International Journal of Applied Agricultural Research
ISSN 0973-2683 Volume 6 Number 3 (2011) pp. 223-236

http://www.ripublication.com/ijaar.htm

Damage to the Agricultural Yield due to Birds, Present Repelling Techniques and its Impacts: An Insight from the Indian Perspective

Manoj Kale[1,2]*, Berit Balfors[1], Ulla Mörtberg[1], Prosun Bhattacharya[1] and Sanjay Chakane[2]

[1]Department of Land and Water Resources Engineering, Royal Institute of Technology (KTH), Teknikringen, 76, SE-100 44 Stockholm, Sweden.
[2]Department of Physics, ASC College, Indapur (Affiliated to University of Pune), Pune-413 302, India
**Corresponding Author E-mail: kmanoj@kth.se*

Abstract

In India, nearly 65% of the people are directly or indirectly dependant on agricultural sector for economic survival. The annual income of farmers is significantly influenced by the yield of the crops, which is continuously decreasing due to natural phenomena and poor technological advancement. However, the particular attention should be paid to the damage caused by birds. While the exact measure of the loss in yield associated with birds is unknown, farmers integrate a number of traditional and conventional techniques to grow and store grains and fruits. Many of the used methods result in extinction of the rare birds. Therefore, there is a need to develop alternative techniques, such as dialogue with the farmers, grain storage authorities and experts in the fields of ornithology, agricultural sectors and field visits, to avoid irreversible harm to the Indian biodiversity. This research analyzes the loss of yield of crop due to birds, explores repelling techniques adopted by the farmers, and addresses the consequences of integrated methods on the bird biodiversity in India. The project unveils the importance an interdisciplinary approach to develop an eco-friendly technique to reduce the loss of both the birds and the crops.

Keywords: bird species; biodiversity; agricultural yield; repelling techniques; crop yield; India.

Introduction

India has worldwide identification for its heritage, rich biodiversity and also attempt for the conservation of environments. There are four major Bird Sanctuaries in India protecting Bird Biodiversity which are Wild Ass Sanctuary-Gujarat, Western Ghats, Namdapha-Arunachal Pradesh and Kangchandzonga NP- Sikkim (World Heritage-convention, 1972). In total 9782 of bird species found in the world and out of these 1179 species are found in India and 147 are endemic species (Chatterjee and Saikai, 2006) which includes 14 critical, 15 endangered, 54 vulnerable and 64 near threatened (IUCN, 2010) (Fig. 1). There are two main reasons of the bird extinction is either humans activities which may be accidental or deliberate activities and decreasing availability of food.

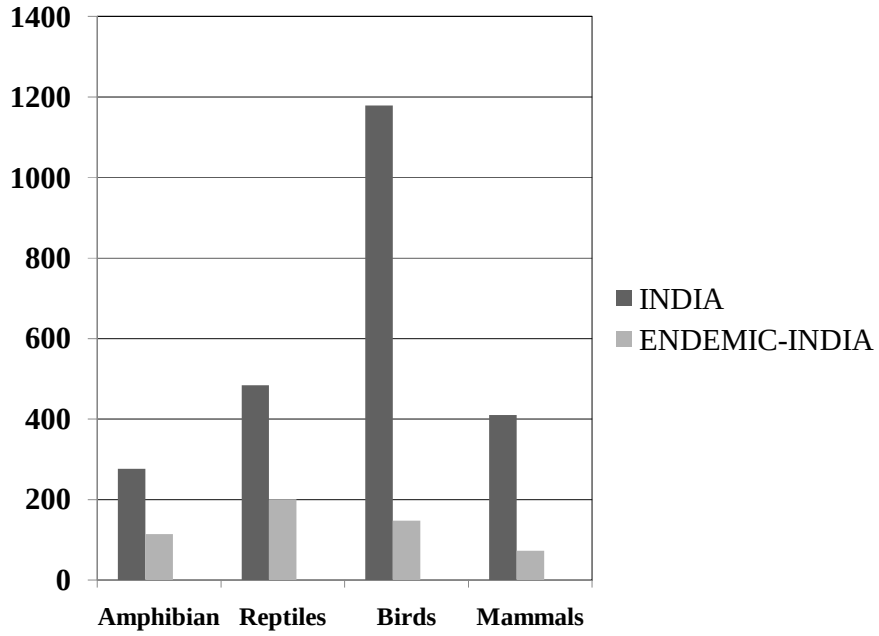

Figure 1: Number of Endemic Species in India.
Source: www.kerenvis.nic.in/isbeid/biodiversity.htm,Visited on 15 Oct 2010
Biodiversity Significance of North East India, Sundipto Chatterjee, 2006
Number of endemic birds is updated, 2010 from 140 to 147, Red List of IUCN from India Threaten Species

In India two- third of population is directly depending on agricultural sector for their livelihood which contribute the one fifth part of GDP of the country (Fig. 2). One fifth population of the world is living on only 2.4% of total land area of the world (Singh et al., 2002). In recent years crops productivity decreases in India due to various factors like poorly maintained irrigation system and current agriculture methods are neither economically nor environmentally sustainable (World Bank, 2008).

