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ISSN: 2594-3146

Journal of Agriculture and Forestry University

Volume 2 2018

Agriculture and Forestry University
Rampur, Chitwan

ISSN: 2594-3146

Journal of Agriculture and Forestry University

Volume 2 **2018**

Frequency of Publication	Annual
Editorial Policy	A medium of publishing original scientific papers
Official Language	English
ISSN	2594-3146
Subject of Interest	Plant Science, Animal Science, Veterinary Science, Forestry, and Social Science

Subscription

Category	**Rate**
SAARC countries	US$ 10.00 postage extra
Other countries	US$ 15.00 postage extra
AFU faculty	NRs. 200.00
AFU students	NRs. 100.00
Other Nepalese citizen	NRs. 300.00
Other organization in Nepal	NRs. 500.00

Mode of Payment	By Bank Draft or Cheque on Bank of Kathmandu, Narayangarh, Chitwan, Nepal. It should be addressed to AFU-Directorate of Research and Extension (Exp), Rampur, Chitwan, Nepal
Correspondence	JAFU Secretariat Agriculture and Forestry University, Rampur, Chitwan, Nepal E-mail: dor@afu.edu.np

Correct citation: Authors detail with surname of first author, first name, followed by first name and surname of other authors in sequence (2018). Title of the article, Journal of AFU (Volume 2): pages, Agriculture and Forestry University, Chitwan, Nepal.

Agriculture and Forestry University
Rampur, Chitwan, Nepal

Journal of Agriculture and Forestry University (JAFU)

Volume 2 **2018**

Review Articles

Research Articles

Research Article

ECONOMIC VALUATION OF POLLINATION SERVICE IN CHITWAN, NEPAL

S. C. Dhakal*
Agriculture and Forestry University, Rampur, Chitwan, Nepal

ABSTRACT

Pollination is a regulatory and production form of ecosystem service. In the global scenario of declining pollinators, the study on potential consequential economic loss and ways to conserve them are essential. In this context, this study was conducted to estimate the economic value of pollination and vulnerability of agriculture to pollinator decline in Chitwan district of Nepal. Bioeconomic approach, which integrated the production dependence ratio on pollinators with total economic value, for the food crops grown in the district was used to assess the economic value of pollination. The total economic value of pollination in the study district accounted to about NRs. 999 millions which represented 11% of the total value of the agricultural production used for human food in 2014 in Chitwan district. In terms of welfare, the consumer surplus losses were estimated as NRs. 1,893 millions and NRs. 3,102 millions for assumed price elasticities of − 1.2 and − 0.8, respectively. Vegetables (48.8%) were the leading crop category in value of insect pollination and vulnerability, followed by edible oil crops (24.9%), fruit (9.4%) and pulses (1.8%). Hence, it is recommended that farmers, policy makers, researchers and other stakeholders are to be mindful of such great value of pollination and its vulnerability to protect pollinators and sustain the environment along with promotion of the peoples' livelihoods.

Key words: Bioeconomic approach, consumers' surplus, pollinators' decline, vulnerability

INTRODUCTION

Agriculture is the mainstay of the livelihood in Nepalese economy, providing primary occupation to about 65.6% of the total population (MOAD, 2016). However, as agriculture is only a means of subsistence for the majority, the share of agriculture to the national Gross Domestic Product (GDP) is minimal, contributing just 31.4% to the total GDP (MOF, 2017). The agricultural land is gradually degrading by heavy use of chemical fertilizers, pesticides and other forms of pollutant technologies in the form of intensive agriculture (Deshar, 2013). In addition, such agrochemicals have led to decline of beneficial insects, such as crop pollinators and bioagents (Thapa, 2006).

Pollination is an important regulatory and production form of the ecosystem services, which provides a variety of benefits including food and fiber, plant-derived medicines, ornamentals and genetic diversity (MEA, 2003). Pollination is the transfer of pollen grains from the anther to the stigma of flowering plants (Roubik, 2002). At the global level, 75% of primary crop species and 35% of crop production depends on animal pollination (Klein et al., 2007).

Declines in the pollinator populations and species diversity widely have raised concerns regarding the potential risks to global food security, particularly to resource poor developing countries like Nepal. In the Hindu Kush Himalayan (HKH) region, evidence of the decline in pollinator numbers has been reported from apple farming in Jumla District of Nepal (Pratap, 2001). An increase in honey hunting and the ruthless hunting of the nests of wild honeybees is contributing to the decline in the population of indigenous honeybees (Pratap, 2010). Evidence of decline in population of *Apis laboriosa* in Kaski District of Nepal was reported in another similar study (Ahmad et al., 2003). Like in many other parts of the world, pollinator loss in Chitwan has been attributed to habitat loss resulting from misuse of fertilizers and pesticides, reluctant in beekeeping, deforestation, loss of natural vegetation, increased commercial agriculture, use of high yielding varieties, and many other abiotic and biotic factors. In addition to increasing habitat loss, wild bees face many of the same health perils as managed bees, and their populations have also been declining (Devkota, 2012).

