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Review Article

Agriculture Intensification - A Devastating Foe of AGRO-Biodiversity

Amit Kour*, Dharambir Singh, Kiran, Nikita Punia and Sunita

Department of Zoology and Aquaculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India

***Corresponding Author:** Amit Kour, Department of Zoology and Aquaculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India.

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Abstract

The increasing demand for food and bio-energy leads to agriculture intensification that has driven the landscape heterogeneity decline, high agrochemical consumption, and abandonment of less fertile land per unit area as a result of which several species associated with farmland are unable to cope with the dramatic decline in both their range and abundance of distribution leading to loss of farmland diversity giving rise to conflict between intensive agriculture production and agro-faunal conservation goals with profound effects on the functioning of ecosystem challenging agro-industry to regulate such practices with sustainable intensification that facilitates persistence of indigenous biodiversity at scales that contribute to biodiversity at the national level for the beneficence of agro-faunal diversity at the same time. This paper assesses intensive farming practices on cropland relative to their impacts on biodiversity to determine whether it can help fill gaps in our knowledge about the management of farm landscape by conservation agriculture-based sustainable intensification approach to prepare species sensitive new strategies and policies to fulfill all the proponents of benefits for conservation of agro-biodiversity.

Keywords: Agroecosystem; Agriculture Intensification; Agro-biodiversity, Conservation Agriculture; Sustainable Intensification

Introduction

The world is in transition from an era of food abundance to food scarcity due to expanding and rapid pace of the booming human population with 40% of the planet's land devoted to food production to feed the growing human population and the practices followed in farm landscape to meet ever-growing food demand which is thought to be rise by 70% by 2050 [46]. The diverse and well-managed agroecosystems provide provisioning (food, fodder, fiber), regulating (flood control, climate regulation, carbon sequestration), supporting (soil formation, nutrient cycling, and cultural (scenic beauty, recreation, agro-tourism) ecosystem services [43], and provide the environment for fauna and flora to flourish but agriculture intensification (AI) has led to perturbation of land surface - an important component of the earth's he climate system, much of which is constantly in use for high crop production rates either by clearing the land covers of forest area or by overusing the same land area for the same crop. Agriculture can conserve the diversity of species found in soil and overall agro-upland biodiversity [7,19] by use of conventional farming practices and organic farming but the low yield of crops production has led to AI that has increased the burden on the natural ecosystem with both pros and cons with disastrous impacts on biodiversity from a global perspective with no simple solutions. However, the futuristic impacts of AI on biodiversity are unclear. According to IUCN, agriculture poses the single largest threat to Red List Threatened Species and is likely to remain the primary driver throughout the twenty-first century [3].

In comparison to disadvantages, advantages are less which in turn has entailed drastic global environmental changes including pesticide use, degradation and depletion of natural resources, unsustainable use of land and water resources leads to alteration of resource availability in an ecosystem indefinitely with minimized impacts on animal welfare, human health [14], significant negative biotic interaction and harms to soil biota by that plays an important role in agro-ecosystem functioning by converting grassland to arable land that negatively alters the abundance, composition, functional and group diversity of flora and fauna. Chemical fuelled intensive agriculture production has killed off the underground ecosystems that act as a habitat for several species acting as the engines to drive cycles essential for food production. Furthermore, the intensive cultivation of a limited number of crops has drastically narrowed the number of plant species upon which humans rely.

