STRENGTHENING AGRO-ECOSYSTEMS RESILIENCE FOR CLIMATE CHANGE ADAPTATION TO IMPROVE FOOD AND NUTRITION SECURITY (TCP/NEP/3701)

BIBLIOGRAPHY

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Summary

This bibliography compilation enlists the relevant literature in project mandated crops like apple, citrus, maize, rapeseed, and cucurbits with respect to eco-friendly cultivation practices of these crops and without disturbing ecosystem services. It compiles over 210 references of national significance, ecosystem services with farm benefits, importance of soil nutrients, beneficial organisms (predators, parasites, pollinators) and some botanicals having pesticide values in pest management.

Introduction

Food production has to be increased by 70% to feed the projected 9 billion people by 2050. To increase crop production and productivity research, training, and extension are the three major areas of agricultural technology development. Climate change and environment degradation has affected crop production and productivity including ecosystem services. Accordingly, agricultural research is changing over time due to recent development in new varieties, advanced technology practices and climate change. Thus, empowerment of small-scale farmers, particularly in rural areas with adoptive technology is the critical component for this growth. The national scenario of area, production and productivity of crops for 2017/18 are presented in Table 1. Production area is limited and productivity in Nepal is very low as compared to developed countries. Therefore, considering all biodiversity services, increasing production and productivity is vital without disturbing ecosystem services.

Table 1. Area, production and productivity of some crops in Nepal

SN	Crop	Area (ha)	Production (mt)	Productivity (mt/ha)
1.	Cereal	3,428,986	10,012,742	2.920
2.	Oilseed	224,595	245,867	1.095
3.	Citrus	25,964	245,176	9.400
4.	Vegetable	286,864	3,958,230	13.798
5.	Coffee	2650	513	0.193
6.	Pulses	311,382	368,741	1.194
7.	Beekeeping	242,000 (Colony)	3,980	-

Source: CBS (2019)

Agro-ecosystem Services

Agroecosystems both provide and rely on ecosystem services to sustain production of food, fiber, and other harvestable goods (Figure 1). Many services have on-farm benefits for farmers, plantation managers, and other people on-site (Table 2).

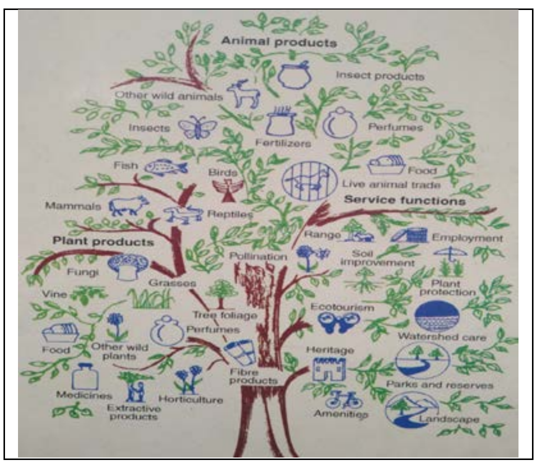


Figure 1. A plant contributing many kinds of benefits to human beings
Source: Kumar (2001)

Table 2. Ecosystem service, descriptions and related on-farm benefits

SN	Ecosystem service	Description	On-farm benefits
1.	Provision of food, feed, fuel and biochemicals	Harvestable goods from agroecosystem	Foods and other goods for on farm consumption or sale
2.	Soil structure and fertility enhancement	Soil structure and processes of nutrient cycling and delivery of nutrient to plants; processing of organic matter and transforming detritus and waste	Support for crop growth and can limit need of chemical fertilizer
3.	Erosion protection	Soil retention limiting soil loss through wind and water erosion	Maintain soil, and the nutrients it contains, to support production
4.	Hydrologic services: Water flow regulation	Buffering and moderation of the hydrologic cycle, including water infiltration into soils and aquifers, moderation of runoff, and plants transpiration	Water in soils, aquifers, and surface bodies available to support plant growth
5.	Hydrologic services: Water purification	Filtration and absorption of particles and contaminants by soil and living organisms in the water and soil	Clean water available for human consumption, irrigation, and other on-farm uses
6.	Pollination	Transfer of pollen grains to fertilize flowers	Necessary for seed set and fruit production in flowering plants and crops
7.	Pest control	Control of animal and insect pests by their natural enemies – predators, parasites, and pathogens	Minimize crop damage and limit competition with crops
8.	Weed control	Botanical component of pest control; suppressing weeds, fungi, and other potential competitors through physical and chemical properties of cover crops, intercrops, and other planted elements	Minimize weed competition with crops
9.	Carbon sequestration	Atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass and soils	Few demonstrable on-farm benefits
10.	Genetic resources	Pool of genetic diversity needed to support both natural and artificial selection	Distinct genotypes (cultivars) allow fruit set in orchards and hybrid seed production; trait diversity (from landraces and wild relatives) supports disease resistance, new hybrids, and climate adaptations
11.	Cultural and esthetic services	Maintaining landscapes that support: esthetics and inspiration; spiritual and religious values; sense of place; cultural heritage; recreation and ecotourism	Esthetics and inspiration; spiritual and religious values; sense of place; cultural heritage; recreation and ecotourism

Source: Garbach, K. et al. (2014)

Soil Organisms and Plant Elements

A fertile soil harbors diverse arrays of abundant organisms (Table 3) as indicators and also a plant growing in fertile soil is a reservoir of nutrients, which is essential for a plant to grow from a seed and complete its life cycle (Table 4).

Table 3. Number of organisms in average farm soil

SN	Organisms	Quantity
1.	All arthropods (including insects)	725 million/ha
2.	Insects	23 million/ha
3.	Bacteria	2.5 billion /gm
4.	Algae	50,000 /gm
5.	Earthworm	6 million/ha

Source: USDA (1985)

Table 4. Essential elements required for plant growth, production and productivity

SN	Element	Form primarily absorbed by plants	Mass (%) in dry tissue	Major functions
	Macronutrients			
1	Carbon	CO_2	45	Major component of plant's organic compounds
2	Oxygen	CO_2	45	Major component of plant's organic compounds
3	Hydrogen	H_2O	6	Major component of plant's organic compounds
4	Nitrogen	NO_3^-, NH_4^+	1.5	Component of nucleic acids, proteins, hormones, chlorophyll, coenzyme
5	Potassium	K^+	1	Cofactor that functions in protein synthesis; major solute functioning in water balance; operation of stomata
6	Calcium	Ca^{2+}	0.5	Important informations and stability of cell walls and in maintenance of membrane structure and permeability, activates some enzyme; regulates many responses of cells to stimuli
7	Magnesium	Mg^{2+}	0.2	Component of chlorophyll; cofactor and activator of many enzymes
8	Phosphorus	$H_2PO_4^+$, HPO_4^{2-}	0.2	Component of nucleic acids, phospholipids, ATP, several coenzymes
9	Sulfur	SO_4^{2-}	0.1	Component of proteins, coenzymes
	Micronutrients			
1	Chlorine	Cl^-	0.01	Requiring for water splitting step of photosynthesis; functions in water balance
2	Iron	Fe^{3+}, Fe^{2+}	0.01	Components of cytochromes; cofactor of some enzymes, needed for photosynthesis
3	Manganese	MN^{2+}	0.005	Active in formation of amino acids; activates some enzymes, required for water splitting step of photosynthesis
4	Boron	$H_2BO_3^-$	0.002	Cofactor in chlorophyll synthesis; may be involved in carbohydrate transport and nucleic acid synthesis; role in cell wall formation
5	Zinc	ZN^{2+}	0.002	Active in formation of chlorophyll; cofactor of some enzymes; needed for DNA transcription
6	Copper	Cu^+, Cu^{2+}	0.001	Compound of many redox and lignin-biosynthetic enzymes
7	Nickle	Ni^{2+}	0.001	Cofactor of enzyme functioning in nitrogen metabolism
8	Molybdenum	MoO_4^{2-}	0.0001	Essential for mutualistic relationship with nitrogen-fixing bacteria; cofactor in nitrate reduction

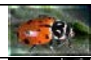
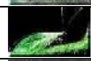
Source: Huang *et al*. (2008)

Basically, soil health is crucial for increasing productivity as it harbors enormous soil inhibiting micro- and macro-organisms. The ecosystem services provided by soil organisms include: decomposition and nutrient cycling, carbon sequestration, maintenance of plant diversity and soil fertility.

Beneficial Insects

Most insects are beneficial in natural ecosystems. As farmers grow crops, certain insects feed on these plants and are thus deemed pests. There are several insects that prey on or parasitize these pest insects (Table 5). Predatory insects are general feeders (feeding many species) or specific feeders (feeding only one or a few species). Parasitoids generally have one offspring develop in a single host insect. In addition, many insects pollinate crops.

Table 5. Some beneficial insects in an agro-ecosystem

SN	Insect	Picture	Use
1.	Lady beetle		Ladybeetles often feed on mites, thrips, scales and aphids.
2.	Lace wing		Lace wings feed on aphids.
3.	Preying mantid		Preying mantids are general predators that catch and feed on moving insects.
4.	Assassin bug		They are general feeders with sucking mouthparts.
5.	Ground beetle		They are fast moving insects and prey on other insects.
6.	Syrphid fly		Adult flies are beneficial for pollination, while the larvae feed on aphids.
7.	Tachnid fly		They feed on other insects.
8.	Braconids		They parasitize on other insects.
9.	Trichogramma		The minute wasps attack insect eggs.
10.	Honeybee		Bees are the best pollinators of plants.
11.	Bumble bee		They are important pollinators of plants.
12.	Wasps		Wasps make mud nests and prey on other insects.

Source: Barbosa (1998).

Pesticidal Plants

Commercial products of neem are available in the market and farmers are using them in vegetables and other field crops. In scattered areas, farmers have been using various botanicals in crude form on various crops in the field and in storage for controlling a variety of pests (Table 5).

Table 5. Pesticidal value of Nepal's indegenous plants

SN	Scientific name of plant	Nepali name	Part and mode of preparation	Action and properties
1.	*Acorus calamus* L.	Bojho	Bulb	Insecticide, insect repellent & contact poison
2.	*Agave Americana* L.	Ketuki	Plant sap	Insect repellent and fish poison
3.	*Allium sativum* L.	Lashun	Bulb	Insect repellent
4.	*Annona squamosa* L.	Sarifa	Leaves, immature fruits & seeds.	Insecticide and parasiticide due to glycerol of hydroxilated acid
5.	*Artemisia vulgaris* L.	Tite pati	Green or dried foliage	Repellent and fumigant against insects due to Santonin, an alkaloid
6.	*Boenin ghausenin albiflora*	Ankuri	Plant & leaf extract	Insect repellent especially to flies
7.	*Canna indica* L.	Sarbada	Extract of flower	Insecticide
8.	*Cinnamomum camphora* Nees	Kapoor	Wood solid crystal	Insect repellent used in preparation of insecticides
9.	*Crotalaria juncea* L.	Chhinchhine	Flower extracts	Effective against many insects
10.	*Chenopodium botrysis* L.	Bethe	Whole plant	Insect repellent
11.	*Derris elliptica* Bench.	Deri	Lateral line root & powdered root	Rotenone extracted from root is active ingredient of many insecticides. Root powder used as insect powder for pets
12.	*Digitalis purpurea* L.	--	Leaves and seeds	Pesticide
13.	*Feenum graeccum*	Methi	Seed	Source of insect repellent and insecticide, due to an alkaloid Trigenelline
14.	*Gynandropsis*	Marcha	Seed oil	Vermicide

15.	*Hedera helix* L.	Kathe lahare	Whole plant	Resistance to some insects
16.	*Heynea trijuga* Rexb.	Ankha taruwa	Foliage	Insect repellent
17.	*Hedychium spp.*	Kewara	Rhizome	Effective against harmful bacteria & fungi due to essential oil
18.	*Kalanchoe pinnata* pers.	Ajambari	Plant juice	Insect repellent
19.	*K. spathulata* DC	Hatti kane	Plant juice	Insect repellent
20.	*Litsea cubeba* Pers	Siltimmur	Leaves & fruits	Insect repellent, wormicide
21.	*Lannea grandis* Engle	Hallongre	Wood	Resistant to termites due to jingan gum
22.	*Mangifera indica* L.	Aap	Powdered plant	Fumigant against mosquito
23	*Mesua ferrea* L.	Nageswar	Wood	Resistant to some types of termites
24.	*Melia azedarach* L.	Bakaino	Foliage, fruit, wood & seed oil	Insecticide & insect repellent. Insecticide preparation due to Nimbidin
25.	*Nicandra phaseoloides* Gaertn	Madisetil	Fresh foliage	Insecticide
26.	*Nicotiana rustica*	Beleyati surti	Leaf	Insecticide and wormicide due to an alkaline Nicotine
27.	*Nicotiana tabacum*	Lampate surti	Leaf	Insecticide and wormicide due to an alkaline Nicotine
28.	*Nerium odorum* Ait	Pahelo karabir	Root, stem, leaf, flower, fruit extract	Contact and stomach poison to rodents, due to Nerin, an alkaloid
29.	*Sapindus mukorossi* Gaertn	Rittha	Fruit	Insecticide and fish poison
30.	*Sesamum indicum* L.	Sesame	Till	Major ingredient of insecticidal preparation
31.	*Tagetes minuta* L.	Sanosayapatri	Foliage	Insect repellent
32.	*Zanthoxylum armatum* DC	Timur	Fruit decoction foliage	Wormicide insect repellent & fish poison, due to Neehercullin an insecticidal component
33.	*Zingiber officinale* Rose	Aduwa	Ingression of rhizome extract	Body immunity against mosquitoes. Insecticide due to essential oil.

Source: Dahal, et al. (1995)

Apple Production Practices

High hill region is well known for commercial cultivation of apple. It is cultivated in Jumla, Mugu, Kalikot Mustang, and part of Rasuawa, Sindhupalchok, Dolakha, Solukhumbu, Rukum, Rolpa. *Soil fertility*: In the apple growers' fields, soil tests for pH, organic matter, NPK and maintaining soil fertility is essential. *Nursery and orchard management:* Nursery soil and site should be free from insect pests and disease, and planting materials purchased from reliable source/registered nursery. Similarly, orchard management includes intercropping, mulching, fertilization and pest management practices in eco-friendly way, such as use of FYM with *Trichoderma* 1.5 kg in 50 kgs of FYM and apply fortified FYM compost to each matured trees helps minimize root rot disease of apple. For insect pest management, spray of Servo oil @10 ml /l of water or Neem based pesticide@3-5 ml/l of water and use of Bt. @ 2gm/l of water at 7 days interval is suggested. During the flowering period honeybees are important for assured pollination of crops (FAO, 2014).

Citrus Production Practices

Citrus is cultivated in mid hill region of Nepal. *Soil fertility*: like in apple, citrus growers' fields needs soil tests for pH, organic matter, NPK and maintaining soil fertility. *Nursery and orchard management:* Nursery soil and site should be free from insect pests and disease, and planting materials purchased from reliable source/registered nursery. Fertilizer application is adjusted according to the soil test results. Growing legume crops as intercropping helps improve soil fertility, as well as trap crops for insect pests and cover crop for moisture retention. Drenching / pasting/ foliar spray with 1% Bordeaux mixture/paste/spray suppress diseases. Citrus psylla transmits citrus greening disease, so timely treatment with Neemoil 4ml/l, and servo oil 2ml/l are useful. Bioagents like, predators like ladybeetles, syrphid fly help suppress pest problems. For fruit fly management food baits and lures are effective when practiced in area wide basis. During the flowering period honeybees are important for assured pollination of crops. Spraying microbial consortium (Bio-fit) @ 1g /l or spraying *Ampelomyces quisqualis* (Powdery Care) @ 0.6g /l water protects cucurbits from mildew diseases (FAO, 2014).

Vegetable Production Practices

Different kinds of vegetables are cultivated by farmers for home consumption and sale. *Soil fertility*: like above growers' fields need soil tests for pH, organic matter, NPK and maintaining soil fertility. *Nursery and farm management:* Nursery soil and site and planting materials should be free from insect pests and diseases. Similarly, controlling aphids or whitefly through predators, parasites is useful to suppress vector transmitted diseases. For fruit fly control, pheromone traps should be placed about 5 per 5000m^2 (FAO, 2014).

Bibliography

This bibliography reviews and enlists the relevant literature in project mandated crops like apple, citrus, maize, rapeseed, and cucurbits in respect to eco-friendly cultivation practices of these crops and without disturbing ecosystem services.

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2. Adara Pardo and Paulo A.V. Borges. 2020. Worldwide importance of insect pollination in apple orchards: A review, Agriculture, Ecosystems & Environment.106839, 293. https://doi.org/10.1016/j.agee.2020.106839. Apple *(Malus domestica*) is one of the most important fruit crops globally. Apple trees depend greatly on insect pollination to achieve high yields and obtain fruits of acceptable marketable quality. Since insects, such as bees and hoverflies, are most important pollinators in apple orchards, a comprehensive understanding of their occurrence and activity is vital to ensure pollination services in this agroecosystem. Here, we review and synthesize the published research on the contribution of insects to apple pollination. In our review, we focused on the following five questions: i) Are there gaps in data availability across geographical regions and research topics? ii) What is the importance of insect pollination at determining yield and fruit quality in apple orchards? iii) What is the relative contribution of wild insects to apple pollination compared to honeybees? iv) What is the influence of landscape context (matrix) on regulating apple pollination? and v) How does agricultural management affect apple pollination?. Results showed that the information is limited for certain large apple producing countries, like China or Brazil. This finding stresses the need for further research in less studied regions. There were also gaps across research topics, highlighting the need for more experimental and empirical studies, particularly on the effect of local management practices on apple pollination. Substantial evidence from qualitative analyze. s supports the fact that insect pollination is essential for ensuring both yields and fruit quality in apple orchards across different regions. Besides, a significant proportion of studies showed that wild pollinators are abundant in apple orchards and they are frequently more effective pollinators than honeybees. Current available findings suggest a critical role of diverse semi-natural habitats surrounding apple orchards to sustain healthy pollinator communities, while the effect of local management was less consistent.

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5. Adhikari, S. 2005. *Plant*-Pollinator Interaction of the Himalayan Lousewort's with Reference to *Pedicularis dendrothauma. In:* R. R. Mill and D. J. Allard (eds.) Paper presented on Asia Section 1st Regional Conference of Society for Conservation Biology, 17-20 November 2005. Organized by the Society for Conservation Biology Asia Section, Kathmandu, Nepal.

6. Adhikari, S. and N.B. Ranabhat. 2011. Bee flora in mid hills of Central Nepal. Journal of Plant Science, Central Department of Botany, Trivuvan University, Kathmandu, Nepal. Beekeeping is one of the promising ventures for economically poor families in Nepal. Knowledge about the bee flora of a certain area is very crucial for the farmers. A study was conducted in mid hills of Central Nepal during 2003-04 and 2008-09 to monitor the common plant species visited by bees with their visiting time and seasons. The flowering period of those plant species were also observed. Observations were made on the bees' activities on flowers of different plant species. Relevant information was also collected through informal key informant interviews. The plant species visited by the bees and the bee species (mainly *Apis cerana* with some *Apis melifera*) themselves were collected, preserved and identified. Plants were categorized as major, medium and minor sources of pollen and/or nectar. The pollen and nectar statuses in different plants were also determined. A total of 158 plant species were identified as main bee flora in the study area. Among them, 19 species were horticultural plants, 42 species were crop plants, 15 species were ornamental plants

and 82 species were wild plants. In total, 38 species were recognized as major, 35 as medium and 30 as minor sources for both nectar and pollen. Months from March to May and August to October were the honey flow periods. Species of *Brassica, Citrus, Pyrus, Berberis, Rubus, Callistemon, Bombox* and *Artemisia* were some of the important plants which bloomed during those months. Winter (mid November to January) and rainy (June and July) seasons were identified as the dearth periods for bees to collect honey. Some of the plants that bloom during winter were *Pisum sativum*, *Ipomoea batata* and *Eupatorium* sp. Similarly, *Lagerstroemia* sp., *Impatiens balsamina*, *Sesamum indicum*, *Zea mays* and many cucurbits bloomed during rainy season. Study has shown that mid-hills of Central Nepal is rich in bee flora and has great potential for beekeeping as many plants bloomed even in dearth periods.

7. Adlerz, W. C. 1966. Honey bee visit numbers and watermelon pollination. *J. Econ. Ent.* 59: 28-30.

8. Adriano Sofo, Alba Nicoletta Mininni, and Patrizia Ricciuti. 2020. Soil Macro-fauna: A key Factor for Increasing Soil Fertility and Promoting Sustainable Soil Use in Fruit Orchard Agro-systems. Agronomy 10:4, pages 456. Soils and crops in orchard agro-systems are particularly vulnerable to climate change and environmental stresses. In many orchard soils, soil biodiversity and the ecosystem services it provides are under threat from a range of natural and manmade drivers. In this scenario, sustainable soil use aimed at increasing soil organic matter (SOM) and SOM-related benefits, in terms of soil quality and fertility, plays a crucial role. The role of soil macro-faunal organisms as colonizers, comminutors and engineers within soils, together with their interactions with microorganisms, can contribute to the long-term sustainability of orchard soils. Indeed, the continuous physical and chemical action of soil fauna significantly affects SOM levels. This review paper is focused on the most advanced and updated research on this argument. The analysis of the literature highlighted that a significant part of soil quality and fertility in sustainably-managed fruit orchard agro-systems is due to the action of soil macro-fauna, together with its interaction with decomposing microorganisms. From the general analysis of the data obtained, it emerged that the role of soil macro-fauna in orchards agro-systems should be seriously taken into account in land management strategies, focusing not exclusively on fruit yield and quality, but also on soil fertility restoration.

9. Afrin, S., A. Latif, N.M.A. Banu, M.M.M. Kabir, S.S. Haque, M.M. Emam Ahmed, N.N. Tonu, and M.P. Ali. 2017. Intercropping Empower Reduces Insect Pests and Increases Biodiversity in Agro-Ecosystem. Agricultural Sciences, 8, 1120-1134. https://doi.org/10.4236/as.2017.810082. Currently insect pest management solely depends on chemical pesticide that continuously affects on environment, biodiversity, animal as well as human health. Outbreak of secondary insect pest is also the cost of pesticide use in field leading crop more vulnerable to more pests. These negative impacts of pesticides have provoked growing interest in the adoption of multi-function agricultural biodiversity that promote pest management, creating interesting challenge for traditional approaches to regulatory compliance. To address multi-function agricultural practice, we tested several intercropping systems with mustard and their effect on pest management. Our results revealed that intercropping systems mustard with onion, garlic, radhuni and coriander significantly reduced pest population over sole crop. However, intercropping mustard with wheat and gram increased pest population in mustard field. This result indicated that all crops are not suitable for intercropping system. Among the tested intercropping systems, mustard with onion and coriander significantly reduced branch and flower infestation and increased pod formation per plant. These four intercropping systems did not significantly affect on honeybee pollinator which are crucial for mustard crop yield. A significant linear relationship was also found between honeybee population and pod formation. Our results indicate that suitable intercropping system can be a potential multi-functional agricultural practice for pest management in mustard crop.

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11. Aidoo, O., R. Kyerematen, C. Mensah, and K. A. Nuamah. 2016. Abundance and Diversity of Insects Associated with Citrus Orchards in Two Different Agro-ecological Zones of Ghana. Journal of Experimental Agriculture International, 13(2), 1-18. https://doi.org/10.9734/AJEA/2016/26238. We investigated the abundance and diversity of entomo-fauna associated with citrus orchards in two different agro-ecological zones of Ghana. Malaise traps, flight interception traps, pitfall traps, chemical ‘‘knock down’’ and visual observation were used for data collection. We recorded a total of 20, 285 individual insects belonging to 387 species from 107 families and 13 orders. Although, several species of insects were common to both agro-ecological

zones, some were more specific to an orchard of a particular zone. Diversity indices such as Shannon-Wiener index, Pielou's evenness and Margalef index were higher in the Coastal Savannah zone than the Semi-Deciduous Rainforest zone during both the wet and the dry seasons. *Oecophylla longinoda* Latreille was the most dominant insect species in each agro-ecological zone, however, they were more abundant in the semi-deciduous rainforest than the Coastal Savannah zone. Our study shows that only 9% of all the 387 insects collected were pests of citrus. This indicates that citrus orchards are potential habitats for insect biodiversity conservation. We therefore recommend that management tactics which have less or no negative effects on natural enemies, pollinators among others but can effectively suppress insect pest populations (such as the use of biological control agents, restriction of herbicides and pesticides) should be adopted. Our study has also provided the first comprehensive inventory of insect species associated with citrus agroecosystems serving as a baseline data for further studies to encourage adoption of economically sound integrated pest management approach for citrus production in Ghana.

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13. Alex, A.H. 1957. Honeybees aid pollination of cucumbers and cantaloupes. Gleanings in Bee Culture 85:398-400.

