act as natural enemies to agricultural pests and provide biological control services in agroecosystems. These natural pest control species of arthropods such as spiders, ladybugs, preying mantis, flies, and wasps reduce the population of pest insects and weeds which reduce the use of chemical pesticides and

herbicides. It has shown that the value of natural pest control services in USA save $13.6 billion per year and more than $400 billion per year globally in the agriculture (ref). The natural insect's predators, parasites and parasitoids contribute approximately 33% of natural pest control. Natural pest control services are susceptible to the heavy use of pesticides in the agriculture.

2. **Pollination**

Pollination is the transfer of pollen from the male parts of a flower to the female parts of a flower of the same species, which results in fertilization of plant ovaries and the production of seeds. Insect pollination is a key ecosystem service provided by a wide range of insect species including bees, wasps, flies, butterflies, beetles and moths contributing to food production, It is estimated that the majority of the world's major food crops , and 90% of all wild flowering plant species, depend on biotic pollination to at least some degree in order to set fruits and seeds Pollinator-dependent crops are also some of the most valuable in terms of nutritional content and fibre, and therefore play an even greater role in nutritional security and human diets. The global value of pollination for commercial food production has been estimated between $235 billion and $577 billion; in addition, it contributes to subsistence agricultural production that feeds many millions of people worldwide. Pollination benefits will become increasingly more important as the demand for pollinator-dependent crops increase with growing human populations. The evidence of pollinator decline has been recorded due to land use change (such as habitat loss, fragmentation, conversion, agricultural intensification, abandonment, and urbanization), pollution, pesticides, pathogens, climate change and competing alien species threatens to reduce yields and crop quality and to weaken food security.