Agricultural development and intensification are one of the topmost threats among several other threats to biodiversity, and the most driving factors that are driving farmers towards unsustainable practices are high demand for food needs and pressing income needs that lead to high yield of crop that goes for more use of pesticides and fertilizers with lack of awareness of their use [58]. Concern over declining biodiversity and the implications for the continued provision of ecosystem services has led, recently, to intense research effort to describe relationships between biodiversity and agro-ecosystem functioning because areas at risk of biodiversity loss by AI are also found in India while not much research studies have been reported in India till now that assess the loss of agrofauna present at a higher trophic level in the agro landscape due to AI. Hardly if there is any study that focuses only on the lower trophic levels, especially on pollinators and pests, etc. In recent times viewing the destructive impacts of AI on ecosystem practices like organic farming, climate-smart agriculture, sustainable agriculture intensification, and conservation-based agriculture are being followed and new agro-practices and technologies/techniques are invented and improvised all over the world and in India also to mitigate the negative impacts of AI on biodiversity, climate, and ecosystem [49,51]. Among various practices as the options for sustainable agriculture, No-till (NT) agro-practice is well adapted to different farming systems around the world and in India that has positive effects on biodiversity [26]. One particular adaptation, Conservation Agriculture based Sustainable Intensification (CASI) combines the strengths of conservation agriculture and sustainable intensification and has succeeded in several farming systems including India [12]. Several programs are running in India to promote organic farming and natural farming but lack of evidence-based consensus on the merits of all these practices and the main drawback is that there is no comprehensive policy framework to promote CASI.

The post-2020 Global Biodiversity Framework has aimed to halt biodiversity loss by 2030 and complete recovery and restoration by 2050 [33] but there is hardly any study on agrobiodiversity in developing countries that gives information on the changing status of agrobiodiversity in the regions practicing intensive agriculture and the other regions where the pattern of intensive farming is changing towards sustainable farming hence, due to lack of information agrobiodiversity has been eroding over time. There is an urgent need for more studies to evaluate how agriculture intensification is leading to the loss of biodiversity by using advanced analytical techniques to identify soil organisms and associated agro-fauna to predict the effects of species loss on the delivery of ecosystem services [20] and to follow and examine ecologically based management strategies that may help in increasing the sustainability of agricultural production [15] while reducing the consequences to stop the deleterious effects of AI and to solidify links between AI, agrobiodiversity, sustainable intensification and ecosystem functioning as sustainable farming and conservation agriculture methods and practices if done right may be helpful in both underground and aboveground [39,40] agro fauna species conservation and will halt land degradation and desertification which in turn would be helpful for the countries to ensure food security and to mitigate climate change. The paradigm shift towards CASI requires the dual goals of using sustainable practices to meet human needs along with the vision of shifting the current role of agriculture from the world's major driver of environmental/climatic change and biodiversity loss to becoming a key contributor to biodiversity conservation [10,21].

AI practices

Farming systems classified by the agro-technological approach are intensive farming systems and extensive farming systems [35]. An intensive farming system also known as a high-input farming system refers to a set of all those patterns of land-use practices with the common feature of increased use of the same resources for agricultural production switching from intermittent to continuous cultivation of the same area of land has with same agricultural inputs to produce more food on a given area of land to increase the overall crop production and yield with various advantages and disadvantages as shown in figure 1 while extensive farming system, designated as low-input farming systems or low-intensity farming system depends on the use of internal resources where the amount of fertilizers, pesticides or other protectors are reduced. AI has dramatically increased food production playing an important role in feeding the world's population but at the cost of detrimental effects on the ecosystem [52]. The adverse environmental impacts, changes in climate, and land-use patterns erode agrobiodiversity. Natural resource depletion (water loss by irrigation and forest clearance to increase agricultural land area) is a major concern [22,34,42]. Conservation technologies and practices shall be practiced in arresting the degradation process. The monoculture crop system had pause a great halt to biodiversity [16] as the agroecosystem has become highly specialized with rice and wheat as the major crops.

