Review Article

Role of birds in agro ecosystem: A review

Abstract

~~Any service that the ecosystem provides to ensure human survival is called an "ecosystem service" Ecosystem services are divided into four categories: provisioning, regulating, supporting, and cultural. Birds provide a fascinatingly diverse range of ecological services that, among other ecosystem services, support human life. As members of ecosystems,~~ birds play many roles in ecosystem ,are including predators, pollinators, scavengers, seed dispersers, pests, predators, nutrient cycling, ecosystem engineers, and many other services. However, the global decline in bird populations means that the ecosystem services provided by these birds are also declining. The services provided by birds are ecologically and economically important, but are not recorded due to insufficient information. Therefore, this review article aims to make clear the role of birds in the ecosystem and their benefits to humans in order to promote their conservation. Healthy bird populations and their habitats would help protect a variety of ecological services that would ultimately improve human well-being.

Keywords: agro-ecosystem,birds,conservation,insectivores,pest control

1. Introduction

Birds play a very important role in ecosystems.Birds contribute to four types of ecosystem services, namely provisioning, regulating,cultural, and supporting (Whelanetal, 2008).Ecosystem services provide direct and indirect benefits to humans through various types of resources and processes. Bird populations are indirectly helpful to human health by regulating services such as bio-indicators, pollinators, seed dispersers, predators, pests, scavengers, nutrient cycling, and ecosystem engineers through their behavior and the services provided by bird products (Sekercioglu, 2006; Wennyet al., 2011). They are the group of vertebrates in the different habitats of the world. Birds are an important component of the natural ecosystem and an important part of the food chain (Whelan et al., 2008). Birds are an essential part of the food web and nutrient cycling. Birds play an important role in human life culturally, socially, scientifically, and as a food source (Siva and Neelanarayanam, 2021). Birds are known as one of the most

important species groups for biodiversity conservation. They keep the environment clean by acting as scavengers, protect the plant community by destroying pests and other vermin, help fertilize plants through pollination, support better plant survival through seed dispersal, and provide nutrient-rich nutrients to the environment (Durairajet al., 2017). Bird community assessment has become an important tool for biodiversity conservation and for identifying conservation actions in areas of high human and animal pressure, especially for aquatic resources. Birds are an important group of animals in an ecosystem and maintain the trophic level. They have their functional role in the ecosystem as potential pollinators and scavengers and are rightly called bio-indicators of nature (Priyankaet al., 2021). In this paper, the role of birds in the ecosystem, especially in agricultural areas, is reviewed and suggestions are made for future research on bird conservation strategies.Add what problems occur in agricultural areas related to the role of animals, especially birds. Also added the method used in linking theory with case studies

2. Birds as Bio-Indicators

Birds are potential bio-indicators for any ecosystem (Balasubramanyan and Imrankhan, 2016).Birds play an important role in assessing environmental impacts upstream and downstream.Birds are used to assess ecosystem quality. Long-term monitoring of bird populations indicates changes in natural and man-made ecosystems. It helps to maintain the biodiversity of the region and is also an indicator of minor changes in biodiversity (Jhenkharet al., 2016). Bird diversity is an important ecological tool that serves as an important indicator for qualitative and quantitative assessment of different habitats. Birds respond to any kind of change in their environmental conditions and therefore are used as bio-indicators (Padoa-Schioppaet al., 2006).Birds are sensitive to changes in the environment and therefore indicate early warnings.Mostly, waterfowl are used as bio-indicators of wetland conditions at both local and regional scales (Zhang, 2011). The diversity of bird populations serves as a strong indicator of the overall health of an ecosystem (Dendupet al., 2021). Birds are considered good indicators of environmental quality and are often used to monitor environmental and ecosystem health and as bioindicators for inhabited areas (Canterbury et al., 2000). Birds are indicator species for forest habitat quality (Moning and Muller, 2008) and respond to changes in habitat structure and are therefore useful indicators for conservation management at regional and landscape scales (Canterbury et al., 2000).Birds are good sentinel species because they are observable, sensitive to

toxicants, and live in a variety of trophic positions (Ferreira, 2011).Therefore, birds are considered good bioindicators. Birds are used as bioindicators in various environmental pollutions, such as raptor population decline caused by DDT (Henry et al., 2010), pollution caused by mining activities (Waylandet al., 2006), and radioactive events such as Chernobyl (Molleretal., 2011). Many bird species are sensitive to pollution and are indicators of human health risk from pollution (Zhang and Ma, 2011). Bird populations are declining due to climate change, habitat loss, and fragmentation (Ceballoset al., 2017). Some anthropogenic activities and the release of pesticides and chemicals in the environment are dangerous to bird populations (Garcia and Fernandaz, 2014). In addition to climate change, the use of plastics, radioactive materials, oil, noise, etc., also plays an important role in affecting the sustainability of birds and ultimately leads to the migration of bird communities (Richard et al., 2021).If birds depend on a habitat that functions in a certain way, bird population trends can provide information about how well the ecosystem is functioning (Durairaj et al., 2017). Bird population is a sensitive indicator of pollution levels in terrestrial and aquatic ecosystems.

