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Impacts of Agriculture Practices on Sustainable Biodiversity in Rajshahi District

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M.Phil Thesis

By

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Dedicated

To my
beloved parents

DECLARATION

I do hereby declare that the thesis entitled "**Impacts of Agriculture Practices on Sustainable Biodiversity in Rajshahi District"** submitted to the Institute of Environmental Science, University of Rajshahi for the award of Master of Philosophy in Environmental Science is the results of my own research work under the supervision of Dr. Md. Redwanur Rahman, Associate Professor, Institute of Environmental Science, Univesity of Rajshahi, Bangladesh.

I further declare that this thesis or any part of it has not been submitted to any other University or Institutions for any degree or diploma. To the best of my knowledge and belief the contents or part thereof the thesis was not published previously by anyone except due reference is made in the text whenever needed.

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CERTIFICATE

This is to certify that the thesis entitled "**Impacts of Agriculture Practices on Sustainable Biodiversity in Rajshahi District"** submitted for the degree of Master of Philosophy is an original research work by Md. Atiqur Rahman, Session: 2009-2010, Reg.: 5827, ID No.: 09106 carried out at the Institute of Environmental Science, University of Rajshahi, Bangladesh under my supervision. The researcher has made some distinct contribution through this original study in the field of Agriculture and conservation of biodiversity. The thesis or any part of this has not been previously presented for any diploma or degree to any other University or Institutions.

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The Author

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List of Abbreviations, Acronyms and Glossary

BADC	-	Bangladesh Agricultural Development Corporation
BCIC	-	Bangladesh Chemical Industries Corporation
DAE	-	Department of Agricultural Extension
DoF	-	Department of Fishery
DPHE	-	Department of Public Health and Engineering
ft.	-	feet
ha.	-	Hectare
M. ton	-	Metric Ton
NGOs	-	Non-Government Organization
UNDP	-	United Nations Development Program

ABSTRACT

Bangladesh is one of the biodiversity rich countries in the world. However, the biodiversity is declining day by day due to anthropogenic activity like human population growth, habitat destruction, pollutions, agriculture, global warming, forest fragmentation etc. Agricultural activities such as tillage, drainage, intercropping, rotation, grazing and extensive usage of pesticides and fertilizers have significant implications for wild species of flora and fauna. Some management techniques, changes in agricultural practices, monocropping, hybridization and land degradation, create such fundamental habit changes that there are significant shift in species composition. The study was conducted to determine the impacts of agriculture practices on sustainable biodiversity in Puthia Upazilla, Rajshahi district. There are number of undesirable environmental impacts associated with natural vegetation and trees, indigenous plant diversity, exotic plant, organic matter, fish diversity, shortage of water, wild life and indigenous bird species diversity, hybrid crops, use of chemical fertilizer, pesticides herbicide, insecticide found in the study area. It was found that, some agricultural practices with the use of modern technologies causes a depletion of biodiversity. There are about 15052 hectre of cultivable land present in Puthia. In 1990s, about 60.2% of people used traditional method of cultivation. On the other hand, now a days about 75% of peoples are using modern methods of cultivation. In 1990, cultivable land area were 36157 acre of which only 12.5% were irrigated but in 2014, cultivale land were 36481 and 100% were under irrigation. About 5-10% tubewell water are available In March-May and 25-30% of tubewell water are available in may-June.Static level of ground water rised and dependency on submersible pump increased. In 2012, 2013, 2014 and 2015 annual rain fall were recorded as 729, 1134, 1475 and 1626 mm respectively in the study area.

About 28 wetlands or beels with 1821 hectore of total land in puthia. Among them, only 890 hectore area were used for cultivation in 1990 and 1739 hectore are using for cultivation in 2014. Now a trend has been started to digging pond in the beel area.

In 1990, cultivation mostly depend on organic manure but in 2014 use of chemical fertilizer has tremendously increased. In 1990 most of the people used only 5-7 items of pesticides on their cultivable land on the other hand the use of pesticide practices increasing in the study area up to 15-22 items in 2014.

There were about 31 species of fruit plants, 29 species of timber plants and 43 species of medicinal plants were commonly found in 1990, but in 2014 it is only 22 species of fruit, 18 species of timber plants and 25 species of medicinal plants are commonly found respectively.