14. Aliev, T.A. 1971. Use of honeybees for mustard pollination. 23rd International Congress on Apiculture.

15. Allen-Wardell G, Bernhardt P, Bitner R, Burquez A, Buchmann S, Cane J. *et al*. 1998. The potential consequences of pollinator declines on the conservation of biodiversity and stability of food crop yields. Conserv. Biol. 12: 1–8. Following reports of dramatic declines in managed and feral honey bees from nearly every region of North America, scientists and resource managers from the U.S., Mexico, and Canada came together to review the quality of the evidence that honey bees as well as other pollinators are in long-term decline and to consider the potential consequences of these losses on the conservation of biodiversity and the stability of the yield of food crops. These experts in pollination ecology confirmed that the last 5 years of losses of honeybee colonies in North America leave us with fewer managed pollinators than at any time in the last 50 years and that the management and protection of wild pollinators is an issue of paramount importance to our food supply system. Although there are conclusive data that indicate 1200 wild vertebrate pollinators may be at risk, data on the status of most invertebrate species that act as pollination agents is lacking. The recommendations from a working group of over 20 field scientists, presented here, have been endorsed by 14 conservation and sustainable agriculture organizations, research institutes, and professional societies, including the Society for Conservation Biology. Among the most critical priorities for future research and conservation of pollinator species are (1) increased attention to invertebrate systematics, monitoring, and reintroduction as part of critical habitat management and restoration plans; (2) multi-year assessments of the lethal and sublethal effects of pesticides, herbicides, and habitat fragmentation on wild pollinator populations in and near croplands; (3) inclusion of the monitoring of seed and fruit set and floral visitation rates in endangered plant management and recovery plans; (4) inclusion of habitat needs for critically-important pollinators in the critical habitat designations for endangered plans; (5) identification and protection of floral reserves near roost sites along the 'nectar corridors' of threatened migratory pollinators; and (6) investment in the restoration and management of a diversity of pollinators and their habitats adjacent to croplands in order to stabilize or improve crop yields. The work group encourages increased education and training to ensure that both the lay public and resource managers understand that pollination is one of the most important ecological services provided to agriculture through the responsible management and protection of wildland habitats and their populations of pollen-vectoring animals and nectar-producing plants.

16. Altiere, M. A. 1999. The ecological role of biodiversity in agroecosystems. Agriculture Ecosystems & Environment, 74, 19–31. https://doi.org/10.1016/S0167-8809(99)00028-6. Increasingly research suggests that the level of internal regulation of function in agroecosystems is largely dependent on the level of plant and animal biodiversity present. In agroecosystems, biodiversity performs a variety of ecological services beyond the production of food, including recycling of nutrients, regulation of microclimate and local hydrological processes, suppression of undesirable organisms and detoxification of noxious chemicals. In this paper the role of biodiversity in securing crop protection and soil fertility is explored in detail. It is argued that because biodiversity mediated renewal processes and ecological services are largely biological, their persistence depends upon the maintenance of biological integrity and diversity in agroecosystems. Various options of agroecosystem management and design that enhance functional biodiversity in crop fields are described.

17. Alva, A.K., D.J. Mattos and S. Paramasivam *et al*. 2006. Potassium management for optimizing citrus production and quality. Int J Fruit Sci 6:3–43. doi: 10.1300/J492v06n01_02. Potassium (K) is highly mobile in plants at all levels, that is, from individual cell to xylem and phloem transport. This cation plays a major role in (1) enzyme activation; (2) protein synthesis; (3) stomatal function; (4) stabilization of internal pH; (5) photosynthesis; (6) turgorrelated processes; and (7) transport of metabolites. Citrus trees generally do not show visible deficiency symptoms across a wide range of K status in the leaves, except when the leaf concentrations drop below 3-4 mg kg21. However, fruit quality is quite sensitive to varying levels of K availability.

High levels of K cause large fruit size with thick and coarse peel. In contrast, K deficiency produces smaller fruits with thin peel. With regard to juice properties, K nutrition has a significant role in juice acidity; that is, high juice acidity with high K availability, while low K availability causes decrease in juice acidity. High K availability in the soil can reduce the uptake of other cations, primarily magnesium, calcium, and ammonium N. In this paper, the available information on the effects of varying availability of K on the fruit yield, postharvest quality of fruit, as well as juice quality is summarized. The current recommendations on the application of soil and leaf analysis for evaluation of the K nutritional status and guidelines for K fertilization are also discussed.

18. Andersen L., B.F. Kühn, M. Bertelsen, M .Bruus, S.E. Larsen, and M. Strandberg. 2013. Alternatives to herbicides in an apple orchard, effects on yield, earthworms and plant diversity. Agric. Ecosys. Environ. 172:1–5. doi:10.1016/j.agee.2013.04.004. https://doi.org/10.1016/j.agee.2013.04.004. In a newly established apple orchard eight alternative methods to weed control in the tree row were compared to a herbicide treatment with respect to effects on tree growth, first-quality fruit yield, earthworms and flora. All treatments were tested at two irrigation schedules, with similar amount of water at a daily or weekly basis. In general, daily irrigation reduced first-quality fruit yield compared to weekly irrigation. Mulching with black polypropylene (MyPex®) and rape straw had a positive effect on first-quality yield and shoot growth, only black polypropylene, compared to herbicide treatment, whereas mulching with paper wool reduced first-quality fruit yield compared to herbicide treatment. Cover crop as tagetes and weed harrowing had similar yield as herbicide treatment, whereas cover crops as grass and hop medick and weed cutting reduced first-quality yield compared to herbicide treatment. Earthworms thrived under rape straw contrary to under black polypropylene and plots with weed harrowing. Treatments had significant effects on species numbers of plants both years, and total vegetation cover generally increased in the second year. Rape straw supported a high production of apples and a large stock of earthworms; however, its support of wild flora is poor, when it is taken into account that a large proportion of the flora in the rape straw was rape established from seeds left with the straw.

19. Andreev, R., R. Olszak, and H. Kutinkova. 2006. Harmful and beneficial entomo-fauna in apple orchards grown under different management systems, Bull. IOBC/wprs 29, 13–19. During the period 1996-2004, the harmful and beneficial insects were observed in apple orchards of the Agricultural University Plovdiv, Bulgaria, grown under different management systems: biological, integrated and conventional (chemical). A total of 43 pests, belonging to 27 families and 5 orders were recorded in the orchard under biological pest management (BPM). In the orchards under IPM and chemical pest management (CPM) 35 and 26 species were found, respectively. The codling moth, Cydia pomonella, is the main pest of all apple orchards in Bulgaria. Other pests with a high population density in the BPM-orchard were the apple sawfly *Hoplocampa testudinea*, the pear lace bug *Stephanitis pyri*, tortricid-moths, the apple clearwing *Synanthedon myopaeformis*, the leopard moth *Zeuzera pyrina* and the weevils: Phyllobius oblongus, *Rhynchites bacchus* and *R. aequatus*. The populations of aphids, leafminers, *Epicometis hirta* and leaf-eating caterpillars increased occasionally. The populations of harmful insects in the IPM-orchard (aphids, leafminers, leopard moth and apple clearwing) increased occasionally. A high population density of harmful insects in the CPM-orchard (leafminers, aphids, *Epicometis hirta*, leopard moth and apple clearwing) was periodically observed. Beneficial insects were very abundant in the BPM-orchard. A total of 30 predators were found, belonging to 4 orders and 7 families. The ladybirds presented the highest population density and were significant as natural regulators of the small pests. Parasitoids from 7 families of Hymenoptera were important natural regulators of aphids, scale insects, leafminers, and tortricids. The population density of beneficial insects was lower in the IPM-orchard, but their importance as natural regulators of pests was still significant. In the CPM-orchard they were found occasionally.

20. Balzan, M., G. Bocci, and A. Moonen. 2014. Augmenting flower trait diversity in wildflower strips to optimise the conservation of arthropod functional groups for multiple agroecosystem services. J Insect Conserv 18:713–728. doi:10.1007/s10841-014-9680-2. Sown wildflower strips are increasingly being established in Europe for enhancing arthropod conservation and the provision of ecosystem services, including biotic pollination and natural pest control. Here we use floral traits to identify different plant functional effect groups. Floral resources were provided in four experimental levels characterised by a cumulatively increasing flower trait diversity and vegetation stand complexity. The first level consisted of a bare control strip, whilst in each subsequent level three wildflower species with different functional traits were added (Level 0: control; Level 1: three Apiaceae species; Level 2: three Apiaceae and three Fabaceae species; Level 3: three Apiaceae, three Fabaceae species, and *Centaurea* jacea (Asteraceae), Fagopyrum esculentum (Polygonaceae), Sinapis alba (Brassicaceae)). Plots with sown wildflower strip mixtures were located adjacent to experimental plots of organically-managed tomato crop, which is attacked by multiple pests and partially relies on bees for fruit production, and hence dependent on the provision of pollination and pest control services. Results obtained here show that the inclusion of functionally diverse wildflower species was associated with an augmented availability of floral resources across time, and this increased the abundance of bees and anthocorids throughout the crop season. Several natural enemy groups, such as parasitoids, coccinelids and ground-dwelling predators, were not

significantly enhanced by the inclusion of additional flower traits within the strips but the presence of flower resources was important to enhance their conservation in an arable cropping system.

21. Balvanera, P., A. B. Pfisterer, N. Buchmann *et al*. 2006. Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecology Letters* 9.10: 1146- 1156. The authors analyzed 446 studies of biodiversity effects on ecosystem functioning. Their analyses showed that biodiversity effects were stronger at the community level than the ecosystem level, and that productivity-related effects decline with increasing number of trophic links between the manipulated and the measured elements.

22. Barbosa, P. (ed.) 1998. Conservation Biological Control. Academic Press, London, UK. 396 p.

23. Barzman, M., P. Bàrberi, A. Birch, P. Boonekamp, S. Dachbrodt-Saaydeh, B. Graf, B. Hommel, J. Jensen, J. Kiss, P. Kudsk, J. Lamichhane, A. Messéan, A. Moonen, A. Ratnadass, P. Ricci, J. Sarah, and M. Sattin . 2015. Eight principles of integrated pest management. Agron Sustain Dev 35:1199–1215. doi:10.1007/s13593-015-0327-9. The use of pesticides made it possible to increase yields, simplify cropping systems, and forego more complicated crop protection strategies. Over-reliance on chemical control, however, is associated with contamination of ecosystems and undesirable health effects. The future of crop production is now also threatened by emergence of pest resistance and declining availability of active substances. There is therefore a need to design cropping systems less dependent on synthetic pesticides. Consequently, the European Union requires the application of eight principles (P) of Integrated Pest Management that fit within sustainable farm management. Here, we propose to farmers, advisors, and researchers a dynamic and flexible approach that accounts for the diversity of farming situations and the complexities of agroecosystems and that can improve the resilience of cropping systems and our capacity to adapt crop protection to local realities. For each principle (P), we suggest that (P1) the design of inherently robust cropping systems using a combination of agronomic levers is key to prevention. (P2) Local availability of monitoring, warning, and forecasting systems is a reality to contend with. (P3) The decision-making process can integrate cropping system factors to develop longer-term strategies. (P4) The combination of non-chemical methods that may be individually less efficient than pesticides can generate valuable synergies. (P5) Development of new biological agents and products and the use of existing databases offer options for the selection of products minimizing impact on health, the environment, and biological regulation of pests. (P6) Reduced pesticide use can be effectively combined with other tactics. (P7) Addressing the root causes of pesticide resistance is the best way to find sustainable crop protection solutions. And (P8) integration of multi-season effects and trade-offs in evaluation criteria will help develop sustainable solutions.

24. Beers, E.H., D.M. Suckling, R.J. Prokopy, and J. Avilla .2003. Ecology and management of apple arthropod pests. In: Ferree D, Warrington IJ (eds) Apples: botany, production and uses. CAB Intern. CABI, Wallingford, pp 489–519.

25. Belmonte, S.A., L. Celi, R.J. and Stahel, *et al*. 2018. Effect of Long-Term Soil Management on the Mutual Interaction Among Soil Organic Matter, Microbial Activity and Aggregate Stability in a Vineyard. Pedosphere 28:288–298. https://doi.org/10.1016/S1002-0160(18)60015-3. Vineyard management practices to enhance soil conservation principally focus on increasing carbon (C) input, whereas mitigating impacts of disturbance through reduced tillage has been rarely considered. Furthermore, information is lacking on the effects of soil management practices adopted in the under-vine zone on soil conservation. In this work, we evaluated the long-term effects (22 years) of alley with a sown cover crop and no-tillage (S + NT), alley with a sown cover crop and tillage (S + T), and under-vine zone with no vegetation and tillage (UV) on soil organic matter (SOM), microbial activity, aggregate stability, and their mutual interactions in a California vineyard in USA. Vegetation biomass, microbial biomass and activity, organic C and nitrogen (N) pools, and SOM size fractionation and aggregate stability were analysed. Soil characteristics only partially reflected the differences in vegetation biomass input. Organic C and N pools and microbial biomass/activity in S + NT were higher than those in S + T, while the values in UV were intermediate between the other two treatments. Furthermore, S + NT also exhibited higher particulate organic matter C in soil. No differences were found in POM C between S + T and UV, but the POM fraction in S + T was characterized by fresher material. Aggregate stability was decreased in the order: S + NT > UV > S + T. Tillage, even if shallow and performed infrequently, had a negative effect on organic C and N pools and aggregate stability. Consequently, the combination of a sown cover crop and reduced tillage still limited SOM accumulation and reduced aggregate stability in the surface soil layer of vineyards, suggesting relatively lower resistance of soils to erosion compared to no-till systems.

26. Bender, S.F., and M.G.A. van der Heijden. 2015. Soil biota enhance agricultural sustainability by improving crop yield, nutrient uptake and reducing nitrogen leaching losses. J. Appl. Ecol. 52:228–239. https://doi.org/10.1111/1365-2664.12351. Efficient resource use is a key factor for sustainable production and a necessity for meeting future global food demands. However, the factors that control resource use efficiency in agro-ecosystems are only partly understood. We investigated the influence of soil biota on

nutrient leaching, nutrient-use efficiency and plant performance in outdoor, open-top lysimeters comprising a volume of 230 L. The lysimeters were filled with sterilized soil in two horizons and inoculated with a reduced soil-life inoculum (soil biota ≤11 μm, microbially dominated) and an enriched soil-life inoculum [soil organisms ≤2 mm, also containing arbuscular mycorrhizal fungi (AMF)]. A crop rotation was planted, and nutrient leaching losses, plant biomass and nutrient contents were assessed over a period of almost 2 years. In the first year of the experiment, enriched soil life increased crop yield (+22%), N uptake (+29%) and P uptake (+110%) of maize and strongly reduced leaching losses of N (−51%, corresponding to a reduction of 76 kg N ha−1). In the second year, wheat biomass (+17%) and P contents (+80%) were significantly increased by enriched soil life, but the differences were lower than in the first year. Enriched soil life also increased P mobilization from soil (+112%) and significantly reduced relative P leaching losses (−25%), defined as g P leached per kg P plant uptake, as well as relative N leaching losses (−36%), defined as kg N leached per kg N plant uptake, demonstrating that nutrient-use efficiency was increased in the enriched soil-life treatment. Soil biota are a key factor determining resource efficiency in agriculture. The results suggest that applying farming practices, which favour a rich and abundant soil life (e.g. reduced tillage, organic farming, crop rotation), can reduce environmental impacts, enhance crop yield and result in a more sustainable agricultural system. However, this needs to be confirmed in field situations. Enhanced nutrient-use efficiency obtained through farming practices which exert positive effects on soil biota could result in reduced amounts of fertilisers needed for agricultural production and reduced nutrient losses to the environment, providing benefits of such practices beyond positive effects on biodiversity.

27. Bengtsson, J. 1998. Which species? What kind of diversity? Which ecosystem function? Some problems in studies of relations between biodiversity and ecosystem function. Appl. Soil Ecol. 10:191–199. https://doi.org/10.1016/S0929-1393(98)00120-6. I examine a number of problems that need to be identified and accounted for when examining the relationships between diversity and ecosystem function. Among these are measures of diversity and complexity in ecosystems: species richness, diversity indices, functional groups, keystone species, connectance, etc, all of which may be difficult to relate to ecosystem function. Several important distinctions, when testing diversity–function relationships empirically, are discussed: Diversity of functional groups, diversity within functional groups vs. total diversity; manipulating variables such as body-size distributions vs. manipulating diversity per se; effects of diversity vs. effects of biomass; and diversity–function relations under stable vs. changing conditions or perturbations. It is argued that for the management and development of sustainable ecosystems, it is probably more important to understand the linkages between key species or functional groups and ecosystem function, rather than focusing on species diversity. This is because there are possible mechanistic relations between what species do in ecosystems and ecosystem function. Diversity, being an abstract and aggregated property of the species in the context of communities and ecosystems, lacks such direct relations to ecosystem functions.

28. Berrie, A.M. and J.V. Cross,. .2007. Producing apples free from pesticide residues. Report of Defra project HH3122STF issued June 2007, 92 pp.

29. Bhandari, G., R.B. Thapa, Y.P. Giri, H.K. Manandhar, D. Lohman, N. Krakhauer, A. Jha, P.k. Jha, N.R. Devkota, P. Thapa and R.A. Mandal. 2017. Maize stem borer, *Chilo partellus* (Swinhoe) distribution along elevational vegetation and climate variability. Maize (*Zea mays* L.) after rice is the second most important crop of Nepal. Maize stem borer, *Chilo partellus* (Swinhoe) is the main polyphagous biotic constraint for the successful cultivation of this crop. Nepalese farmers are very vulnerable to the threats faced by climate change because they rely on weather-dependent rain-fed agricultural systems for their subsistence livelihood. With rise in temperature, the insect-pests are expected to extend their geographic range from tropics and subtropics to temperate regions at higher altitudes along with shifts in cultivation areas of their host plants. There has been reports that the plant damage and grain yield reduction due to this pest ranges 20-87% and 15-60%, respectively. Its total developmental period was 25-30 days and completed 5 generations in a year in Chitwan condition with its high incidence in lower elevation (<600m), followed by mid altitude (600-1500m) and less frequently observed in the higher altitude (1500-1900m and sometimes up to 2088 m altitude. Understanding its biology/phenology with respect to climate change and maize crop growing areas at different altitudes in useful.

30. Bhalla, O.P., Verma, A.K., Dhaliwal, H.S. 1983. Insect visitors of mustard bloom (*Brassica campestres* Var, *sarson*), their number and foraging behavior under mid-hill conditions. Journal of Entomological Research 7:15-17.

31. Bista, S. and G.P. Sivakoti. 2001. Honeybee Flora at Kavre, Dolakha District. J. Nepal Agric. Res. Vol. 4: Adequate knowledge about bee flora is the prerequisite to initiate bee keeping. A study was conducted at Kavre area of Dolakha district during 1997-1999 to identify existing bee flora and develop a floral calendar. Based on the interview with bee farmers and visual observations, 119 important plant species were recorded, out of which 47 species were found major sources for honeybees. Spring season (mid-March to mid-June) and autumn season (mid-Sept to Oct) were identified as honey flow periods having a number of floral plants such as *Guizotia abyssinica*, *Fraxinus floribunda*, *Prunus cerasoides*, *Pyrus communis*, *Castanopsis indica*, *Brassica* spp., *Citrus* spp., *Berberis* spp., *Rubus* spp., *Rhododendron* spp. and *Trifolium* spp. Winter season (mid- Nov to Feb) is the critical dearth period with a few flowering plants like *Reinwardtia indica*, *Pogestemon glaber*, *Caesalpinia* spp. and *Eupatorium* spp. Depending upon the climatic conditions, possibility of planting multipurpose plants has been discussed. Based on available flora, major characteristics of these plant species, utility status and flowering duration a bee floral calendar was developed for Kabre. To conserve these floras, attention must be made to maintain and multiply the existing flora.

32. Björkman, T. 1995. Role of honeybees (Hymenoptera: Apidae) in the pollination of buckwheat in eastern North America. J. Econ. Entomol. 88:1739-1745. Seed production in buckwheat, *Fagopyrum esculentum* Moench, can be lower than expected from the plant biomass. Low seed production is often blamed on inadequate pollination. Honey bees, *Apis mellifera* L., were at least 95% of the insect visitors to buckwheat flowers in fields of central New York State. The number of times each flower was visited by a honey bee ranged from zero to >40, but the number of honey bee visits did not increase daily seed initiation if each flower was visited at least twice. Pollen delivery sometimes limited seed set, but limitation was not associated with low honey bee visitation frequency. The yield and genetic quality of buckwheat is best with pollen deliveries of at least 10 grains, but honey bees (It-livered less pollen. The time between delivery of the 1st and 10th pollen grain was ≍ 1 h, which is more than enough for fertilization to occur. Buckwheat in New York is pollinated primarily by honey bees, but bee behavior is not well adapted to the crop, and the effectiveness of bees as pollinators was not improved at higher bee populations.

33. Bockstael, N. E., A. M. Freeman, R. J. Kopp, P. R. Portney, and V. K. Smith. 2000. On measuring economic values for nature. *Environmental Science & Technology* 34.8: 1384-1389. The authors explained the concept of "values" in so far as it applies to economics, and presented methods to measure the economic values of nature. They explained that the economic value for an ecosystem service relates to the contribution it makes to human well-being.

34. Bohensky, E., and Y. Maru. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "Integration"? Ecology and Society, 16(4), 6. Despite the increasing trend worldwide of integrating indigenous and scientific knowledge in natural resource management, there has been little stock-taking of literature on lessons learned from bringing indigenous knowledge and science together and the implications for maintaining and building social-ecological system resilience. In this paper we investigate: (1) themes, questions, or problems encountered for integration of indigenous knowledge and science; (2) the relationship between knowledge integration and social-ecological system resilience; and (3) critical features of knowledge integration practice needed to foster productive and mutually beneficial relationships between indigenous knowledge and science. We examine these questions through content analyses of three special journal issues and an edited book published in the past decade on indigenous, local, and traditional knowledge and its interface with science. We identified broad themes in the literature related to: (1) similarities and differences between knowledge systems; (2) methods and processes of integration; (3) social contexts of integration; and (4) evaluation of knowledge. A minority of papers discuss a relationship between knowledge integration and social-ecological system resilience, but there remains a lack of clarity and empirical evidence for such a relationship that can help distinguish how indigenous knowledge and knowledge integration contribute most to resilience. Four critical features of knowledge integration are likely to enable a more productive and mutually beneficial relationship between indigenous and scientific knowledge: new frames for integration, greater cognizance of the social contexts of integration, expanded modes of knowledge evaluation, and involvement of inter-cultural "knowledge bridgers."

35. Bot, A. and J. Benites. 2005. The importance of soil organic matter. Key to drought-resistant soil and sustained food production. Bull FAO N° 80 89–94.

36. Boyd, J., and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics* 63.2-3: 616-626. The authors defined ecosystem services as components of nature, directly enjoyed, consumed, or used; they suggested that services are end products of nature. They stated that practical units of measurement are stocks (e.g., number of bees), and that services are spatially explicit.

37. Bradford, M.A. 2014. Good dirt with good friends. Nature 505:486–487. https://doi.org/10.1038/nature12849.

38. Brown, M, and T. Tworkoski. 2004. Pest management benefits of compost mulch in apple orchards. Agric Ecosyst Environ 103:465–472. doi:10.1016/j.agee.2003.11.006. The effect of compost application on weed, fungal, and insect pest management in apple orchards was investigated from 1999 to 2001. Composted poultry manure was applied in June 1999 to half of two small research orchards which had previously received little or no management. The compost provided weed control for 1 year after application. There was no effect of compost on apple scab (*Venturia inaequalis*) infection. In a laboratory experiment, growth of the brown rot fungus (*Monilinia fructicola*) was significantly slower on a compost substrate than a sterilized compost substrate. The compost significantly affected arthropod abundance during two years after application, with more predators and fewer herbivores in the compost treated plots. Populations of spotted tentiform leafminer (*Phyllonorycter blancardella*) and migrating woolly apple aphid (*Eriosoma lanigerum*) nymphs were reduced in the compost plots. This study showed that the use of compost in an orchard ecosystem is beneficial to management of weed, fungal, and insect pests. The use of compost as a mulch in orchard ecosystems should be encouraged as a sustainable management practice because of a potential to reduce pesticide use.

39. Bryan, B. A., C. M. Raymond, N. D. Crossman, and D. H. Macdonald. 2010. Targeting the management of ecosystem services based on social values: Where, what, and how? *Landscape and Urban Planning* 97.2: 111-122. This study used methods from ecology to conduct a spatial analysis for conservation planning that considers social values. According to the authors, biophysical and economic values are mapped for spatial planning, but social values are rarely considered. This study illustrated how identifying and mapping social values might help manage ecosystem services at the landscape level.

40. Busari, M. A., S. S. Kukal, A. Kaur, R. Bhatt, and A.A. Dulazi. 2015. Conservation tillage impacts on soil, crop and the environment. International Soil and Water Conservation Research, 3(2), 119–129. https://doi.org/10.1016/j.iswcr.2015.05.002. There is an urgent need to match food production with increasing world population through identification of sustainable land management strategies. However, the struggle to achieve food security should be carried out keeping in mind the soil where the crops are grown and the environment in which the living things survive. Conservation agriculture (CA), practising agriculture in such a way so as to cause minimum damage to the environment, is being advocated at a large scale world-wide. Conservation tillage, the most important aspect of CA, is thought to take care of the soil health, plant growth and the environment. This paper aims to review the work done on conservation tillage in different agro-ecological regions so as to understand its impact from the perspectives of the soil, the crop and the environment. Research reports have identified several benefits of conservation tillage over conventional tillage (CT) with respect to soil physical, chemical and biological properties as well as crop yields. Not less than 25% of the greenhouse gas effluxes to the atmosphere are attributed to agriculture. Processes of climate change mitigation and adaptation found zero tillage (ZT) to be the most environmental friendly among different tillage techniques. Therefore, conservation tillage involving ZT and minimum tillage which has potential to break the surface compact zone in soil with reduced soil disturbance offers to lead to a better soil environment and crop yield with minimal impact on the environment.

41. Cáceres, D. M., E. Tapella, F. Quétier, and S. Díaz. 2015. The social value of biodiversity and ecosystem services from the perspectives of different social actors. *Ecology and Society* 20.1:62. This paper quantified how different social actors perceive the ecosystem services associated with six ecosystem types in Argentina. The authors found that subsistence farmers and extension officers valued more ecosystem services associated with pristine forests than the other social actors. In addition, conservation officers and policymakers identified many more ecosystem services than cattle ranchers and large farmers.