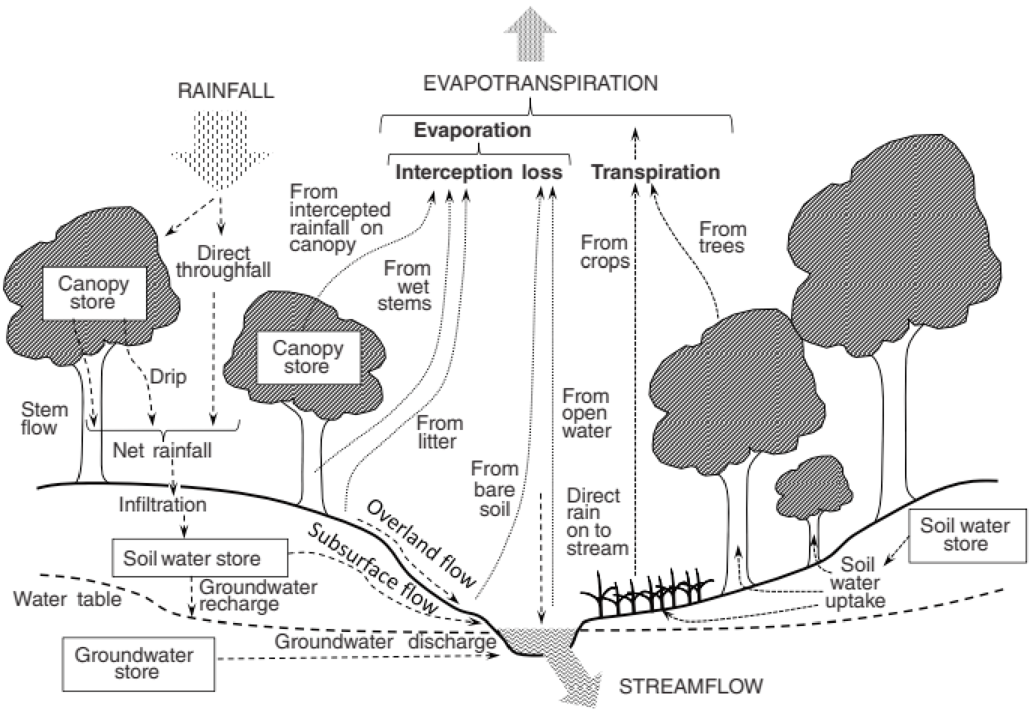
3. **Soil quality and fertility**

Soil is a heterogeneous mixture of minerals, decomposing organic matter and living biomass that supplies nutrients for plant growth and higher trophic levels. The human life and comfort depend on soil quality and its fertility, health and management to sustain its productive capacity. Soil quality refers to a range of soil properties and functions that support plant productivity and is assessed by soil biological, physical, and chemical means. Soil and nutrients are key ecosystem services that are often linked in agricultural management practices. Soil organic matter (SOM) is a key component of soil quality and delivery of many ecosystem services and an integrator of several soil functions and provides about 50% of the crops nitrogen needed to the plant. SOM in the topsoil which in turn provides energy and substrate for soil biota activities and their contributions to soil structure and nutrient cycling. Similarly, soil carbon also plays a major role in soil structure that enhances the infiltration, soil water retention, porosity and aeration. A combination of soil biological and chemical properties and process determine soil nutrient availability. Various soil living organism play a significant role in maintaining soil structure and nutrient cycling by their movement through the soil, by breaking down litter, and by binding soil particles with their excrement. Soil provides the physical support and mediates the availability of water for plants. It provides a habitat for many species of bacteria, fungi, nematodes, microarthropods and larger arthropods in soil are known to control agricultural pests and pathogens and contribute to a variety of important environmental functions such as decomposition, recycling of nutrients, breakdown of pollutants and storage of essential elements. The agricultural practices carried out can also result in negative effects on important soil physiochemical properties such as organic matter content

and structure and have led to erosion and leaching of nutrients. About 85% of agricultural land contains areas judged to have been degraded by erosion, salinization, compaction or soil compression, nutrient depletion, biological degradation or pollution.

4. **Water quantity and quality**

Agricultural production relies on the water-related ecosystem services, ranging from water supply (quantity), to purification (quality), and flood protection. Worldwide, agriculture accounts for about 70 % of all water use and up to 95 % in many developing countries and thus influences both the quantity and quality of water available for other human uses. It is estimated that by 2025, over 3 billion people are likely to be experiencing water stress. Water quantity and quality ecosystem services, derived essentially from how ecosystems underpin the water cycle which is an important renewable resources. Ecosystems do not create water; however, they can modify the amount of water moving through the landscape. These modifications result from ecosystem influence on the hydrologic cycle, including local climate, water use by plants, and modification of ground surfaces that alter infiltration and flow patterns. The changes in agricultural practices could contribute to water quantity by promoting the recharge of groundwater aquifers and resources.



5. **Climate regulation**

Ecosystem services play an important role in strategies for tackling climate change: mitigation and adaptation. Agroecosystems contribute to mitigation because of their capacity to remove carbon from the atmosphere and to store it, particularly under no- or reduced-till management of soils. Agricultural management can also enhance carbon sequestration through soil conservation and the introduction of trees in agroforestry systems. Ecosystems services regulate the global climate by storing greenhouse gases. For eg. effective manure management can significantly reduce emissions from animal waste. Replacing synthetic nitrogen fertilizers with biological nitrogen fixation by legumes can reduce CO^2 emissions from agricultural production by half. Similarly, improved agriculture practices can offset greenhouse gas emissions by increasing the capacity for carbon uptake and storage in soils and in plant biomass, i.e. carbon sequestration. Soil carbon sequestration thus provides additional ecosystem services to agriculture itself, by conserving soil structure and fertility, improving soil quality, increasing the use efficiency of agronomic inputs, and improving water quality by filtration and denaturing of pollutants.

