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Review Paper

A Review: Pollinator Services and Its Economic Evaluation

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***Abstract* - Pollinators are a crucial part of our ecosystem which aids the life of almost all living organisms present in this universe, and their contributions are justifiable according to Paretian efficient conditions. Though the services are an inseparable part of our life, property rights issues have made it difficult to evaluate the real worth of their services by Coase guidelines, the possible externalities they put to this universe, and the actual impact that free raiders have caused. This paper is based on techniques to incorporate those hidden services in economic assessment and policy formulation. For the economic evaluation of their services, we can quantify their values based on people's willingness to pay for the service, which aids in estimating the market value of producer and consumer's surplus, and the cost of the alternate means to achieve the same services, through production factor method, etc. To identify the sustainability of these ecosystem services, the regulation of pesticide use has to be integrated with these services. Farmers should focus not only on monoculture, but also on intensive farming, chemicals, making the least use of GMOs, and following Permaculture techniques in living and cultivation.**

Keywords* - *Externality, Contingent valuation, Permaculture, Ecosystem services.

I. INTRODUCTION

Agriculture is a fundamental way of living on this earth as the world's food is derived from agriculture. Countries throughout the world have yet to reveal the actual reduction of natural resources because of excessive exploitation. In addition, the world's food production is still not at par level with the global food demand [1]. Global inequality has also created a very big loophole where one group enjoys most of the resources and services while others are deprived of even the basics. Besides that loophole, the rapid increase in population and increasing need for food has led to a substantial demand for agriculture production [2]. Notwithstanding, strong evidence of considerable agriculture and rural development benefits from investment in competitiveness at the farm level [3], uptake and implementation around the world livestock and agriculture production remain underprivileged [4]. To meet the demand of the growing population and the non-stretchability of land at the same time, producers are forced to increase the intensity of cropping and multiply the use of chemicals, fertilizers, and high-density cropping. The productivity of land is in decreasing ratio because of the imbalance between input and output. Past work has shown that rural development is generally dismissive of agricultural actions and focused more on meeting the production demands and conditions [5, 6]. This has been a serious implication for food policy. Though the major problem is how agriculture has been underway, the people involved in agriculture have nearly reached the sustainability limit of existing land. Most often they enjoy exceeding the limit of land productivity. Many factors may contribute to this increasing food demand across the globe where the concentration of the world should be and how a solution can be developed. Despite the issues surrounding agriculture sustainability, the goal remains on achieving high productivity with very low input or very low cost-incurring inputs. Some of the major concerns today would be keeping the soil alive, sustaining, and permitting more lives (visible or invisible) to enjoy the fair share. This helps in ensuring that humans enjoy the fair distribution of resources, so that they derive only what they need and give the same amount of energy back once they take it [7]. For the sake of land permanence, the best way to increase the land productivity would be using pollinators that increase the food production to a very considerable amount without any special intervention while leaving the nature livable [8].

Many pollinators account for the increased yield of the food crops and entire agricultural produce. Some of them are insects like the honey bee, hawk moths, butterflies, wasps, flies, birds, bats, and around 1000 vertebrate pollinator species[9, 10]. There is a huge diversity of flowering crops and plants in nature required to get fertilized with the pollen of either the same or different plants. Though pollination also occurs through abiotic means like air, water, and rain, these methods of pollination are not so precise and effective as compared with pollinator-mediated pollination [11]. They keep on providing ecosystem services to mankind although the actions of mankind have caused their loss from the entire universe. This demonstrates that the ecosystem services are not taken into account in the conservation and management for the long-term sustainability of the entire diversity in the world, which involves humans too [12].