2. Birds as pollinators

Bird-plant interactions in ecosystems and agricultural ecosystems play a major role and have implications for pollination and seed dispersal (Lunberg and Moberg, 2003). Many wild birds play a very important role in food production because of their pollination behavior (Borges, 2003). For several plant or tree species, pollination is carried out by many Nectarivorus species (Family: Nectariniidae) that feed mainly on nectar. Exclusive pollinators such as bees, birds, and bats play different roles in fruit formation in different wild and domesticated plants (Klein, 2007). The most important pollinators in the ecosystem are bees, flies, and buzzing birds, while pollinators from the lepidopteran group are present but less abundant. Bird pollination is most prevalent in tropical and subtropical regions where flowers and nectar are available throughout the year to support pollination by nectar-bearing birds (Merino and Nogueras, 2003). Globally, a total of 920 bird species are involved in pollination. Examples of pollinator birds include hummingbirds, sunbirds, false sunbirds, flower peepers, white-eyes, honeyeaters, lories, and honeycreepers (Mahendiran and Azeez, 2018).Sunbirds and spider hunters are the most important insect groups among pollinator birds in Africa andAsia.Honeyeatersareimportantpollinators(MerinandNogueras,2003).About5%offoodandmedicinalplantsarebenefitedbysuchpollinatorbirds.

In India, many studies show that birds such as black drongo, mynas, crows, thrushes, rose-ringed parakeets, golden-backed woodpeckers, bulbuls, flower peckers, titmice, and lorikeets visit and pollinate flowers (Solomon and Rao, 2006). In total, more than 290 bird species are involved in pollination and seed dispersal, including sunbirds, mynas, starlings, and oriental white-eyes, which are frequent visitors and probably the most important pollinators of the avifauna (Balasubramanian, 2012). Few attempts have been made to evaluate the services of plant and insect pollinators in economic terms, and few attempts have focused on birds (Kellermann, 2008).The role of birds as pollinators has tremendous positive impacts on the ecosystem and agroecosystem by maintaining biodiversity through their pollination behaviors that sustain plant species that have direct and indirect benefits to humans and other organisms.

3. Birds as SeedDispersingAgent

Bird foraging and seed dispersal behaviors play an important role in the ecosystem. Seed dispersal is critical to the ecosystem for maintaining biodiversity, species distribution, population dynamics, and ecological balance in the ecosystem. Birds disperse the seeds of many tree and plant species that are of immediate use to humans, whether for medicine, food, timber, or other purposes (Asep and Hesti, 2011). These services are mainly observed in frugivorous bird species, which include nearly 48 families (1/3 of all living bird species) that feed exclusively on fruits (Mahendiran and Azeez, 2018).Birds disperse seeds over a much greater distance than other dispersal media such as wind (Clarket al., 2005).In natural ecosystems, birds are an important disperser of plant seeds, promoting and maintaining biodiversity and community structure (Charalambidou and Santamaria, 2005). Birds are one of the most important seed dispersers of about 80,000 species of angiosperms, of which about 25,000 are trees, shrubs, and herbaceous plants (Mahendiran and Azeez, 2015). In addition, birds contribute to reforestation in deforested areas by germinating and dispersing seeds, thereby reducing the cost of reforestation (Wunderl, 1997).Birds provide an important ecosystem service by promoting forest growth, which will help mitigate climate change in the future, and they provide a number of other services that primarily benefit humans.

Birds help in the propagation of plant species by acting as seed dispersers (Balasubramanyan and Imran Khan, 2016). Seed dispersal is a process that controls long-term plant community dynamics and vegetation recovery in human-disturbed habitats (Howe and Miriti, 2004). Birds play an important role in maintaining and restoring plant communities as

seed dispersers (Pejcharet al., 2008). An important function of frugivorous birds is seed dispersal and pollination (Sekercioglu, 2006). Seed dispersal by birds is thought to significantly affect the patterns of ecological and genetic diversity of many plant species (Jordan Karubianet al., 2012).Seeds can adhere to the feathers of birds through structures on the seed.Birds disperse seeds, such as those of the mistletoe owl, by carrying them on their beaks after feeding (Alice, 2021).