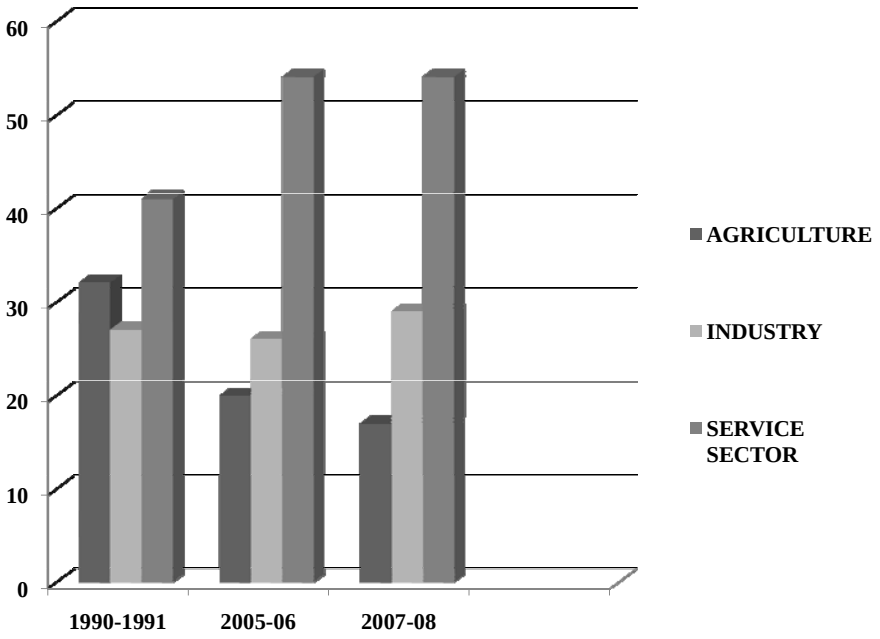

Figure 2: Contribution of various sectors in the Indian GDP (Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India

The bird activities results the damage of crops and grains in grain stores and rice-shelling yards which vary state to state and area to area. In India most of such activities of birds are either advantageous or disadvantageous to the formers. Birds create negative impact on most of agricultural activities and some activities attract birds as special feeding opportunities (Ormerod and Watkinson, 2003). The food of the birds is of mostly three types which depend on grains, seeds, fruits, green vegetation of the crop plants and grasses, insects, other arthropods rodent, etc. found in soil, crops and other plants (O'Connor and Shrubb, 1986). Thus birds plays duel role in Indian Agro-Ecosystem (Ali, 1949, 1971).

The systematic procedure to develop a robust statistical method for assessing bird damage to crop, particularly to fruits which provides accurate assessment data that can be used for scientific research and for evaluation of bird management method and devices (Saxton, 2006). Such methods are not yet developed and established in order to understand the intensity of the damage due to birds in different states and union territories in India.

On the other hand in order to reduce the damage of farmers and grain storage activity, various bird killing techniques are used such as chemical repellent, net, spike guards, traditional methods such as shooting the birds with gunshot, making sound with help of crackers in order to scare birds (Subramanya, 1982). All these birds management methods are less effective and cause great damage to the certain threaten species and migratory bird which produce the adverse effect on conservation of biodiversity on a local, regional and global scale.

The purpose of this research is to understand the management which includes both the conservation of useful species and bird repelling techniques. The assessment of environmental impact of different bird repelling or killing technique, its affect on biodiversity and conservation measures is also important tool. In this investigative research, there is a great scope for methodological innovations as a result of which alternative systems of inquiry are being appreciated and operation is required in order to assess the field situation.

Through in this background paper we want to point out that there should be a rigid framework in order to avoid killing of birds and also the interdisciplinary research may be carried out with the help of experts in Ornithology, Zoology, Physics and Engineering in the direction to save the damage of farmers as well as save the life of birds and is also essential to identify the areas where the killing of birds carried out for different reasons and suitable mitigation measure should be taken by concerned authorities in order to save the lives of birds. Otherwise the insufficient mitigation measures for the conservation of threaten bird species which result in increase in their number from 140 to 147 and which may increase in future.