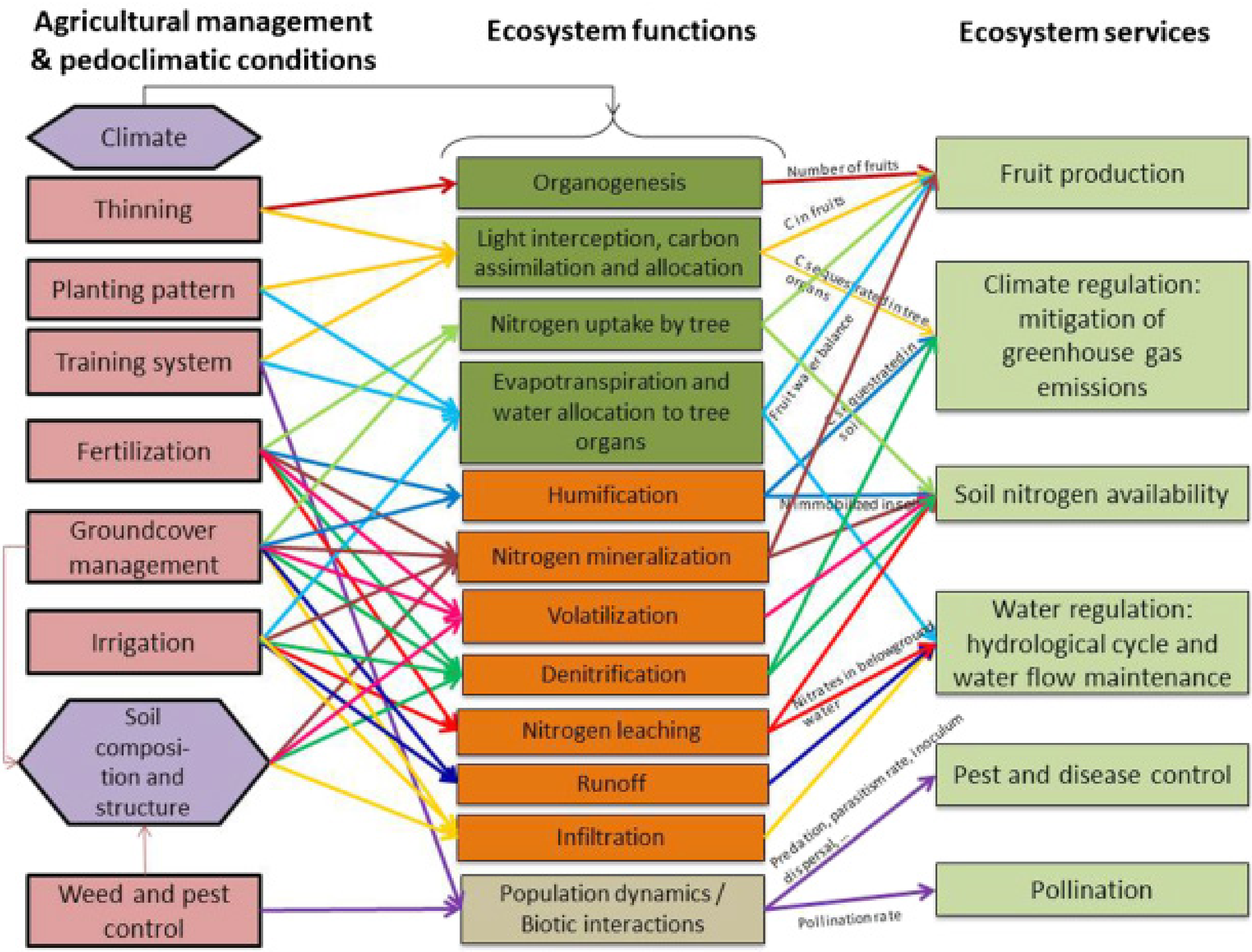
Conservation and management of ecosystem services

The individual and interacting effects of agriculture intensification, habitat loss and climate change causes loss of biodiversity, and thus influence important agroecosystem services. These processes often result in reduced landscape and species diversity (including populations of birds and pollinators) , increased soil erosion, and overall reduced soil quality; all of which can lead to crop yield decrease. To overcome this problem, the approach of combining productive and environmental functions of agriculture is essential. The concept of ecological intensification entails the environmentally friendly replacement of anthropogenic inputs and/or enhancement of crop productivity, by including regulating and supporting ecosystem services management in agricultural practices.

The following practices are examples of ecological intensification approaches that could be adopted to conserve and manage agrocecosystem services:

- Using vegetative cover as an effective soil and water-conserving measure, conservation tillage practices, mulching, use of legume cover crops, green manures, and organic manures.
- Integrated Soil Fertility Management (ISFM) i.e. the judicious use of both organic and inorganic sources of nutrients rather than either alone.
- Using nutrient recycling mechanisms through the use of crop rotations, crop/livestock mixed systems, agroforestry and intercropping systems based on legumes.
- Water management to the crop to reduce water stress
- Choice of crops and associated plants which have high nutrient use efficiency.
- Natural pest regulation enhanced through biodiversity manipulations.
- Create and conserve the habitats and resource needs for pollinators.
- 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.
- The practice of ‘integrated pest and pollinator management’ (IPPM) strategies which encourage last-resort use of pesticides that are less toxic for pollinators and pest natural enemies, and avoiding pesticide application during the crop blooming period so as to minimize exposure.

Linking agricultural management, ecosystem functions and ecosystem services in the orchard agroecosystem (Demestihas et al 2017)



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