42. Cadotte, M. W., K. Carscadden, and N. Mirotchnick. 2011. Beyond species: Functional diversity and the maintenance of ecological processes and services. *Journal of Applied Ecology* 48.5:1079-1087. The authors made a clear case for using functional diversity instead of species richness when analyzing the relationship between biodiversity and ecosystem functioning. They stated that functional diversity should be incorporated into conservation and restoration analyses and decision making to ensure the maintenance of ecosystem processes and services.

43. Camara, K.M., W.A. Payne, and P.E. Rasmussen. 2003. Long-term effects of tillage, nitrogen, and rainfall on winter wheat yields in the Pacific Northwest. Agron. J, 95, 828–835. https://doi.org/10.2134/agronj2003.8280. Sustainable cropping systems are essential for agronomic, economic, and environmental reasons. Data from a winter wheat (*Triticum aestivum* L.)/summer fallow rotation experiment, in eastern Oregon, was used to evaluate long-term effects of tillage, N, soil depth, and precipitation on yield. The soil is a Walla Walla silt loam (coarse-silty, mixed, mesic Typic Haploxeroll). The experiment consisted of three tillage treatments (moldboard plow, offset disk, and subsurface sweep) and six N treatments. Four main time periods (1944–1951, 1952–1961, 1962–1987, 1988–1997), were identified, within which experimental treatments were consistently maintained. Depth to bedrock ranged from 1.2 to 3.0 m. Yield was significantly greater (>300 kg ha^{-1}) for the moldboard plow than for the subsurface sweep in all time periods. Yield was generally greater (>100 kg ha^{-1}) for the

moldboard plow than for the offset disk, but only significantly in Time Periods 3 and 4. For Periods 1 and 2, the addition of N fertilizer tended to produce higher yields, regardless of quantity or distribution of rainfall. For Period 3, yield did not increase with the addition of more than 45 kg N ha^{-1}, which we attribute to below-normal precipitation. For Period 4, when precipitation was above average, yield increased with the addition of up to 90 kg N ha^{-1}. Results demonstrated that despite beneficial effects on soil properties, conservation tillage has tended to be less productive for this cropping system than moldboard plowing, probably due to lack of downy brome weed control in the conservation tillage systems.

44. Campbell, C.G. 1997. Buckwheat *Fagopyrum esculentum* Moench. Institute of Plant Genetics and crop Plant Research, Gatersleben / International Plant Genetic Resources Institute,, Rome, Italy.

45. Canali, S., G. Roccuzzo, F. Tittarelli, C. Ciaccia, S. Fiorella, and F. Intrigliolo. 2012. Organic Citrus: Soil Fertility and Plant Nutrition Management. In: Srivastava A. (eds) Advances in Citrus Nutrition. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4171-3_24. During the last decade, the organic food and farming (OFF) sector has grown considerably worldwide. Citrus play an important role in organic farming systems, being one of the most highly demanded products on the market for organic produce. In this chapter, the criteria for citrus orchards fertility management and plant nutrition in the organically managed agroecosystems are discussed in the light of the most relevant scientific literature. Moreover, two case studies carried out in Southern Italy and aimed at comparing conventional and organic orange management in terms of yield, yield quality and long-term impact on soil fertility are reported. The body of knowledge available and the results presented demonstrate that organic citrus management is a technically feasible option for citrus growers. In addition, the shift to organic farming could contribute to enhance the environmental sustainability of citrus productions in the long term.

46. Canali, S. A. Trinchera, F. Intrigliolo, L. Pompili, L. Nisini, S. Mocali, and B. Torrisi. 2004. Effect of long term addition of composts and poultry manure on soil quality of citrus orchards in Southern Italy. Biol. Fertil. Soils 2004, 40, 206–210. https://doi.org/10.1007/s00374-004-0759-x. A 6-year study was conducted in an organically managed orange orchard located in Sicily (Southern Italy) to assess the effect of compost and organic fertiliser utilisation on soil quality. Adopting a randomised-block experimental design with three replicates, four treatments were carried out. In treatments 1 and 2, two different composts (C1 from distillery by-products and C2 from livestock waste) were applied. The plots of treatment 3 were fertilised using dried poultry manure. The control treatment was fertilised by mineral/synthetic fertilisers. In order to verify the hypothesis that composts and organic fertilisers improve soil fertility, soil quality was evaluated by selecting dynamic soil parameters, as indicators linked to C and N cycles. Total organic C, total N, C/N ratio, humified fraction, isoelectric focussing (IEF) of extracted organic matter, microbial biomass C, potentially mineralisable N under anaerobic conditions, potentially mineralisable C, C mineralisation quotient and metabolic quotient were determined for each sample. Moreover, the Community Level Physiological Profile (by Biolog technique) was defined, calculating derived functional biodiversity and versatility indexes. Parameters related to IEF and potentially mineralisable C showed significant differences among the treatments. Moreover, total C, total N and humification parameters tended to increase, while no differences were observed in biodiversity indexes. On these findings, it was concluded that composts and poultry manure only weakly affected soil properties, though they increased soil potentially available nutritive elements to crops.

47. Carpenter, S., E. Bennett, and G. Peterson. 2006. Scenarios for ecosystem services: An overview. *Ecology and Society* 11.1: 29. This paper evaluated the Millennium Ecosystem Assessment scenarios and their implications for the management of ecosystem services. After conducting quantitative and qualitative analyses, the authors concluded that the MEA scenarios are a tool for analyzing trade-offs between ecosystem services and exploring logical consequences for different policies that manage ecosystem services.

48. Carpenter, S. R., H. A. Mooney, J. Agard, *et al*. 2009. Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proceedings of the National Academy of Sciences* 106.5: 1305-1312. This paper argues that the current science evaluating ecosystem services is fragmented. The authors advocated for science that elaborates on a social-ecological systems approach, claiming that policies and practices for ecosystem services could be enhanced by evaluating the feedbacks between biophysical and social systems.

49. CBS. 2019. Agriculture statistics Nepal. Central Bureau of Statistics, Ramshah Path, Kathmandu, Nepal.

50. Chan, K. M. A., M. R. Shaw, D. R. Cameron, E. C. Underwood, and G. C. Daily. 2006. Conservation planning for ecosystem services. *PLoS Biology* 4.11: 2138-2152. The first incorporation of multiple ecosystem services targets alongside biodiversity in a conservation planning analysis. The case study in the central coast ecoregion of California included crop pollination, forage production, water provision, carbon storage, outdoor recreation, and flood mitigation alongside biodiversity targets using the Marxan planning tool.

51. Chan, K. M. A., P. Balvanera, K. Benessaiah, et al. 2016. Opinion: Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences* 113.6: 1462-1465. The authors argued that conservation has mostly focused on instrumental or intrinsic values of nature, but that it is time to engage with a third class of values that they term relational values. Relational values are preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms, between people and nature**.**

52. Chan, K. M. A., T. Satterfield, and J. Goldstein. 2012. Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics* 74:8-18. The authors argued that the effectiveness of the ecosystem services framework in decision making is hindered by the conflation of services, values, and benefits, and a failure to treat diverse kinds of values. The authors distinguished eight dimensions of values, and proposed a typology for the classification of the nonuse and cultural values of ecosystem services.

53. Ching, L.L. and D. Stabinsky. 2011. Ecological agriculture is climate resilient. In: UN Climate Change Conference November 28-December 9, 2011, Durban, Third World Network Briefing Paper 1. Penang: Third World Network.

54. Choruma, D.J. and O.N. Odume. 2019. Exploring Farmers' Management Practices and Values of Ecosystem Services in an Agroecosystem Context—A Case Study from the Eastern Cape, South Africa. Sustainability 2019, 11, 6567. https://doi.org/10.3390/su11236567. Globally, farmers remain the key ecosystem managers responsible for increasing food production while simultaneously reducing the associated negative environmental impacts. However, research investigating how farmers' agricultural management practices are influenced by the values they assign to ecosystem services is scarce in South Africa. To address this gap, a survey of farmers' agricultural management practices and the values they assigned towards ecosystem services was conducted in the Eastern Cape, South Africa. Results from the survey show that farmers assign a high value on food provisioning ecosystem services compared to other ecosystem services. Irrigation and fertilizer decisions were mostly based on achieving maximum crop yields or good crop quality. The majority of farmers (86%) indicated a willingness to receive payments for ecosystem services (PES) to manage their farms in a more ecosystems-oriented manner. To encourage farmers to shift from managing ecosystems for single ecosystem services such as food provision to managing ecosystems for multiple ecosystem services, market-oriented plans such as PES may be employed. Effective measures for sustainable intensification of food production will depend on the inclusion of farmers in the development of land management strategies and practices as well as increasing farmers' awareness and knowledge of the ecosystem services concept.

55. Ciaccia, C.. A. La Torre, F. Ferlito, E. Testani, V. Battaglia, L. Salvati, and G. Roccuzzo. 2019. Agroecological Practices and Agrobiodiversity: A Case Study on Organic Orange in Southern Italy. Agronomy 2019, 9, 85. https://doi.org/10.3390/agronomy9020085. The integration of Agroecological Service Crops (ASCs) into agroecosystems can provide several ecological services, such as nutrient cycling and disease and weed management. A two-year experiment on an organic orchard was carried out to compare barley (B) and horse bean (HB) ASCs with a control without ASC (Cont) in combination with fertilizers. Their effects on soil fertility and weed- and soil-borne fungi communities were evaluated by direct measurements, visual estimation, and indicators computation. A Principal Component Analysis (PCA) was used to identify latent patterns and redundancy among variables, whereas a correlation analysis was used to discriminate the compared systems within the PCA matrix. The empirical results of this study put in evidence the correlation among soil, weed, and fungal variables. A slight contribution of fertilizers on the system's variability was observed, whereas a clear effect of ASCs was highlighted. The systems differed in weed communities, with the lowest density associated to B and the highest to Cont. B showed the highest fungal diversity, with changes in community compared to HB. HB showed a contribution on soil fertility, being associated to organic matter increase and N availability, and evidencing mixed impacts on soil quality and ecosystem functioning. Overall, the above-ground diversity and below-ground community results were inter-correlated.

56. Collison, C. H. 1973. Nectar secretion and how it affects the activity of honey bees in the pollination of hybrid pickling cucumbers *Cucumis sativus* L. M.Sc. Thesis, Michigan State University, East Lansing, USA.

57. Colloff, M., E. Lindsay, and D. Cook. 2013. Natural pest control in citrus as an ecosystem service: integrating ecology, economics and management at the farm scale. Biol. Control 67:170–77. https://doi.org/10.1016/j. biocontrol.2013.07.017. While we were completing a year-long survey of soil invertebrates in eight citrus orchards in South Australia, there was an outbreak of Kelly's citrus thrips (*Pezothrips kellyanus*). Four growers in our survey reported their orchards were free of thrips, while the others reported suffering serious economic damage. A retrospective analysis, using data from the invertebrate survey, showed that orchards without thrips damage all had dense ground cover (perennial grasses, diverse forbs and with a deep litter layer), whereas orchards with thrips damage all had patchy ground cover (bare

mineral soil with scattered annual weeds or a sparse monoculture of lucerne or oats and no litter layer). Orchards with dense ground cover and no thrips damage had far denser populations of predatory mesostigmatid mites (mean 6471 ± 692 m−2 1 SE) compared with orchards with patchy ground cover and thrips damage (1097 ± 126 m−2). Most Mesostigmata (total 17 spp.) were generalist predators, capable of feeding on thrips larvae when they move from the fruit to the soil to pupate. We suggest the absence of thrips damage is causally related to the presence of a diverse, abundant fauna of natural enemies, enhanced by good quality ground cover habitat and that growers with no thrips damage are benefitting from the ecosystem service of natural pest control. Using three scenarios of increasing severity of thrips damage (10%, 20% and 40%), we estimated the mean value of natural pest control of thrips as an ecosystem service was A$ 2640, A$ 4610 and A$ 8540 per hectare for those orchards that benefited from the service, whereas those orchards that received no such benefit potentially lost A$ 1970, A$ 3260 and A$ 5850 respectively. Our findings led to the planting of improved ground cover as habitat for predators by three growers, and the development of a commercial predator biocontrol agent for thrips by a fourth, based on mites harvested from his orchard. Growers who had effective natural pest control of thrips are more likely to have greater economic resilience in relation to price volatility shocks than those growers who do not benefit from this ecosystem service.

58. Connor, L.J., Martin, E.C. 1969. Honeybee activity in hybrid cucumbers. (*Apis melifera* L.). Entomological Society of America 24:25-26.

59. Costanza, R., R. d'Arge, R. de Groot, and S. Farber. 1998. The value of the world's ecosystem services and natural capital. *Ecological Economics* 25:3-15. The authors estimated the economic value of seventeen ecosystem services for 16 biomes, based on published studies and some original calculations. The estimated value of the world's ecosystems was US$33 trillion per year, and the authors suggested that this is a minimum estimate due to nature's uncertainties.

60. Cross, J,, M. Fountain, V. Marko, C. Nagy. 2015. Arthropod ecosystem services in apple orchards and their economic benefits. Ecol. Entomol. 40:82–96. doi:10.1111/een.12234. Apple is grown as a long-term perennial crop and orchards provide relatively stable ecological habitats. Only a small proportion of the diverse fauna of arthropods that can inhabit the orchard ecosystem are important pests, the majority of species being minor pests, beneficial or benign. In this paper, the interacting ecosystem services provided by five contrasting naturally occurring arthropod groups in cool temperate apple orchards are reviewed, and their economic benefits broadly quantified. These are: The roles of bees and other insects in apple pollination increasing yields and fruit quality, the economic value of which may be significantly underestimated. Naturally occurring, pesticide-resistant phytoseiid predatory mites and their role in regulating phytophagous mites. They eliminate the need for 1–2 acaricide sprays per annum and the risk of acaricide resistance. The earwig *Forficula auricularia* L. and its role in regulating several important apple pests. There is great variability in populations between orchards for reasons not fully understood. It is estimated that *F. auricularia* reduces insecticide applications by 2–3 per annum and reduces pest damage. Mutualism between the common black ant *Lasius niger* (L.) and important pest aphids, the roles of competitors, natural and artificial food sources, and ant exclusion in disrupting mutualism which can foster biocontrol of aphids by generalist predators so greatly reducing the need for sprays. Beneficial epigeic arthropods and their role in predating the soil dwelling life stages of insect pests. These contribute to the control of pest populations although the level of suppression is not consistent depending on several ecological factors.

61. Dahal, L., Baker, S.L., and Gyawali, B.K., 1995: "Promoting Proper Use of Pesticides use in Nepal", HMG/Ministry of Agriculture/Winrock International, Nepal.

62. Dahal, K.M., B. Poudel, A.P. Poudel, S., Piya, B. Khanal and A.P. timilsina Coll. & Eds). 2019. New agriculture technology. Government of Nepal, NARC Outreach Division, Khumaltar, Lalitpur, Nepal. Agriculture plays an important role in the economic development of Nepal and commercialization of agriculture is our responsibility. This collection and compilation includes newer and improved technologies in agriculture tested by NARC in its outreach program with this compilation in Nepali language for technology transfer to the farmers in Nepal.

63. Daily, G. C. 1997. Introduction: What are ecosystem services? In *Nature's services: Societal dependence on natural ecosystems*. Edited by G. C. Daily, 1-10. Washington, DC: Island Press. This book chapter provided the first clear definition for

ecosystem services. It explained that these maintain biodiversity and the production of ecosystem goods, such as seafood, forage, and timber. The authors stated that in addition to the production of goods, ecosystem services are life-support functions such as cleansing, recycling, and renewal, as well as aesthetic benefits.

64. Daily, G. C., S. Polasky, J. Goldstein, et al. 2009. Ecosystem services in decision making: Time to deliver. *Frontiers in Ecology and the Environment* 7.1: 21-28. This article operationalized the concept of ecosystem services to inform decision making. It created a conceptual framework that included the biological (i.e., ecosystems, services) and socioeconomic dimensions of ecosystem services (i.e., values, institutions, decisions).

65. Dale, V.H. and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological Economics, 64(2), 286–296. https://doi.org/10.1016/j.ecolecon.2007.05.00. Agriculture produces more than just crops. Agricultural practices have environmental impacts that affect 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. Understanding the contribution of various agricultural practices to the range of ecosystem services would help inform choices about the most beneficial agricultural practices. To accomplish this, however, we must overcome a big challenge in measuring the impact of alternative agricultural practices on ecosystem services and of ecosystem services on agricultural production. A framework is presented in which such indicators can be interpreted as well as the criteria for selection of indicators. The relationship between agricultural practices and land-use change and erosion impact on chemical use is also discussed. Together these ideas form the basis for identifying useful indicators for quantifying the costs and benefits of agricultural systems for the range of ecosystem services interrelated to agriculture.

66. Daniel, T. C., A. Muhar, A. Arnberger, et al. 2012. Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences* 109.23: 8812-8819. This paper stressed the importance for integrating social science methods in the assessment of cultural ecosystem services. The authors linked ecological structures and functions to various cultural ecosystem services.

67. Darwin, C. 1876. *The effects of cross and self fertilization in the vegetable kingdom.* London: Murray.

68. de Bello, F., S. Lavorel, S. Díaz, et al. 2010. Towards an assessment of multiple ecosystem processes and services via functional traits. *Biodiversity and Conservation* 19.10: 2873-2893. This literature review synthesized the available information connecting functional traits with ecosystem processes and services. They introduced the term trait-service clusters to inform decision making regarding the conservation and management of ecosystem services.

69. de Groot, R. S., R. Alkemade, L. Braat, L. Hein, and L. Willemen. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity* 7.3: 260-272. The authors described the main challenges associated with the integration of ecosystem services in environmental management, including (1) a lack of indicators to test the capacity of ecosystems to provide services, (2) a lack of methods that apprehend the importance of the value of ecosystem services, and (3) a lack of management institutions that deal with multiple ecosystem services.

70. Demestihas, C., D. Plénet, and M. Génard *et al*. 2017. Ecosystem services in orchards. A review. Agron. Sustain. Dev. 37, 12 (2017). https://doi.org/10.1007/s13593-017-0422-1. Arboriculture must maintain acceptable fruit production levels while preserving natural resources. This duality can be analyzed with the concept of ecosystem service. We reviewed the literature on orchards to explain how ecological functions modified by agricultural practices provide six ecosystem services - fruit production, climate regulation, soil nitrogen availability, water regulation, pest and disease control, and pollination - and which indicators could describe them. The major points are, first, that orchards have a high potential of multiple services. They can sequester from 2.4 to 12.5 t C/ha/year. Their perennial character and multi-strata habitat, as well as the opportunity of creating diversified hedgerows and cover crops in alleys, may contribute to a high level of biodiversity and related services. Second, every service depends on many functions. Fruit yield, which could reach up to 140 t/ha in apple orchards, is increased by light interception, carbon allocation, and nitrogen and water uptake. Third, agricultural practices in orchards have a strong impact on ecosystem functions and, consequently, on ecosystem services. Over-fertilization enhances nitrogen leaching, which reduces soil nitrogen availability for the plant and deteriorates the quality of drained water. Groundcover increases humification and reduces denitrification and runoff, thus enhancing soil nitrogen availability and water regulation. It also enhances biotic interactions responsible for pest control and pollination. Pruning may increase fruit quality trough a better carbon allocation but decreases pest control by fostering the dynamics of aphids. To study multiple ecosystem services in orchards, we suggest using models capable of simulating service profiles and their variation according to management scenarios. We then refer to the available literature to show that conflicts between provisioning and regulating services can be mitigated by agricultural practices.

Improved knowledge of soil processes and carbon balance as well as new models that address multiple services are necessary to foster research on ecosystem service relationships in orchards.

71. Devkota, D.C., K.R.Gosai and D. Devkota. 2017. Economic impact analysis of current climate change variability and future impacts in agricultural sectors of Nepal. Nepal Journal of Environmental Science 591):49-56. Nepal's economy is largely based on agriculture, predominantly small scale farming and about half of which is dependent on natural rainfall in Nepal and is highly climatic sensitive sector. Historically, the sector has been affected by floods, droughts and erratic rainfall. This study focused on the impacts and economic costs of climate change in agriculture and assessed perception of communities of Kaski and Mustang districts on frequency and intensity of hailstorm events over time including their related impacts.

72. Devkota, F. P. 2000. Impacts of bee pollination on the yield of broccoli (*Brassica campestris* var. *botrytis* L.) under Chitwan condition. M. S. Thesis submitted to Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal.

73. Dhakal, G. 2003. Efficiency of *Apis mellifera* L. and *Apis cerana* F. for pollinating mustard and buckwheat. M. Sc. Thesis submitted to Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal.

74. Di Prima, S,, J. Rodrigo-Comino, and A. Novara *et al*. 2018. Soil Physical Quality of Citrus Orchards Under Tillage, Herbicide, and Organic Managements. Pedosphere 28:463–477. https://doi.org/10.1016/S1002-0160(18)60025-6. Soil capacity to support life and to produce economic goods and services is strongly linked to the maintenance of good soil physical quality (SPQ). In this study, the SPQ of citrus orchards was assessed under three different soil managements, namely no-tillage using herbicides, tillage under chemical farming, and no-tillage under organic farming. Commonly used indicators, such as soil bulk density, organic carbon content, and structural stability index, were considered in conjunction with capacitive indicators estimated by the Beerkan estimation of soil transfer parameter (BEST) method. The measurements taken at the L'Alcoleja Experimental Station in Spain yielded optimal values for soil bulk density and organic carbon content in 100% and 70% of cases for organic farming. The values of structural stability index indicated that the soil was stable in 90% of cases. Differences between the soil management practices were particularly clear in terms of plant-available water capacity and saturated hydraulic conductivity. Under organic farming, the soil had the greatest ability to store and provide water to plant roots, and to quickly drain excess water and facilitate root proliferation. Management practices adopted under organic farming (such as vegetation cover between the trees, chipping after pruning, and spreading the chips on the soil surface) improved the SPQ. Conversely, the conventional management strategies unequivocally led to soil degradation owing to the loss of organic matter, soil compaction, and reduced structural stability. The results in this study show that organic farming has a clear positive impact on the SPQ, suggesting that tillage and herbicide treatments should be avoided.

75. Dias, N.P., M.J. Zotti, P. and Montoya, *et al*. 2018. Fruit fly management research: A systematic review of monitoring and control tactics in the world. Crop Protection 112:187–200. https://doi.org/10.1016/j.cropro.2018.05.019. Several fruit fly species are invasive pests that damage quality fruits in horticultural crops and cause significant value losses. The management of fruit flies is challenging due to their biology, adaptation to various regions and wide range of hosts. We assessed the historical and current approaches of fruit fly management research worldwide, and we established the current knowledge of fruit flies by systematically reviewing research on monitoring and control tactics, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. We performed a systematic review of research outputs from 1952 to 2017, by developing an a priori defined set of criteria for subsequent replication of the review process. This review showed 4900 publications, of which 533 publications matched the criteria. The selected research studies were conducted in 41 countries for 43 fruit fly species of economic importance. Although 46% of the studies were from countries of North America, analysis of the control tactics and studied species showed a wide geographical distribution. Biological control was the most commonly studied control tactic (29%), followed by chemical control (20%), behavioral control, including SIT (18%), and quarantine treatments (17%). Studies on fruit flies continue to be published and provide useful knowledge in the areas of monitoring and control tactics. The limitations and prospects for fruit fly management were analyzed, and we highlight recommendations that will improve future studies.

76. Díaz, S., S. Demissew, J. Carabias, et al. 2015. The IPBES conceptual framework—connecting nature and people. *Current Opinion in Environmental Sustainability* 14:1-16. The articulation of and justification for the IPBES Conceptual Framework, which will orient the work of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. The framework features a diverse set of conceptualizations of nature and its benefits and associated values, including intrinsic, instrumental, and relational.

77. Didelot, F., L. Brun, and L. Parisi. 2007. Effects of cultivar mixtures on scab control in apple orchards. Plant Pathol 56:1014–1022. doi:10.1111/j.1365-3059.2007.01695.x. The effects of two mixtures of resistant and susceptible apple cultivars on the development of scab caused by Venturia inequalis were observed in an experimental orchard over four years, initially for

two years without fungicides against scab, and subsequently for two years with a moderate fungicide schedule. The row-by-row and within-row mixtures included a susceptible cultivar and a resistant cultivar in equal proportions. Without fungicides, the results showed a significant reduction of disease incidence over both years (7·3 to 21·3%), and severity in the second year (35·4%) in the within-row mixtures, compared to the monoculture of the susceptible cultivar. The best results were obtained when the within-row mixture was associated with moderate fungicide treatments; in this case the reduction in disease incidence reached 75·1% on leaves and 69·7% on fruits during the growth phase. The characteristics of the Venturia inaequalis/Malus × domestica pathosystem and the results obtained in this experiment suggest a moderate but not negligible ability of cultivar mixtures for reducing epidemics of the disease.

78. Elena S. A., Aleksandr L. B. 2000. Bee visitation, nectar productivity and pollen efficiency of common buckwheat. Scientific Research Institute of Groat Crops, Shevchenko St. 13, Kamenets Podolsky, 32316, Ukraine. Fagopyrum 17: 77-80. (Abstract: Common buckwheat is broadly used for honey production in bee-keeping as well as for grain production. Due to its short vegetative period and the possibility of cultivation during the whole non-frost period, common buckwheat can be used as a honey-producing crop. Bees visit buckwheat for the collection of nectar and pollen grains. Honey and pollen efficiency of buckwheat depends on the biological characteristics of cultivated varieties.

79. Engel, S., S. Pagiola, and S. Wunder. 2008. Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* 65.4: 663-674. This paper described payments for ecosystem services programs and their scope. It summarized the characteristics of PES programs and how PES compared to other policy instruments. The authors concluded that PES is attractive in situations where ecosystem service providers are poor, marginalized landholders, given the association with the beneficiary- pays rather than the polluter-pays principle.