Pollinators are special kinds of natural resources that are both nonexcludable and non-rivalry types. They are found in nature but are not bound by any sort of discrimination, except the impact of climate and altitude on their presence. They simply make natural copulation by carrying pollen for the stigma region of the recipient flowers [11,51]. Starting from tiny insects, like the ladybird beetle to large animals like money and rodents, pollinators are among one of the most widely distributed categories in nature [7, 8, 13]. Though pollinator species are extremely diversified, their contribution to pollination is only significantly done by just a few of them. Some of the major contributors are honey bees, houseflies, butterflies, moths, and beetles. [14]. However, their importance for ecosystem services has been overlooked. What is more, this resource has faced major impacts from market distortion, which fails to internalize its positive externality [15]. Most people in the world know their contribution to fulfilling the food demand of the world. In countries like Nepal where the farmers are illiterate and ignorant generally, people do not know the importance of pollinators for increasing their food production significantly compared with the food produced without them [16]. For this kind of resource that is very much common for all and non-excludible, the property rights are not properly assigned to a certain group or individual. This leads to the absence of bargaining power over these services due to human activities detrimental to the climate and biodiversity change [17]. The services they provide belong to Paretian efficient conditions where no one is worsened off and else who receive the services are benefitted. In the condition where property rights are assigned to a specific person, the Coase theorem is applied for compensating the externality provided, and this theorem is not applicable except for the self-owned honey bees that are very strict to their radius of flight and return to where they belong, which gives chance for Coasian condition for internalizing the positive externality and also proper bargaining situation [18, 19]. Even the role of the government in managing this universal conflict is not seen around the globe, and wherever initiated the goal was unachieved, the social cost imparted by them is extremely higher than by the production or consumption of other goods or services. Society is privileged to enjoy the services without any sort of discrimination (free-rider syndrome) [20]. The main problem associated with them is intensive chemical pollution in Agroecology and severe climate change, which requires their northward sifting of this diversity to prevent the extinction of those on the edge of the north. The population and diversity of one of the most significant honey bees and houseflies are irreversibly decreasing every day [14].

II. DISCUSSION

A. Pollinators:

Pollinators are a key component of global biodiversity, providing vital ecosystem services to crops and plants. These pollinators can be insect pests, mammals, birds, and many more. The category of pollinators is very diversified. These pollinators range from as small as fairy flies and as big as human beings and other animals which help in accidental pollination. Most of the pollinators are small insects from the order *Hymenoptera* (e.g., honey bee, ants, wasps, bumble bee, and braconids) and others are from *Lepidoptera* (moths and butterflies), Diptera (Housefly) [21].

B. Role of pollinator:

Pollinators are those animals that carry pollen grain from the anther of a flower to the stigma of another flower of the same or different flower. This transfer results in fertilization of the egg cell inside the stigma with the pollen and forms the future embryo. This embryo results in a seed that will be covered by the fruit. The seed is essential for the propagation and formation of a new generation. However, the fruit is for the consumption of all the animals (Heterotrophs). Pollination occurs by different means, either animate or inanimate. Animate pollination is very common and effective between the two. Within the animate insect, pollination is known to be very much necessary at least for 70-108 major crops [22]. The animate pollination service provides us with over three-quarters of the staple crop plants, and 80% of all flowering plants across the globe. The economic valuation of animate pollination to the world's agriculture only has been estimated to be around 200 billion USD every year. According to above one lakh (100 thousand), different animate agents work for the pollination of more than 250,000 species of flowering plants across the world [23].

Pollination is a mutually beneficial activity for both plants and pollinators. As a result of pollination, the plants and crops produce seeds that can be propagated into new ones. In turn, pollinators receive nectar and pollen rewards from the flower they visit. The nectar they receive is rich in carbohydrates and pollen is rich in protein, fat, minerals, vitamins, and many more Phytochemicals. Indeed, there are an estimated 300,000 species of flowering plants worldwide that require animal pollinators [24]. This tremendous floral variety supports the diversity of pollinators, and the vast majority of these pollinators are insects. While there are only about 1,000 vertebrate pollinator species, it is estimated that there are at least 16,000 different species of bees worldwide [25]. Most of the pollinators are flying and are flower-loving which makes them very much effective means of pollination in flowering plants and crops.

C. Pollination ecosystem and services:

Crop pollination is done mainly by the wild pollinators and is the best understood animate ecosystem service prevalent in nature. Pollination originating from natural habitats is recognized as an important ecosystem service; in contrast, home-reared pollinators – mainly *Apis mellifera* (the European honey bee) are considered a very important agriculture input [26-28].