The main objectives of this paper are: (i) to review the magnitude of the problem of crop damage and food grain loss by various species of birds, (ii) to point out important problems and gaps in the knowledge in agro-ecosystem and bird biodiversity, and (iii) to suggest an interdisciplinary approach for future research in India in the field of applied agricultural ornithology.

Material and Methods

The Study Area: Location, physiography and climate

Maharashtra is third largest state (in India) after Rajasthan and Madhya Pradesh, situated in north centre of Indian Peninsula which is located between $76^0$00' E longitude and$20^0$00' N latitude. Total geographic area 307,713 sq. km which is 9.4% of total geographical area of India with 96.75 million population (Census of India, 2001).Maharashtra is bordered by the state of Madhya Pradesh to north, Chhattisgarh to the east, Andra Pradesh to southeast, Karnataka to the south and Goa to the southwest (Fig 3). The state of Gujarat lies to the northwest, with the union territory of Dadra and Nagar Haveli sandwiched between the borders. The Arabian Sea makes up Maharashtra west coast. Maharashtra consists of two major relief divisions. The plateau is the part of the Deccan table and Konkan coastal strip abutting on the Arabian Sea. The state of Maharashtra forms a huge irregular triangle with its base on the west coast of India, overlooking the Arabian Sea. The long and not more than 80 km wide, is Konkan dotted with paddy fields and coconut gardens. The major part of Maharashtra is underlined by rocks of volcanic origin the lavas. The lava beds are distinctive feature of landscape in Maharashtra and many of them present as black and massive girdles a spectacular display on the scarp face of the Sahyadri, mountain range. In India, the states are divided into the following administrative units: Division, Districts, Sub-Division, Blocks and *Panchayats*. Geographically and historically, Maharashtra has five main regions namely *Vidarbha, Marathwada, Khandesh* and North Maharashtra, *Western Maharashtra* and *Konkan* Regions comprise *Mumbai*

city and *Mumbai Sub-urban division*. Maharashtra consists of 35 districts and every district is divided into 4 to 16 Blocks (Maps of India, 2006).

Figure 3: Map of study area in India. (Source: Google Maps, visited on 10 Dec. 2010).

The Union Territory of Dadra and Nagar Haveli is situated on the western coast of India between the parallel of 20^0 and 20^0 20' N latitude and between the meridian 72˚50' and 73˚15' of longitude and its geographical area is 491 sq. km with population 2,20,451 (Census of India, 2001). The territory is surrounded on the west, north and east by Valsad district of Gujarat and in the south east by Thane districts of Maharashtra. The district has a hilly terrain especially towards the north-east where it is surrounded by ranges of Sahyadri Mountain (Western Ghats).The central region of the land is almost plain and the soil is rich and fertile.

The terrain is intersected by the river *Daman Ganga* and tributaries. The river rises in *the ghat* 64 km from coast and discharges itself in the Arabian Sea at the port of *Daman*. The climate of the region is warm and humid during the summer but less warm during the monsoon from June to September, bring copious rain to territory. The average rainfall is about 250 to 300cm, per year.

Pune is the district selected for the study area from the state of Maharashtra which is located in the western part of the state at a latitude $18^0$31' N and a longitude $73^0$51'E with geographical area of 15, 6621 sq.km and extends on the Deccan Plateau on the west. The total population of 7,232.555 (Census of India, 2001) and average

temperature of Pune varies between 35^0C in summer and about 6.6^0C winter with an average rainfall is about 68cm.

Literature review

India is ratified the world heritage convention in 1977 and since five natural sides Kaziranga National Park, Keola Deo National Park,Manas National Park, Sundarbans National Park and Nanda Devi National Park are known for area of outstanding universal value. As North Eastern Region of India which includes state of Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram, Nagaland, Sikkim and the Assam plains are recognize as a Endemic Bird Area by Royal Society for protection of birds and the international council for bird prevention, UK and this part of India is a home for about 850 birds species (ICBP, 1992, Bibby et al 1998).There is the occurrence of endanger and vulnerable species in this area (Islam and Rahmani, 2004). Fifty percent of restricted species are considered as threaten species in this area and one of the major Tropical evergreen forest region which is known as the Western Chats includes Mumbai south to the Maharashtra, Karnataka, Kerala and Tamil Nadu is also important in biodiversity prospective (Rodger and Panwar, 1988).

There is very less amount of written work on the topic 'damage of crops, grains and fruits due to birds and its estimation and damage management in Maharashtra'. One reason for this is less research done on damage assessment and its analysis as it is practically laborious and time consuming i.e. in order to do such research someone must have to go to fields and count or estimate the impact every time at each of crops and grains which is practically very laborious. There is lot of research carried out on the international platform and also few research work carried out in few states of India regarding damage assessment.

