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BASELINE DATA ON ANTHROPOGENIC PRACTICES IN THE AGRO-ECOSYSTEM OF POTHWAR PLATEAU, PAKISTAN

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ABSTRACT

Human mediated changes have a marked impact on landscape structure as well as biodiversity in agricultural landscapes where continuous farming operations lead to the development of large-scale homogeneous farmland with reduced biodiversity. This study was conducted to collect baseline data about the activities of local people in the agro-ecosystem of Pothwar plateau, Pakistan through a questionnaire survey. Information reported by the selected 94 farmers revealed that wheat intercropped with mustard is a major crop cultivated in this region followed by groundnut and maize. Livestock grazing is common with goat most popularly reared. Cutting, harvesting (for fuel wood/animal feed) and burning of field boundary vegetation is not a common practice in Pothwar plateau. Agro-chemicals are used by 72% farmers to enhance crop yield. Except rodent pests of groundnut, the prevalence of pests and diseases was low in the study area. Consequently, few farmers employed chemical methods of pest control. Manual weeding is popular in the region. Environment education and awareness of local people about biodiversity and wildlife conservation is low and hunting is a common practice. This study generated useful baseline information that could be employed with other research studies for developing biodiversity conservation strategy in this agro-ecosystem.

Key words: Agro-ecosystem, Anthropogenic practices, Human activities, Croplands

INTRODUCTION

Agro-ecosystems are open systems where the aim is to maximize the production of selective plants which requires continuous human intervention (Birasal, 2014). Local farming practices alter the landscape structure and biodiversity in croplands. The complex heterogeneous landscapes are simplified due to agriculture. Generally agricultural intensification leads to reduced/low biodiversity but different groups respond differently to this impact (Flohre *et al*., 2011).

In agricultural landscapes, wild vegetation bordering the crop fields is usually subjected to burning, mowing and ploughing to maintain it in early successional stages or vegetation free areas. The use of fertilizers and pesticides as well as tillage and weed control operations transforms the habitat and ultimately affects biodiversity. Herbicides are also used to reduce the woody vegetation cover along the field borders. These anthropogenic practices disturb the composition of natural flora in these patches (Riddle and Moorman, 2010). Anthropogenic activities result in land-use changes and affect community structure of wild species of plants and animals in agricultural landscapes (Dallimer*et al*., 2010). Human-mediated changes also alter the predator-prey interactions among species of carnivorous mammals e.g. wolves and predatory birds e.g. sparrowhawks and piscivorous birds in the ecosystems (Hebblewhite and Merrill, 2008; Wiese *et al*., 2008; Millon *et al*., 2009).

Unfortunately in Pakistan studies on the effects of human mediated changes on landscape biodiversity and particularly biodiversity of agro-ecosystems have not been addressed so far. Such studies are lacking in Pothwar area as well though there have been few reports that productivity of Pothwar rangelands has decreased 2.5-7 times due to over-grazing, soil compaction, removal of vegetation especially shrubs for fuel wood and de-vegetation of fragile slopes. It has also been reported that due to loss of vegetation cover, water erosion is particularly affecting agro ecosystems of Pothwar leading to habitat degradation (Ahmad, 1990; Shinwari and Shinwari, 2010). This study was thus carried out to determine the anthropogenic practices in the agro-ecosystem of Pothwar plateau in order to collect baseline data about the activities of local people that might affect biodiversity in this agro-ecosystem.

MATERIALS AND METHODS

Study Area: This study was conducted in Pothwar plateau of Pakistan (33º 30′ 0″ N and 73º 0′ 0″ W) which is a dissected region with undulating topography, gullies, low fertility and erratic rainfall falling mainly in July and August. The total area of Pothwar plateau is ≃ 13,000 km^2 with elevation varying between 305 - 610 m (Nadeem *et al*., 2012). Climate is semi-arid to humid. The summer temperature ranges between 15 ºC and 40 ºC while the range of winter temperature is generally between 4 ºC and 25 ºC but it can occasionally drop

below freezing (Hussain *et al*., 2003). Around 110,600ha area of Pothwar plateau is being cultivated (GOP, 2002-03). Four percent of the cultivated area of Pothwar plateau is irrigated while 96% is dependent on rain (Majeed *et al*., 2010).Agriculture consists of two types of cropping systems: wheat-maize/millet and wheat-groundnut (Arif and Malik, 2009). Along the field boundaries, apart from shrubs, fast growing trees have been planted for browse and fodder (Nizami *et al*., 2004; Hussain *et al*., 2009).