A total of 184 plant species were identified in the six study villages during last one year 2014. Among the 184 plant species, 45% weed species, 15% vegetable, 12% fruits species, 10% timber species, 4% spices and 14% medicinal plants species.

In case of wild animal, in 1990 about 21 species were seen in the study area but depletion of wild animals are occurring in the study area, Only about 14 species rarely found in 2014. About total 34 species of birds recorded and were common in 1990. But only 25 species are common in 2014. About 39 species of fish were common in 1990. But only 21 species are common in 2014.

A total of 75 animals species were identified in the six study Villages during last one year 2014. Among the 75 animals species, 3% livestock, 4% poultry, 3% pet animals, 19% wild animals, 33% birds and 38% fishes species.

Findings of this study that cultivation/land used pattern (50%), Use of chemical fertilizer (9.2%), Use of pesticide etc. (16%), Irrigration (4.4%), Hybrid, HYV and Exotic plant (4.5%), Use of modern agriculture technology (5.2%), Habitat distruction (3.4%), Road constration and urbanization (4.7%) and others (2.6%)

were the causes of loss of biodiversity mentioned by the respondents. But there occur a depletion among the species in time to time and upto 2014 which is mostly done by anthropogenic activities.

During data collection from questionnaires, it was found that most of the farmers did not taken the training of proper use of insecticides, pesticides, weedicides and chemical fertilizers. But the have the realization to the necessity of sustainable Biodiversity conservation. Additionally impacts of agriculture practices on sustainable biodiversity afford an opportunity for researchers to make further researches, particularly about the conditions in which native and diverse species will flourish.

Chatper 1
Introduction

1.1 General Background of Agricultural Practices in Bangladesh

In recent years increasing agricultural production is an important environmental issue in Bangladesh. About 75 percent of the people living in rural areas who are directly or indirectly involved in agriculture. The farmers of the country are the centre point of agriculture.

Sattar (1994) reported that Agriculture imposes external costs upon society through pesticides, nutrient runoff, excessive water usage, and other assorted inputs. In 2010, the International Resource Panel of the United Nations Environment Program published a report assessing the environmental impacts of consumption and production of agricultural commodities. The study found that agriculture and food consumption are two of the most important drivers of environmental pressures, particularly habitat change, climate change, water use and toxic emissions. Agriculture accounts for 70 percentage of withdrawals of freshwater resources. The improved agricultural practices have tremendous relevance to environmental pollution and Bangladesh is not an exception to this.

Shahabuddin *et.al.* (1992) reported that Irrigation water is one of the vital and costly inputs in agriculture. The present irrigated area of Bangladesh is about 29% of the total cultivated area (43% receive surface water irrigation and 57% utilize ground water). In general Bangladesh faces a problem of excess water during the wet season, while water is in short supply during the dry season. Over the years, the dry season demanded for irrigation water has increased considerably. Such increasing demands adversely affected inland fisheries.

On the other hand, scarcity of water during the dry season is a major contributor to the desertification process. It is a serious environmental pollution problem in Bangladesh. There are indications that in many areas of the country, increasing

rate of incidence of water born diseases like diarrhoea and dysentery is related to a lowered water table.

Karim *et.al.* (1997) reported that Chemical fertilizers and pesticides have been widely and extensively used in Bangladesh agriculture. Continuous use of inorganic fertilizers alone to soils had a deleterious effect on soil productivity and a steady declining trend in crop productivity associated mainly with loss of inherent soil fertility. Excessive uses of chemical fertilizers also reduce water conservation capacity of soil. Annual depiction of nutrient (NPKS) under intensive cultivation ranges between 180-250 kg/ha. The organic matter of more than 50% of cultivated soils in Bangladesh is said to he below the critical level of 1.5% and still declining at an alarming rate. Large quantities of chemical fertilizers and pesticides are being used in this country and their annual use is steadily increasing.

Therefore, it is clear that large scale use of fertilizers, pesticides and irrigation water by the farmers for a long period as well as non judicious use have been damaging the natural resources such as land, fishes, beneficial insects, soil microbe, etc. Agriculture and environment has a close relationship and interacts with each other in such a way that the health of agriculture depends on the proper functioning of environmental process and the health of environment depends upon a respectful agriculture.