Methodology

Field study and visits

Methodology of data collection is based on field evidence and analysis of the issues from the field experience of the study area Pune and Dadra and Nagar Haveli. This is one of the methods of identification of certain gaps in the research field. The base of field studies and visits is to realize the need by learning and doing method. Number of field visits were carried out to the farms during the year 2009-2010 in the study area. Farms and grains stores of Village Randha from Dadra and Nagar Haveli and Indapur from Pune District were continuously monitored and damage assessment was carried out and it is found that in few cases where no bird control was used, would result in total loss. It is also found that there is no systematic method to assess crop and grain damage in India and traditional methods to control this damage from birds are insufficient, non- scientific, tiresome and hectic. Farmers have to stand on their toes to save their losses from birds from sunrise to sunset during post harvesting seasons.

Questionnaires survey

Our research focuses on conventional method of investigation such as questionnaire

survey with participatory method which is interesting and innovative and at the same time representative and trustworthy. In order to understand research need and evaluate the demand of agriculture sector for statistical analysis of damage of crops and grains by birds is concern and also to understand the awareness of importance of bird in the agro ecosystem, the questionnaire is distributed among the farmers, worker in the grain store departments and other related elements of the society who depends directly or indirectly on the agriculture for their food and livelihoods. The questioner was based on percentage damage of crops and grains due to bird and traditional and modern techniques used by farmers and workers in order to avoid the loss and their effectiveness. In this process we interviewed 178 and 346 farmers from Silvassa and Pune respectively and main focus of this survey was to understand actual condition of research topic at different levels.

Statistical Analysis

In order to analyze the result of survey, Delphi Method is use to calculate the impact of birds on the damage of agricultural yield This analysis leads to the conclusion that 73% farmers considered that damage produced by birds is serious problem and 85% expressed the need of modern ecofreindly bird scaring techniques Table-1. Most of the farmers expressed that this damage is dependent upon types of crops and seasons and it varies area to area while 40% of farmers considered that damage of crops and grains is about 35-60% and 25% farmers expressed that this damage is 0-35% in certain area (Fig 4) while 65% farmers consider that traditional techniques of bird scaring are not effective (Fig 5).

Table 1: Statistical Analysis of Result of survey.

Question	Yes	No	Can't say
Are birds producing damage to the crops and grains?	73%	22%	5%
Is there a need of modern ecofreindly bird scaring techniques?	85%	2%	13%
Is damage percentage depending upon type of crops?	90%	8%	2%
Is damage percentage depends upon seasons?	93%	4%	3%

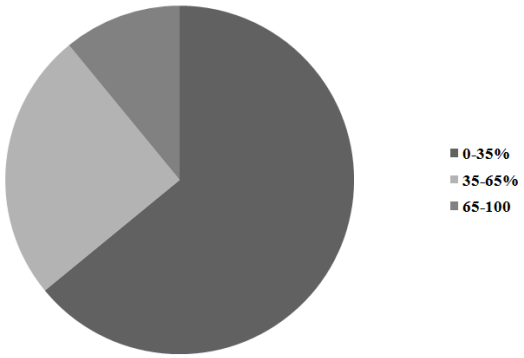

Figure 4: Response of the farmers to the survey on percentage of damage of crops and grains due to birds from *Silvassa (DNH*, India) and *Indapur (Pune*, Maharashtra)

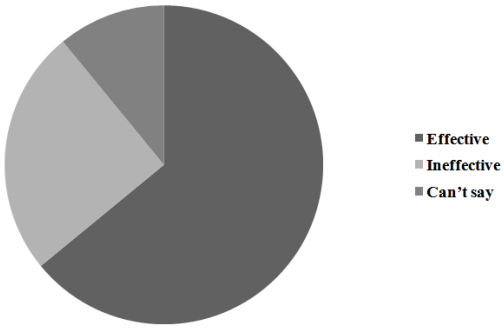

Figure 5: Response of the farmers to the survey on effectiveness of traditional bird scaring techniques from *Silvassa (DNH*, India) and *Indapur (Pune*, Maharashtra)