Data collection: This study was based on a questionnaire survey. The farmers aged 27 to 54 years who owned or worked at farmlands of Pothwar plateau were selected for gathering data on anthropogenic practices of the area. Information on the following parameters were sought from the interviewees; i) livestock owned by farmers, ii) use of crop field boundary vegetation for livestock grazing, animal feeding or as fuel wood and burning or harvesting of this vegetation for any other purpose, iii) pests, diseases, weeds, etc. which affect their crops, iv) use of chemical fertilizers and pesticides, v) record of hunting/trapping of any bird species for food, game and/or pet keeping. The data were presented by calculating percentages.

RESULTS

Information reported by the selected 94 farmers (through personal interviews) on anthropogenic activities at the croplands of Pothwar plateau is detailed in the following paragraphs.

Crop types: Out of 94 farmers interviewed, 90 reported to cultivate wheat indicating it to be the most abundant crop grown in Pothwar plateau, followed by groundnut. Mustard is also cultivated by most of the farmers by intercropping with wheat and there were recorded numerous wheat mixed mustard fields in the study area. The third most important crop was maize cultivated by 64% farmers, while 57% farmers reported cultivation of millet at their farmlands. Relatively less cultivated crops included chickpea, mash and mung beans, barley, sorghum and oats (Table 1).

Livestock: Seventy six out of 94 farmers owned livestock including goats, cattle, sheep and buffaloes (Fig. 1). Goat was the most popular animal reared by 70% farmers which was followed by cattle, reared by 63% farmers. Forty one percent of the farmers had sheep in their stocks while buffaloes were owned by 29% farmers. None of the interviewees reported custody of camel but a few had possession of assess and horses.

Only 19% farmers allowed livestock grazing in their farmlands. Majority graze the animals in wild vegetation adjacent to the farms. Grazing of animals in croplands is mostly allowed after harvest or during pre-monsoon season (mid April to mid June). The farmers reported no particular timing of grazing and the animals are allowed to remain in the crop fields from morning till evening. The duration of grazing period depends upon farm owner's decision, either to sow the following crop or to leave the field fallow in order to conserve rain water for the next winter crop.

Cutting and burning of crop field boundary vegetation: In response to inquiry on harvesting of crop field boundary vegetation for animal feeding, response of 58 out of 94 (61.7 %) farmers was positive. These farmers reported to plant fast growing shrubs for fodder and browse. The grasses and shrubs are cut at ground level for animal fodder. Only 17% farmers reported to use crop field boundary vegetation (mostly shrubs) for fuel wood. Generally, the cutting is subject to household demand. However majority of the farmers collect fuel wood from wild scrub forest areas adjacent to their farmlands. Only 19% farmers used to burn crop fields and associated vegetation after harvesting of crop, in order to enhance soil nutrients but this does not seem to be a common practice among the farmers of Pothwar plateau.

Use of fertilizers: Seventy two percent of 94 interviewed farmers reported to use chemical fertilizers in their crops (Table 2). Commonly used fertilizers are urea ($CO(NH_2)_2$) and DAP or diammonium phosphate ($(NH_4)_2HPO_4$). These fertilizers are mostly used in wheat and groundnut crops at various growth stages. Some farmers apply DAP with sowing of crop seeds and use urea after crop germination. A small number of farmers (12 of 94) apply calcium sulfate dihydrate ($CaSO.2H_2O$) popularly called gypsum in groundnut crop while only nine farmers reported to use cow dung as farm manure.