Seed dispersal by birds is called ornithochory and falls under the group of zoochory, which means seed dispersal by animals (HansLambers, 2021). Most ornithochores(plants with seeds dispersed by birds) have conspicuous diaspores that are attractive to fruit-eating birds such as thrushes, pigeons, barbets (Capitonidae), toucans, and hornbills (Bucerotidae). They all either excrete the hard parts containing the embryo or regurgitate them damaged (HansLambers, 2021).Birds disperse the seeds in a variety of ways, e.g. when feeding, when transferring (they fly with the seed fruit from the second floor and may drop it on their mouthparts),by dropping (the seeds are scattered along with the droppings),by sticking the seeds to their bodies or feet with small hooks or spikes made from the seed structure (Channing, 2021).Birds play an important role in plant dispersal by eating a variety of berries and disposing of their waste along with the berry seeds. The birds provide good fertilization with their droppings and provide good growing conditions for the seeds (Taburet al., 2010).

4. Birds as Pest controller (Predator)

Predators are one of the most important extrinsic factors acting on animal populations and are a strong selective force in the evolution of form and function (Begonet al., 2005). Birds are dangerous predators with the ability to pounce on unsuspecting animals. They attack insects, reptiles, turtles, and worms (Emmanuel Kingsley, 2022). Eagles, hawks, hawks, owls, kites, and buzzards are some birds of prey. They are grouped under the term birds of prey. The black vulture (Aegypiusmonachus) is the heaviest and largest bird of prey in the world. Integrated pest management uses all available techniques to reduce the occurrence of pests before they cause economic damage and to provide economic benefits to farmers. One of these techniques is biological control, which is a major concern for farmers and an important ecosystem service provided by a variety of organisms and expected to be a sustainable solution for the agroecosystem (Rusch, 2016). The use of avian groups to control insects and other pests in the agroecosystem that also cause damage to other valuable plants that have higher economic value.

Recent studies have shown that insectivorous birds, which feed mainly on insect populations, play an important role in various agroecologies(Sekercioglu, 2006; Maas et al., 2015).

Insectivorous birds are observed in agricultural ecosystems (Table 1) and reduce pest infestations in many agricultural and horticultural crops such as apple, broccoli, cacao, coffee, corn, kale, grapes, and oil palms. For example, Mols and Visser (2007) reported that birds reduce pest infestations and increase yield by 66 percent in Dutch apple orchards. Similarly, researchers in Boreno reported that pest control by birds prevented 9 to 26 percent of fruit losses in oil palm plantations (Koh, 2008).Birds are among the important and efficient arthropod predators in agroecosystems, with 50 percent feeding primarily on insects and 75 percent feeding occasionally on invertebrates (Whelan et al., 2015). Studies of predation on insect pests by birds in natural and agricultural areas have found that invertebrate reductions by birds range from 20 to 70 percent (Jedlickaet al., 2014). This predation by birds not only reduces the number and incidence of herbivores, but also significantly reduces foliar damage and plant mortality and can result in up to a 60 percent increase in crop yield or fruit production (Whelan et al., 2015).

The study reported that the presence of large numbers of insect herbivores reduced the number of insect pests, resulting in less herbivore damage in coffee plantations in Guatemala (Greenberg et al., 2000).Matt Johnson (2010) reported that the reduction in coffee berry borer damage and the presence of insect herbivores in coffee plantations increased coffee yield and farmer income in Jamaica. In addition, nests of great tits in apple orchards lead to greater numbers of birds in the area feeding on caterpillars that can cause damage to crops, resulting in significantly higher crop yields (Greenberg et al., 2000; Mols and Visser, 2002). The use of birds in pest control can eliminate the need for pesticide use, limiting the use of potentially hazardous chemicals and reducing costs to farmers by eliminating the need to purchase harmful pesticides. Birds control not only invertebrate pests, but also vertebrate pests such as rodents. Field trials conducted in Israel have shown that a trained barn owl scares small rodents and significantly reduces the consumption of seeds by rodents (Oriet al., 2018). Owls have also been shown to control rat populations in various field crops such as wheat, rice, and corn. Oil palm growers in Malaysia use barn owl nests to control rodents in the field because rodents develop resistance to rodenticides such as warfarin and bromadiolone (Duckett, 1991).Previously, a reciprocal relationship between birds and livestock has been noted to be beneficial to humans as well. Because birds are predators, many birds settle on livestock such as cattle and feed on veterinary

pests that live on the animals. This behavior is most commonly observed in cattle egrets, which are particularly known to survive in this manner (Burnie, 2007). The birds benefit from a readily available food source and the animals benefit from the elimination of harmful parasites because the birds reciprocate. In many parts of the world, people rely on cows for meat (food) and milk. Milk production declines and cows become very weak when infested with ticks and other parasites. This is confirmed by a study conducted in Pakistan, where birds as prominent predators control these parasites, resulting in healthier and more productive cows (Perveenet al., 2010). In many ways, bird control of parasites on livestock is even more effective than pesticides.