80. FAO—Food and Agriculture Organization of the United Nations. Integrated Soil and Water Management for Orchard Development. Role and Importance; FAO: Rome, Italy, 2005. Available online: http://www.fao.org/3/a0007e/ a0007e00.htm (accessed on 25 March 2020).

81. FAO. 2014. Local good agriculture practice: Nepal IPM standard. National IPM Program, DOA/PPD, Harihar Bhawan, Lalitpur, Nepal. Local good agricultural practices for national IPM standards are outlined for some vegetable crops with fruits like apple, citrus including tea and ginger.

82. FAO. 2019. The state of the world’s biodiversity for food and agriculture In: J. Bélanger & D. Pilling (eds.). FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 p. Biodiversity is the variety of life at genetic, species and ecosystem levels. Biodiversity for food and agriculture (BFA) is, in turn, the subset of biodiversity that contributes in one way or another to agriculture and food production. It includes the domesticated plants and animals raised in crop, livestock, forest and aquaculture systems, harvested forest and aquatic species, the wild relatives of domesticated species, other wild species harvested for food and other products, and what is known as “associated biodiversity”, the vast range of organisms that live in and around food and agricultural production systems, sustaining them and contributing to their output. Biodiversity for food and agriculture is indispensable to food security, sustainable development and the supply of many vital ecosystem services. Biodiversity makes production systems and livelihoods more resilient to shocks and stresses, including to the effects of climate change. It is a key resource in efforts to increase food production while limiting negative impacts on the environment. Securing and enhancing the multiple roles of BFA will require sustainable use and conservation of the ecosystems, species and genetic diversity.

83. Free, J.B., Ferguson, A.W. 1979. Foraging of bees on oil-seed rape (*Brassica napus* L) in relation to the stage of flowering of the crop and pest control. Journal of Agricultural Science Cambridge 94:151-154.

84. Free, J.B., Nuttall, P.M. 1968. The pollination of oilseed rape (*Brassica napus*) and the behaviour of bees on the crop. Journal of Agricultural Science Cambridge 71:91-94.

85. Garbach, K., J.C. Milder, M. Montenegro, D.S. Karp and F.A.J. DeClerck. 2014. Biodiversity and ecosystem services in agroecosystem. Elsevier Inc.

86. Garratt, M.P.D., C.L. Truslove, D.J. Coston, R.L. Evans, E.D. Moss, C. Dodson, N. Jenner, J.C. Biesmeijer, and S.G. Potts. 2014. Pollination deficits in UK apple orchards. J Pollinat Ecol 12:9–14. Apple production in the UK is worth over £100 million per annum and this production is heavily dependent on insect pollination. Despite its importance, it is not clear which insect pollinators carry out the majority of this pollination. Furthermore, it is unknown whether current UK apple production, in terms of both yield and quality, suffers pollination deficits and whether production value could be increased through effective management of pollination services. The present study set out to address some of these unknowns and showed that solitary bee

activity is high in orchards and that they could be making a valuable contribution to pollination. Furthermore, fruit set and apple seed number were found to be suffering potential pollination deficits although these were not reflected in apple quality. Deficits could be addressed through orchard management practices to improve the abundance and diversity of wild pollinators. Such practices include provision of additional floral resources and nesting habitats as well as preservation of semi-natural areas. The cost effectiveness of such strategies would need to be understood taking into account the potential gains to the apple industry.

87. Giles, K.L., B.P. McCornack, T.A. Royer, and N.C. Elliott. 2017. Incorporating biological control into IPM decision making. Curr. Opin. Insect Sci. 20: 84–89. https://doi.org/10.1016/j.cois.2017.03.009. Of the many ways biological control can be incorporated into Integrated Pest Management (IPM) programs, natural enemy thresholds are arguably most easily adopted by stakeholders. Integration of natural enemy thresholds into IPM programs requires ecological and cost/benefit crop production data, threshold model validation, and an understanding of the socioeconomic factors that influence stakeholder decisions about biological control. These thresholds are more likely to be utilized by stakeholders when integrated into dynamic web-based IPM decision support systems that summarize pest management data and push site-specific biological control management recommendations to decision-makers. We highlight recent literature on topics related to natural enemy thresholds and how findings may allow pest suppression services to be incorporated into advanced IPM programs.

88. Gómez-Baggethun, E., R. de Groot, P. L. Lomas, and C. Montes. 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics* 69.6: 1209-1218. The authors summarized the history of the conceptualization of ecosystem services. The authors argued that the ecosystem services history started with the utilitarian framing of beneficial ecosystem functions as services to increase public interest in biodiversity conservation, and then moved toward the incorporation of ecosystem services into markets and payment schemes.

89. Gomez, C., L. Brun, D. Chauffour, and D. De Le Vallée. 2007. Effect of leaf litter management on scab development in an organic apple orchard. Agriculture, Ecosystems and Environment 118, 249– 55. https://doi.org/10.1016/j.agee.2006.05.025. Ascospores of Venturia inaequalis produced on scabbed leaves in the leaf litter are the main source of primary inoculum, causing infections in apple orchards. The purpose of this 2-year experiment, carried out in a commercial organic orchard, was to assess the effect of combining leaf sweeping from the alleys with leaf ploughing in within the row on scab inoculum and development. In 2003, scab severity was monitored at different distances from the unremoved leaf areas to estimate ascospore spreading. Scab incidence and severity were low in 2003 and high in 2004. At fruit harvest, both years, the leaf litter removal method reduced fruit scab incidence by 82.5% and 54.6% respectively, and fruit scab severity by 74.0% and 67.7%, respectively. Measures of scab lesion gradient indicated that ascospore spreading was not important beyond a 20 m distance from the source. The number of trapped ascospores observed in 2004 in the leaf removal treatment was reduced by 95%. Results from this 2-year experiment showed that leaf litter management by leaf removal allowed a reduction in apple scab inoculum and development and demonstrated the benefit of a complete removal of the leaf litter, when combining leaf sweeping from the alleys with leaf ploughing in within the row.

90. GON. 2018. Nepal's sixth national report to the convention on biological diversity. Government of Nepal, Ministry of Forests and Environment (MoFE), Singh Durbar, Kathmandu, Nepal. The CBD was ratified by Nepalese parliament on November 23, 1993, and enforced in Nepal since February 21, 1994. The revised Nepal's NBSAP for 2014-2020 is a comprehensive framework for translating targets into national action and achieving the nation's goals to conserve the biodiversity. The NBSAP progress has been assessed against 58 national indicators for meeting the 20 Aichi Biodiversity Targets (ABT) under five strategic goals. The assessment reveled that out of 58 targets, 3 (5.2%) targets were achieved before deadline 2020, 12 (20.7%) targets were on track to achieve by 2020, 38 (65.5%) targets were towards progress but at an insufficient rate and there was no overall progress for 5 (8.6%) targets. This report includes findings of the newly formed state level consultation/workshops that had been conducted at all seven states as well as consultation with communities in 26 districts. The 6th National Reporting to the CBD analysis of progress toward international biodiversity targets result suggests that despite accelerating policy and management responses to the biodiversity crisis, political commitment and institutional mainstreaming at the federal, state and local levels are needed to be reflected in improved trend to achieve the ABT by 2020.

91. Goodman, R., Hepworth, G., Kaczynski, P., McKee, B., Clarke, S., Bluett, C. 2001. Honeybee pollination of buckwheat (*Fagopyrum esculentum* Moench cv. Manor). Aust.J.Exp.Agr. 41:1217-1221. The role of honeybees (*Apis mellifera*) in the pollination of buckwheat cv. Manor was studied in a commercial planting at Smeaton, Victoria. Honeybees comprised 80% of all insect visitors to this crop. Other insects included ladybirds (*Coccinella transversalis* and *C. undecimpunctata*), hoverflies (*Meangyna viridiceps*), drone flies (*Eristalis* sp.), blowflies (Calliphoridae), cabbage white butterflies (*Pieris rapae*), small bush flies and native bees. The activity of honeybees and other insects increased seed production from 91.5 g/plot (plots closed to insects) to 180.4 g/plot (plots open to insects).

92. Grafton-Cardwell, E.E., L.L. Stelinski, and P.A. Stansly. 2013. Biology and Management of Asian Citrus Psyllid, Vector of the Huanglongbing Pathogens. Annu. Rev. Entomol 58:413–432. https://doi.org/10.1146/annurev-ento-120811-153542. The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is the most important pest of citrus worldwide because it serves as a vector of "Candidatus Liberibacter" species (Alphaproteobacteria) that cause huanglongbing (citrus greening disease). All commercially cultivated citrus is susceptible and varieties tolerant to disease expression are not yet available. Onset of disease occurs following a long latent period after inoculation, and thus the pathogen can spread widely prior to detection. Detection of the pathogen in Brazil in 2004 and Florida in 2005 catalyzed a significant increase in research on *D. citri* biology. Chemical control is the primary management strategy currently employed, but recently documented decreases in susceptibility of *D. citri* to several insecticides illustrate the need for more sustainable tools. Herein, we discuss recent advances in the understanding of *D. citri* biology and behavior, pathogen transmission biology, biological control, and chemical control with respect to "Candidatus Liberibacter asiaticus." Our goal is to point toward integrated and biologically relevant management of this patho-system.

93. Hamakawa, H. 1986. [Foraging behavior of honeybees (*Apis cerana* and *A. mellifera*) and *Vespula flaviceps* visiting flowers of buckwheat (*Fagopyrum esculentum*). Honeybee Sci. 7:53-56. As many as 3094 specimens of adult citrus pollinators collected from district Haripur represented four orders of insects i.e., Diptera with 16 species, Hymenoptera with 14 species, Lepidoptera with 3 species and Coleoptera with 2 species. The calculated values of relative abundance showed that is most abundant species in ecosystem followed by sp. and . Musca domestica Sarcophaga Apis mellifera. All calculated values of diversity indices except Shannon-H does not show significant difference. Shannon's diversity shows that Naseem Town is most diverse locality then Nikrian B with relative values of 2.213 and 1.136

94. Hauck, J., C. Görg, R. Varjopuro, O. Ratamäki, and K. Jax. 2013. Benefits and limitations of the ecosystem services concept in environmental policy and decision making: Some stakeholder perspectives. *Environmental Science & Policy* 25:13-21. This article summarized the policies that address ecosystem services at various levels within the European Union. The authors described two challenges that arose when formulating and implementing policies related to ecosystem services: (1) valuing ecosystem services across scales and (2) analyzing trade-offs that occur when one ecosystem service is preferred over another.

95. Heal, G., G. C. Daily, P. R. Ehrlich, et al. 2001. Protecting natural capital through ecosystem service districts. *Stanford Environmental Law Journal* 20:333-364. This article presented the idea of "ecosystem services districts" as a mechanism to protect ecosystem services. Based on US legislation, the authors stated that there are few explicit protections for ecosystem services because the legal protection of ecosystems was not the primary objective when drafting environmental laws. For example, the Clean Air Act and Clean Water Act were based on health standards, and the Endangered Species Act is species specific.

96. Hirokawa, K. H. 2011. Sustaining ecosystem services through local environmental law. *Pace Environmental Law Review* 28:760-826. The author argued that the value embedded in ecosystem services is relevant to local regulation and local governance. Claiming that the impacts of ecosystem services losses are pronounced at a local level, the author suggested that regulation by local governments may be the most effective way to slow or mitigate such ecosystem services losses.

97. Hondebrink, M.A., L.H. Cammeraat, and A. Cerd`a. 2017. The impact of agricultural management on selected soil properties in citrus orchards in Eastern Spain: A comparison between conventional and organic citrus orchards with drip and flood irrigation. Sci Total Environ. 581-582: 153–160. The agricultural management of citrus orchards is changing from flood irrigated managed orchards to drip irrigated organic managed orchards. Eastern Spain is the oldest and largest European producer of citrus, and is representative of the environmental changes triggered by innovations in orchard management. In order to determine the impact of land management on different soil quality parameters, twelve citrus orchards sites were selected with different land and irrigation management techniques. Soil samples were taken at two depths, 0–2 cm and 5–10 cm for studying soil quality parameters under the different treatments. Half of the studied orchards were organically managed and the other six were conventionally managed, and for each of these six study sites three fields were flood irrigated plots and the other three drip irrigated systems. The outcome of the studied parameters was that soil organic matter (SOM) and aggregate stability were higher for organic farms. Bulk density and pH were only significantly different for organic farms when drip irrigation was applied in comparison with flooded plots. C/N ratio did not vary significantly for the four treatments. Although there are some points of discussion, this research shows that a combination of different management decisions leads to improvement of a couple of soil quality parameters. Organic management practices were found to be beneficial for soil quality, compared to conventional management for soils with comparable textures and applied irrigation water.

98. Hsieh, F. K., Chen, C. T., Chang, C. P., and Chang, S. Y. 2001. Foraging activities and numerical changes of honeybees on buckwheat, rape, and pear. Plant Prot. Bull. 44: 1-13. The number of *Apis mellifera* foragers peaked between 0930 h and 1130 h at the beginning of buckwheat's blooming season and when buckwheat was in full bloom. However, the highest number of foragers occurred between 0830 h and 1030 h during the late blooming period. Most *A. cerana* foragers appeared before 0930 h with numbers starting decline after 1030 h at each stage of the blooming season of buckwheat. The number of honeybee foragers on Beeline^R- sprayed buckwheat plots did not show significant difference from the control plot. The total number of grains per buckwheat plant from the Beeline^R- sprayed plots was significantly higher than that of control plot, but the weight of 1000 grains did not differ. *A. mellifera* foraged the rape before 1130 h, similar to the buckwheat. Most *A. mellifera* foragers on pear flowers were found within 50 m of the beehive, but not more than 150 m. *A. cerana* foragers were not found more than 100 m from the beehive. *A. mellifera* foraged pear flowers mainly for pollen. The percentages of pollen foragers in two tested orchards were 54 % and 46 %, which are respectively 1.4 and 2.7 fold the percentages of the nectar foragers. On the contrary, *A. cerana* foraged mainly for nectar and the population of nectar foragers was two and three folds larger than those of the pollen foragers. The main pollen-foraging activity of *A. mellifera* occurred between 1100 h and 1500 h, but the nectar-foraging activity occurred at 1300 h. The nectar-foraging activity of *A. cerana* mostly occurred between 1500 h and 1700 h. When the grafted scions of Hosui and Kosui varieties were opened to honeybee pollination, the percentages of fruit setting were 46 % and 78 %, respectively, and each scion could bear an average of 2.2 pears. Hand pollination resulted in 50 % fruit setting and 1-2 pears on each scion. When the *A. mellifera* colonies were placed in a pear surrounded orchard the mean daily number of dead workers (86) was 6 times that of the colonies placed in a relatively isolated orchard. But, there were no differences in the number of dead workers of *A. cerana*, with daily numbers of dead workers between 9 and 10.

99. Hobbs, P.R., K. Sayre, and R. Gupta. 2008. The role of conservation agriculture in sustainable agriculture. Philos. Trans. R. Soc. Lond. B 363:543–55. https://doi.org/10.1098/rstb.2007.2169. The paper focuses on conservation agriculture (CA), defined as minimal soil disturbance (no-till, NT) and permanent soil cover (mulch) combined with rotations, as a more sustainable cultivation system for the future. Cultivation and tillage play an important role in agriculture. The benefits of tillage in agriculture are explored before introducing conservation tillage (CT), a practice that was borne out of the American dust bowl of the 1930s. The paper then describes the benefits of CA, a suggested improvement on CT, where NT, mulch and rotations significantly improve soil properties and other biotic factors. The paper concludes that CA is a more sustainable and environmentally friendly management system for cultivating crops. Case studies from the rice–wheat areas of the Indo-Gangetic Plains of South Asia and the irrigated maize–wheat systems of Northwest Mexico are used to describe how CA practices have been used in these two environments to raise production sustainably and profitably. Benefits in terms of greenhouse gas emissions and their effect on global warming are also discussed. The paper concludes that agriculture in the next decade will have to sustainably produce more food from less land through more efficient use of natural resources and with minimal impact on the environment in order to meet growing population demands. Promoting and adopting CA management systems can help meet this goal.

100. Huang, P.M., Y. Li and M.E. Summer (eds.). 2008. Handbook of soil sciences resource management and environmental impacts. CRC Press, Boca Raton, Florida, USA. It is a comprehensive reference work on the discipline of soil science as practiced today. The new edition has been completely revised and rewritten to reflect the current state of knowledge. It contains definitive descriptions of each major area in the discipline, including its fundamental principles, appropriate methods to measure each property, many examples of the variations in properties in different soils throughout the world, and guidelines for the interpretation of the data for various applications (agricultural, engineering, and environmental impacts.

101. Hummel, R. 2002. Effects of vegetable production system on epigeal arthropod populations. Agric Ecosyst Environ 93:177–188. doi:10.1016/S0167-8809(01)00346-2. Populations of epigeal arthropods were monitored in vegetable production systems under varying degrees of sustainable agricultural practices in Fletcher, NC (USA). Two tillage types (conventional plow and disk, strip-tillage (ST)), two input approaches (chemically based, biologically based) and two cropping schedules (continuous tomato Lycopersicon esculentum Mill.], 3-year rotation of sweet corn [Zea mays L.]/cabbage [Brassica oleracea L.], cucumber [Cucumis sativus L.]/cabbage and tomato) were employed from 1995–1998. A second study with tomatoes was performed in 1997–1998 to separate effects of pesticide use, intercropping and herbicide application. Pitfall traps (48-h sample period) were used at ∼25-day intervals to monitor relative activity of carabid beetles (Coleoptera: Carabidae), staphylinid (Coleoptera: Staphylinidae) beetles and lycosid spiders (Araneidae: Lycosidae). Carabids and lycosids appeared to be more active in systems with ground cover. Trap catches of carabid species were not significantly affected by insecticide input, but trap catches of lycosids were lower in plots with conventional insecticide use. No consistent effect of tillage was found over time, although Scarites spp. were more active in minimally disturbed habitats in 1998. Two distinct patterns of seasonal activity were observed for carabid beetles and lycosid spiders. Ground cover generally enhanced abundance of carabids and lycosids, while tillage type, pesticide use and crop rotation had different effects.

102. IPCC. 2014. Summary for policymakers. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1–32). Cambridge: Cambridge University Press.

103. Inclán, D.J., P. Cerretti, and L. Marini. 2015. Landscape composition affects parasitoid spillover. Agric. Ecosyst. Environ. 208:48–54. https://doi.org/10.1016/j.agee.2015.04.027. The intensification of agriculture has led to a severe simplification of agricultural landscapes, resulting in a marked reduction in the diversity of insect natural enemies. However, how this simplification shapes the movement of insect parasitoids between crop and non-crop habitats (i.e., spillover) is still unclear. We examined the potential spillover of tachinid parasitoids from semi-natural habitats into apple orchards across different landscapes. We sampled commercial apple orchards localized in three landscape types (forest-, grassland- or apple-dominated landscapes) to first evaluate if landscape composition affects the local species richness in apple orchards. Second, we tested whether the contribution of forest and grassland habitats to the local tachinid community composition of apple orchards changes according to landscape composition. We found that landscape composition did not affect local tachinid species richness in apple orchards, while it affected the species spillover. Independently of the landscape, we found highly nested communities of tachinids between apple orchards and forest habitats suggesting a strong spillover of tachinids between these habitats. In contrast, tachinids in apple orchards were nested with grassland habitats only in landscapes dominated by apple orchards. Our results have important implications for the conservation of insect parasitoids in agricultural landscapes, as the spillover of species in the crop can be affected by the type and the area of semi-natural habitats in the surrounding landscape.

104. Jackson, S., and L. R. Palmer. 2015. Re-conceptualizing ecosystem services: Possibilities for cultivating and valuing the ethics and practices of care. *Progress in Human Geography* 39.2:122-145. The authors rejected the conventional notion of payments for ecosystem services (PES) as either an economic or an environmental strategy. They suggested that nature is valued in so far as it relates to actual human and nonhuman interrelations and practices, and that the relationship between people and nature should be the valued stock instead of the "fixed stock of ecosystem services.

105. Jha, P. and M. Sivakoti. 2017. Climate change and biodiversity in Nepal. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. Biodiversity and climate are interconnected and climate change has been widely recognized as one of the serious threats to organisms. This negative consequences of climate change are drawing more attention and are linked with human health, ecosystem service and livelihood. Nepal having the diverse climate and varied biodiversity, is one of the countries vulnerable to climate change.

106. Jha, P.K., R.B. Thapa and J.B. Shrestha. 2005. Conservation and management of pollinators for sustainable agriculture through an ecosystem approach. Final report submitted to FAO Nepal, Pulchowk, Lalitpur, Nepal. Plants and animal species have been taxonomically studied in Nepal, but very little work exists on mutualistic contribution as pollination and pollinators. Insects, birds and mammalian species have been acting as pollinating agents in nature. There are 8724 species of insects, 181 species of mammals and 861 species of birds reported from Nepal. Out of these, insects are the major pollinators followed by birds, and a very few mammals. There is a high probability of new records of pollinating insects from Nepal. It is believed that Hymenopteran insects are important pollinators but insufficiently explored in Nepal. Honey bees contribute significantly in pollination of crops and wild plants, and Nepal is one of the countries rich in honeybee species. There are five species of bees indigenous to Nepal, and in addition to those, one exotic species, European honey bee *Apis mellifera* L. has been successfully introduced (in Nepal) in the 1990s through India, and now its population dominates in many areas. Some bird species have been recorded as good pollinators, but habitat destruction is believed to affect the population of such birds. There exist a few studies on the bee flora and pollens in Nepal. About 300 plant species have been studied for their pollen structure and taxonomy. Studies indicate decline in pollinators in some of the areas. Habitat loss, high rate of deforestation, increasing use of pesticides and growing pollution, climate change, introduction of new species (e.g. *Apis mellifera* L.), and low level of awareness about pollinators, lack of emphasis upon pollinators are some major causes that have been identified to affect the population of pollinators. Conservation of pollinators has not been given due attention in Nepal, and efforts to conserve biological diversity in the ecosystems have directly and indirectly conserved pollinators. There are 16 protected areas covering 18.36% of Nepalese land and protects biodiversity. In the last few years, Nepal has given emphasis on integrated pest management, which can protect pollinators to some extent. Bee keeping is popular in many areas. It has played an important role in conservation of pollinators. There are over a dozen publications that can be used as pollinators catalogues. Entomology Division of NARC has an insect museum having 1863 species of insects, Natural History Museum of Tribhuvan University houses over 1000 species of insects, birds and mammals. Annapurna Regional Museum, Pokhara houses a very good collection of butterflies. Two useful electronic flora databases (Medicinal and Aromatic Plant Database of Nepal, MAPDON and Floral Database of Nepal, FLODON) have been developed by Central Department of Botany, T.U. in collaboration with Ethno-botanical Society of Nepal (ESON) and Natural History Museum, London. The present report includes a list of global and regional networks and initiatives on pollinators

as well as concerned institutions in Nepal. A list of relevant laws, regulation, policies and plans have also been analyzed with brief description of important policies and strategies (Agriculture Perspective Plan, Nepal Biodiversity Strategy, National Agriculture Policy, Periodic Plans, Nepal Environmental Policy and Action Plan), and market related acts and laws. There is a need to document traditional knowledge about pollinators. Traditional knowledge about honeybees has been recorded by a few workers in Nepal. The knowledge about Apitherapy, traditional treatment of bee diseases, local hive preparation and management of honeybees, and bee flora that provide pollen and nectar are recorded by few workers. Teaching and training on pollinators and pollination biology are relatively inadequate, and there is a need to develop human resources, particularly taxonomists and ecologists, and to aware people about the important component of ecosystem. Over two hundred references have been listed related with pollens, taxonomy, beekeeping, pollination, bee flora, and pollinators.

107. Joshi, B.K., A.K. Acharya, D. Gauchan and P. Chaudhary. 2017. The state of Nepal's biodiversity for food and agriculture. Ministry of Agricultural Development, Kathmandu, Nepal. Biodiversity underpins the livelihoods and wellbeing of humankind on earth. Not all nations are fortunate to enjoy rich biodiversity, but Nepal, despite being a small country, harbors world's 3.2% flora and 1.1% fauna, ranks the 31st richest country in the world and 10th in Asia in terms of biodiversity. A total of 284 flowering plants, 160 species of animals, one species of bird, and 14 species of herpeto fauna are endemic to Nepal. Astonishingly varied geographic, ecological, climatic, socioeconomic, and cultural factors are making possible such a tremendous biodiversity to exist. A large number of biodiversity is useful for food and agriculture and they are grouped as crop, livestock, aquatic, forest and associated biodiversity. A large number of local varieties of crops and vegetables, livestock breeds, fish species, and wild edible species are eroding from their habitats and growing environments. Introduction of new technologies including varieties, erosion of traditional knowledge, poor utilization of local landraces, lack of proper policies, and poor implementation of policies are key underlying factors contributing to genetic erosion. The Government of Nepal has made several initiatives in collaboration with relevant stakeholders to formulate and revise policies, facilitate conservation and utilization of agro-biodiversity, document information and knowledge.

108. Kamler, F., Pasakova, I. 1987. Pollinationof winter rape (*Brassica napus* var. *arvensis*) and the setting of pods. Pages 337-339. 31st International Apicultural Congress of Apimondia Warsaw 1987. Apimondia Publishing House, Bucharest.

109. Kapil, R.P., Grewal, G.S., Kumar, S., Atwal, A.S. 1971. Insect pollinators of rape seed and mustard. Indian J.Ent. 33:61-66.