D. The status of the pollinator:

Pollination is a very intimate part of the entire ecosystem. It is a sacred ecosystem service that is as old as the world's existence. The main actors in the pollination process are pollinators which connect different crops, plants, and vegetations to fulfill one another's needs. The agricultural ecosystem without pollinators is beyond the imagination of those who know the agricultural ecosystem in detail. However, the population of these service providers is

gradually decreasing day by day. This can result in a significant decrease in the population of wild plant diversity, which is just maintained through the pollination services of the pollinators and the products are freely exploited by human's kind without any intervention for its maintenance and conservation. The reason for the decline in the population of pollinators is mainly the degradation of their habitat and the practice of monoculture [29]. The decline of their population would also risk wider ecosystem stability, food security, and human welfare ultimately [22, 27]. Many studies conducted by hundreds of researchers throughout the globe point out the problem of the declining population of pollinators [30, 31]. A very big problem is the lack of a global monitoring program, and regional monitoring is very poor and only limited to a very small area [32].

Several studies show evolutionary shifts in the pollination ecosystem from insect-mediated to bird-mediated in many generations of angiosperms that are present in approximately 65 families [33]. Similarly, the birds also become more specialized in nectar ivory in some parts of Africa, Asia, and Australia[34]. From one perspective, it is a good thing that the pollinators are increased and well specialized for pollination, but this means the pre-existing pollinators are gradually decreasing, allowing other species to take their place.

E. The economic valuation of pollination services:

These days, the attention to the valuation of ecosystem services is gaining more traction. The valuation including potential monetary loss associated with agricultural production is a strategy for quantifying its effect on overall production, food security, and the global economy as the basis to drive policy and actions [35]. The ecosystem service given by insect pollinators and the economic value of these services has become increasingly essential. This service is considered one of the headline ecosystems services. Qualitative valuation of the ecosystem services provided by the pollinators can be relatively easy work and is generally subjective to do, yet quantitative valuation is more challenging and riskier. However, sometimes the confusing values estimated for the pollination service may cause huge uncertainty. Some of the approaches for the valuation of pollination services include using market prices, damage cost method, and production factor method.

1)Contingent valuation method:

One of the common methods for economic evaluations of ecosystem services is the contingent valuation method which is very common for non-marketable goods. This method is based on a random survey among people who know the importance of pollination as ecosystem services, the externalities of pollination, and the willingness to pay for the ecosystem services per year [36].

2) Market price method:

If we are to calculate the value of pollination services in a particular place, the consumer's and producer's surpluses have to be calculated. The consumer's surplus can be estimated through the demand curve that is prepared by farmers' willingness to hire commercial bee hives for pollination at different prices. The producer surplus will be estimated from the revenue of commercial beekeeping deducting the cost incurred in beekeeping including the capital cost and shadow cost of labor [37].

3) Cost-based methods:

In this method, an assumption is made, "what if the pollinators are completely absent?" In this case, people have to use techniques like hand pollination or using a blower. The costs of using those alternative services are estimated, and the same value is assigned to the service provided by the pollinators [38]. The cost-based method may also come into existence by evaluating the producer's surplus due to the services of pollinators as compared to their complete absence [39].

4) Production factor method:

This method generally operates in two steps. First, physical changes in a biological resource or ecological function on economic activity are estimated. That means the production share due to the pollination is assessed. The second step is the effect of these environmental changes in terms of corresponding changes in the marketed output of the corresponding activity. In other words, the ecosystem service is treated as an 'input' into the economic activity, and, like any other input, its value can be equated with its impact on the productivity of the marketed output [40].

5) Other methods:

Some other methods require the identification of the extent of pollinator decline and the impact on agricultural prices [28], but the valuation of the vulnerability of world agriculture is confronted with pollinator decline [41].