Table.1. List of predatory birds in agro ecosystemadd more literature and better research of the last 10 years in order. At the same location, you can compare the conditions before and now

S. No.	Pest	Predator	Reference
1.	Garden snail, *(Achatinafulica)* Caterpillars, Insects, Lizards, Young mice	Crow pheasant, *(Centropussinensis)*	(Narayan regmi, 2003)
2.	Crabs	House crow, *(Corvussplendens)*	
3.	Grasshoppers	Cattle egret, *(Bubulcus ibis)* Crow pheasant, *(Centropussinensis)* Small green bee eater, *(Meropsorientalis)* Blue-tailed bee eater, *(Meropsphilippinus)*, Common myna, *(Acridotheristristris)*, Bank myna, *(Acridotherisginginianus)*, Indian tree pie, *(Dendrocittavegabunda)*, House crow, *(Corvussplendens)* Red-vented bulbul, *(Pycnonotuscafer*)	
4.	Moths and butterflies	Magpie robin, *(Copsychussaularis)*, Black drongo, *(Dicrurusadsimilis)* Jungle babbler, *(Turdoidesstriatus)*.	
5.	Weevils	Indian treepie, *(Dendrocittavagabunda)*	
6.	Aphid	Large-pied wagtail, *(Motacillamaderaspatensis)*	
7.	Rats and mice	Owl, Housecrow, *(Corvussplendens)* Jungle crow, *(Corvusmacrorhynchos)*	

5. Birds as Non-InsectPest

Birds play a dual role in agroecosystems, both as pests and as biological control agents: some birds adversely affect agricultural products by scavenging crops while foraging. They

cause great damage especially to ripening cereals, fruits and vegetables and also to young seedlings. Birds cause severe damage to various stages of crops and reduce yield (Table 2)(Suresh and Kambrekar, 2021). Most of the bird species are insectivores and play an important role in biological control of pest populations and thus are beneficial to farmers in agriculture and also perform various functions such as nutrient suppliers, which mainly increase soil fertility, and predators of rodents.Insectivorous birds have been shown to be successful biological control agents in some agroecosystems (Karp et al., 2013). The incidence of non-insect pests on various crops grown in India has been estimated to be about 30 percent of the crop production losses due to insects and non-insect pests. Non-insect pests are enormous and can cause significant damage to our agriculture by severely damaging crops in the field and stored grains in warehouses. The most common non-insect pests include mites, rodents, birds, wild boars, elephants, etc. (Vishwavidyalaya, 2021).

Table 2.The extent of bird damage in agricultural crops

S. No.	Crop	Stage of damage	Birds	Extent of loss (%)	Reference
1	Groundnut	Ripening	Crows	24	(Suresh and Kambrekar, 2021)Other sources can be added to strengthen the statement
2	Maize	Sprouting	Babblers, Crows, Doves	20	
3	Mustard	Ripening	Crows, Parakeets	63	
4	Pearl millet	Ripening	Parakeets, Sparrows, Weaverbirds	10-100	
5	Peas	Ripening	Pigeon	54	
6	Pulses	Sprouting	Doves, Pigeons, Parakeets, Sparrows	66	
7	Rice	Sprouting Ripening	Cranes, Parakeets, Saras, Sparrows, Weaverbirds, Sparrows, Weaverbirds	41 26	
8	Sorghum	Ripening	Doves, Pigeons	12-85	
9	Sunflower	Sprouting Ripening	Crows Crows, Parakeets,	65 22	
10	Wheat	Sprouting	Crows	17-20	