110. Kardol, P., W.N. Reynolds, R.J. Norby, and A.T. Classen. 2011. Climate change effects on soil microarthropod abundance and community structure. Applied Soil Ecology, 47(1), 37–44. https://doi.org/10.1016/j. apsoil.2010.11.001. Long-term ecosystem responses to climate change strongly depend on how the soil subsystem and its inhabitants respond to these perturbations. Using open-top chambers, we studied the response of soil microarthropods to single and combined effects of ambient and elevated atmospheric [CO2], ambient and elevated temperatures and changes in precipitation in constructed old-fields in Tennessee, USA. Microarthropods were assessed five years after treatments were initiated and samples were collected in both November and June. Across treatments, mites and collembola were the most dominant microarthropod groups collected. We did not detect any treatment effects on microarthropod abundance. In November, but not in June, microarthropod richness, however, was affected by the climate change treatments. In November, total microarthropod richness was lower in dry than in wet treatments, and in ambient temperature treatments, richness was higher under elevated [CO2] than under ambient [CO2]. Differential responses of individual taxa to the climate change treatments resulted in shifts in community composition. In general, the precipitation and warming treatments explained most of the variation in community composition. Across treatments, we found that collembola abundance and richness were positively related to soil moisture content, and that negative relationships between collembola abundance and richness and soil temperature could be explained by temperature-related shifts in soil moisture content. Our data demonstrate how simultaneously acting climate change factors can affect the structure of soil microarthropod communities in old-field ecosystems. Overall, changes in soil moisture content, either as direct effect of changes in precipitation or as indirect effect of warming or elevated [CO2], had a larger impact on microarthropod communities than did the direct effects of the warming and elevated [CO2] treatments. Moisture-induced shifts in soil microarthropod abundance and community composition may have important impacts on ecosystem functions, such as decomposition, under future climatic change.

111. Kareiva, P., H. Tallis, T. H. Ricketts, G. C. Daily, and S. Polasky. 2011. *Natural capital: Theory & practice of mapping ecosystem services*. Oxford: Oxford Univ. Press. A comprehensive treatment of ecosystem service analysis from the perspective of the InVEST tool for Integrated Valuation of Ecosystem Services and Tradeoffs, of the Natural Capital Project.

112. Karp, D.S., R. Moses, S. Gennet, M.S. Jones, and S. Joseph, *et al*. 2016. Agricultural practices for food safety threaten pest control services for fresh produce. J. Appl. Ecol. 53:1402–12. https://doi.org/10.1111/1365-2664.12707. Over the past

decade, several foodborne disease outbreaks provoked widespread reforms to the fresh produce industry. Subsequent concerns about wildlife vectors and contaminated manures created pressure on growers to discontinue use of manure-based composts and remove nearby semi-natural vegetation. Despite widespread adoption, impacts of these practices on ecosystem services such as pest control have not been assessed. We used a landscape-scale field experiment to quantify associations between compost applications, semi-natural vegetation, pest control services and lettuce yields on organic farms throughout California's Central Coast, a region experiencing food safety reforms. We found that farms with surrounding semi-natural vegetation supported a diverse arthropod assemblage, whereas a herbivore-dominated assemblage occupied farms in simplified landscapes. Moreover, predatory arthropods consumed more herbivores at sites with more surrounding non-crop vegetation and reduced aphid pest infestations in lettuce. Compost improved lettuce yields by increasing soil nutrients and organic matter, but affected neither pest control nor Escherichia coli prevalence. Synthesis and applications. Food safety concerns are prompting practices that simplify farms and landscapes. Our results demonstrate that two practices – elimination of manure-based composts and removal of non-crop vegetation – are likely having negative impacts on arthropod biodiversity, pest control and soil quality. Critically, our findings and previous research suggest that compost can be applied safely and that habitat removal is likely ineffective at mitigating food safety risk. There is thus scope for co-managing fresh produce fields for food safety, ecosystem services, and biodiversity through applying appropriately treated composts and stopping habitat removal.

113. Kenter, J. O. 2016. Editorial: Shared, plural, and cultural values. *Ecosystem Services* 21 (Part B): 175-183. This is an editorial that introduced the special issue of *Ecosystem Services*, which arose from the UK National Ecosystem Assessment (2012–2014). The author raises awareness on shared and cultural values. Shared values are considered as the values we hold in common that communities and societies formed through a long-term process of socialization. Cultural values are considered as the values that reflect the importance of culture in managing and valuing ecosystems.

114. Kevan, P.G., Eisikowitch, D. 1990. The effects of insect pollination on canola (*Brassica napus* L. cv. O.A.C. Triton) seed germination. Euphytica 45.

115. Kibblewhite MG, Ritz K, Swift MJ. 2008. Soil health in agricultural systems. Philos. Trans. R Soc. Lond. B 363:685–701. https://doi.org/10.1098/rstb.2007.2178. Soil health is presented as an integrative property that reflects the capacity of soil to respond to agricultural intervention, so that it continues to support both the agricultural production and the provision of other ecosystem services. The major challenge within sustainable soil management is to conserve ecosystem service delivery while optimizing agricultural yields. It is proposed that soil health is dependent on the maintenance of four major functions: carbon transformations; nutrient cycles; soil structure maintenance; and the regulation of pests and diseases. Each of these functions is manifested as an aggregate of a variety of biological processes provided by a diversity of interacting soil organisms under the influence of the abiotic soil environment. Analysis of current models of the soil community under the impact of agricultural interventions (particularly those entailing substitution of biological processes with fossil fuel-derived energy or inputs) confirms the highly integrative pattern of interactions within each of these functions and leads to the conclusion that measurement of individual groups of organisms, processes or soil properties does not suffice to indicate the state of the soil health. A further conclusion is that quantifying the flow of energy and carbon between functions is an essential but non-trivial task for the assessment and management of soil health.

116. Kinzig, A. P., C. Perrings, F. S. Chapin, et al. 2011. Paying for ecosystem services—promise and peril. *Science* 334.6056: 603-604. The authors summarized the promises and limitations of the payment for ecosystem services schemes. They stated that markets are useful for addressing environmental issues, but are not a panacea. Effective mechanism design requires a deep understanding of the linkages between biodiversity, ecosystem functions, and ecosystem services. Moreover, they listed four mechanisms that protect ecosystem services: (1) regulation and penalty, (2) cap and trade, (3) direct payments, and (4) self-regulation.

117. Kopelkievskii, G.V. 1960. Bees and the buckwheat seed crop. Pchelovodstvo Mosk. 37:36-39.

118. Kopelkievskii, G.V. 1976. [Honeybee (pollination) and seed production of buckwheat.]. Neunylov et al.(eds) Genetika, selektsiia, semenovodstvo i vozdelyvanie grechikhi.171-180.

119. Kovács-Hostyánszki, A., Z. Elek, K. Balázs, C. Centeri, E. Falusi, P. Jeanneret, K. Penksza, L. Podmaniczky, O. Szalkovszki, and A. Báldi. 2013. Earthworms, spiders and bees as indicators of habitat quality and management in a low-input farming region—A whole farm approach. Ecological Indicators, 33, 111–120. https://doi.org/10.1016/j. ecolind.2013.01.033. The benefits of low input farming on biodiversity and ecosystem services are already well-established, however most of these studies focus only on the focal field scales. We aimed to study whether these benefits exist at the whole farm scale, to find the main environmental driving effects on biodiversity at the whole farm scale in farms of different grassland grazing intensity, applying three well-known species diversity indicator groups of different ecological traits. Edaphic (earthworms), epigeic

(spiders) and flying (bees) taxa were sampled in each identified habitat type within 18 low-input farms in Central Hungary, 2010. The number of habitat types, the number of grassland plots, the cumulative area of grasslands and habitat type had an effect on the species richness and abundance of spiders, while grassland grazing intensity influenced the species richness of bees. Both bees and spiders were sensitive to vegetation and weather conditions, resulting in more bees on flower-rich farms and those having higher temperature; and more spiders on farms with more heterogeneous vegetation structure and in low-wind areas. Relatively few earthworms were found in the whole study, and their abundance was not influenced by any of the farm composition and management variables. We conclude that local field management (grazing intensity of grassland patches) can have a farm scale effect, detectable on species diversity indicators that have high dispersal ability and strong connection to grasslands as important foraging sites (bees). However, other farmland biota (spiders) is also strongly determined by farmland composition and habitat diversity, therefore the maintenance of a mosaic within-farm habitat structure is strongly recommended. The application of earthworms as farmland composition or management indicators is strongly restricted because of their special needs of soil conditions.

120. Kremen, C. 2005. Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters* 8.5: 468-479. The author introduced a conceptual framework with four components for linking biodiversity with ecosystem services: (1) identifying the ecosystem service providers, (2) determining community structure that influences functions in landscapes, (3) assessing environmental factors that influence service provisioning, and (4) assessing the spatiotemporal scale over which providers and services operate.

121. Lant, C. L., J. B. Ruhl, and S. E. Kraft. 2008. The tragedy of ecosystem services. *BioScience* 58.10: 969-974. The authors stated that managing ecosystem services reflects the tragedy of the commons. They stated that ecosystem services fell in a social trap due to the institutions that govern them and the law that applies to them (for example, property law reinforcing privatization). This paper presented some ideas on how to better manage and address the administration of ecosystem services, for example via ecosystem services districts.

122. Lipper, L. N. McCarthy, D. Zilberman, S. Asfaw and G. Branca (eds.). 2018. Climate smart agriculture building resilient to climate change. FAO, Rome Italy. Eradicating poverty, ending hunger, and taking urgent action to combat climate change and its impacts are three objectives the global community has committed to achieving by 2030 by adopting the sustainable development goals. Climate change however is expected to act as an effective barrier to agricultural growth in many regions, especially in developing country contexts heavily dependent on rain-fed agriculture. FAO is actively working to support countries in grappling with the challenge of managing agriculture to reduce hunger and poverty in an increasingly climate constrained world. FAO launched the concept of climate smart agriculture (CSA) in 2009 to draw attention to linkages between achieving food security and combating climate change through agricultural development, and the opportunities for attaining large synergies in doing so. This book elucidates concepts, principles and cases of climate smart agriculture including policy issues.

123. Lichtenberg, E.M., C.M. Kennedy, C. Kremen, P. Batáry, F. Berendse, *et al*. 2017. A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes. Glob. Change Biol. 23:4946–57. https://doi.org/10.1111/gcb.13714. Agricultural intensification is a leading cause of global biodiversity loss, which can reduce the provisioning of ecosystem services in managed ecosystems. Organic farming and plant diversification are farm management schemes that may mitigate potential ecological harm by increasing species richness and boosting related ecosystem services to agroecosystems. What remains unclear is the extent to which farm management schemes affect biodiversity components other than species richness, and whether impacts differ across spatial scales and landscape contexts. Using a global metadataset, we quantified the effects of organic farming and plant diversification on abundance, local diversity (communities within fields), and regional diversity (communities across fields) of arthropod pollinators, predators, herbivores, and detritivores. Both organic farming and higher in-field plant diversity enhanced arthropod abundance, particularly for rare taxa. This resulted in increased richness but decreased evenness. While these responses were stronger at local relative to regional scales, richness and abundance increased at both scales, and richness on farms embedded in complex relative to simple landscapes. Overall, both organic farming and in-field plant diversification exerted the strongest effects on pollinators and predators, suggesting these management schemes can facilitate ecosystem service providers without augmenting herbivore (pest) populations. Our results suggest that organic farming and plant diversification promote diverse arthropod meta communities that may provide temporal and spatial stability of ecosystem service provisioning. Conserving diverse plant and arthropod communities in farming systems therefore requires sustainable practices that operate both within fields and across landscapes.

124. Loreau, M., S. Naeem, P. Inchausti, et al. 2001. Biodiversity and ecosystem functioning: Current knowledge and future challenges. *Science* 294.5543: 804-808. This paper analyzed the relationship between ecological performance and diversity at different scales. They stated that while experiments have showed a positive linear relationship between species richness and

ecological performance, scaling up to regional scales remains elusive. Species-area relations imply that the long-term maintenance of diversity at local scales requires a much higher diversity at regional scales.

125. Luck, G. W., G. C. Daily, and P. R. Ehrlich. 2003. Population diversity and ecosystem services. *Trends in Ecology & Evolution* 18.7: 331-336. The authors advocated for a more integrative approach for assessing biodiversity decline. They argued that considering population size, distribution, genetic differentiation, and population density are key to reflect the changes to biodiversity and the effects on ecosystem service provisioning.

126. Luck, G. W., R. Harrington, P. A. Harrison, et al. 2009. Quantifying the contribution of organisms to the provision of ecosystem services. *BioScience* 59.3: 223-235. The purpose of this paper was to elaborate on the unit concept of ecosystem service providers. The authors introduced the concept of a continuum between service providing units and ecosystem service providers (SPU-ESP continuum).

127. Luck, G., K. M. A. Chan, U. Eser, et al. 2012. Ethical considerations in on-ground applications of the ecosystem services concept. *BioScience* 62.12: 1020-1029. The first comprehensive consideration of ethical implications of a diverse set of applications of the ecosystem services concept, including as a communication tool, for policy guidance and priority setting, and for designing economic instruments for conservation. Concerns discussed include the anthropocentric framing, economic metaphor, monetary valuation, commodification, sociocultural impacts, changes in motivations, and equity implications.

128. Mahamood, R., W. Ahmad, M.K. Rafique, G. Sarwar and A. Shahzad. 2017. Pakistan J. Zool. 49(3):897-903. Pollination deficit in apple orchards at Murree, Pakistan. A study was conducted in twenty different managed and unmanaged apple orchards of Murree for determining relationship of different pollinator groups with crop yield. Apple is dependent on insect pollinators to set fruit. Farmers in Pakistan are generally not aware of pollination needs of apple. Results depicted a high population decline of Syrphids and Non-Apis bees. Syrphids were recorded as 12.65 to 13.85 per 250 flowers in 2013 but decreased in year 2014 by 7.82 to 7.88 per 250 flowers and Non-Apis bees was recorded as 6.15 to 7.59 per 250 flowers in 2013 which also decreased and recorded as 5.35 to 5.70 per 250 flowers in year 2014. The results showed the trends of increase in population of *Apis mellifera* and *Apis cerana* between 8.22 to 11.5 per 250 flowers in 2013 as compared to 1.12 to 13.92 per 250 flowers in 2014, whereas population of indigenous *Apis cerana* varied between 3.80 to 5.44 h per 250 flowers in 2013 as compared to year 2014 where it was recorded as 4.34 to 5.56 honey bees per 250 flowers. Apple fruits yield per tree ranged between 214.56 to 218.64 in 2013 and 2014 respectively. Average fruit weight varied between 124.84 to 127.34 g, average number of seeds varied between 7.95 to 7.73 seeds per fruit and yield per tree was recorded between 28.92 to 31.65 kg per tree. Number of Apple fruits per tree ranged between 145.72 to 164.58 in 2013 and 2014, respectively. Average fruit weight varied between 103.66 to 112.13 g and average number of seeds varied between 7.73 to 7.95 seeds per fruit and yield per tree was recorded between 17.34 to 21.78 kg per tree. Eighteen different species were recorded under 16 genus and 07 families. *Ceratina hieroglyphica*, *Halictus subauratus*, *Osmia caerulescens* were reported first time from Pakistan.

129. Martín-López, B., C. Montes, and J. Benayas. 2007. The non-economic motives behind the willingness to pay for biodiversity conservation. *Biological Conservation* 139.1-2: 67-82. The authors explored attitudes toward biodiversity using a contingent valuation survey in the Doñana National Park in Spain. Their analyses showed that willingness to pay for the conservation of biodiversity was associated with affective factors, rather than ecological factors. People valued species that were phylogenetically closer to humans and those that provided utilitarian values to humans, and perceived less value in species important for ecosystem functioning.

130. Mel'nichenko, A.N. 1962. Biological basis for increasing the yield of buckwheat by different sowing dates and degrees of saturation of bee pollination. Uchen.Zap.Gorkov.Univ. 55:5-43.

131. Mesquida, J., Renard, M. 1978. Entomophilous pollination of male-sterile strains of winter rapeseed (*Brassica napus* L Metzger var. *oilfera*) and a preliminary study of alternating devices. 4th International Symposium on Pollination. Maryland Agricultural Experimental Station Miscellaneous Publication . pp. 49-57.

132. Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being. Washington, DC: Island Press. This report from a major international assessment process defined ecosystem services as “the benefits people obtain from ecosystems” (p. V) and defined four categories of ecosystem services (i.e., provisioning, supporting, regulating, and cultural). This report analyzed the state of the earth’s ecosystems and ecosystem services in the period from 2001 to 2005. The analysis showed that 60 percent of ecosystem services (including 70 percent of cultural ecosystem services) have been degraded.

133. Miñarro, M., and E. Prida. 2013. Hedgerows surrounding organic apple orchards in north-west Spain: potential to conserve beneficial insects. Agric For Entomol 15:382–390. doi:10.1111/afe.12025. Flowering plant species in hedgerows may

be food sources for beneficial insects and therefore play a role in biodiversity conservation and agroecosystem functioning. Research was conducted in eight organic cider-apple orchards in Asturias (north-west Spain) aiming to (i) identify the native flowering plants in the surrounding hedgerows and (ii) assess the attractiveness of those flowers for beneficial insects, such as pollinators and natural enemies of pests. A total of 7745 flowers belonging to 63 plant species were recorded in the hedgerows from May to September 2012. Flower abundance and species richness decreased as the season progressed. Orchard differences were observed for plant species richness but not for the total number of flowers in the hedgerows, likely as a result of similar management among orchards. Hymenoptera pollinators (honey bees, bumblebees and wild bees) accounted for 37.8% of the total insects recorded visiting flowers, whereas predatory hoverflies (14.9%) were the dominant natural enemies. The attractiveness for insects was assessed for 21 of the flowering plant species identified in the hedgerows. Flowering plants differed in the number of taxa that they attracted and in their attractiveness for particular insect groups and for insects as a whole. The present study described the floral composition of the hedgerows that surround apple orchards and identified the local floral resources that could provide benefits for farmers by improving ecosystem services of pollination and biological control of pests.

134. Mohr, N.A., Jay, S.C. 1990. Nectar production of selected cultivars of *Brassica campestris* L. and *Brassica napus* L. J.Apic.Res 29:95-100.

135. Montanaro, G., C. Xiloyannis, V. Nuzzo, and B. Dichio. 2017. Orchard management, soil organic carbon and ecosystem services in Mediterranean fruit tree crops. Sci Hortic 217:92–101. doi:10.1016/j.scienta.2017.01.012. Agriculture is not only appointed to produce food but has the potential to provide a range of ecosystem services (ES) depending on the management options adopted at field scale. Information on the impact of management practices adopted in fruit tree crops on ES is fragmented and often not fully codified. This paper focuses on some Mediterranean fruit tree crops i.e. peach (Prunus persica), apricot (Prunus armeniaca), olive (Olea europaea) groves and vineyards (Vitis vinifera), and links mainly soil processes and functions to the provisioning, regulating and sociocultural ES. The effects of field practices (e.g., tillage/no-tillage, cover crops, retention/burning of pruning residues, mineral/organic fertilization) on manageable soil properties (e.g., porosity, organic carbon content, composition of microbial community) and related functions (e.g., supply of nutrients, water storage, soil stability, above-ground biodiversity) were examined. The analysis draws the attention to the pivotal role of the soil organic carbon (SOC) stocks on soil aggregates and erodibility, soil water storage, use of fresh water for irrigation, plant nutrition, biodiversity, nutrient storage and absorption of pesticides. Sociocultural services delivered by tree crops are also discussed. This paper highlights the dependence of ES on the sustainable field practices adopted, particularly those aimed at increasing SOC stocks (e.g., no tillage, increased carbon input, recycling of pruning residuals, cover crops). The outcomes presented may strengthen the significance of increasing SOC management practices for fruit tree crops and be supportive of the implementation of environmentally friendly policies assisting in the conservation or the improvement of the soil natural capital.

136. Monzo, C., and P.A. Stansly. 2017. Economic injury levels for Asian citrus psyllid control in process oranges from mature trees with high incidence of huanglongbing. PLoS ONE 12(4): e0175333. https://doi.org/10.1371/journal. pone.0175333. The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama, is the key pest of citrus wherever it occurs due to its role as vector of huanglongbing (HLB) also known as citrus greening disease. Insecticidal vector control is considered to be the primary strategy for HLB management and is typically intense owing to the severity of this disease. While this approach slows spread and also decreases severity of HLB once the disease is established, economic viability of increasingly frequent sprays is uncertain. Lacking until now were studies evaluating the optimum frequency of insecticide applications to mature trees during the growing season under conditions of high HLB incidence. We related different degrees of insecticide control with ACP abundance and ultimately, with HLB-associated yield losses in two four-year replicated experiments conducted in commercial groves of mature orange trees under high HLB incidence. Decisions on insecticide applications directed at ACP were made by project managers and confined to designated plots according to experimental design. All operational costs as well as production benefits were taken into account for economic analysis. The relationship between management costs, ACP abundance and HLB-associated economic losses based on current prices for process oranges was used to determine the optimum frequency and timing for insecticide applications during the growing season. Trees under the most intensive insecticidal control harbored fewest ACP resulting in greatest yields. The relationship between vector densities and yield loss was significant but differed between the two test orchards, possibly due to varying initial HLB infection levels, ACP populations or cultivar response. Based on these relationships, treatment thresholds during the growing season were obtained as a function of application costs, juice market prices and ACP densities. A conservative threshold for mature trees with high incidence of HLB would help maintain economic viability by reducing excessive insecticide sprays, thereby leaving more room for non-aggressive management tools such as biological control.

137. Morandin, L.A., Winston, M.L. 2005. Wild bee abundance and seed production in conventional, organic, and genetically modified canola. Ecol.Appl. 15:871-881.

138. Morandini, Lora A., Winston, Mark L. 2007. Wild bee abundance and seed production in conventional, organic and genetically modified Canola. Ecological Applications1-11.

139. Muniappan, R. 2017. Climate change, agriculture and food security. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. The Anthropocene era has brought many advancements in science and technology but has also caused environmental damage, climate change, and biodiversity loss. All these exert an impact on agriculture, fisheries, and forestry. The earth has warmed up by 1.7 ^{0}C since 1880. Since, 1950, global warming has been caused by human releasing of greenhouse gases. In the long-run if emissions continue unchecked, it will cause the icecaps to melt resulting in a rise in sea level. This could cause collapse of agriculture. Asian monsoon will become less reliable and for billion of peoples who depend on monsoon for irrigation and livelihood, any disruption could be catastrophic.

140. Naeem, S., J. C. Ingram, A. Varga, et al. 2015. Get the science right when paying for nature's services. *Science* 347.6227: 1206-1207. This article pointed to the weakness of natural sciences in the design and evaluation of payments for ecosystem services, and provided a suite of principles and guidelines for such programs to be successful from a natural-science perspective. Principles included ecological dynamics, baselines, inclusion of multiple services, monitoring, metrics, and ecological sustainability.

141. Naghski, J. 1951. No honey from tarrary buckwheat. Am.Bee J. 91:513-513.

142. Naidoo, R., and T. H. Ricketts. 2006. Mapping the economic costs and benefits of conservation. *PLoS Biology* 4.11: 2153-2164. The first comprehensive valuation of multiple ecosystem services in a conservation context, this article characterized the costs and benefits of conservation surrounding a protected area in the Atlantic forests of Paraguay. Ecosystem services included sustainable bush meat harvest, sustainable timber harvest, bio-prospecting, existence value, and carbon storage.

143. Nelson, E., G. Mendoza, J. Regetz, et al. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment* 7.1: 4-11. The first application of the spatially explicit InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs). The case study in the Willamette Basin, Oregon, assessed tradeoffs between a suite of ecosystem services (carbon sequestration, soil conservation, water quality, and storm peak mitigation), biodiversity, and commodity production via stakeholder- defined scenarios.

144. Neupane, K.R. 2001. Foraging preference of honeybee species to selected horticultural crops. M.Sc. Thesis, submitted to IAAS, Rampur, Chitwan, Nepal.

145. Neupane, K. R. and R. B. Thapa. 2005. Pollen collection and brood production by honeybees (*Apis mellifera* L.) under Chitwan condition of Nepal**.** A study was carried out to investigate pollen foraging, storage and its impact on *Apis mellifera* L. brood production throughout the year under Terai condition of Nepal in 2003-2005. Number of pollen foragers, amount of pollen stored as beebread and brood in the colony differed significantly during different seasons. Number of pollen foragers (117.5 bees/ hive/ 5 min) and amount of pollen as beebread (2439.0 gm/hive) and number of brood (14787.2 brood cells/hive) were the highest during spring season, while the lowest number of pollen foragers (38.1 bees/ hive/5 min.) stored the lowest amount of beebread or pollen store (152.5 gm /hive) and produced the lowest number of brood (3811.7 brood cells/ hive) and bees in rainy season. Autumn, winter and summer seasons were normal for pollen collection and brood production, while starvation and nutritional deficiencies due to the acute shortage of pollen in rainy season was the major reason to decline or collapse the bee population before the honey flow season. Therefore, feeding bees with adequate amount of nutritionally rich pollen during rainy season is essential to maintain a healthy and strong bee colony for the production of higher honey and other hive products.

146. Neupane, K.R., D. D. Dhakal, R.B. Thapa and D.M. Gautam. 2006. Foraging performance of giant honeybees (*Apis dorsata* Fab.) to selected horticultural crops. J. Inst. Agric. Anim. Sci. 87-92. Foraging preference of giant honeybee, *Apis dorsata* Fab. to selected horticultural crops, litchi, *Litchi chinensis* Sonner, lemon, *Citrus limon* (Lin.) Burm. f., bottlebrush, *Callistemon citrinus* (Curtis) Skeels, cucumber, *Cucumis sativus* Lin., radish, *Raphanus sativus* Lin., and summer squash, *Cucurbita pepo* L., was studied during their blooming time at IAAS, Rampur, Chitwan, Nepal, 2001. The flowering of all six species of experimental plants started in the first week of March and lasted for two months with a peak flowering from 15 March to 5 April. Foraging preference of bees at 7.30, and 11.00 am and 3.00 pm and 5.30 pm during early, mid and late periods of flowering was assessed. Honeybees foraging at different times of day during early, mid and late flowering periods differed significantly. The highest mean number ($8.04/min/m^2$) of *A. dorsata* workers was recorded on bottle brush flowers at 7.30 am during early flowering period followed by litchi, summer squash and the lowest ($0.25/min/m^2$) on citrus at 5.30 pm during late flowering period. The bees never visited to the flowers of radish and cucumber. Pollen was preferentially collected from bottlebrush, summer squash and citrus in the morning and nectar from litchi and bottlebrush flowers throughout the day. Pollen

foragers spent less time (2.9 sec/flower) and visited more flowers (17.96/min) when bees collected both pollen and nectar from the same plant. The number of outgoing and incoming foragers were the highest (59.0, 14, 44.0, 15/min/colony) at 7.30 am during mid flowering period and the lowest (17.6, 7, 17.0, 2/min/colony) at 5.30 pm during late flowering period, respectively.