Lack of environmental education and awareness programs training and motivation activities; rural people used cowdung, homestead waste, crops and vegetables wastes as fuel instead of managing the crop field which lead to vulnerable soil erosion, nutrient depletion, or other natural hazards like air and water pollution. In this case the farmers need training and motivation about production and judicious processing, preservation and utilization of organic waste from various sources for sustainable livelihood. So, it is necessary to increase environmental awareness of the farmers about sustainable system. Sustainable system is a management strategy which helps the producer to choose

hybrids and varieties, a soil fertility package, a pest management approach, a tillage systems and a crop rotation to reduce costs at purchased inputs, minimize the impact at the system on the immediate and the off-farm environment and provide a sustained level of production and project from farming.

The extent of awareness may vary from one farmer to another farmer due to influence of various factors. Because, behaviour of an individual is greatly influenced by the totality of one's characteristics. It is therefore, very important to know the relative awareness of the farmers about environmental degradation in agricultural farming.

1.2 Relation between Agriculture and Environment in Bangladesh

Agriculture and environment has a close relationship. The existence of human being depends on proper and pollution free environment. Environmental pollution, which is caused in many ways, has now become an alarming issue of the modern world. Population of the world tended in many aspects of increasing production level for feeding the extra mouth. To feed the large number of world's population, the need to boost agricultural production serves as a powerful driving force to promote the intensive use of land, high yielding varieties, agro-chemicals and irrigation which has impacted disastrously on the wider environment, agro-ecosystems and human health (Maredia and Pingali, 2001). IUCN (2000) reported that agricultural intensification and expansion have destroyed biodiversity and habitats, driven wild species to extinction, accelerated the loss of environmental production services and eroded agricultural genetic resources essential for food security in the future.

Bhuiyan and Harman (1991) reported that use of agricultural technology has made a significant contribution to the increased food grain production in Bangladesh. Dorosh (2000) said that agricultural production has improved dramatically in the last two decades due to the advancement in modem technologies. But the indiscriminate use of agricultural technology in certain

areas like ground water, pesticides, shrimp farming, etc. also caused tremendous environmental hazards particularly in the reduction of fish production, human and animal health hazards, large scale killing of beneficial insects and the allied biological organisms that make an imbalance in the natural orders of both flora and fauna. Due to improper use of agro-chemicals and irrigation water, most of the farming and fishing communities in many technological zones of Bangladesh are affected. Before the introduction of "Green Revolution Technology" packages, the use of agro-chemicals was very limited in Bangladesh. But after the introduction of "Green Revolution" packages, the use of chemical fertilizers and pesticides has been widely and extensively used in Bangladesh agriculture. Large quantities of chemical fertilizers and pesticides are being used in this country and their annual use is steadily increasing. On the other hand, the successful introduction of HYV, the application of better management techniques, and the increasing demand for fertilizers and labour are predicted for a rapid extension of irrigation in the country.

Yu *et at.* (2009) reported that the use of chemical fertilizer on their agriculture land and lose of their ecological system effects the water source which causes pollution to both the surface and ground water, which also highly impacts human water use and also makes water a scare resource. Agriculture activities, by using chemical fertilizers creates negatives impacts on soil fertility because of the long-term resistance the ecosystem has of pesticide which results in the lost of beneficial organisms, earthworm, micro-organism, and other species. Pesticides can also impact mammals, butterflies, bees, amphibians, plant, and soil fertility.

In addition, Khaleque (1993) and Reazuddin (1994) reported that about 50 percent of the fertilizers applied to soil remain unused and causes enormous chemical reactions resulting in deterioration in the water conservation capacity of soil. It also causes imbalance to soil's natural capacity to resist decay. Chemical fertilizers also contribute to global warming by emitting nitrous oxide (one of the greenhouse gases), in the atmosphere. Global warming potential of

this gas is 180 to 300 times higher than that of carbon dioxide. Most of the emissions of nitrous oxide are from biotic sources with nitrogen fertilizer application accounting for one fifth of the volume.