F. The solutions to the existing problems

To address the declining population of these sacred service providers and halt this decline, information regarding the importance of the externality of the service they provide, pollinator species that are in danger, their distribution, the rate of decline, and the consequences on the ecosystem as well as a human being should be understood as much as we can [42]. This is a problem as big as how food is important to us because it affects the availability of resources, the environment, and diversity. The initiative against the prevailing problem should be started at the policy level to ensure their conservation and, if possible, aimed to secure a permanently sustainable level. Although balancing environmental sustainability, while having all the commercial goals and low-cost strategies, is extremely problematic and costly, this effort is ecologically sound and profitable in long run [43]. Some of the solutions are as follows:

1) Policy regarding pesticides:

There should be a provision banning the use of harmful chemicals in agriculture. The farmers should not be allowed any sort of insects or pests as everything in the universe is an essential part of the ecosystem [52]. To balance one another. almost every component is connected or dependent on one another directly or indirectly. The chemicals should be

replaced by organic pest repellents that are safe for insects. Those who use pesticides in the crop should be punished legally. For avoiding the loss or damage of any specific pest in the field, farmers should follow companion planting or cropping techniques [44].

2) Using Permaculture principles:

With the help of companion planting, the diversity of the agro-ecosystem will increase and help the pollinators flourish with the wider options to feed and survive. Crop diversification can be a risk-minimizing factor against crop failure and at the same time increases the LER (Land Equivalent Ratio) [45]. Also, the use of non-native hybrid varieties for high production should be strictly discouraged. Nature is the best teacher and one can learn from the environment about how things are interconnected. This helps to understand the best measure that has been known to naturally perform well [46].

3) Climate change mitigation:

In addition to pesticides, climate change is also increasing the problem for the pollinators by adversely changing the living condition. Pollinators and other organisms are also migrating northwards to avoid the impact of climate change. This can be mitigated by increasing afforestation programs in the area where such resources are lacking [47]. The trees and crops provide a micro-climate for the bio-diversity to avoid external unfavorable conditions, which increases the potential to survive under normal conditions. What is more, the emission of greenhouse gases should also be reduced [48]. The use of renewable sources, while reducing the use of pollution-emitting technologies can be fruitful.

4) Conserving the habitat of pollinators:

Another solution is maintaining the area of agriculture and forest. Land fragmentation and the increasing need for settlement, and commercialization should be strictly prohibited. To date, the extent of cultivable land and the forest area is decreasing day by day due to activities like the construction of roadways, airports, and houses. This adversely hampers biodiversity [48].

5) Farming for these pollinators:

Some of the pollinators like honey bees can be raised in the farmland by creating a suitable honeybee garden, such as by involving an orchard of fruits. This can provide mutual benefit, double the profit, and conserve the population of pollinators. In this technique, the cost of cultivation is paid by both farmers and the bees [49].

6) No genetically modified organisms (GMOs):

Genetically modified crops and organisms are not the real part of nature and they tend to distort the balance in nature. They increasingly dominate the local species, and hence they should be discouraged [50].

III. SUMMARY AND CONCLUSION

The pollinators are a very intimate part of our ecosystem not just because they provide us with very necessary ecosystem services but also because all components of nature are important to create balance in nature. Among the pollinators, the honeybee is the major pollinator for most flowering plants. Although they provide very important ecosystem services, their services are not incorporated in the cost-revenue evaluation. The positive externality they provide to society is known to many of us but due to the property rights issues, the bargaining between the parties has caused the market failure. The government is not even interested in assuring and paying the ecosystem services. Pollinators have been adversely affected by climate change, chemical pollution, intensive cropping, and the lack of natural cultivation. The commercial farming practice is detrimental to the habitat of most pollinators. The declined population of these pollinators is reducing the yield of plants and crops every year, which subsequently interrupts the ecosystem. Reducing these vital components of the ecosystem destroys the environmental balance and gives more opportunities for undesirable organisms to thrive.

For the valuation of the ecosystem services, one can follow the contingent valuation method, market price method, cost-based method, production factor method, or several other pertinent methods. For overcoming the problems, we should restrict the use of harmful chemicals and apply strict policies for those practicing monoculture, intensive farming, and chemicals. The use of GMOs should also be strictly banned, and cultivation should be aimed at the sustainability of natural resources in the long run. Weaker policies like taxation (legal bribing for doing naturally illegal activities) may be economically feasible, but this is not a permanent solution. The permanent solution would be doing natural resource conservation, permaculture farming, and toxic-free farming. The activities leading to climate change should be strictly prohibited. If we can follow all of these, the pollinators will thrive and therefore provide substantial ecosystem services to humans.

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