147. Nicholls, C.I., and M.A. Altieri. 2012. Plant biodiversity enhances bees and other insect pollinators in agroecosystems. Agron Sustain Dev, A review. doi:10.1007/s13593-012-0092-y. Thirty-five percent of global production from crops including at least 800 cultivated plants depend on animal pollination. The transformation of agriculture in the past half-century has triggered a decline in bees and other insect pollinators. In North America, losses of bee colonies have accelerated since 2004, leaving the continent with fewer managed pollinators than at any time in the past 50 years. A number of factors linked to industrial modes of agriculture affect bee colonies and other pollinators around the world, ranging from habitat degradation due to monocultures with consequent declines in flowering plants and the use of damaging insecticides. Incentives should be offered to farmers to restore pollinator-friendly habitats, including flower provisioning within or around crop fields and elimination of use of insecticides by adopting agroecological production methods. Conventional farmers should be extremely cautious in the choice, timing, and application of insecticides and other chemicals. Here, we review the literature providing mounting evidence that the restoration of plant biodiversity within and around crop fields can improve habitat for domestic and wild bees as well as other insects and thus enhance pollination services in agroecosystems. Main findings are the following: (1) certain weed species within crop fields that provide food resources and refuge should be maintained at tolerable levels within crop fields to aid in the survival of viable populations of pollinators. (2) Careful manipulation strategies need to be defined in order to avoid weed competition with crops and interference with certain cultural practices. Economic thresholds of weed populations, as well as factors affecting crop–weed balance within a crop season, need to be defined for specific cropping systems. (3) More research is warranted to advance knowledge on identifying beneficial weed species and ways to sponsor them to attract pollinators while not reducing yields through interference. (4) In areas of intensive farming, field margins, field edges and paths, headlands, fence-lines, rights of way, and nearby uncultivated patches of land are important refuges for many pollinators. (5) Maintenance and restoration of hedgerows and other vegetation features at field borders is therefore essential for harboring pollinators. (6) Appropriate management of non-cropped areas to encourage wild pollinators may prove to be a cost-effective means of maximizing crop yield.

148. Pagano, M.C. *et al*. 2016. Mycorrhizas in Agroecosystems. In: Pagano M. (eds) Recent Advances on Mycorrhizal Fungi. Fungal Biology. Springer, Cham. https://doi.org/10.1007/978-3-319-24355-9_8. The increasing consideration for more information to better understand agroecosystems and soils under different management has been recognized. The study of surface and deep soil responses to global change and how to enhance the resilience of soil ecosystems is thus urgently recommended. The examination and use of arbuscular mycorrhiza, which link the biotic and soil components providing ecosystem services for crops in the different associated soils, is reviewed. This chapter discusses advances in mycorrhizal fungi potential drawing on recent research worldwide. Studies on mycorrhizas have developed largely; however, the applications of mycorrhizas in agriculture and environmental issues are still incipient, and its limitations are also discussed.

149. Page, K., Y. Dang, and R. Dalal. 2013. Impacts of conservation tillage on soil quality, including soil-borne crop diseases, with a focus on semi-arid grain cropping systems. Australasian Plant Pathology, 42(3), 363–377. https://doi.org/10.1007/s13313-013-0198-y. Conservation tillage is a system of management that leaves at least 30 % of the soil surface covered by residue between crop harvests and planting, and may be combined with appropriate crop rotations to improve soil fertility and disease/weed management. This review examines the effect of conservation tillage on soil biological, chemical, and physical properties and how these interact to affect crop production. Improvements in physical attributes are widely observed under conservation tillage, and these improvements often lead to increased rates of water infiltration and storage. Increases in bulk density in the absence of cultivation, however, may lead to decreases in soil aeration. Conservation tillage may also lead to many soil chemical changes. Decreases in soil pH, changes to cation exchange capacity, and alterations to nutrient availability have all been observed. Changes to biological processes are generally characterised by increases in soil organic carbon (SOC) at or near the surface of the soil profile, along with subsequent increases in soil microbial biomass and diversity. However, the presence of plant diseases and weeds may also increase under conservation tillage management. In semi-arid environments, the increases in soil water storage afforded by conservation tillage often lead to increased yield, especially in dry years. However, where crop disease and weed growth, a lack of plant available nutrients, and/or adverse soil structure limit plant development, lower yields may also be observed. Holistic systems that incorporate appropriate crop rotations, fertilizer and weed management are required to help control the negative aspects of conservation tillage, and ensure that improvements in soil quality lead to increases in crop production.

150. Partap, U. and T. Partap. 1997. Managed crop pollination: The missing dimension of mountain agricultural productivity. ICIMOD, Kathmandu, Nepal.

151. Partap, U. and T. Partap. 2002. Warning signal from the apple valley of the HKH: Productivity concerns and pollination problems. ICIMOD, Kathmandu, Nepal.

152. Partap, U., A.N. Shukla and L.R. Verma 2000. Comparative foraging behavior of *Apis cerana* and *Apis mellifera* in pollinating peach and plum flowers in Kathmandu valley, Nepal. *In:* M. Matsuka, L. R. Verma, S. Wongsiri, K. K. Shrestha and U. Pratap. (eds) Asian Bees and Beekeeping Progress of Research and Development. Oxford and IBH Pub. Co. Pvt. Ltd, New Delhi, India. pp. 193-197.

153. Partap, V. and Partap T. 2001. Declining Apple Production and Worried Himalayan Farmers: Promotion of Honeybees for Pollination. *Issues in Mountain Development*. ICIMOD. KTM. Nepal, Vol.-1.

154. Peterson, R. B., D. Russell, P. West, and J. P. Brosius. 2010. Seeing (and doing) conservation through cultural lenses. *Environmental Management* 45.1: 5-18. This paper critiqued the traditional ways of doing conservation. The authors asked for the inclusion of cultural lenses and anthropologists to conservation. They explained how local communities and local context shape conservation. The paper mostly criticized the permanent exclusion of social dimensions to conservation, and gave some insights on how these can be integrated.

155. Plieninger, T., S. Dijks, E. Oteros-Rozas, and C. Bieling. 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* 33:118-129. A spatially explicit participatory mapping of cultural ecosystem services and several "dis-services" in Eastern Germany. Results reveal perceptions of bundles of services that vary according to respondents' sociodemographic characteristics.

156. Pokhrel, S. 2006. Status and management of domesticated and wild honeybees (*Apis* spp.) in Chitwan, Nepal. Ph.D. Dissertation, TU, Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal.

157. Pokhrel, S., R.B. Thapa. F.P. Neupane and S. M. Shrestha. 2006. Absconding behaviors and management of *Apis cerana* Fab. Honeybee in Chitwan Nepal. J. Inst. Agric. Anim. Sci. 27:77-86. Twelve colonies of five-framed *Apis cerana* F. with about equal brood, hive storage and colony strength were prepared in November 2004 and the colony development parameters recorded. One-third of the colonies absconded in summer and about one-sixth in rainy season, while non-absconded colonies also slowed comb building, brood rearing, colony strength and hive storage in summer and rainy seasons. Feeding sugar candy and pollen substitute prevented absconding in May and July. Three weeks feeding in May resulted higher comb building (15.0%), higher brood rearing (158.8%), stronger colony strength (15.0%) and higher hive storage (171.2% honey, 270.9% pollen) in June. Those colonies having higher brood mite (*Varroa jacobsoni* Oud.) in winter absconded earlier.

158. Pokhrel, S., R.B. Thapa. F.P. Neupane and S.M. Shrestha. 2007. Feeding management of *Apis mellifera* Lin. Honeybee in relation to its supersedure in Chitwan, Nepal. IAAS. Res. Adv. 1: 99-113.

159. Power, A.G. 2010. Ecosystem services and agriculture: Tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 2959–2971. https://doi.org/10.1098/rstb.2010.0143. Agricultural ecosystems provide humans with food, forage, bioenergy and pharmaceuticals and are essential to human wellbeing. These systems rely on ecosystem services provided by natural ecosystems, including pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling and hydrological services. Preliminary assessments indicate that the value of these ecosystem services to agriculture is enormous and often underappreciated. Agroecosystems also produce a variety of ecosystem services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services. Depending on management practices, agriculture can also be the source of numerous disservices, including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. The tradeoffs that may occur between provisioning services and other ecosystem services and disservices should be evaluated in terms of spatial scale, temporal scale and reversibility. As more effective methods for valuing ecosystem services become available, the potential for 'win–win' scenarios increases. Under all scenarios, appropriate agricultural management practices are critical to realizing the benefits of ecosystem services and reducing disservices from agricultural activities.

160. Potschin, M., R. Haines-Young, R. Fish, and R. K. Turner. 2016. *Routledge handbook of ecosystem services*. London and New York: Taylor & Francis. A comprehensive reference text on ecosystem services including their biophysical characterization, economic valuation, and inclusion in decision making.

161. Pullaiah, T. (ed.). 2019. Global biodiversity V-1: Selected countries in Asia. Apple Academic Press Inc, Canada. The term 'biodiversity' came into common usage in the conservation community after the 1986 National Forum on BioDiversity, held in Washington, DC, and publication of selected papers from that event, titled Biodiversity, edited by Wilson (1988). Biodiversity is now the buzzword of everyone from parliamentarians to laymen, professors, and scientists to amateurs. There is

a need to take stock on biodiversity of each nation. The present attempt is in this direction. The main aim of the book is to provide data on biodiversity of each nation. The ultimate aim of the book is for the conservation of biodiversity and its sustainable utilization.

162. Olsson, P., C. Folke, and F. Berkes. 2004. Adaptive co-management for building resilience in social-ecological systems. *Environmental Management* 34.1: 75-90. This paper presented examples from Sweden and Canada to show how local groups self-organized for ecosystem management and adapted to changing conditions. The authors recognized that adaptive co-management of ecosystems depended on each of the following: leaders with vision, enabling legislation to create social space for ecosystem management, capacity for monitoring environmental feedback, and combining various sources of knowledge. Adaptive co-management can be applied to the management of ecosystem services.

163. Rahman, K.A. 1940. Insect pollinators of toria (*Brassica napus* Linn. var. *dichotoma* Prain) and sarson (*Brassica campestris* Linn. var. *sarson* Prain) at Lyallpur. Indian J.Agric.Sci 10:422-447. Rahman L, Chan KY, Heenan DP (2007) Impact of tillage, stubble management and crop rotation on nematode populations in a long-term field experiment. Soil Tillage Res 95(1–2):110–119. doi:10.1016/j.still.2006.11.008. The population abundance of free-living and plant-parasitic nematodes was investigated in a long-term rotation/tillage/stubble management experiment at Wagga Wagga Agricultural Institute, New South Wales (NSW), Australia. The treatments were a combination of two crop rotations: wheat (*Triticum aestivum*)–wheat and wheat–lupin (*Lupinus angustifolius*); two tillage systems: conventional cultivation (CC) and direct drill (DD); and two stubble management practices: stubble retention (SR) and stubble burnt (SB). Plots of one of the wheat–wheat treatments received urea at 100 kg N ha^{-1} during the cropping season. Soil samples from 0–5 and 5–10 cm depths were collected in September (maximum tillering), October (flowering) and December (after harvest), 2001, to analyse nematode abundance. Soil collected in September was also analysed for concentrations of total and labile C, and pH levels. Three nematode trophic groups, namely bacteria-feeders (primarily Rhabditidae), omnivores (primarily Dorylaimidae excluding plant-parasites and predators) and plant-parasites (*Pratylenchus* spp. and *Paratylenchus* spp.) were recorded in each soil sample. Of them, bacteria-feeders (53–99%, population range 933–2750 kg^{-1} soil) dominated in all soil samples. There was no difference in nematode abundance and community composition between the 0–5 cm and 5–10 cm layers of soil. The mean population of free-living and plant-parasitic nematodes varied significantly between the treatments in all sampling months. In most cases, total free-living nematode densities (Rhabditidae and Dorylaimidae) were significantly ($P < 0.001$) greater in wheat–lupin rotation than the wheat–wheat rotation irrespective of tillage and stubble management practices. In contrast, a greater population of plant-parasitic nematodes was recorded from plots with wheat–wheat than the wheat–lupin rotation. For treatments with wheat–wheat, total plant-parasitic nematode (*Pratylenchus* spp. and *Paratylenchus* spp.) densities were greater in plots without N-fertiliser (295–741 kg^{-1} soil) than the plots with N-fertiliser (14–158 kg^{-1} soil). Tillage practices had significant ($P < 0.05$) effects mostly on the population densities of plant-parasitic nematodes while stubble management had significant effects ($P < 0.05$) on free-living nematodes. However, interaction effects of tillage and stubble were significant ($P < 0.01$) for the population densities of free-living nematodes only. Population of Rhabditidae was significantly higher in conventional cultivated plots (7244 kg^{-1} soil) than the direct drilled (3981 kg^{-1} soil) plots under stubble retention. In contrast, plots with direct drill and stubble burnt had significantly higher populations of Dorylaimidae than the conventional cultivation with similar stubble management practice. No correlations between abundance of free-living nematodes, and concentration of total C and labile C in soil were observed in this study. These results showed that stubble retention contributed for enormous population density of free-living (beneficial) nematodes while conventional cultivation, irrespective of stubble management, contributed for suppressing plant-parasitic nematodes.

164. Rasmussen, P.E., and C.R. Rohde. 1988. Long-term tillage and nitro-gen fertilization effects on organic nitrogen and carbon in a semiarid soil. Soil Sci. Soc. Am. J. 52:1114–1117. https://doi.org/10.2136/sssaj1988.036159950052 00040041x. Maintaining or improving soil organic matter has high priority in agriculture because of its beneficial effect on soil physical, chemical, and biological properties. Soil organic N and C were measured 44 yr after establishment of a long-term experiment to evaluate tillage and fertilizer effects in a winter wheat (*Triticum aestivum* L.)-fallow rotation on a coarse-silty mixed mesic Typic Haploxeroll. Main treatments consisted of three primary tillage systems, one conventional (moldboard plow) and two stubble mulch (offset disc, subsurface sweeps). Subplots consisted of six N treatments, 493, 728, 986, 1221, 1714, and 2207 kg N ha^{-1} applied over 44 yr. Organic N and C in the top 75 mm of soil were 26 and 32% higher, respectively, in the two stubble mulch systems than in conventional tillage, and equal below 75 mm. Stubble mulch plots contained 245 kg more N ha^{-1} than conventionally tilled plots, representing the conservation of 5.7 kg N ha^{-1} yr^{-1}. Nitrogen fertilization increased soil N linearly in all tillage treatments, with 18% of the applied N incorporated into the soil organic fraction. Applied N also increased soil C linearly on plots with previous S application. Soil C was higher on plots with no previous S than on comparable plots with previous S, however, which suggests an S deficiency that altered S, but not N, transformations in soil. Identical N fertilization

effects on soil organic N and C in both stubble mulch and conventional tillage suggests that N transformations were the same in both systems,

165. Ribeiro, G.S., E.M. and A. C. Cald. 2017. Biology of pollination of *Citrus sinensis* variety 'Pera Rio.' Rev Bras Frutic 39:. https://doi.org/10.1590/0100-29452017033. Aspects related to the floral biology of *Citrus sinensis* 'Pera Rio' variety were studied in the present work aiming to obtain information about the pollination ecology in the local agriculture. Studies of flowering, anthesis, pollen / ovule ratio, stigmatic receptivity, pollen viability, nectar characterization and floral visitors were carried out. From the data studied, the following information was obtained: C. sinensis variety 'Pera Rio' flourishes in two annual periods (dry and rainy), the anthesis occurs from 9:00 AM with duration of 24 hours, during which period stigma receptivity, pollen viability and nectar secretion are highly significant, demonstrating that the species also possesses characteristics of allogenic plants. *Apis mellifera* was a floral visitor, with a greater number of individuals with a Relative Frequency (RF) of 51.1%. Melipona scutellaris obtained second place in visits with RR = 23.6%; Followed by *Trigona spinipes* with FR = 17.7%. The two seasons (dry and rainy) presented high similarity (Morisita index = 0.64). *C. sinensis* has floral biology favorable to cross pollination and bees *A. mellifera* and *M. scutellaris* are potential pollinators of this fruit in the conditions in the region of the Recôncavo Baiano. The reproductive system of *C. sinensis* is mixed, being favorable to entomophilic pollination.

166. Rijal, S. and R.B. Thapa. 2017. Assessment of pollination deficit in rapeseed (Brassica campestris L. var. toria) and its impact on yield in different agro-ecosystems of Chitwan, Nepal. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. Crop pollination is crucial for increasing yield, ensuring food security, improving livelihoods of farmers and pollinators' conservation as well. The pollination treatments in rapeseed were: i) open pollination; ii) plants caged with honeybees (*Apis mellifera* L.); iii) hand pollination; and iv) control (plots caged without pollinators) replicated four times. Then pollinators visiting flowers, plant growth, and yield were recorded. There was different levels of pollinators in semi-natural, organic and intensive agriculture sites, however deficit in pollination noticed in intensive agriculture field resulting in lower yield. The dominant pollinators were: Hymenopterans, mostly honeybees (*Apis mellifera* L., *Apis cerana* F., *Apis dorsata* F. and *Apis florea* F.) including other pollinators like Syrphid flies, *Syurphus* sp., *Eristalis* sp. as dominant dipteran pollinators and some other Coleopteran and Lepidopteran pollinators, respectively.

167. Rodrigo Martínez-Sastre, Daniel García, Marcos Miñarro and Berta Martín-López. 2020. Farmers' perceptions and knowledge of natural enemies as providers of biological control in cider apple orchards, Journal of Environmental Management, 266, (110589). https://doi.org/10.1016/j.jenvman.2020.110589. While the importance of biological control for crop production is widely acknowledged, research on how farmers perceive on-farm natural enemies remains scarce. This paper examines cider-apple farmers' perceptions and knowledge of the concept of biological control and the specific organisms underpinning its provision (i.e. natural enemies) in the cider-apple orchards of Asturias (N Spain). Although these orchards host a high diversity of natural enemies, certain pests continue to be a problem, e.g. the codling moth and the fossorial water vole. By conducting 90 face-to-face surveys, we found that farmers "under-estimated" the importance of biological control and the role played by natural enemies in suppressing pests from cider-apple orchards. Furthermore, farmers were particularly unaware of the indirect benefits of biological control, such as the increased quality and yield of product. Farmers also perceived that different taxa of natural enemies contribute to biological control to differing extents, for example, birds, such as buzzard, robin and tit, were perceived as the most important natural enemies, while arachnids and insects (excluding ladybug) were perceived as less important. This perceived difference in the biological control contribution of vertebrates and invertebrates could be influenced by farmers' local knowledge, acquired on-farm through daily experiences, as well as from external sources. In addition, we found that farmers did recognize many interactions between natural enemies and pests, although there were serious misconceptions and knowledge gaps. Finally, we revealed that education level, being a full-or part time farmer rather than a 'hobby' farmer, time spent working in agriculture, and orchard size are all factors that positively influence farmer's perception of natural enemies. Our results provide insights for a future management of cider-apple orchards which promotes biological control through: (1) creating initiatives to develop farmers' knowledge regarding biological control and natural enemies, (2) fostering traditional farming systems that contribute to preserving local ecological knowledge of biological control, and (3) establishing networks of farmers so they can learn from each other and share local knowledge.

168. Roe, D., N. Seddon, and J. Elliott. 2019. Biodiversity loss is a development issue a rapid review of evidence. International Institute for Environment and Development, London, UK. From genes to micro-organisms to top predators and even whole ecosystems, we depend on biodiversity for everything from clean air and water to medicines and secure food supplies. Yet human activities are destroying biodiversity around 1000 times faster than natural 'background' rates. This global biodiversity crisis is hitting the poorest communities first and hardest, because they can ill-afford to 'buy in' biodiversity's

previously-free goods and services (and are already bearing the brunt of climate change). So why does the development community often ignore biodiversity loss? This paper unpicks misunderstandings and sets out the evidence that biodiversity loss is much more than an environmental problem – it is an urgent development challenge.

169. Rode, J., E. Gómez-Baggethun, and T. Krause. 2015. Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence. *Ecological Economics* 117:270-282. A comprehensive review of the empirical evidence for the theory of motivational crowding out, by which the addition of monetary incentives undermine existing motivations for conservation. The authors found evidence of "crowding out" and, to a lesser extent, of "crowding in".

170. Rosa García, R,, and M. Miñarro. 2014. Role of floral resources in the conservation of pollinator communities in cider-apple orchards. Agric. Ecosys. Environ. 183:118–126. doi:10.1016/j.agee.2013.10.017. Pollinators are generally assumed to be in decline but a proper habitat management could help to conserve pollination services. In 2012 we surveyed the groundcover in nine cider-apple orchards to (I) identify the floral and faunal communities present in the ground floor, (II) assess the attractiveness of the local spontaneous flowers to insects and (III) determine the role that the flower community may play for the conservation of the associated arthropods in general and of pollinators in particular. The apple orchards provided a continuous succession of floral resources in the groundcover with differences among orchards in the abundance, richness and diversity of flowers. Flowering plant species were visited by a wide variety of insects, mostly from the orders Hymenoptera (70%) and Diptera (25%). Wild bees accounted for 27% of hymenopterans and hoverflies for 30% of dipterans. Flowering plants differed in the number of taxa they attracted and in their attractiveness for particular insect groups and for insects as a whole. A total of 16,159 arthropods were collected from the groundcover, and 2064 individuals belonged to taxa involved in the pollination. Pollinators and arthropods (exemplified by hemipterans and coleopterans) differed between orchards and periods and were affected by the plant community. Plant species richness and the abundance of some plant species favored the presence of both pollinators and arthropod assemblages while flower abundance had only a marginal effect on those communities. Pollinators were also affected by plant diversity. Among-orchard differences in the plant community suggest that management recommendations must be site-specific to ensure the permanent availability of diverse floral resources for the arthropod community and for pollinators in particular. Therefore, a proper groundcover management could provide benefits for apple growers by improving pollination services.

171. Roubik, D.W. (ed.). 2014. Pollinator safety in agriculture. FAO, Rome, Italy. A careful look at pollinators can help us understand how they may live and carry out their vital function in our world, and how we can manage not to destroy or poison much of it ourselves. Honeybees have extraordinary capacities of flight, homebuilding, and food seeking, as well as many defenses from natural enemies. In the brain of a bee there is a map of the environment, and a sharp memory of where food and stress sources exist. The complex dynamics of many things are learned by bees. They make a living by making the right choices, permitted by gathering the correct information. Our struggle to understand and maintain our own environment in a healthy state closely matches the bee's instinctive pursuit. The greening of pollination is our goal. That is, native or wild pollinators can be sustained, while those sought and utilized in agriculture can benefit from the same practices and insights. Our human environment will also become safer, as our crops receive the benefits that only the pollinating animals can bring them. This book, keyed to practitioners in the tropical world, testifies that we can positively alter the way food is produced by managing agriculture to avoid known exposure risks of pollinators to pesticides. GEF/UNEP-supported project on the "Conservation and Management of Pollinators for Sustainable Agriculture, through an Ecosystem Approach", FAO and its partners in seven countries have been developing tools and guidance for conserving and managing pollination services to agriculture.

172. Rowen EK, Tooker JF, Blubaugh C. 2019. Managing fertility with animal waste to promote arthropod pest suppression. Biol. Control 134:130–40. https://doi.org/10.1016/j.biocontrol.2019.04.012. Fertility management is key to maintaining soil quality in crop systems and can have important implications for plant growth and insect pest populations. Organic fertility amendments, particularly animal manures, are hypothesized to simultaneously promote plant vigor, herbivore resistance, and top-down pest suppression. Animal-waste fertilizers influence pest control in at least two ways: first, they can affect prey suppression from the bottom up by changing macro- and micronutrient concentrations in the plant, shaping the rhizosphere community, elevating production of defensive chemicals and altering herbivore-induced plant volatiles (HIPVs). Second, animal-waste fertilizers can affect conservation biological control from the top down by improving the soil-surface habitat for predators through altered soil tilth, organic matter, water retention, and by supporting decomposers communities that also feed soil-dwelling predators as non-pest prey. However, while animal-waste fertilizers may enhance pest suppression when applied correctly, when manure is overused there are also costs of excess fertility pest management and water quality. In this review of the existing body of research on interactions between animal-waste fertilizers, herbivores, and natural enemies, we summarize trends, report costs and benefits, and identify research opportunities for future studies.

173. Ruhl, J. B., and J. Salzman. 2007. The law and policy beginnings of ecosystem services. *Journal of Land Use & Environmental Law* 22.2: 157-172. This article is a review on the development of ecosystem services as it grew from a concept to become a central way of understanding and doing conservation. It also discussed the roles of national governments and international organizations in the policies that protect ecosystem services.

174. Sahu, R.C., R.B. Thapa, C.K. Mandal, S.M. Shrestha and M. Sapkota. 2007. Effect of Endosulphan on the mortality of forager honeybees (*Apis mellifera* L. and *Apis cerana*). IAAS. Res. Adv.1: 147-150.