Result and Discussion

Case study

Many crops are damaged by birds, with a little knowledge available of actual economic loss is done by House Sparrows, House Crow, Common Myna, Asian Koel, Greater Coucal, Red – Vented Bulbul and Red Wattled Lapwing graze on the crop and most of the time uprooting them in search of wireworm and other soil invertebrates (Porter et al., 1994; Boyce et al., 1999; Tracey and Saunders-2003 and Dewar-2006). The great damage to the crop is noticed when they are in mature stage by the Baya and Munias during the observations carried in Hyderabad, India and these birds with house crow can reduce the crop yield by more than 55% (R.L. Bruggers, 1986). In addition to above list of birds, the rose ringed parakeet, Psittacula Krameri is the most common and the destructive birds of India which inflicts huge damage to grain of standing crops, orchard fruits and vegetable crops.(Kushwaha and Prabhat,2004) A single Parakeet consume about 15.0 gm of sunflower seed per day. These birds can cause 10% to 40% damage and may cause 90% in isolated area in the field of sunflower. Where the Sunflower is an important edible oil seed crop in India. Continues research in Karnataka, India is going on evaluation of high yielding sunflower varies with less prone to bird depredation (B.G. Prakash, 2007). Birds like common Myna, jungle Myna, Brahminy Myana, jungle Crow and white cheeked Bulbul damage the crops of grapes in a great extent of grapes in Himachal Pradesh, India (Patyal and Rana, 2003). These damages can result not only limited to yield loss but also affects on grapes which decrease the quality of the wine (Loinger et al., 1977). Thus bird pests constitute a significance limitation of productivity.

(Dhindsa 1994) carried out research in this field in state of Punjab, which is one of the most important agricultural states in India. Almost 90% of the agricultural land is facilitated with sound irrigation system with adequate tube well and cannel arrangement and it produces 22% of country's wheat, 9% of rice and 6 % of cotton. According to estimation of damage potential it is found that loss due to bird is considerably large (fig 6). These birds are also responsible for the activities like spoiling the site area, damaging the gunny bags and contaminated grains with their droppings in the grain stores. Such research indicates that the need of research in

damage estimation in Maharashtra, which is also most important state in the field of agriculture and to develop the concerned measure.

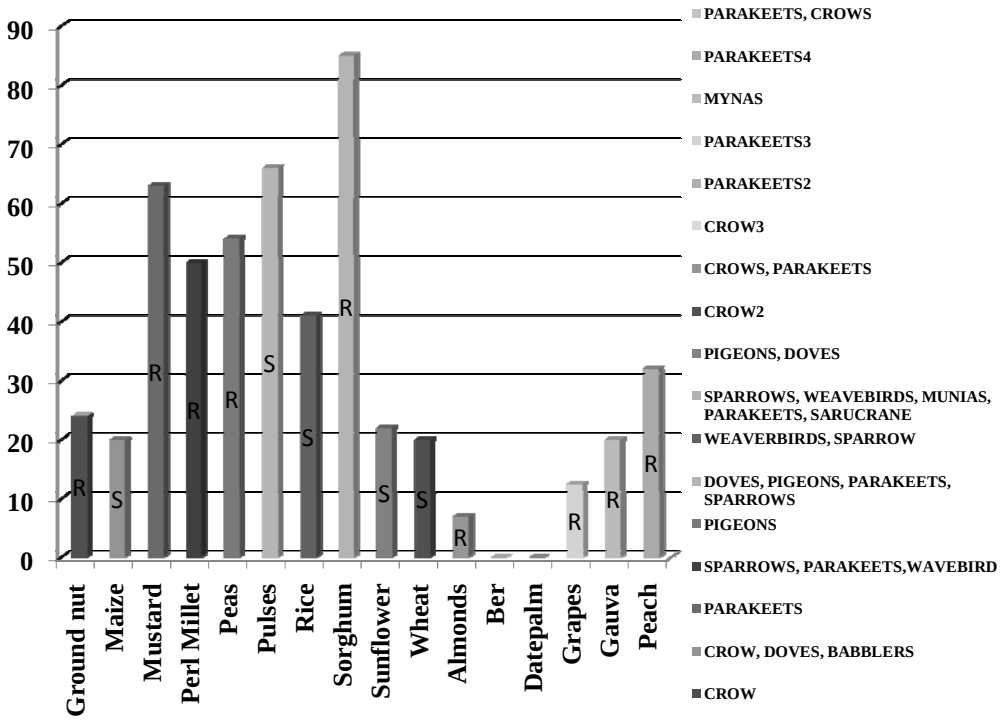

Figure 6: Extent of damage made by different bird species to crops and fruits (Perl Millet is recorded -10-100; Sorghum is recorded-12-85 in Ripening Season), R-Ripening Season and S-Sprouting (Dhindsa and Harjeet, 1994)

Indian Peafowl was accessed by (Sathyanaryana 2002) in Tamil Nadu, and conclude that Peafowl consumed 0.99 gm/m^2 area/day and total damage is estimated 1.9 % paddy tiller/m^2 per day and he also suggests mitigation measure which is reflective ribbons as a bird scaring device which can save paddy, ground nut, onion and ladies finger.