Impact of AI on biodiversity

Agricultural land contains exceptional levels of biodiversity in an extremely small land area but the loss of biodiversity due to AI

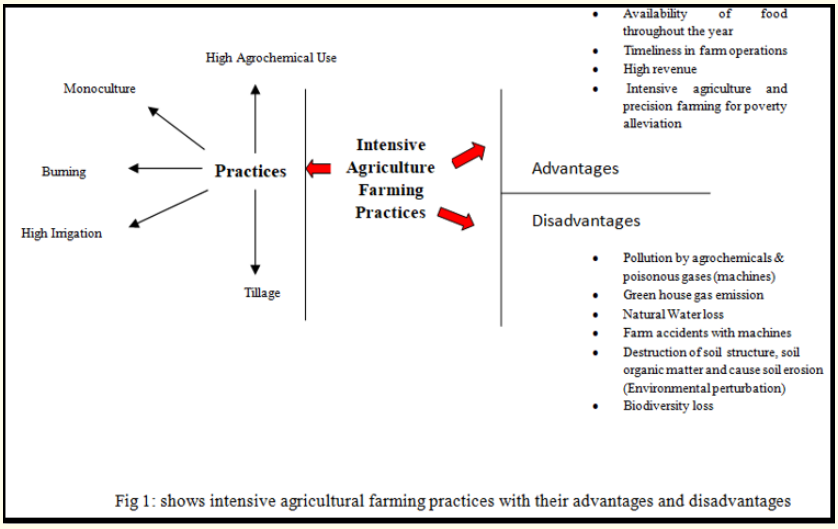

Figure 1: Show intensive agriculture farming practices with their advantages and disadvantages.

limits the naturally available resources which lead to disproportionate impact and biodiversity crisis all over the world like:

Plant diversity

AI has led to continuous reduction of plant taxonomic and functional diversity across arable systems, loss of plant species richness, change in floristic composition and vegetable structure, loss of forest-dependent species, and shift from native to alien-dominated plant communities [8,24,53].

Soil biota

AI has caused harm to soil biota that plays an important role in agro-ecosystem functioning by converting grassland to arable land that negatively alters the abundance, composition, functional and group diversity of soil biota where taxonomic groups with larger body size (earthworms, enchytraeids, micro-arthropods, and nematodes) tend to be primarily, more sensitive and more negatively affected by short-term consequences of conversion (disturbance, loss of habitat) than smaller-sized (protozoan, bacteria, and fungi) taxonomic groups predominantly affected by long term consequences (probable loss of organic matter) manipulates biodiversity and hence affects ecosystem process rates [37,38].

On arthropods

Insects functioning in agricultural landscapes play a crucial role in the proper functioning and maintenance of the ecosystem because they act as an (i) integral part of natural networks of food chains and food webs by being a food source for other organisms (birds, amphibians, and mammals) (ii) pollinators (iii) biocontrol agents (iv) seed dispersal [18]. However, AI practices have deleterious effects on arthropod communities either directly or by removal of available food sources resulting in loss of habitats for insects, and other species leading to disturbances in trophic networks, extinction of endemic species, and higher exposure to vulnerability to secondary extinctions in ecosystems along with far-reaching negative consequences also on human wellbeing.

Bee communities native to farmland provides full "free pollination" services even for a crop with heavy pollination requirements that signifies the importance of diversity for sustainable crop production but over the years continued use of pesticide and degradation of the agro-natural farm landscape has led to injurious effects and yearly variation in community composition and a steep depletion in diversity and abundance of native farmland bees has been observed leading to insufficient pollination services rendered by bees alone [27]. Several invertebrate pollinator species like bees and butterflies are on the verge of extermination all over the world [4,48]. According to IUCN, the unsustainable expansion of agriculture around the world has led to the destruction of wetlands-the areas with exceptional levels of biodiversity in an extremely small land area having a high priority for designating new key biodiversity areas, which is the main force driving the decline of dragonflies worldwide as they use these water bodies to breed as a result several other species are also at risk of extinction, threatening many other wetland species with severe impacts on amphibians, migratory birds and mammals such as *Pyrenean desman* [59].