175. Sahu, R.C., R.B. Thapa, C.K. Mandal, S.M. Shrestha and M. Sapkota. 2007. Performance of *Apis mellifera* L. in thermocol hive during spring and summer season in Chitwan, Nepal. IAAS. Res. Adv.1: 151-154.

176. Sapkota, S., R.B. Thapa, R. Regmi, N. Krakuer, A. Jha, N. R. devkota, P. K. jha and P. Thapa. 2017. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. Recent studies have proven that healthy levels of biodiversity and functional diversity promote sustainable ecosystem functioning. Similarly, in agro-ecosystem high levels of biodiversity are expected to maintain ecosystem services. In this respects dung beetles are of considerable ecological and economical importance because of their role in decomposition of animal excrement, the cycling of nutrient and the resulting enhancement in the productivity of grassland ecosystem.

177. Satterfield, T., R. Gregory, S. Klain, M. Roberts, and K. M. A. Chan. 2013. Culture, intangibles and metrics in environmental management. *Journal of Environmental Management* 117:103-114. This article addresses the difficult but necessary collaboration of researchers of culture in the valuation of ecosystem services and environmental management. The authors propose and describe a suite of alternative methodologies for valuation in quantitative-qualitative terms, borrowing from risk assessment.

178. Sandhu, H.S., S.D. Wratten, and R. Cullen. 2007. From poachers to gamekeepers: Perceptions of farmers towards ecosystem services on arable farmland. International Journal of Agricultural Sustainability, 5(1), 39–50. https://doi.org/10.1080/14735903.2007.9684812. Management of ecosystem services (ES) is vital to maintain and improve the productivity of agricultural systems in order to meet the food demands of a growing human population. However, some land management practices can severely reduce the ecological and financial contribution of some of these services to agriculture, which in the longer term can offset the ability of farming to produce large amounts of food and fibre. Therefore, to improve the understanding and enhancement of these services, it is crucial to know the opinions of farmers who manage ES on their land. Being in close contact with the land provides them with an opportunity to understand its natural processes and functions as well as to act as its stewards. This paper describes ES associated with arable farming in Canterbury, New Zealand and analyses the results of a survey of farmers' perceptions of these services. There was no difference between the measured perceptions of these services by organic and conventional farmers except in the case of biological control. However, organic farmers gave a higher score to 16 individual services compared with conventional farmers. Also, for organic farmers, the importance of some of these services increased significantly with the number of years the farmers had been operating under an organic regime.

179. Sayer, J., T. Sunderland, J. Ghazoul, J.L. Pfund, D. Sheil, E. Meijaard, and L.E. Buck. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proceedings of the National Academy of Sciences of the United States of America, 110(21), 8349–8356. https://doi.org/10.1073/pnas.1210595110. “Landscape approaches” seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals. Here we synthesize the current consensus on landscape approaches. This is based on published literature and a consensus-building process to define good practice and is validated by a survey of practitioners. We find the landscape approach has been refined in response to increasing societal concerns about environment and development tradeoffs. Notably, there has been a shift from conservation-orientated perspectives toward increasing integration of poverty alleviation goals. We provide 10 summary principles to support implementation of a landscape approach as it is currently interpreted. These principles emphasize adaptive management, stakeholder involvement, and multiple objectives. Various constraints are recognized, with institutional and governance concerns identified as the most severe obstacles to implementation. We discuss how these principles differ from more traditional sectoral and project-based approaches. Although no panacea, we see few alternatives that are likely to address landscape challenges more effectively than an approach circumscribed by the principles outlined here.

180. Scherr, S.J., and J.A. McNeely. 2008. Biodiversity conservation and agricultural sustainability: towards a new paradigm of ‘eco-agriculture’ landscapes. Philosopy Transaction R Society London B Biological Science, 363(1491), 477–494. https://doi.org/10.1098/rstb.2007.2165._The dominant late twentieth century model of land use segregated agricultural production from areas managed for biodiversity conservation. This module is no longer adequate in much of the world. The Millennium Ecosystem Assessment confirmed that agriculture has dramatically increased its ecological footprint. Rural

communities depend on key components of biodiversity and ecosystem services that are found in non-domestic habitats. Fortunately, agricultural landscapes can be designed and managed to host wild biodiversity of many types, with neutral or even positive effects on agricultural production and livelihoods. Innovative practitioners, scientists and indigenous land managers are adapting, designing and managing diverse types of 'eco-agriculture' landscapes to generate positive co-benefits for production, biodiversity and local people. We assess the potentials and limitations for successful conservation of biodiversity in productive agricultural landscapes, the feasibility of making such approaches financially viable, and the organizational, governance and policy frameworks needed to enable eco-agriculture planning and implementation at a globally significant scale. We conclude that effectively conserving wild biodiversity in agricultural landscapes will require increased research, policy coordination and strategic support to agricultural communities and conservationists.

181. Shrestha, J.B. and B.N. Singh 1996. The training manual of beekeeping. Published by Non-formal Education Kathmandu, Nepal. The training manual of beekeeping depicts the full explanation about the principles and practices of beekeeping in Nepal with adequate guidance of practical exercises for the grass-root level beekeepers.

182. Shrestha, J.B. 2006. Beekeeping. In: Dahal, D. (ed) Nepal Agriculture Technology Book. Agriculture Information and Communication Centre. Ministry of Agriculture and Cooperatives, Government of Nepal (GON). Pp 216-220. The book on agriculture technology including beekeeping depicts the full explanation about the principles and practices of agricultural technology in Nepal with adequate guidance for the grass-root level farmers and beekeepers.

183. Shrestha, J.B. 2001. Investigation of the parasitic mites; Tropilaelaps clareae Delfinado and Baker, and their host Apis dorsata Fabricius in Chitwan, Nepal. **Thesis, M.Sc. Agriculture (Plant Protection).** Institute of Agriculture and Animal Science, Rampur, Chitwan, Tribhuvan University, Napal. 79 pp. The study was carried out to find out the mites attacking Apis dorsata Fabricius, their rate of infestation and intensity (the number of mites per cell infested), and the trend of A. dorsata colony migration in Chitwan district. Samples of deserted combs of the last and the current seasons, those of live bees and brood were collected three times (at one and half month's interval) from five sites and examined under microscope for mite infestation. Monthly observations on the arrival and departure of A. dorsata colonies at eight sites were also taken throughout the year. The mite found in brood cells and adult bees (A. dorsata) was only Tropilaelaps clareae Delfinado and Baker whereas, Forcellinia galleriella Womersley was also found in deserted comb samples. The overall (general) mean (± SE) rate of brood cell infestation by T. clareae was 7.24 (± 0.66) %. The mean (± SE) number of T. clareae per 100 brood cells was 16.67 (± 2.04) and the mean (± SE) number of T. clareae per 100 adult bees was 0.51 (± 0.06). The overall mean (± SE) parasitic intensity (number of T. clareae per unit cell infested) was 1.98 (± 0.13). Almost all of the above variables increased steadily but significantly over sampling times (mid-December 2000, January-end 2001 and mid-March 2001). The mean (± SE) percent cells infested by T. clareae in deserted combs was 3.0 (± 0.38) % and the mean (± SE) number of T. clareae per 100 cells was 4.05 (± 0.53). The mean (± SE) parasitic intensity was 1.41 (± 0.10). Similarly, the mean (± SE) number of F. galleriella per 100 cells in deserted combs was 55.38 (± 4.38). The mean (± SE) survival (hours) of T. clareae in vials at room temperatures ($21^{o} – 30^{o}$ C) was 8.12 (± 0.58) hours. The mean number of colonies declined steadily from May to August (2000), no colony in September and October (2000), got the highest peak in January (2001), and started again declining from March (2001) onward. The annual mean (± SE) number of A. dorsata colonies was 6.07 (± 0.74). The monthly mean number of colonies was negatively correlated with the monthly mean temperature, and significantly affected by both 'Time' and 'Sites'. It reveals that A. dorsata needs conservation for bio-diversity maintenance.

184. Shrestha, J.B. 1993. Comparing pollen foraging strategy of honey bee (Apis mellifera L.) colonies. **Thesis, Diploma in Apiculture (Post-graduate).** College of Cardiff, University of Wales, U.K. 89 pp. It was intended to compare and contrast the pollen foraging strategy of the honeybee colonies (Apis mellifera L) by analyzing pollen load samples trapped from their hives. Two colonies of approximately equal strength were moved to the site (Berry Hill Farm, Castleton, Cardiff, UK) and pollen traps were attached to the entrance of the hives, before honeybees were released at the new site. Pollen load samples trapped from both colonies were daily collected at 2.00 pm and 7.30 pm. There was no pollen collected in the morning by honeybee colonies until 10.00 am. Each collected samples of pollen load were individually separately homogenized and two slides from each sample were prepared for microscopical examination. The first colony collected 20 species of pollen over the whole duration of study (from 6^{th} May to 14^{th} May, 1993), and among them 19 species were similar. The species occupying three highest mean percentages of pollen in samples trapped from the first colony were Malus species (43.26 %), Crataegus monogyna (16.7 %) and Prunus / Pyrus (9.85 %), and those in the samples trapped from the second were Malus species (27.22 %), Fragaria x ananassa (19.4 %) and Acer pseudoplatanus (13.87 %). While comparing two commercially important fruit crops it was revealed that the first colony had preference for Malus species whereas the second colony had preference for Fragaria x ananassa (Table 14.1-14). The first colony gathered up to 6.43 times as much Malus species pollen as the second colony did (Table 14.1).

Conversely, the second colony collected up to 57.83 times as much Fragaria x ananassa pollen as the first colony did. There was no significant difference between weights of samples collected by both colonies.

185. Shrestha, J.B. 2007. World Trade Organization (WTO) and Its Implications on Nepalese **Apiculture** In: Agricultural Development Journal, Vol. 4 (2063/64). June 6, 2007. GON, Nepal. Pp 20. Having been a member of WTO Nepal needs to abide by WTO agreements, especially the Agreement on the application of sanitary and phyto-sanitary measures (SPS) and the Agreement on Technical Barriers to Trade (TBT).This has some crucial and challenging implications on Nepalese apiculture. Nepal became deprived of the opportunity to export honey to European Union (EU) countries, as Nepal had to have a **residue-monitoring plan**, approved by the EU, conforming to the regional norms such as Council Directive 96/23/EC of 29 April 1996. The infrastructures (including laboratory facilities from central to local levels with competent human resources) must be developed with a categorical mandate and authorities for quality control of the products, their standardization, and their marketing system with appropriate facilities for the monitoring, validation and certification system for food safety, hygiene, production and processing standard. It entails that building and strengthening domestic capacity of different key stakeholders be realized including public institutions, the bureaucracy, private sector, civil society, and academic institutions and focusing in the development of human resource increasing core competencies and promoting specialization in the most crucial areas. Nepal must develop the range of exports, both goods and services and enhance capacity to be able use system tools to realize potential opportunities available in WTO to protect domestic industries and apicultural entrepreneurship as well as to sustain meeting challenges emerging in the WTO regime. By dint of acquiring the WTO membership, Nepal has a claim for equal rights in the international trading system. It necessitates that building supply side be focused and a smooth trading mechanism be put in place, activating the trade monitoring authority, modernizing customs administration and simplifying customs operations. WTO membership has also opened up opportunities of markets of the rest of the member states for Nepalese exports - both goods and services.

186. Shrestha, J.B. 2006. Integrated pest management (IPM) and organic honey. In: Proceedings of the seminar organized by Plant Protection Society Nepal-2003, Harihar Bhawan, Lalitpur on 25-27 August 2006 (2063/5/9-11). Integrated Pest Management (IPM) is an applied ecology approach to provide the means of protecting and improving human, animal, and plant health in a way that is sensitive to the environment and to sustaining natural resources. IPM is the selection, integration, and implementation of control as determined by anticipated economic, ecological, and sociological consequences. IPM is a sustainable approach to managing pests (insects, diseases, weeds, etc.) by combining tools such as biological, cultural, physical and chemical in a way that minimizes economic, health and environmental risks. IPM is not biological control, although biological control is a useful tactic. IPM is not an organic program although we may integrate organic materials into our control tactic. Nor is IPM anti-pesticidal, but generally it attempts to reduce chemical dependency with a mix of control tactics. IPM allows beekeepers to adopt a more balanced approach to mite and disease control that is safer for the beekeeper, bees, hive products and the environment. The hives should consist of natural materials presenting no risk of contamination to the environment or the bee products. The treatment and management of hives should respect all the principles of organic animal husbandry contained in International Standards. The health of bees should be based on prevention of disease, using techniques such as adequate selection of breeds, favorable environment, balanced diet and appropriate husbandry practices. The sources of natural nectar, honeydew and pollen should consist essentially of organically produced plants and/or naturally occurring (wild) vegetation. IPM-FFS and /or organic farming should be highly promoted in order to reduce or minimize the application of pesticides, solve various technological problems for producing high quality honey or other bee products and their processing.

187. Shrestha, J.B. 2006. Combating desertification with sericulture and apiculture In: The Journal of Agriculture and Environment. Gender Equity and Environment Division. Ministry of Agriculture and Cooperatives, GON, Nepal. Pp 6-13. Desertification is an accumulative outcome of unsustainable land use practices along with deforestation, inappropriate farming practices, intensive agriculture, overgrazing, landslides and floods, and shifting cultivation. These factors destabilize ecosystems, accelerate silting of reservoirs and other water bodies, and change hydrological regime resulting in land degradation process. Sericulture has a positive impact on the environment, since it encourages the plantation of mulberry plants, and increases vegetation and green land, which in turn bring about the positive effect towards preventing or reversing desertification. As roots of mulberry plants are very profuse and robust, they are very helpful in holding soil firmly and preventing soil erosion. Honeybees and beekeeping combat desertification through pollination of valuable plant species, which contribute to soil conservation, control erosion, and provide valuable resources for wildlife. Through beekeeping, communities are empowered to utilize the natural resources that are in their environment and they learn how to manage, take care of and earn money through utilizing the resources. It is a valuable conservation tool, instigating people to derive economic benefit not only from indigenous forests but also from other floral resources in a non-destructive way, ensuring local participation in conservation efforts.

188. Shrestha, J.B. 2006. Honey quality and trade opportunities in the context of World Trade Organization (WTO). In: Proceedings of the seminar organized by Plant Protection Society Nepal-2003, Harihar Bhawan, Lalitpur on May 10, 2005 (Baisakha 27, 2062). Honey produced in Nepal is of high quality, however, the monitoring, validation and certification system is weak, and the food safety, hygiene, production and processing standard are also not guaranteed. For these purposes, the infrastructures (including laboratory facilities from central to local levels with competent human power) must be developed with clear-cut mandate and authorities for quality control of the products, their standardization and their marketing system with appropriate facilities. Broadly speaking, to sustain in the WTO regime, Nepal faces two major challenges viz. it must develop the range of exports, both goods and services and enhance capacity to use tools available in WTO to protect local industries and agricultural entrepreneurship. WTO membership has ensured equal rights to Nepal in the international trading system. It entails that building supply side be focused and a smooth trading mechanism be put in place, activating the trade monitoring authority, modernizing customs administration and simplifying customs operations. WTO membership has also opened up opportunities of markets of at least 147 countries for Nepalese exports- both goods and services. Shrestha, J.B. (2005) Keeping bees in cities. In: The Journal of Agriculture and Environment. Published by Ministry of Agriculture and Cooperatives, HMG, Nepal. In the context of monotonous and hectic lifestyle of city-dwellers, urban beekeeping can prove to be a relieving hobby in addition to the income generation and nutritional supplement through bee products. Beekeeping is a noble occupation that is within the capabilities of nearly anyone and that can be started with very little capital and place to get benefits from it. Through beekeeping, communities are empowered to utilize the natural resources that are in their environment and they learn how to manage, take care of and make money from the resources in their own environment. It is a valuable conservation tool, instigating people to derive economic benefit not only from indigenous forests but also from other floral resources in a non-destructive way, ensuring local participation in conservation efforts. It also makes a very significant contribution to other forms of agriculture by effecting or accomplishing the pollination of many economically important plants. Bees produce other products that can be harvested and put to good use, including beeswax, propolis, royal jelly, and bee venom. Even the pollen they bring back to the hive can be harvested, which is rich in protein and makes a healthy food supplement in diets.

189. Shrestha, J.B. 2004. Honeybees and environment. In: The Journal of Agriculture and Environment. Published by Ministry of Agriculture and Cooperatives, HMG, Nepal. The main significance of honeybees and beekeeping is pollination of plant species, which contribute to soil conservation, control erosion, and provide valuable resources for wildlife. Basically, flowers provide nectar and pollen for bees and bees provide cross-pollination for plants -- a kind of inter-dependence resulting in various co-evolutions. The natural environment is required to provide bees and plants with habitat or nesting sites. As a result of cross-pollination by bees, somatic, reproductive and adaptive heterosis or hybrid effects occur in plant progeny, either in a single way or in different combinations bringing about significant qualitative and quantitative changes in the economic and biological characters of plants. Honeybees often facilitate genetic enrichment of native plants through cross-pollination activities for adaptation of plants to the changing environment and for the development of new varieties. Development and promotion of agro-forestry can improve, provide or reconstruct pollinators' habitats and provide forage resources contributing greatly to the conservation and protection of pollinators and hence to sustainable agricultural development. Organic farming or integrated pest management programs should be highly promoted in order to minimize the use of pesticides.

190. Shrestha, J.B. and T.B. Thapa. 2004. The context of the WTO Agreements on Sanitary and Phytosanitary (SPS) Measures and Technical Barriers to Trade (TBT) and Nepal. South Asia Watch on Trade, Economics and Environment (SAWTEE) Briefing Paper. To take benefits from the WTO Agreements Nepal must play a proactive role especially on the part of Agreement on Sanitary and Phyto-sanitary Measures, SPS) and Agreement on Technical Barriers to Trade, TBT, which are important agreements pertinent to WTO. Being one of the least developed countries, Nepal should be able to capture the opportunities and facilities provisioned in Special and Differential Treatment of the WTO. Nepal must be very efficient and capable of achieving the desired result with the minimum use of resources, time, and effort.

191. Shrestha, J.B. 2003. The World Trade Organization (WTO) Agreement on Sanitary and Phytosanitary Measures and farmers' rights in Nepal. Paper presented in 'National Workshop on Protecting farmers' Rights for Food Security and Sustainable Livelihood' organized by National Alliance for Food Security - Nepal (NAFOS) and USC-Nepal. 06 □ 07 August 2003, Dhulikhel. Agreement on Sanitary and Phytosanitary Measures (SPS) is one of the important agreements of WTO and it brings about both opportunities and challenges for the protection of health of human beings, animals and plants in Nepal. It also provides with the opportunities for getting justice against the unjust and discriminatory behavior against the least developed countries like Nepal. There are no separate laws or acts concerning farmers’ rights in Nepal, although they are needed as soon as practicable. However, they have been mentioned in short in various acts. Nepal needs its own sui generic for biodiversity conservation and protection of its traditional technologies, resources and innovations.

192. Shrestha, J.B. and K.K. Shrestha. 2000. Beekeeping in Nepal: Problems and potentials. In: Fourth Asian Apicultural Association International Conference Kathmandu, Nepal, March 23-28, 1998. Asian bees and beekeeping, progress of research and development: proceedings edited by M. Matsuka, L.R. Verma, S. Wongsiri, K. K. Shrestha, and U. Partap. New Delhi, Oxford and IBH Publishing Co. Pvt. Ltd. Pp 262-265. In Nepal, bee-keeping with *Apis cerana* F. is taken up by rural farmers as a traditional household integral part of agricultural activities. They keep bees in hollow logs and/or wall cavities. Top bar log hives or even frame hives can be seen in some of trained beekeepers. Seasonal management or routine inspection of hives is only practiced by some trained bee-keepers in top bar or frame hives. The beekeepers of Nepal face two dearth periods in the mid hills rich in beekeeping. Migration of colonies is not practiced. Bee-keeping with *Apis cerana* F. has various problems such as absconding, higher swarming tendency, frequent absence of queen, frequent fighting and robbing, susceptibility to diseases and pests, low honey yields. Deforestation and environmental degradation, the use of pesticides, bee-equipment standardization, applied research, training programs with follow-ups need further attention. Nepal is very rich in various bee species and bee flora having a great potential for their improvement. Training trainers and in turn farmers to use the available technology, selection and multiplication of colonies having better traits, promotion of managed bee pollination through zonations can make *Apis cerana* F. bee-keeping a sustainable income generating activity at the door steps of the rural poor. The potentiality and the stimulus in beekeeping deserves the international support for further work in *Apis cerana* F. beekeeping with a larger goal of alleviating poverty and helping food security in the region.

193. Shrestha, J.B. 1989. Traditional beekeeping in Nepal and its prospects. In: Proceedings of 1st Asia-pacific conference on Entomology, Chiangmai, Thailand, November 17-23, 1989. Nepal is blessed with wide range of natural resources including vegetation providing with an ideal environment for the development of beekeeping. In Nepal, Traditional beekeeping has been an important heritage since time immemorial. There is tremendous scope for developing beekeeping in Nepal. Deforestation and environmental degradation need greater attention not only for the betterment of beekeeping but also for overall sustainable development in the country. Joint but coordinated effort of all stakeholders must be directed towards flourishing beekeeping with proper impetus for the optimum utilization of full potential of the boon of the natural resources in Nepal.

194. Simon, S., J. Bouvier, J. Debras, and B..Sauphanor. 2010. Biodiversity and pest management in orchard systems. A review. Agron Sustain Dev 30:139–152. doi:10.1051/agro/2009013. Conventional agriculture is based on a high level of chemical inputs such as pesticides and fertilizers, leading to serious environmental impacts, health risks and loss of biodiversity in agro-systems. The reduction of pesticide use is a priority for intensively sprayed agricultural systems such as orchards. The preservation and promotion of biodiversity within orchards and their boundaries is therefore an issue to explore. Indeed, orchard systems contain high plant diversity and perennial multi-strata designs that provide wealthy resources and habitats to living communities such as beneficial organisms. Orchards thus offer favorable areas to maintain food-webs within the agro-system, provided that favorable situations are not altered by cultural practices such as applying an excess of pesticides. Here, we analyzed literature on the effects of the manipulation of plant diversity and habitats on the control of pests by arthropod and bird communities in apple, pear and peach orchards. Many investigations focus on the role of plant management to enhance biodiversity in orchards but only 22 research reports presenting 30 case studies were dedicated to the study of the ecosystem service provided by plant diversity for orchard pest control. The underlying mechanisms were seldom demonstrated, and the tested grass covers and tree assemblages aimed at favoring either the beneficial complex or only some beneficial species to control one or a few pests. The effect of plant management on pest control was mostly positive (16 cases) or null (9), but also negative in some cases (5). This finding reveals the difficulties of identifying selected plants or plant assemblages for the control of key pests. We conclude that further research is needed to identify the processes involved on different scales for biological control. Orchard systems should be re-designed to optimise ecosystem services provided by biodiversity.

195. Singh, M.M. 2001. Pollination ecology of common buckwheat (*Fagopyrum esculentum*) in different agro-ecozones of Nepal with particular reference to the role of the Himalayan honeybee, *Apis cerana.*, National Workshop on Research and Development on Buckwheat, Kathmandu (Nepal), 13-14 Sep. 2001. This paper presents the findings of two studies - one conducted on foraging behaviour of Himalayan honeybee (*Apis cerana* F.) on flowering buckwheat (*Fagopyrum esculentum* Moench) in November 2001 to 2002 and another on its impact on the grain quality and yield increment of this crop conducted during 2000-2002 under different pollination treatments at Kirtipur, Kathmandu valley. *Apis cerana* bees started their foraging activities early in the morning (06.14} 0.004) and ceased late in the evening (17.28} 0.011). Total duration of foraging activity was 10:00 h and the average duration of foraging trip was 4.5 �} 0.14 min. Two peaks of foraging activities were observed between 08.30 to 10.30 (Peak I) and 11.30 to 13.30 O' clock (Peak II). The peak I period was the main foraging period and peak II was the second foraging period, both were very useful from the pollination point of view. After this, *Apis cerana* activity slowly diminished to a standstill at 17.30 pm. The time spent by *Apis cerana* on the buckwheat inflorescence at different hours of the day 09.00, 12.00, 15.00 O' clock showed longest (24) 3 min) in the morning and it decreased as the afternoon approached.

This study revealed that *Apis cerana* bee pollination increased grain set in terms of the total number of grains per plant (169.76} 4.10), grain weight (33.03} 0.26 g) and grain yield (4.40} 0.12 g). It also increased the value of fertility (16.08} 0.21) and harvest index (35.32} 0.35) when compared with Control pollination/excluding all the insects (CP) and Open pollination (OP) treatment. This is mainly due to greater number of pollinators in the Bee pollination (BP) treatment, their longer duration of foraging and also due to superior pollinating efficiency of *Apis cerana* bees.

196. Six, J., S.D. Freyn, R.K. Thietn, and K. Batten. 2006. Bacterial and fungal contributions to carbon sequestration in agroecosystems. Soil Sci Soc Am J 70:555. doi:10.2136/sssaj2004.0347. This paper reviews the current knowledge of microbial processes affecting C sequestration in agroecosystems. The microbial contribution to soil C storage is directly related to microbial community dynamics and the balance between formation and degradation of microbial byproducts. Soil microbes also indirectly influence C cycling by improving soil aggregation, which physically protects soil organic matter (SOM). Consequently, the microbial contribution to C sequestration is governed by the interactions between the amount of microbial biomass, microbial community structure, microbial byproducts, and soil properties such as texture, clay mineralogy, pore-size distribution, and aggregate dynamics. The capacity of a soil to protect microbial biomass and microbially derived organic matter (MOM) is directly and/or indirectly (i.e., through physical protection by aggregates) related to the reactive properties of clays. However, the stabilization of MOM in the soil is also related to the efficiency with which microorganisms utilize substrate C and the chemical nature of the byproducts they produce. Crop rotations, reduced or no-tillage practices, organic farming, and cover crops increase total microbial biomass and shift the community structure toward a more fungal-dominated community, thereby enhancing the accumulation of MOM. A quantitative and qualitative improvement of SOM is generally observed in agroecosystems favoring a fungal-dominated community, but the mechanisms leading to this improvement are not completely understood. Gaps within our knowledge on MOM-C dynamics and how they are related to soil properties and agricultural practices are identified.