Farmers' report on pests, diseases and weeds: Overall 70 out of 94 farmers reported to have pest/disease and weed problems in their crops (Table 3). Rodents (mainly rats) were reported to be top most vertebrate pests inflicting damage to groundnut crop while some farmers also reported porcupine and wild boar damage to their crops. Only 17% farmers considered birds as pests, which was attributed to flocks of house sparrow (*Passer domesticus*) feeding in wheat, millet and sorghum crops at maturity stages. Twenty percent farmers reported insect pest problem in their crops which has been detailed in Table 4. Aphid species namely *Schizaphis graminum*, *Rhopalosiphum maidis* and *Sitobion miscanthi* are pests of wheat and maize. Shoot fly (*Atherigona soccata*) and maize stem borer (*Chilo partellus*) infest maize and millet. In groundnut, problem of red hairy caterpillar (*Amsacta albistriga*) was reported which devours the crop leaves.

The problem of weeds was reported by 60 out of 70 farmers in almost all crops. The list of weeds reported

includes *Alternanthera pungens*, *Cannabis sativa*, *Ipomoea eriocarpa*, *Abutilon indicum*, *Cynodon dactylon*, *Cyprus rotundus*, *Convolvulus arvensis* and *Carthamus oxycantha* (Table 5).Forty six farmers reported about diseases in their crops. All of these were fungal diseases namely early and late leaf spot, stalk and root rot, smut disease as well as rust (Table 6).

Pest and disease control: The farmers' opinion on practices employed for management of pest and disease problems in their field crops revealed following information. Manual removal of weeds was found to be a common practice which was reported by 83% of the interviewees (Table 7). Manual killing of rodents was reported by only 8% farmers. Some farmers reported the use of burrow smoking method for rodent control, especially in groundnut crop. None of the farmer reported the use of scaring devices e.g. scarecrows and netting to manage the bird pests.

Among chemical control methods pesticides and herbicides were used by 49% farmers. A detail of the pesticides and herbicides used by farmers is given in Table 8. More than half of the interviewed farmers used poisoned baits containing zinc phosphide for killing of rodent pests in their crops.

Table 1. Summary of farmers' report on cultivation of different food crops in agro-ecosystem of Pothwar plateau of Pakistan.

Common name of crop	Scientific Name	Farmers reporting (n*)
Wheat	*Triticum aestivum*	90
Groundnut	*Arachis hypogaea*	76
Maize	*Zea mays*	60
Millet	*Pennisetum typhoides*	54
Mung	*Vigna radiate*	16
Mash	*Vigna mungo*	26
Barley	*Hordeum vulgare*	18
Sorghum	*Sorghum bicolor*	18
Oats	*Avena sativa*	9
Mustard	*Brasicca compestris*	72
Chickpea	*Cicer arietinum*	46

*Multiple responses

Farmers' views on crop field boundary vegetation, its use by birds and bird hunting: Eighty two out of 94 farmers admitted that crop field boundary vegetation is beneficial for their livelihood particularly used for animal feeding and fuel wood. However, only 3% farmers considered its usefulness as the birds' habitat. Most of them believed that if density of granivorous birds increased in their croplands they would become potential pests of their crops. Wildlife hunting is a popular sport and 43% farmers liked it. Generally, partridges (*Francolinus pondicerianus*) in maize crop, waterfowl (ducks) at rainwater ponds and quail (*Coturnix coturnix*) in wheat crop are hunted in this area. However, since populations of game birds are low in agro ecosystems, therefore, bird hunting is carried out in scrubland/forest or wherever they are found.

Table 2. Farmers' response on use of fertilizers in their crops in agro-ecosystem of Pothwar plateau, Pakistan.

Farmers using fertilizer(n)*	Name of fertilizer
62	Urea
62	DAP
12	Gypsum
18	Other (organic manure)

*Multiple responses

Table 3. Description of crop pests and diseases reported by farmers of Pothwar plateau, Pakistan.

Pests/Diseases	Crops	Farmers reporting (n)*
Wild boar	Wheat, groundnut, maize	8
Rodents	Groundnut, maize, millet	58
Birds	Wheat, millet, sorghum	12
Insects	Wheat, groundnut	14
Weeds	Wheat, groundnut, maize, millet	60
Diseases	Wheat, groundnut	46

*Multiple responses

Table 4. Common insect pests of field crops reported by farmers of Pothwar plateau, Pakistan.