This research focused on economic valuation of pollination service and vulnerability assessment of agriculture in the study area to the decline in pollinators. The location-specific empirical research findings from this study could be guiding tools for promotion of pollination service in a sustainable manner.

* Corresponding author: nepal_dhakal@ymail.com

MATERIALS AND METHODS

This study was based on secondary data collected on production and price of different crop commodities. The methodologies for estimation of the economic value of pollination and vulnerability of agricultural production to decline in pollinators were started from the categorization of crops grown in Chitwan district into different categories based on the dependency ratio to animal pollinators. The scoring of degree of dependency of crop production on insect pollination was categorized into five classes: (i) essential (production reduction by 90% or more without flower visitors, meaning that production requires animal pollination), (ii) high (40 to less than 90% reduction), (iii) modest (10 to less than 40%), (iv) little (greater than 0 to lessthan10%), and (v) no reduction (Klein et al., 2007). Dependency ratio was further enumerated for minimum and maximum value along with the mean dependency ratio of a particular crop upon animal pollinators. Total economic value of production was estimated by multiplying the production with price of respective commodity or commodity groups. Economic value of crop dependent on insect pollination was further estimated by multiplying total economic value of the crop with the dependency ratio. The next assessment was made about the vulnerability ratio of agricultural production to insect pollination. This estimation was done with ratio of the economic value of insect pollination to the total value of crop and expressed in percentage for ease of simplicity in interpretation. Vulnerability ratio was estimated individually for different categories of crops like cereals, fruits, oilseed crops, pulses, roots, tubers, spices, sugar crops and vegetables; and on an overall average level as well. The details of the above description on the total economic value of crop production, economic value of insect pollination and the vulnerability ratio assessment model are presented in following equation (Turner et al., 2003).

$$RV = \frac{IPEV}{EV} = \sum_{i=1}^{I} (Pi \times Qi \times Di) * 100\% / \sum_{i=1}^{I} (Pi \times Qi)$$

Where,

RV = Vulnerability ratio
EV = Economic value
IPEV = Economic value of insect pollination
P_i = Price of i^{th} crop
Q_i = Quantity produced of i^{th} crop
D_i = Reported value of dependency (Klein et al., 2007)

Consumer surplus related to crop pollination in Chitwan was estimated using the approach adopted by Gallai et al. (2009). This approach gives the value of consumers' surplus directly with the use of assumed constant value of price elasticity of demand, economic value of the crop and dependency ratio of a particular crop on insect pollination. According to this approach, consumer surplus is basically sum of two components. The first component is the difference in farm revenue without pollination and the revenue with pollination. The second component is the value placed on the product by consumers who will buy at the low price but would not have bought at the high price of the product in the absence of pollination. The details of the algebraic model used to estimate the impact of pollinators decline on consumer surplus is expressed here under.

$$CSloss = \frac{PiQi}{1+E} ((1/1-D)^{1+E}-1)$$

Where,

CSloss = Consumers' surplus loss
P_i = Price of i^{th} Crop
Q_i = Quantity of i^{th} crop
E = Assumed value of elasticity of demand

RESULTS AND DISCUSSION

Animal pollination dependent crops

The efforts on economic valuation of pollination service were started from the listing of crops and crop categories grown in the district Table (1). The dependency of crop production on animal pollinators was then segregated into essential, great, modest, little and no increase category based on known values of dependency on insect pollinators. Cucurbits was the single category of crop in the essential group of dependency grown in the district. Whereas, buckwheat, mango, guava, peach, plums and apricot were the crop

in the great pollination dependency group. Similarly, other commodities like okra, broad beans, eggplants, coffee, oilseeds, and soybean were the crops and crop categories that have modest degree of dependency on animal pollinators. The rest of the crops like beans, peas, chillies, peppers, tomato, lemons, linseed, orange, papaya, persimmons, pigeon peas were in the category of little pollinator dependent. The last category of the crops, with no increase in edible parts due to pollination, Morse and calderone (2001) included lentil, maize, millet, rice, sugarcane and wheat in the study area.

Table 1. Dependency of different crops to animal pollination grown in Chitwan

Crop	Dependence upon insect pollination	Dependence ratio		
		Min	Max	Mean (D)
Cucurbits	Essential	0.9	1	0.95
Mango, guava, buckwheat, peach, pears, plum and apricots	Great	0.4	0.9	0.65
Broad bean, coffee, oilseed crops and soybean, okra and eggplants	Modest	0.1	0.4	0.25
Beans, peas, chillies, peppers, tomato, lemons, limes, linseed, oranges, papaya, persimmons, pigeon pea	Little	0	0.1	0.05
Lentils, maize, paddy, wheat, millets	No increase	0	0	0

Source: Klein et al., 2007

Economic value of insect pollination in Chitwan

The estimated value of the pollination by insect pollination to the agricultural economy of the study district calculated using the market price valuation is presented in Table (2). The best estimate of the value of pollination by insect to agricultural crops in Chitwan is approximately NRs. 999 millions in 2014 prices. The figure indicates only use value of main product as human consumable goods. Cucurbits, buckwheat, oilseeds and tomato occupy the largest value dependent on insect pollination in descending order.