6. Birds as Scavengers and Sanitary agents

The ability of birds to collect waste is an important means of waste disposal in many places, helping to prevent disease outbreaks that can occur when animal carcasses accumulate (Markandyaet al., 2008). Scavenging birds are common in agroecosystems and play an important role in foraging, nutrient cycling, and waste removal (Whelanetal., 2008). Vultures play a role in

decomposing carcasses. Diurnal raptors such as eagles, hawks, and kites, and corvids such as ravens and crows are also common scavengers (Read and Wilson, 2004). Obligate scavengers are rare in vertebrates but well known in invertebrates, such as burying beetles, yellow bugs, and blowflies. Fly larvae are also common scavengers of organic material at the bottom of freshwater. Tokunagayusurikaakamusi, for example, is a scavenger at the bottom of lakes whose adults almost never eat and live only a few weeks. Scavenging can be a direct and indirect method of disease transmission. Scavengers of infected carcasses can become hosts for certain pathogens and thus be vectors of disease themselves (Read and Wilson, 2004). Scavengers are very important agents in the ecosystem. Most bird species feed only on animal carcasses, ingesting them opportunistically when available, while the vulture is undoubtedly a known and obligate feeder of this species. Vultures provide one of the most important ecosystem services, but are less studied and underappreciated in the avifauna. Through their scavenging, vultures and other carnivorous vertebrates contribute to waste removal, disease regulation, and nutrient cycling (DeValutet al., 2003).Vulture birds keep the environment clean and protect humans, livestock, and wildlife from infections and other contagious diseases by quickly and efficiently disposing of carcasses in the ecosystem. Vultures also have the ability to resist and detoxify bacterial toxins in rotting meat. Vultures' stomachs secrete extremely high levels of acids that result in the killing of all pathogenic bacteria through the consumption of carcasses, thus reducing disease in the ecosystem. In the Serengeti, vultures do an excellent job consuming hundreds of pounds of carcasses per kilometre each year. In Yemen, vultures remove up to 25% of organic waste produced by humans in urban areas (Gangosoet al., 2013).

In India, vulture populations are declining nowadays due to poisoned carcasses and less food competition between wild dogs and rats for carrion, leading to an increase in their population. The increase in these potential disease vectors (wild dogs and rats) led to the outbreak of rabies and dog attacks on humans and also the outbreak of bubonic plague in western India, which killed 54 people in 1994. The decline in vulture populations led to an increase in rabies cases and the death of about 48,000 people (Markandyaet al., 2008). This clearly shows that the value of birds to people is very high and underscores the immediate importance of healthy birds to human ecosystem benefits.

7. Roleof birdsin nutrient cycling

Bird feces have significant value in agriculture. In agriculture, bird droppings are used as fertilizer because they contain potassium, nitrogen, phosphate and other nutrients. This can easily convert to ammonia and serve as a fertile fertilizer for plants by contributing to the nitrogen content of the soil. The contribution of birds to increasing soil fertility on farms is very limited. The role of birds in agriculture has recently been documented as 38.0% on the planet (Clay, 2004).The transfer of nutrients and the formation of soils are important services provided by birds in an ecosystem that allow primary producers to begin their work, which leads to the distress of primary consumers and leads to the colonization of the area by top predators and the maintenance of biodiversity (MEA, 2005). The role of birds in nutrient cycling has been demonstrated in many habitats to date. Because of their ability to fly and move through different habitats, birds can transport nutrients from one place to another, which is especially important in areas where plant growth is limited by the availability of nutrients.Birds contribute to nutrient cycling in all habitats, but most impressively in aquatic habitats (Anderson and Polis, 1999). Ellis (2005) reported that seabirds are more likely to be found in both coastal areas, where they process large amounts of food in a small space. In this way, seabirds transport nutrients from the aquatic zone to the terrestrial zone. Large amounts of guano deposits (rich in phosphates) and excreta from birds can influence plant growth and fast-growing vegetation to become more productive compared to land without birds. Removal of nesting seabirds affects plant growth and plant communities (Croll etal., 2005; Bellingham et al., 2010). This ecosystem service is provided primarily by waterfowl, which aremostly done by aquatics birds where they transferred nutrients between aquatic and terrestrial ecosystem.

8. Conclusions

Birds provide a numerous key role in the agro ecosystem. Seed dispersal behavior of birds helps to maintain biodiversity and species richness by distribution numerous plant species in ecosystem. In addition their scavenging behavior in nature prevents various infectious diseases by cleaning local habitats carcasses which may harbor pathogenic microorganisms. Avian predator role in biological control program mainly insectivore's bird's control various herbivorous pest such as invertebrate and vertebrate pest and increase crop yield and also avian predator is indirectly reducing farmer's expenses by avoiding purchasing of harmful pesticides.Other service like pollination behavior also has significant importance in sustaining ecosystem and human welfare. Most of the services provided by birds have economic and

ecological value but few of them not classified. In future research policies focus on conservation of avifauna, restoration and management of their habitats are highly needed. Conserving and maintaining healthy bird's population and their habitat would preserve diverse ecosystem services by benefiting many different living species and finally human welfare.

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