Common name	Scientific name	Crop being damaged
Wheat aphid	*Schizaphis graminum*	Wheat, maize
Corn aphid	*Rhopalosi phummaidis*	Wheat, maize
Indian grain aphid	*Sitobion miscanthi*	Wheat
Maize stem borer	*Chilo partellus*	Maize, pearl millet
Shoot fly	*Atherigona soccata*	Maize
Red hairy caterpillar	*Amsacta albistriga*	Groundnut

Table 5. The weed problem reported by farmers in field crops of Pothwar plateau, Pakistan.

Common name	Local name	Scientific name	Crop being infested
Sessile joyweed	Itsit	*Alternanthera pungens*	Wheat
Marijuana	Bhang	*Cannabis sativa*	Wheat, maize
Purple morning glory	Ilra	*Ipomoea eriocarpa*	Maize
Indian mallow	Kanghi	*Abutilon indicum*	Groundnut
Bermuda grass	Khabbal	*Cynodon dactylon*	Wheat, groundnut, maize
Nut grass	Dela	*Cyprus rotundus*	Wheat
Creeping jenny	Lehli	*Convolvulus arvensis*	Wheat, groundnut
Wild safflower	Poli/kandyari	*Carthamus oxycantha*	Wheat, groundnut, maize

Table 6. Farmers' reports on crop diseases prevalent in agro-ecosystem of Pothwar plateau, Pakistan.

Common name	Scientific name	Host Crop
Early leaf spot	*Cercospora arachidicola*	Groundnut
Late leaf spot	*Phaeoisariopsis personata*	Groundnut
Stalk rot	*Fusarium moniliforme*	Wheat, maize
Root rot	*Sclerotium rolfsii*	Wheat, maize, groundnut
Loose smut	*Ustilago tritic*	Wheat
Rust	*Puccinia striiformis*	Wheat, maize

Table 7. Farmers' reports on different methods and techniques employed for management of pests and diseases in agro ecosystem of Pothwar plateau, Pakistan.

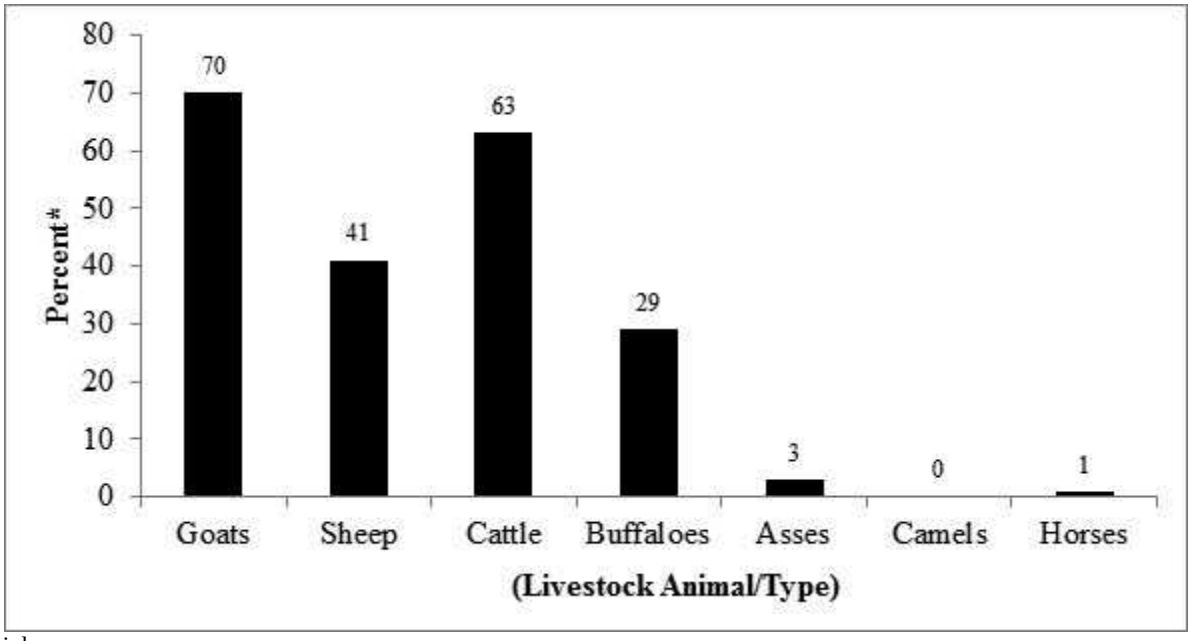
Method/Technique	Farmers reporting (n=70)*
Non-chemical control	
Hand weeding	58
Pests chased (rodents)	6
Use of scaring devices (birds)	None
Rodent burrow smoking	8
Trapping (for rodents)	14
Chemical control	
Use of pesticides and herbicides	34
Poison baiting (Zinc phosphide) for rodents	38