Table 2. Economic value of insect pollination in Chitwan district of Nepal

Crop	Average price (NRs./mt)	Production (mt)	Total value of crop (TVC) In NRs. millions	Economic value of insect pollinators (EVIP) in NRs. millions
Cucurbits	37,500	16,718	626.93	595.58
Okra	42,000	3,616	151.87	37.97
Eggplants	33,000	3,386	111.74	27.93
Beans/peas	71,000	1,788	126.95	6.35
Beans, dry	89,740	500	44.87	2.24
Broad beans	60,634	353	21.40	5.35
Buckwheat	45,628	1,200	54.75	35.59
Chillies	150,069	207	31.06	1.55
Tomatoes	50,081	6,030	301.99	15.10
Lemons/ limes	127,000	100	12.70	0.64
Linseed	38,391	160	6.14	0.31
Mango and guava	50,000	1,696	84.80	55.12
Oilseeds	73,000	10,855	792.42	198.10
Oranges	60,420	1,689	102.05	5.10
Papayas	90,000	320	28.80	1.44
Peaches	70,500	45	3.17	2.06
Pears	55,000	62	3.41	2.22
Pigeon peas	516	144	0.07	0.00
Plums	57,500	10	0.58	0.37
Overall total	40,859	7,416	9066.23	999.11

Source: Authors' estimation based on secondary data obtained from DADO, Chitwan, 2014

Vulnerability assessment

The value of agricultural crops dependence on animal pollination was estimated using dependency ratio at mean level. Table 3 presents the economic value of animal pollinators and vulnerability ratio. The aggregate vulnerability level of agricultural production to the pollinators decline in Chitwan District was 11%. This vulnerability ratio is quite high as compared with other economies because of growing vegetable production as dominant sub-sector of agriculture in Chitwan district. The reported vulnerability ratios of some other studies using similar methodologies were Africa (8.2%), South Asia (6%), European Union (10%) and USA (11%) (Turner et al., 2003). Breaking it to crop categories components, vegetables, Winfree et al., (2007) oil crops, fruit and pulses have the vulnerability ratios of 48.8, 24.9, 9.4 and 1.8 percentages, respectively. Consumers' surplus loss estimated at elasticity coefficient 0.8 and 1.2 has shown the loss value of about NRs. 3,103 millions and NRs. 1,893 million respectively in the study area (Table 4). Some crops like cereals, roots and tubers, spices and sugar crops grown in the district possess zero level of vulnerability to pollinator decline.

Table 3. Vulnerability of agricultural crops to pollinators decline grown in Chitwan district

Crop category	Average price (NRs./mt)	Total value of crop (TVC) In NRs. millions	Economic value of insect pollinators (EVIP) in NRs. millions	Ratio of vulnerability (RV) in percentage
Cereals	17,114	4165.39	0.00	0.0
Fruits	44,787	716.32	67.03	9.4
Oil crops	72,696	822.56	204.41	24.9
Pulse	73,543	425.37	7.60	1.8
Roots and Tubers	35,310	1261.17	0.00	0.0
Spices	130,234	184.54	0.00	0.0
Sugar crops	9,955	14.93	0.00	0.0
Vegetables	44,128	1475.94	720.07	48.8
Total		9066.23	999.11	11.0

Source: Author's estimation based on secondary data obtained from DADO, Chitwan (2014)

Table 4. Consumers' surplus loss (NRS. millions) agricultural crops to pollinators decline grown in Chitwan district

Crop category	Consumers' surplus loss	
	E= -0.8	E= -1.2
Cereals	0.00	0.00
Fruits	114.90	94.48
Oil crops	242.07	228.55
Pulse	8.66	8.28
Roots and Tubers	0.00	0.00
Spices	0.00	0.00
Sugar crops	0.00	0.00
Vegetables	2737.90	1561.86
Total	3103.53	1893.17

Source: Authors' estimation based on secondary data obtained from DADO, Chitwan (2014)

CONCLUSION

Using a bioeconomic approach, the value of pollination in the Chitwan district of Nepal was calculated, and vulnerability was estimated for the case of a decline in pollinators. It was concluded that agriculture production of Chitwan has ample numbers of essential to the modest degree of pollination dependent crops such as cucurbits, buckwheat, mango, guava, peach, plums, okra, broad beans, eggplants, coffee, oilseeds and

soybean. The estimated economic value of insect pollination to agricultural crops was approximately NRs. 999 million in 2014 prices and this was 11% of total production by value. This vulnerability ratio is quite high because of commercial pockets of vegetables in the study area. Considering the huge value of pollination services, raising awareness at all levels about the importance of pollination, beekeeping and other natural pollinators should be considered . It is suggested to consider and prioritize pollination as a technological input in agricultural development programs of the nation.

ACKNOWLEDGEMENTS

The author express his gratitude to the Global Pollination Project (GPP) funded by GEF and implemented by Institute of Agriculture and Animal sciences for the financial support to conduct this study.

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