In one of the nebhouring state, Gujarat, it found that population of Indian Sarus crane (which is one of the Global threaten species) has declined at the alarm which is considered as one of the pest by farmers and it produces damage in the range of 0.2 to 13.6% to the paddy crops (Borad, 2001). He also expresses the need to educate the farmers regarding the conservation of this most endangered species. In order to solve such problems and protect the loss of biodiversity, there is need of accurate damage assessment and identification of the ecofreindly solution.

(Shivankar 2008), of Pune, Maharashtra, as his study area concludes that Pune and nearby area is known for its principal product of sugar cane and it is also known as

sugar belt. Yield of sugar crop is affected by birds like House Sparrows, House Crow, Common Myna, Asian Koel, Greater Coucal, Red Vented Bulbul and Red Wattled Lapwing because of their abundance and produce damage to crop which is considerably large (Fig 7). This indicates that there is a need of development of proper techniques which can save the birds and also the loss of farmers.

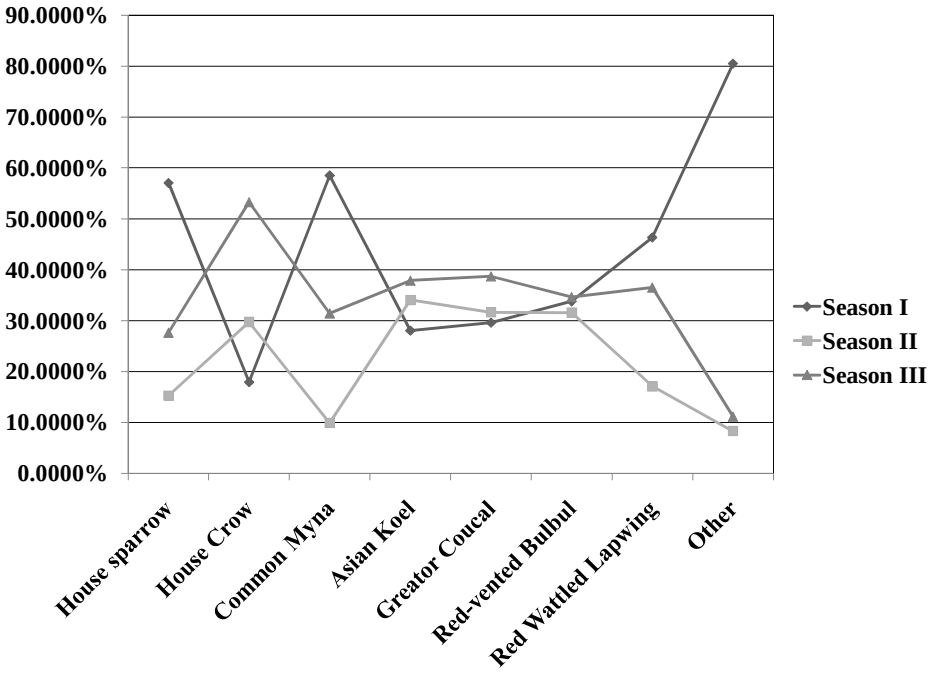

Figure 7: Relative abundance of birds in various seasons in sugarcane beet fields in Pune, Maharashtra, India. (Season I-Winter (2005-06); II-Summer (2006); III-Winter (2006-07)) (Data source: Shivankar, 2008)

Bird scaring, repelling and killing techniques presently use to reduce damage of crops and grains

The management of harmful birds consists of number of techniques which is mention in **Table-2**. Out of these methods few are non-effective and most of methods are non-ecofreindly and produce direct harm to the biodiversity. These technique consist o mainly different bird repellent technique such as visual repellent, chemical repellent, bioacoustics repellent, optical repellent.

Killing most of the birds are illegal in India (Singh and Dungan, 1955) in spite of that it is strong belief among the farmers that Killing the birds is considered as a surest way to free from the problem of birds and they use techniques which consist of shooting, trapping, fumigation, poison baiting, egg and nest destruction, killing with the help of gun and catching them in trap. All these will produce the damage to the threaten and migratory birds and also produce damage to the conservation of

biodiversity. Killing the birds is not a proper solution of the problem and such an attempt is disapproved on the international background such as mass killing of *Quelea* in Africa and *Sturnus vulgaries* in Europe (Dhindsa and Saini, 1994). Importance of discussion about bird life in ecosystem is often neglected in the consideration of economic losses and present bird management programs are not implemented in the ecofreindly way because this nature of the damage, both spatially and temporally, is due to sporadic feeding behaviour and mobility of birds.

Table 2: Existing bird repelling techniques used in agricultural sectors on India.