*Multiple responses

Table 8. List of herbicides reportedly used by farmers of Pothwar plateau, Pakistan.

Trade Name	Category	Active Ingredient	Crop being treated
Bromoxynil + mcpa	Herbicide	2-methyl-4 chloro-phenoxyacetic acid	Wheat, maize, groundnut
Pilipri pre-mixtra gold	Herbicide	Fenvalerate	Maize, groundnut
Furadan*	Insecticide	Carbofuran	Maize
Sumicidin	Insecticide	Fenvalerate	Wheat, maize, groundnut
Karate	Insecticide	Lambda-cyhalothrin	Groundnut
Daconil	Fungicide	Chlorothalonil	Groundnut

*Banned in Canada and the European Union



*Multiple responses

Figure 1. Reports on various livestock animals owned by 94 farmers interviewed in the agro-ecosystem of Pothwar plateau, Pakistan.

DISCUSSION

This study was based on interviews of 94 farmers randomly selected from the agro-ecosystem of Pothwar plateau. The result showed that the agriculture predominantly consists of summer (Kharif) crops of groundnut (*Arachis hypogea*), millet (*Pennisetum typhoides*), sorghum (*Sorghum biclor*), mash (*Vigna mungo*) and mung beans (*Vigna radiata*) whereas; the winter (Rabi) crops include wheat (*Triticum aestivum*), chickpea (*Cicer arietinum*), barley (*Hordeum vulgare*) and mustard (*Brassica campestris*). Maize (*Zea mays*) is grown during both the seasons. These results are supported by Hayat (2005) and Majeed *et al*. (2010). Majority of the farmers cultivate wheat on priority, because early spring rains in this arid region are particularly useful to increase wheat yield (Kazmi and Rasul, 2009) and it is staple food of human population. In many areas of Pothwar plateau, mustard is intercropped with wheat which is not only used as human food but also as livestock fodder. Turk and Tawaha (2003) reported that *Brassica* spp. release glucosinolates that inhibit the seed germination of weeds. Quite recently, Awan *et al*. (2012) worked on efficacy of (*Brassica campestris*) and sunflower (*Helianthus annus*) to control weeds in wheat crop of Pothwar plateau and found that these crop plants have allelopathic potential for weed management by restraining the growth of many weed species. Although farmers cultivate mustard for their livelihood, this indigenous practice actually saves their main crop from the weeds' infestation.

Few farmers cultivate legumes (mash and mung beans) but wheat-fallow cropping pattern is dominant. However, many studies have highlighted the importance of wheat-legumes cropping pattern in Pothwar not only in terms of nutrient conservation (Safdar *et al*., 2002; Hayat and Ali, 2010) but also for substantial increase in overall crop productivity of this area (Manf and Fayyaz, 2006; Arif and Malik, 2009). Groundnut is the second most popular crop of this area (Din *et al*., 2009; Majeed *et al*., 2010). Most of the farmers from district Chakwal cultivated groundnut. Ali *et al*. (2002) also reported that southern parts of Pothwar plateau are drier with sandy soil and are suitable for groundnut production.

The results of this study revealed that 80% farmers owned livestock with goat the most commonly reared ungulate followed by cattle. These findings are similar to those of Nosheen *et al*. (2011). Afzal and Naqvi (2004) found that rate of livestock rearing is high in Pothwar as they provide alternate income source in case of crop failure. Majority of farmers did not allow livestock grazing on their farmlands because there is plenty of wild vegetation in the associated rangeland landscapes of Pothwar. These results are supported by Ahmad *et al*. (2006).