Amphibians and reptiles

AI and land transformation are among the major global threats affecting herpetofauna. Among the various terrestrial faunal species, herpetofauna is the most vulnerable to land transformation due to their low vagility, their dependence on microhabitats, and their sensitivity to environmental changes [2]. The transformation of traditional rainfed agriculture into intensively irrigated agriculture, arable agriculture over traditionally managed mixed agriculture, and pasture and other agricultural practices have clarified declining effects on local biological communities [1,11] that show high dependence on specific terrestrial ecosystems and low dispersal capabilities such as amphibians and reptiles [50]. The increasing use of pesticides in agro-land and pesticide residues exposure to ago-fauna is probably highly affecting and diminishing factor for both larval and adult amphibians and reptile populations.

Terrestrial reptiles especially lizards present in farmland play several important functions. Based on their diet, insectivore reptiles act as pest control agents by eating insect pests of crops [28,32] which in turn helps them to survive effectively. But, depletion and extensive as well as intensive use of natural resources for agriculture is among the most common threats affecting terrestrial reptiles worldwide [5]. Reptiles have small home ranges and limited ability to disperse, as a result, are affected even by small changes in farm landscape like changing patterns of agricultural land use [6,41] and overuse of agrochemicals that directly or indirectly affect reptile fauna either by causing physiological, anatomical and reproductive impediments or by depleting the food resources of reptile fauna.

Aves

Several bird species use agricultural land for various purposes such as feeding, breeding, and nesting. Many migratory bird species use agrifields as a stopover [9,25] to rest and meet their energy demands for migration to long routes. However, AI acts as one of the major factors contributing to farmland avian biodiversity loss by (i) shifting crop time that creates unfavorable breeding conditions [13] (ii) increasing harvesting efficiency that prevents feeding on unharvested seeds [57] (iii) feeding on available pesticide-contaminated food sources that leads to several physiological, anatomical, behavioral, fertility and developmental deformities in birds [30,31,45,54].

Mammals

Intensive farming practices on the agrarian landscape have affected the availability and predictability of food resources to small insectivore mammals and their ability to reach food resources [56] because of changing land-use patterns, and habitat fragmentation such as moles and shrews, as they are less mobile than other species so they are more prone to depletion [17]. Several mammalian species show population-level negative responses to rapidly declining prey availability caused by the application of pesticides on impacts rather than at the individual level [44]. Although the number of mammalian or other species or taxa affected by AI practices is not known so much attention is required to assess changes over time and the effectiveness of policy changes. Many bat species are on the edge of severe population decline by using intensive agriculture practices all over the globe which is considered to be one of the main factors in reducing roost availability and foraging habitat of bats [36].

Concept of super-weeds and superbugs

AI has been thought to be involved with the creation of conditions that are suitable for the production of super-weeds, superbugs, and parasite growth [47]. Parasite growth leads to the emergence of new parasites and the re-emergence of parasites that were previously considered “under control”. Several cases of risks have been reported leading to zoonotic disease emergence that proves the epidemiological interaction between wildlife and agriculture and shows the close linkage of emergence or reemergence of zoonotic diseases with the evolution of the agriculture-environment nexus which limits our ability to predict, prevent, and respond to zoonotic disease emergence [23,29].

Conclusion

The ever-growing population and their increasing food and biofuel demands across the globe have made it extremely difficult to revert from the current trend of AI. Several agricultural practices are the main reasons for reducing roost availability and foraging habitat of agro-faunal biodiversity. Negative impacts of AI on Agrobiodiversity have received relatively little attention and these are restricted to only a few countries. However, there is less information regarding the number of taxa sensitive to intensive agriculture practices so, species-based risk evaluations are needed to improve agro-biodiversity conservation actions in farm landscapes. Species that are sensitive to any changes in the agricultural landscape can be used as bioindicator species to examine and reform the positive and negative impacts of conservation policies framed to conserve the diversity of farmland. Implementation of CASI will be a crucial step in improving the declining ratio of farmland faunal species and ensuring a sustainable management of agricultural systems.

Competing Interests

There is no conflict of interest between authors.

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