197. Smith, P. 2012. Soils and climate change. Current Opinion in Environmental Sustainability, 4(5), 539–544. https://doi.org/10.1016/j.cosust.2012.06.005. Soils contain vast reserves (∼1500 Pg C) of carbon, about twice that found as carbon dioxide in the atmosphere. Historically, soils in managed ecosystems have lost a portion of this carbon (40–90 Pg C) through land use change, some of which has remained in the atmosphere. In terms of climate change, most projections suggest that soils carbon changes driven by future climate change will range from small losses to moderate gains, but these global trends show considerable regional variation. The response of soil C in future will be determined by a delicate balance between the impacts of increased temperature and decreased soil moisture on decomposition rates, and the balance between changes in C losses from decomposition and C gains through increased productivity. In terms of using soils to mitigate climate change, soil C sequestration globally has a large, cost-competitive mitigation potential. Nevertheless, limitations of soil C sequestration include time-limitation, non-permanence, displacement and difficulties in verification. Despite these limitations, soil C sequestration can be useful to meet short-term to medium-term targets, and confers a number of co-benefits on soils, making it a viable option for reducing the short term atmospheric CO2 concentration, thus buying time to develop longer term emission reduction solutions across all sectors of the economy.

198. Soulé, M. 2013. The "new conservation." *Conservation Biology* 27.5: 895-897. This editorial describes the new conservation as a movement that goes beyond the protection of biodiversity and instead seeks to enhance those natural systems that benefit the widest number of people, especially the poor. The author criticized this approach, and stated that if implemented, this type of conservation would hasten ecological collapse globally.

199. Sridhar, V., K.S. Nitin, R. Asokan and A. Adiga. 2017. Use of CLIMEX to identify the potential areas for spread of *Tuta absoluta* under climate change. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. *Tuta absoluta* is an oligphagous pest on solanaceous crops having a potential of causing 100% damage in tomato. Though it is of South American origin recently invaded other countries in Europe, Africa and Asia in recent years. In 2014 and 2016, it was reported from India and Nepal, respectively. Changing climatic conditions could favor its distribution in other parts of Asia. By using a bioclimatic software CLIMEX, it is possible to predict distribution of *T. absoluta* with reference to 1^0C, 2^0C and 3^0C rise in temperature in different parts of the world with particular reference to India and Nepal. Various implications of climate change on *T. absoluta* potential spreads are included in this presentation.

200. Swift, M.J., O. Andrén, L. Brussaard, M. Briones, M.-M. Couteaux, K. Ekschmitt, A. Kjoller, P. Loiseau, and P. Smith. 1998. Global change, soil biodiversity, and nitrogen cycling in terrestrial ecosystems: Three case studies. Global Change Biology, 4(7), 729–743. https://doi.org/10.1046/j.1365-2486.1998.00207.x. The relative contribution of different soil organism groups to nutrient cycling has been quantified for a number of ecosystems. Some functions, particularly within the N-cycle, are

carried out by very specific organisms. Others, including those of decomposition and nutrient release from organic inputs are, however, mediated by a diverse group of bacteria, protozoa, fungi and invertebrate animals. Many authors have hypothesized that there is a high degree of equivalence and flexibility in function within this decomposer community and thence a substantial extent of redundancy in species richness and resilience in functional capacity. Three case studies are presented to examine the relationship between soil biodiversity and nitrogen cycling under global change in ecosystem types from three latitudes, i.e. tundra, temperate grassland and tropical rainforest. In all three ecosystems evidence exists for the potential impact of global change factors (temperature change, CO2 enrichment, land-use-change) on the composition and diversity of the soil community as well as on various aspects of the nitrogen and other cycles. There is, however, very little unequivocal evidence of direct causal linkage between species richness and nutrient cycling efficiency. Most of the changes detected are shifts in the influence of major functional groups of the soil biota (e.g. between microflora and fauna in decomposition). There seem to be few data, however, from which to judge the significance of changes in diversity within functional groups. Nonetheless the soil biota are hypothesized to be a sensitive link between plant detritus and the availability of nutrients to plant uptake. Any factors affecting the quantity or quality of plant detritus is likely to change this link. Rigorous experimentation on the relationships between soil species richness and the regulation or resilience of nutrient cycles under global change thus remains a high priority.

201. Stringer, L.D. R. Soopaya, and R.C. Butler *et al*. 2019. Effect of Lure Combination on Fruit Fly Surveillance Sensitivity. Sci. Rep. 9:2653. https://doi.org/10.1038/s41598-018-37487-6. Surveillance for invading insect pests is costly and the trapper usually finds the traps empty of the target pest. Since the successful establishment of new pests is an uncommon event, multiple lures placed into one trap might increase the efficiency of the surveillance system. We investigated the effect of the combination of the Tephritidae male lures – trimedlure, cuelure, raspberry ketone and methyl eugenol – on catch of *Ceratitis capitata*, *Zeugodacus cucurbitae*, *Bactrocera tryoni*, B. dorsalis, *B. aquilonis* and *B. tenuifascia* in Australia and the USA (not all species are present in each country). The increase in trap density required to offset any reduction in catch due to the presence of lures for other Tephritidae was estimated. The effect of increasing trap density to maintain surveillance sensitivity was modelled for a hypothetical population of B. tryoni males, where the effective sampling area of cuelure traps for this species has been estimated. The 3-way combination significantly reduced the catch of the methyl eugenol-responsive B. dorsalis. Unexpectedly, we found that trimedlure-baited traps that contained methyl eugenol had ×3.1 lower catch of *C. capitata* than in trimedlure-only-baited traps in Australia, but not in Hawaii where no difference in catch was observed, we cannot satisfactorily explain this result. Based on the data presented here and from previous research, combinations of some male lures for the early detection of tephritid flies appear compatible and where there is any reduction in surveillance sensitivity observed, this can be offset by increasing the density of traps in the area.

202. Szabo, T.I., Smith, M.V. 1970. The use of *Megachile rotundata* for the pollination of greenhouse cucumbers. Pages 95-103 in The Indispensable Pollinators. editors. A Report of the 9th Pollination Conference. Hot Springs, Arkansas, October 1970. University of Arkansas Agricultural Extension Service.

203. TEEB. 2010. *Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB*. Geneva: TEEB. This report synthesized the incorporation of economic concepts in decision making regarding environmental management. TEEB presented an approach that captures multiple economic values of nature, including various techniques for their assessment. The authors made the case for systematic appraisal of the economic contribution of biodiversity and ecosystem services to human well-being.

204. Thapa, R. B. 2006. Impact assessment of beekeeping program: A case study of selected VDCs of Kaski district, Nepal ICIMOD, Lalitpur, Nepal.

205. Thapa, R.B. 2006. Honeybees and other insect pollinators of cultivated plants, A review. J. Inst. Agric. Anim. Sci. 27:1-23. Insects are viewed from the harmful perspectives and aimed at killing them through several means including indiscriminate use of deadly chemicals. If good judgment made keeping views on sustainable crop production, natural balance and pollution free environment, they are important component of the ecosystem and their beneficial aspects are immense. One of them is that insects provide pollination service to plants. The study showed that over 50 species of insects visited flowers of 17 different species of selected crops during flowering periods. The visiting preferences of insects to flowers of different crops differed among the crop species and insect species as well. In fact, of the total pollination activities, over 80% is performed by insects and bees contribute nearly 80% of the total insect pollination, and therefore, they are considered the best pollinators. The manmade agro-ecosystem exerted pressure and forced to decline pollinators and their diversity, which resulted in reduced agricultural productivity again threatening biodiversity. Management of wide diversities of honeybees and other beneficial insects and flowering plant species occurring in Nepal help to maintain diversity of flora and bee fauna, pollination and reward hive products in the service of mankind. This paper covers honeybees and other insect species visiting various crop flowers.

206. Thapa, R.B., S. Pokhrel and S. Tiwari. 2008. Agrochemical database of Field and Home garden crops in Chitwan, Nepal. Proceedings of the Workshops on Conservation and Management of Pollinators for Sustainable agriculture through and Ecosystem Approach - Global Pollinator Project/Pilot Activities. *In:* R.B Thapa (ed.) Global Pollinator Project-FAO/UNDP and Institute of Agriculture and Animal Sciences, Rampur Chitwan Nepal. pp. 22-23.

207. Thapa, R.B., S. Pokhrel and S. Tiwari. 2008. Bibliography of pesticides, buckwheat and Mustard. Proceedings of the Workshops on Conservation and Management of Pollinators for Sustainable agriculture through and Ecosystem Approach - Global Pollinator Project/Pilot Activities. *In:* R.B Thapa (ed.) Global Pollinator Project-FAO/UNDP and Institute of Agriculture and Animal Sciences, Rampur Chitwan Nepal. pp. 24-25.

208. Thapa, R.B., S. Pokhrel and S. Tiwari. 2008. Field Experiment on Pollination Management in Chitwan,Nepal. Proceedings of the Workshops on Conservation and Management of Pollinators for Sustainable agriculture through and Ecosystem Approach - Global Pollinator Project/Pilot Activities. *In:* R.B Thapa (ed.) Global Pollinator Project-FAO/UNDP and Institute of Agriculture and Animal Sciences, Rampur Chitwan Nepal. pp. 30-36.

209. Thapa, R.B., S. Pokhrel and *S. Tiwari.* 2008. Good Pollination Practices Adopted by the farmers in Chitwan, Nepal. Proceedings of the Workshops on Conservation and Management of Pollinators for Sustainable agriculture through and Ecosystem Approach - Global Pollinator Project/Pilot Activities. *In:* R.B Thapa (ed.) Global Pollinator Project-FAO/UNDP and Institute of Agriculture and Animal Sciences, Rampur Chitwan Nepal. pp. 37-43.

210. Thapa, R.B., S. Pokhrel and S. Tiwari. 2008. Insect Flower visitors on Buckwheat, Bittergourd and Mustard in Chitwan,Nepal. Proceedings of the Workshops on Conservation and Management of Pollinators for Sustainable agriculture through and Ecosystem Approach - Global Pollinator Project/Pilot Activities. *In:* R.B Thapa (ed.) Global Pollinator Project-FAO/UNDP and Institute of Agriculture and Animal Sciences, Rampur Chitwan Nepal. pp. 28-29.

211. Thapalya, S. 2017. Hot is here: Climate change and its impact on biodiversity. Abstract of the International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihood, 10-12 January 2017, Kathmandu, Nepal. Food and biodiversity, and lack of it, could be where a challenging climate exerts some of its most troublesome impacts in society. Climate change is more vulnerable impact in developing countries like Nepal. The rapidly retreating glaciers (30m/yr), rise in temperature (>0.06 ^{0}C), erratic rainfall are the situations Nepal is facing today. Biodiversity is also being affected as useful flora, fauna, medicinal, food and nutrition related plants may disappear. For example average crop yield is expected to drop down to 50% in Pakistan, whereas cron production in Europe is expected up to 25%. Where CO2 was increased over present day level by about 50%, the yield rose by 7% for rice and 8% for wheat. The adverse impacts can be mitigated through COP, Kyoto protocol, social awareness and by other different political methodology.

212. Thayer, A.W., A. Vargas, A.A. Castellanos, C.W. Lafon, B.A. McCarl, D.L. Roelke, K.O. Winemiller, and T.E. Lacher. 2020. Integrating agriculture and ecosystems to find suitable adaptations to climate change. Climate, 8(1), 10. https://doi.org/10.3390/cli8010010. Climate change is altering agricultural production and ecosystems around the world. Future projections indicate that additional change is expected in the coming decades, forcing individuals and communities to respond and adapt. Current research efforts typically examine climate change effects and possible adaptations but fail to integrate agriculture and ecosystems. This failure to jointly consider these systems and associated externalities may underestimate climate change impacts or cause adaptation implementation surprises, such as causing adaptation status of some groups or ecosystems to be worsened. This work describes and motivates reasons why ecosystems and agriculture adaptation require an integrated analytical approach. Synthesis of current literature and examples from Texas are used to explain concepts and current challenges. Texas is chosen because of its high agricultural output that is produced in close interrelationship with the surrounding semi-arid ecosystem. We conclude that future effect and adaptation analyses would be wise to jointly consider ecosystems and agriculture. Existing paradigms and useful methodology can be transplanted from the sustainable agriculture and ecosystem service literature to explore alternatives for climate adaptation and incentivization of private agriculturalists and consumers. Researchers are encouraged to adopt integrated modeling as a means to avoid implementation challenges and surprises when formulating and implementing adaptation.

213. Thomas Bjorkman and Pearson. K 1995. The Inefficiency of. Honeybees in the Pollination of Buckwheat. Current Advances in Buckwheat Research (1995): 453–462. Seed production in buckwheat (*Fagopyrum esculentum* Moench) can be much lower than expected from the plant biomass, and this low seed production has been blamed on inadequate pollination. Honey bees (Apis melli/era L.) were at least 95% of the insect visitors to buckwheat flowers in fields of central New York State. The number of times each flower was visited by a honey bee ranged from zero to over 40, but there was no relationship between the number of bee visits and the daily seed initiation if there were at least two. Pollen delivery sometimes limited seed set, but limitation was not associated with low bee activity. Buckwheat performs best with pollen deliveries of at least 10 grains, but

bees delivered small quantities. The time between delivery of the first pollen grain and the tenth was about an hour, more than enough for fertilization to have occurred. Pollination of buckwheat in New York is accomplished primarily by honey bees, but their pollination behavior is not well-adapted to the crop, and their effectiveness is not improved at higher populations.

214. Thomas, G.A., Dalal, R.C., and J. Standley. 2007a. No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics. Soil Tillage Res 94:295–304. https://doi.org/10.1016/j.still.2006.08.005. No-till (NT) system for grain cropping is increasingly being practiced in Australia. While benefits of NT, accompanied by stubble retention, are almost universal for soil erosion control, effects on soil organic matter and other soil properties are inconsistent, especially in a semi-arid, subtropical environment. We examined the effects of tillage, stubble and fertilizer management on the distribution of organic matter and nutrients in the topsoil (0–30 cm) of a Luvisol in a semi-arid, subtropical environment in southern Queensland, Australia. Measurements were made at the end of 9 years of NT, reduced till (RT) and conventional till (CT) practices, in combination with stubble retention and fertilizer N (as urea) application strategies for wheat (*Triticum aestivum* L.) cropping. In the top 30 cm depth, the mean amount of organic C increased slightly after 9 years, although it was similar under all tillage practices, while the amount of total N declined under CT and RT practices, but not under NT. In the 0–10 cm depth, the amounts of organic C and total N were significantly greater under NT than under RT or CT. No-till had 1.94 Mg ha−1 (18%) more organic C and 0.20 Mg ha−1 (21%) more total N than CT. In the 0–30 cm depth, soil under NT practice had 290 kg N ha−1 more than that under the CT practice, most of it in the top 10 cm depth. Microbial biomass N was similar for all treatments. Under NT, there was a concentration gradient in organic C, total N and microbial biomass N, with concentrations decreasing from 0–2.5 to 5–10 cm depths. Soil pH was not affected by tillage or stubble treatments in the 0–10 cm depth, but decreased significantly from 7.5 to 7.2 with N fertilizer application. Exchangeable Mg and Na concentration, cation exchange capacity and exchangeable Na percentage in the 0–10 cm depth were greater under CT than under RT and NT, while exchangeable K and bicarbonate-extractable P concentrations were greater under NT than under CT. Therefore, NT and RT practices resulted in significant changes in soil organic C and N and exchangeable cations in the topsoil of a Luvisol, when compared with CT. The greater organic matter accumulation close to the soil surface and solute movement in these soils under NT practice would be beneficial to soil chemical and physical status and crop production in the long-term, whereas the concentration of nutrients such as P and K in surface layers may reduce their availability to crops.

215. Tilman, D., K.G. Cassman, P.A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. Nature, 418(6898), 671–677. A doubling in global food demand projected for the next 50 years poses huge challenges for the sustainability both of food production and of terrestrial and aquatic ecosystems and the services they provide to society. Agriculturalists are the principal managers of global useable lands and will shape, perhaps irreversibly, the surface of the Earth in the coming decades. New incentives and policies for ensuring the sustainability of agriculture and ecosystem services will be crucial if we are to meet the demands of improving yields without compromising environmental integrity or public health.

216. Tisdall, J.M. 1994. Possible role of soil microorganisms in aggregation in soils. Plant Soil 159:115–121. In many soils, roots and fungal hyphae, especially those of vesicular arbuscular mycorrhizal (VAM) fungi, stabilize macro-aggregates (>250 µm diameter); organic residues, bacteria, polysaccharides and inorganic materials stabilize micro-aggregates (<250 µm). This review discusses the factors (including other organisms) which affect VAM hyphae and their extracellular polysaccharides in soil, and the subsequent effect on stability of aggregates. The review also discusses the possible role of other organisms, including ectomycorrhizal fungi, in the stability of soil, and suggests future research.

217. Tooker, J.F., M.E. O'Neal, and C. Rodriguez-Saona. 2020. Balancing Disturbance and Conservation in Agroecosystems to Improve Biological Control. Annu. Rev. Entomol. 65:81–100. https://doi.org/10.1146/annurev-ento-011019-025143. Disturbances associated with agricultural intensification reduce our ability to achieve sustainable crop production. These disturbances stem from crop-management tactics and can leave crop fields more vulnerable to insect outbreaks, in part because natural-enemy communities often tend to be more susceptible to disturbance than herbivorous pests. Recent research has explored practices that conserve natural-enemy communities and reduce pest outbreaks, revealing that

different components of agroecosystems can influence natural-enemy populations. In this review, we consider a range of disturbances that influence pest control provided by natural enemies and how conservation practices can mitigate or counteract disturbance. We use four case studies to illustrate how conservation and disturbance mitigation increase the potential for biological control and provide co-benefits for the broader agroecosystem. To facilitate the adoption of conservation practices that improve top-down control across significant areas of the landscape, these practices will need to provide multifunctional benefits, but should be implemented with natural enemies explicitly in mind.

218. Walmsley, A. and A. Cerdà. 2017. Soil macro-fauna and organic matter in irrigated orchards under Mediterranean climate. Biol. Agric. Hort. 2017, 33, 247–257. https://doi.org/10.1080/01448765.2017.1336486. Soil fauna abundance and diversity and organic matter content are key indicators for the rate of soil degradation in Mediterranean-type ecosystems. The soil macro-fauna populations were examined in three orange (*Citrus sinensis*) orchards and one persimmon (*Diospyros kaki*) orchard, with the same soil type and different management systems, to establish whether organic management benefits soil fauna and soil quality and what is the effect of flood irrigation. Vegetation cover, soil organic matter, bulk density and moisture were measured at each experimental site within the Canyoles watershed in Eastern Spain in summer of 2015. Earthworm abundance was highest at the organic orchard with flood irrigation, followed by the organic orchard with drip irrigation, with juvenile endogeic earthworms being the dominant group. Soil isopoda was the dominant group of the arthropod macro-fauna, with highest abundance in the drip-irrigated organic orchard. Earthworm presence was highest in the flood-irrigated orchard, whereas soil arthropoda abundance was highest at the drip-irrigated organic site, where a thick litter layer was present. The soil organic matter was higher and soil bulk density lower at the organic orchards sites compared to conventional ones. The results suggested that organic farming was beneficial for soil biological activity, though the conversion from flood to drip irrigation can have a negative impact on earthworms, which may cause a decrease in infiltration capacity of the soil.

219. Wiesmeier, M., L. Urbanski, E. Hobley, B. Lang, M. von Lützow, E. Marin-Spiotta, B. van Wesemael, E. Rabot, M. Ließ, and N. García-Franco, *et al*. 2019. Soil organic carbon storage as a key function of soils—A review of drivers and indicators at various scales. Geoderma 2019, 333, 149–162. https://doi.org/10.1016/j.geoderma.2018.07.026. The capacity of soils to store organic carbon represents a key function of soils that is not only decisive for climate regulation but also affects other soil functions. Recent efforts to assess the impact of land management on soil functionality proposed that an indicator- or proxy-based approach is a promising alternative to quantify soil functions compared to time- and cost-intensive measurements, particularly when larger regions are targeted. The objective of this review is to identify measurable biotic or abiotic properties that control soil organic carbon (SOC) storage at different spatial scales and could serve as indicators for an efficient quantification of SOC. These indicators should enable both an estimation of actual SOC storage as well as a prediction of the SOC storage potential, which is an important aspect in land use and management planning. There are many environmental conditions that affect SOC storage at different spatial scales. We provide a thorough overview of factors from micro-scales (particles to pedons) to the global scale and discuss their suitability as indicators for SOC storage: clay mineralogy, specific surface area, metal oxides, Ca and Mg cations, microorganisms, soil fauna, aggregation, texture, soil type, natural vegetation, land use and management, topography, parent material and climate. As a result, we propose a set of indicators that allow for time- and cost-efficient estimates of actual and potential SOC storage from the local to the regional and subcontinental scale. As a key element, the fine mineral fraction was identified to determine SOC stabilization in most soils. The quantification of SOC can be further refined by including climatic proxies, particularly elevation, as well as information on land use, soil management and vegetation characteristics. To enhance its indicative power towards land management effects, further "functional soil characteristics", particularly soil structural properties and changes in the soil microbial biomass pool should be included in this indicator system. The proposed system offers the potential to efficiently estimate the SOC storage capacity by means of simplified measures, such as soil fractionation procedures or infrared spectroscopic approaches.

220. Wilcove, D. S., and J. Lee. 2004. Using economic and regulatory incentives to restore endangered species: Lessons learned from three new programs. *Conservation Biology* 18.3:639-645. This article investigated the effectiveness of three incentive-based programs for restoring endangered species on private lands in the United States. The authors found that the "safe harbor" provision of the US Endangered Species Act and Environmental Defense's Landowner Conservation Assistance program both yielded conservation on private lands.

221. Williams, I.H., Martin, A.P., White, R.P. 1986. The pollination requirements of oil-seed rape (*Brassica napus* L). J. Agric. Sci. Camb. 106:27-30.

222. Williams, I.H., Martin, A.P., White, R.P. 1987. The effect of insect pollination on plant development and seed production in winter oil-seed rape (*Brassica napus* L). J.Agric.Sci.Camb. 109:135-139.

223. Yardim, E. and C. Edwards. 2002. Effects of weed control practices on surface-dwelling arthropod predators in tomato agroecosystems. Phytoparasitica 30:379–386. Weed control, an important practice in agroecosystems to protect crop production, is usually achieved with herbicides. However, these pesticides are expensive, pose potential risks to the environment, may affect some beneficial organisms indirectly, and decrease overall arthropod biodiversity, including pests and their natural enemies, by removing weeds that might act as hosts or shelters for many organisms. The activity density response of important surface-dwelling arthropod predators (ground beetles [Coleoptera: Carabidae], ants [Hymenoptera: Formicidae] and spiders [Arachnida: Araneae]) to herbicides (trifluralin and paraquat), and to two alternative weed management practices (rye straw mulch and mechanical treatment to maintain weeds below threshold levels, in comparison with an untreated check), was assessed using pitfall traps. The mulch treatment had the greatest effect on activity density, reducing the number of predators trapped significantly (P<0.05). Herbicide use resulted in significant (P<0.05) reductions in the activity density of ground beetles. Most predators were trapped in the check plots — which had the highest weed biomass, followed in turn by numbers trapped in the threshold weed control treatment, the full herbicide application and the mulch treatment plots.

224. Wunder, S. 2005. Payments for environmental services: Some nuts and bolts. *CIFOR Occasional Paper* 1-24. This report defined the payments for ecosystem services and provides suggestions for PES design. It is an assessment based on a literature review with observation from field research conducted in Latin America and Asia. The conclusions on the report state that users will continue to drive PES, but their willingness to pay will only increase if schemes can demonstrate clear additionality.Yardim E, Edwards C (2002) Effects of weed control practices on surface-dwelling arthropod predators in tomato agroecosystems. Phytoparasitica 30:379–386. Weed control, an important practice in agroecosystems to protect crop production, is usually achieved with herbicides. However, these pesticides are expensive, pose potential risks to the environment, may affect some beneficial organisms indirectly, and decrease overall arthropod biodiversity, including pests and their natural enemies, by removing weeds that might act as hosts or shelters for many organisms. The activity density response of important surface-dwelling arthropod predators (ground beetles [Coleoptera: Carabidae], ants [Hymenoptera: Formicidae] and spiders [Arachnida: Araneae]) to herbicides (trifluralin and paraquat), and to two alternative weed management practices (rye straw mulch and mechanical treatment to maintain weeds below threshold levels, in comparison with an untreated check), was assessed using pitfall traps. The mulch treatment had the greatest effect on activity density, reducing the number of predators trapped significantly (P<0.05). Herbicide use resulted in significant (P<0.05) reductions in the activity density of ground beetles. Most predators were trapped in the check plots — which had the highest weed biomass, followed in turn by numbers trapped in the threshold weed control treatment, the full herbicide application and the mulch treatment plots.

225. Wunder, S. 2005. Payments for environmental services: Some nuts and bolts. *CIFOR Occasional Paper* 1-24. This report defined the payments for ecosystem services and provides suggestions for PES design. It is an assessment based on a literature review with observation from field research conducted in Latin America and Asia. The conclusions on the report state that users will continue to drive PES, but their willingness to pay will only increase if schemes can demonstrate clear additionality.

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