Cutting, harvesting and burning of field boundary vegetation is not a common practice in Pothwar plateau. Several studies have highlighted that these practices lead to habitat degradation in agricultural landscapes but in this study it was found that field boundary vegetation use is quite low. One important reason of this is that size of fields is usually small and

there are large patches of uncultivated patches in the area. It could be assumed that farmers meet their requirements from these non-crop areas. Shah *et al*. (2012) found that most of the farmers of Pothwar plateau have less than two hectares of land for cultivation. The local people meet their demands of firewood and timber from the adjacent wild areas.

The use of chemical fertilizers is presumably at moderate level in Pothwar area, with reports of use by 72% farmers. Some international studies (Philip, 2001; Firbank *et al*., 2008) have depicted that these fertilizers are harmful for ecosystem. However, it has been reported that fertilizers are essential for better crop yield in this region due to low soil fertility and mineral deficiencies (Ahmad *et al*., 1990; Kazmi and Rasul, 2009).

Except rodent pests of groundnut, the prevalence of pests and diseases was low in the study area. Consequently, few farmers employed chemical methods of pest control. Weeds are a problem but manual weeding is popular practice, presumably for its use in animal fodder, thus a few surface herbicides are used. These findings are similar to those of Hussain *et al*. (2003) and Shah *et al*. (2012) who reported that pesticides are used at a low scale in this region due to inextensive agriculture.

The farmers had no idea if the birds inhabiting crop field boundary vegetation were beneficial or harmful to their field crops. However, it should be acknowledged that birds are important consumers of both insects (including many pest species) and weed seeds, thus indirectly the presence of birds within farmed areas is beneficial for agriculture (Wenny *et al*., 2011; Orlowski *et al*., 2014). Ahmad (1991) investigated through a farm survey that 77% farmers consider rodents as pests instead of birds in Pothwar area. This was also true in this study. Environment education and awareness of local people about biodiversity and wildlife conservation was found be lacking and hunting is a common practice. Although any reliable data on bird hunting in Pothwar plateau are not available, Mahmood *et al*. (2011) while studying birds' trade at pet shops of the region found that many people capture birds from wild, e.g. house sparrow (*Passer domesticus*), common myna (*Acridotheres tristis*), bank myna (*Acridotheres ginginianus*), baya weaver (*Ploceus philippinus*), common quail (*Coturnix coturnix*), ringed dove (*Streptopelia decaocto*) and partridges (*Francolinus* spp.) and sell them in the local bird markets to earn their livelihoods.

The data of current study could serve as a baseline for monitoring the impacts of agricultural practices as well as an input in conservation decision making process. This could generate farmer friendly management recommendations for the reconciliation of agriculture with biodiversity conservation.

Suggested conservation measures: In order to maintain profitable agriculture while retaining faunal biodiversity, some of the suggestions are;

- Multiple cropping should be promoted to increase the floral diversity of this agro-ecosystem which in turn would not only provide food variety to local people but would also promote faunal biodiversity.
- Habitat fragmentation should be minimized to the possible extent.
- Unwanted human activities (i.e. illegal hunting, poaching fuel wood collection and livestock grazing) should be minimized to a possible extent in wild areas through effective management and effective implementation of existing laws.
- Instead of expanding the area under agriculture, improved crop varieties should be introduced to achieve optimum crop yield from the existing cultivable land.
- Use of agrochemicals should be rationalized to the possible extent for reducing their negative impact on soil, water, flora and fauna.
- Environment education and awareness of local communities is a crucial component of conservation. It shall be made integral part of formal education at primary and high school level. Whereas, local folks can be reached through print and electronic media.
- Further research on biodiversity-environment relationships is essential for devising effective conservation strategies in this less studied ecosystem of Pothwar plateau.

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REFERENCES

Afzal, M. and A. N. Naqvi. (2004). Livestock resources of Pakistan: Present status and future trends. Sci. Vision, 9: 1-14.