Technique	Bird	Crops	Reference
Polypropylene pelene metallic shining ribbon	G	G	S. Suubramanya, 1982
The white cloth banging	Egret	Paddy	Kiruba et al 2007
Erection of Scare crows, noise-making devices like crackers and carbide guns with polythene bags	G	G	Subramanya, 1982
Chemical bird Repellents are use like Trimethacarb, Methiocarb and Curb	G	Broadcasting wheat seeds and ripening grains	Bruggers et al. 1984
Spraying of neem kernel powder solution	G	G	Suubramanya,1982
Pre- recorded distress call of parakeet (Bio-acoustic method)	Parakeet	G	Suubramanya, 1982
Killing and catching of birds	G	G	Singh and Dungan, 1955
Methicarb(4Methylthio)3, 5 xylyl-N-methyl carba-mate, a pesticide and Thiram (tetramethythiumram sulphide), a fungicide	G	G	P.SSandhu and Toor,1987
Poisonous chemical	G	G	Bhatnagar, 1976

G-Not specified

Present status of crop damage due to birds and control techniques in field area

The damage to sorghum and pearl millet (*bajara crop*) is a major concern by birds like sparrows (different spp.), parrot, pigeon, etc. The sunflower is being mostly damaged by parrot, crows, and pigeon. The extent of damage varies as per location and area available for damage. In general 20-22 % damage is being noted on sorghum and bajara crop. However the sunflower damage extends to 25 to 65 % depending on the location of cropped area.

The bird scaring techniques followed traditionally are Drum sticking, Models of scares (statues like man), reflecting ribbons, *Cracking and Kavan (Gophan*).

Agriculture and bird management in Maharashtra

Agriculture is one the main occupation in rural area of state of Maharashtra. The major crop grown in the state include Rice, Jowar, Bajra, Wheat, Pulses, Cotton, Sugarcane, Ground nut and Soybean, Turmeric, Onions and other vegetables. Maharashtra is famous for its fruit production. The major fruits produced in the state are Mangoes, Bananas, Grapes and Oranges, Nagpur and Nasik are the major producers of fruits which are supplied to various countries in the world every year that helps grow business of export. The damage of crops, grain and fruit which cannot be weighed estimated or calculated directly in the field. Fruit crops the greatest damage occurs close to harvest when workers are busy with harvesting and have no time to see the damage due to birds. In Maharashtra, there is no such scientific method still developed which can analysis the damage and save the farmers from such loss. This is the scenario for other states of India and neighbouring country. The above aspects of need of ecofreindly technique are expected to go a long way in exploring, validating and reinforcing in the field of agriculture, ecosystem and bird management techniques. There is need of methods which can assess loss of the farmers due to which degree of accuracy can be improved and established the proper way to solve the problem.

Conclusions

Though India is known for its rich biodiversity and agriculture, hence it is concluded that present bird management methods are neither scientific nor ecofreindly which results danger to the bird lives and impact on agro ecosystem. It is also found that these techniques are not that efficient to manage the problem permanently. After the several observations it is concluded that bird repellent like neem powder and reflective ribbons are not effective for repelling the birds, though these techniques are ecofreindly. There is a need of interdisciplinary research in the development of ecofreindly bird repelling techniques. It is also concluded that visual estimation for the crops, fruits and grains damage is not accurate damage assessment process and there is future scope for research in the development of some scientific method for the assessment of these losses in India.

If the status of bird's habitat destruction and hunting pressure continues in the similar manner, then other birds could also join the ranks of endangered species. The major threat of bird is from habitat destruction, fragmentation and hunting. In addition to this pesticide poisoning is also one of the factors for bird extinction. The rigid framework should be made in order to avoid killing of birds and also the interdisciplinary research should be carried out with the help of experts in Ornithology, Zoology, Physics and Engineering which leads the decrease in damage of farmers and also increase in the life of birds.

There is a great need of environmental impact assessment to estimate the agricultural zones of India affected by such damage.

It is also necessary to identify the areas where the killing of birds carried out for different reasons and suitable mitigation measure should be taken by concern authorities in order to save their lives.