Ahmad, M. (1990). Groundnut in the dry land agriculture of Pothwar. Barani Agric. Res Div. (BARD) Project, Pakistan Agricultural Research Council, Islamabad, Pakistan, 22 pp.

Ahmad, M. (1991). Barani Agricultural Research and Development Project (BARD)-Activities and Achievements 1982-1991. Pakistan Agricultural Research Council, Islamabad, Pakistan, 152 pp.

Ahmad, M., F. A. Raza, J. Masood and I. Ali. (2006). Ecological assessment of production potential

for rangeland vegetation in southern Attock. Pakistan J. Agric. Soc. Sci., 2(4): 212-215.

Ahmad, S., M. Khan and M. Zaheer-ul-Ikram. (1990). Soil and water conservation and integrated land use in Pothwar, Pakistan. In: Soil physics-application under stress management. Barani Agricultural Research and Development Project (BARD), Pakistan Agricultural Research Council, Islamabad, Pakistan.

Ali, S., G. D. Schwenke, M. B. Peoples, J. F. Scott and D. F. Herridge. (2002). Nitrogen yield and economic benefits of summer legumes for wheat production in northern Pakistan. Pakistan J. Agron., 1: 15-19.

Arif, M. and M. A. Malik. (2009). Economic feasibility of proposed cropping patterns under different soil moisture regimes of Pothwar Plateau. Int. J. Agric. Biol., 11: 27-32.

Awan, F. K., M. Rasheed, M. Ashraf and M. Y. Khurshid. (2012). Efficacy of Brassica, Sorghum and Sunflower Aqueous Extracts to control wheat weeds under rain-fed conditions of Pothwar Pakistan. J. Anim. Plant Sci., 22(3): 715-721.

Birasal, N. R. (2014). Agricultural Ecosystem: An encouraging field for ornithologists. J. Biodiver. Endang. Spp., 2(1): 119.

Dallimer, M., K. J. Gaston, A. M. J. Skinner, N. Hamley, S. Acs and P. R. Armsworth. (2010). Field-level bird abundances are enhanced by landscape-scale agriculture environment scheme uptake. Biol. Lett., 6: 643-646.

Din, N. U., A. Mahmood, G. S. S. Khattak, I. Saeed and M. F. Hassan. (2009). High yielding groundnut (*Arachis hypogea* L.) variety 'golden'. Pakistan J. Bot., 41(5): 2217-2222.

Firbank, L. G., S. Petit, S. Smart, A. Blain and R. J. Fuller. (2008). Assessing the impacts of agricultural intensification on biodiversity: A British perspective. Philos. Trans. R. Soc. Lond B: Biol. Sci., 363(1492): 777-787.

Fohre, A., C. Ficher, T. Aavik, J. Bengtsson, F. Berendse, R. Bommarco, P. Ceryngier, L. W. Clement, C. Dennis, S. Eggers, M. Emmerson, F. Geiger, I. Guerreo, V. Hawro, P. Inchausti, J. Liiva, M. B. Morales, J. J. Onate, T. Part, W. W. Weisser, C. Winqvist, C. Thies and T. Tscharntke. (2011). Agricultural intensification and biodiversity partitioning in European landscapes comparing plants, carabids and birds. Ecol. Appl., 21: 1772-1781.

GOP. (2002-03). Crops under production. Food, Agriculture and Livestock Division, Economic Wing, Islamabad. p. 2-12.

Hayat, F., and S. Ali. (2010). Nitrogen fixation of legumes and yield of wheat under legume-wheat rotation in Pothwar. Pakistan J. Bot., 42(4): 2317-2326.

Hayat, R. (2005). Sustainable legume-cereal cropping system through management of biological nitrogen fixation in Pothwar. Ph. D Thesis (Unpublished). PMAS Arid Agriculture University Rawalpindi, Pakistan. p. 121.

Hebblewhite, M. and E. Merrill. (2008). Modelling wildlife-human relationships for social species with mixed-effects resource selection models. J. Appl. Ecol., 45(3): 834-844.

Hussain, I., A. M. Cheema and A. A. Khan. (2003). Small rodents in the crop ecosystem of Pothwar Plateau, Pakistan. Wildl. Res., 30: 269-274.

Hussain, A., S. N. Mirza, T. A. Khan and M. A. Naem. (2009). Determination of relative species composition and seasonal plant communities of Nurpur reserved forest in scrub rangeland of district Chakwal. Pakistan J. Agric. Sci., 46 (1): 34-39.

Kazmi, D. H. and G. Rasul. (2009). Early yield assessment of wheat on meteorological basis for Potohar region. Pakistan J. Meteor., 6(11): 73-87.

Mehmood, T., S. M. A. Shah, M. Rais and M. S. Nadeem. (2011). An investigation of animal species trade at pet shops of Rawalpindi and Multan cities. J. Anim. Plant Sci., 21(4): 822-829.

Majeed, S., I. Ali, S. M.Zaman and S. Ahmad. (2010). Productivity of Mini Dams in Pothwar Plateau: A diagnostic analysis. Research Briefings, Natural Resource Division, Pakistan Agricultural Research Council, Islamabad. 2(13): 1-19.

Manf, A. and H. Fayyaz. (2006). Effect of sulphur on fatty acid accumulation in Brassica cultivars. Int. J. Agric. Biol., 8: 588-592.

Millon, A., J. T. Nielsen, V. Bretagnolle and A. P. Moller. (2009). Predator-prey relationships in a changing environment: the case of the sparrowhawk and its avian prey community in a rural area. J. Anim. Ecol., 78: 1086-1095.

Nadeem, S. M., R. Naz, S. I. Shah, M. A. Beg, A. R. Kayani and T. Mahmood. (2012). Season and locality related changes in the diet of Asiatic jackal (*Canis aureus*) in Potohar, Pakistan. Turk. J. Zool., 36(1): 1-8.

Nizami, M., I. M. Shafiq, A. Rashid and A. Aslam. (2004). The soils and their agricultural development potential in Potwar. WRRI and NARC, Isl. Pakistan, p. 5-7.

Nosheen, F., T. Ali, H. N. Anwar and M. Ahmad. (2011). Participation of rural women in livestock management and their training needs in Potohar region. Pakistan Vet. J., 31(1): 40-44.

Orłowski, G., J. Karg, and G. Karg. (2014). Functional invertebrate prey groups reflect dietary responses to phenology and farming activity and pest control services in three sympatric species of aerially foraging insectivorous birds. PLoS ONE 2014a; 9(12): e114906. doi:10.1371/journal.pone.0114906

Philip, R. B. (2001). Ecosystems and human health: Toxicology and environmental hazards. 2nd edition. CRC Press, Boca Raton, Florida.

Riddle, R. D. and C. E. Moorman. (2010). The importance of agriculture-dominated landscapes and lack of field border effect for early-succession song bird nest success. Avian Consv. Ecol., 5(2): 9.

Safdar, A., G. D. Schwenke, M. B. Peoples, G. F. Scott and D. F. Herridge. (2002). Nitrogen yield and economic benefits of summer legumes for wheat production in rain-fed northern Pakistan. Pakistan J. Agron., 1: 15-19.

Shah, N. A., I. Saeed, A. Farooq and M. Afzal. (2012). Adoption and economic impact of improved wheat varieties in rain-fed Pothwar, Punjab, Pakistan. J. Biotech. Ph. Res., 3(5): 94-103.

Shinwari, M. I. and M. I. Shinwari. (2010). Botanical diversity in Pakistan; Past, present and future. World Environment Day, June 2010. p. 85-104.

Turk, M. A., and A. M. Tawaha. (2003). Allelopathic effect of black mustard (*Brassica nigra* L.) on germination and growth of wild oat (*Avenafatua* L.). Crop Protec., 22: 673-677.

Wenny, D. G., T. DeVault, M. Johnson, D. Kelly, C. H. Sekercioglu, D. Tomback, and C.J. Whelan. (2011). The need to quantify ecosystem services provided by birds. Auk, 128: 1-14.

Wiese, F. K., J. K. Parrish, C. W. Thompson and C. Matanto. (2008). Ecosystem based management of predator-prey relationships: piscivorous birds and salmonids. Ecol. Appl., 18(3): 681-700.