References

[1] Agriculture Department, Policy Note, 2005 (Government of Tamil Nadu, India, Available online at www.tn.gov.in/ policy notes/ agriculture.htm)Visited on 20 Oct 2010
[2] Dash M C, fundamentals of Ecology, Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2001,525.
[3] Saini H K and Toor H S 1991 Feeding ecology and damage potential of feral pigeons Columba livia in agricultural habitat; Gelfaut 81, 195-206
[4] Dewar, Alan M and David A. Cooke 2006, pest. Sugar Beet (Eds. Philip A. Draycott). Pp. 316-350.
[5] Shivankar, S. B. Magar, S. B., Shinde, V. D., Ghodake,. P. V.,Yadav, R.G., and Patil, A.S. 2008. Role of avian community in reduction of spodoptera pest population in Sugar belt at Pune,
[6] Rashid, A, 1972. Produce losses by birds in standing wheat crop in Punjab province. P. 28. Department of Agriculture Marketing, West Pakistan Agriculture University, Lyallpur
[7] Robert, T. J, 1978. Information collected by the Vertebrate Pest Control Centre on regional birds pest problem and species responsible, 20 March 2004
[8] Muhummad Ubaidullah, Losses to house sparrow to wheat crop in central Punjab, Department of Zoology and fisheries, University of Agriculture, Faisalabad. Pakistan, http:// www.ijab.org Visited on 16 Nov 2010
[9] Vertebrate Pest Conference Collection, University of Nebraska, Preliminary Investigation of Trimethacarb as a bird repellent in developing countries (1984). By R. L.Bruggers, P. Sultana, J. E. Brooks.
[10] Lucknow Journal of Science. 2004,Issue 1.Ecology of Psittaculla karmeri, Scopoli, a ferruginous birds with special reference toits role as a pest of crop and fruits Kushwaha Pramod Kumar, Prof. Kumar Prabhat.
[11] S Suubramanya, Journal of Biosciences Volume 19, Number 4, 1982, 369-380, DOI: 10.1007/BF02703174
[12] Bhatnagar R K 1976a Significance of birds management and control; Pesticides 10 74-73
[13] Chhangani. A.K. and Mohnot, S.M. (2004) Is Diclofenac the only cause of vulture decline? Current Science, 87(11): 2004
[14] Ali S.1949 Bird friends and foes of the cultivator; Indian Farming 10: 385-387
[15] Ali S. 1971 Sunder Lal Hora memorial lecture. Ornithology in India: its past present and future; Proc. Indian Natl. Sci. Acad. B37 99-113
[16] S.J.Ormerod and A.R.Watkinson. Journal of applied Ecology 200, 37,699-705
[17] O'Connor R and Shrubb M 1986 Farming and birds (Cambridge University Press)
[18] M C, fundamentals of Dash Ecology, Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2001,525.
[19] Vertebrate Pest Conference Collection, University of Nebraska, Preliminary investigation of Trimethacarb as a bird repellent in developing countries(1986). By R.L. Bruggers, P. Sultana, J. E. Brooks

[20] Lucknow Journal of Science. 2004, Issue 1.Ecology of Psittaculla karmeri, Scopoli, a ferruginous birds with special reference to its role as a pest of crop and fruits. Kushwaha Pramod Kumar, Prof. Kumar Prabhat
[21] Suubramanya S., 1982 Maize, Bird damage and management, Journal of Biosciences 19(4): 369-380, (DOI: 10.1007/BF02703174) www.ikisan.com/Visited on 21/Oct/2010
[22] P.T.Walker Centre for Overseas Pest Research (U.K.Overseas Development Administration) London, Gt. Britain Nov 1982
[23] Indian Journal of Traditional Knowledge, Vol. 5 (1), January 2006.Traditional pest management practices in Kanyakumari district, southern India. By S Kiruba, B P Mishra, S Israel Stalin.
[24] Vertebrate Pest Conference Collection, University of Nebraska, Preliminary Investigation of Trimethacarb as a bird repellent in developing countries (1984). By R. L.Bruggers, P. Sultana, J. E. Brooks.
[25] Singh R P and Dungan G H 1955, How to catch crows?; Allahabad Farmer 29 59-67
[26] Bhatnagar R., K., 1976 Significance of birds management and control; Pesticides 10 74-73
[27] www.birdlife.org/action/science/species/asia, Visited on 15 Nov 2010
[28] Indiatoday.intoday.in/site/Story/79713/India/Birds Visited on 20 Nov 2010
[29] Gowdy, J.M., 2000. Terms and concepts in economical economics. Wildlife Society Bulletin, 28:26-33.
[30] Loinger, C., Cohen, S. Dror, N., Berlinger, M.J., 1977. Effect of grape cluster rot on wine quality. American Journal of Enology and Viticulture, 28:196-199.
[31] Porter, R.E.R., Rudge, M.R., McLennan, J.A.1994. Birds and small mammals, a pest control manual. Manaaki Whenau Press, Lincoln, New Zealand.
[32] Saxton, V. P., 2006. Final report to sustainable farming fund, New Zealand.
[33] Dale Hoiberg, Indu Ram Chandani, 2000, Student's Britannica India, Popular Prakashan. World Bank, 2008.India Country Overview 2008