The devastating ecological imbalance is also caused due to indiscriminate use of pesticides. Pesticide is a hazardous entity for our ecosystem but its use cannot be avoided for boosting up agricultural production. Pagiola (1995) reported that pesticides pollute the environment and its exposure creates serious hazards to human being, animals, fishes and other organisms of the ecosystem. The rapid increase in the use of pesticides in agriculture in recent years has led to concern about its environmental effects. Two dangers are of particular importance in this context. First, pesticides use can have adverse health effects for farm workers and others exposed to pesticides. Second, it might contaminate ground and surface water, harming downstream users of that water and damaging inland fisheries. Ziauddin *et.al.* (1991) reported that high level of pesticides leaching to the water sources have also been blamed for causing regular out breaks of epidemic diseases in fishes and is said to have disseminated the fish populations in certain areas. On the other hand, use of improper doses of insecticides makes the insect pest resistant requiring further stronger doses of chemicals. Consequently, the field crops bearing a heavy load of chemicals causing drastic lethal effects on the consumers.

Irrigation water is one of the vital and costly inputs in modem agriculture. It adds iron, arsenic and other heavy minerals in soils. As a result, acidity of soil has been increased, and soil organisms, earthworms or other organisms have been decreased in soil.

From different viewpoints, it is clear that large scale use of fertilizers, pesticides and irrigation water by the farmers for a long period has been seriously affecting on the ecosystem. Non judicious use of pesticides and fertilizers damages natural resources such as soil, fishes, beneficial insects, soil microbes etc. though it is possible to boost up production by using more agro-chemicals and irrigation

water but it will gradually reduce the per unit production of output for the long term. So, it is needed urgently to reduce the use of agro-chemicals and irrigation water for economic benefit of the country as because many unwanted problems arise due to their abuse.

In this regard, sustainable farming system is a prime consideration to save the environment. Sustainable agriculture encompasses soil and crop productivity economics and the environment. Sustainable agriculture is the integration of agricultural management technology to produce quality food and fibre while maintaining or increasing the soil productivity, farm productivity, and the environmental quality. There is a wide scope to maintain sustainability by following the techniques of organic farming *i.e.*, use of organic fertilizers, biofertilizers, and integrated pest management (1PM) techniques and also by reducing country's population growth to a manageable size.

1.3 Biodiversity

1.3.1 Biodiversity: Definition

Biodiversity or biological diversity is a *neologism* and a *portmanteau* word. It is the diversity of and in living nature (WorldIQ, 2009). Keystone Center (1991) stated that it is the diversity life, ranging from the level of gene to species. Biodiversity is often used as a measure of the health of biological systems. In the simplest of terms, biological diversity is thevariety of life and its processes; and it includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur. However, there are several other definitions available in literature as described below.

The Convention on Biological Diversity (CBD, 1992) defines 'Biological diversity' as the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biological diversity, simply stated, is the diversity of life. As defined in the proposed US Congressional Biodiversity Act, HR1268 (1990), biological diversity means the full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and encompasses ecosystem or community diversity, species diversity, and genetic diversity (Jensen *et.al.*, 1990).

1.3.2 Biodiversity: Concepts and Elements

Biodiversity is not simply the number of genes, species, ecosystems, or any other group of things in a defined area. A definition of biodiversity that is altogether simple, comprehensive, and fully operational (*i.e.* responsive to real-life management and regulatory questions) is unlikely to be found. Noss (1990) said that more useful than a definition, perhaps, would be a characterization of biodiversity that identifies the major components at several levels of organization. According to WRI (1992), biodiversity is the totality of genes, species, and ecosystems in a region.

Keystone Center (1991) stated that biodiversity can be divided into three hierarchical categories - genes, species, and ecosystems that describe quite different aspects of living systems and that scientists measure in different ways. This hierarchy of the parts and processes of biological diversity is admittedly artificial, and it has a distinct human context. However, it provides a focus for a concept that is infinitely varied and dynamic and that must be addressed in light of the full spectrum of human needs and aspirations.

Because biological diversity is so complex, and much of it is hidden from our view, unknown, or both, it is necessary to establish means of addressing its distinct and measurable parts. Most basic of these is ***genetic variation***. Genetic variation within and between populations of species affects their physical characteristics, viability, productivity, resilience to stress, and adaptability to change.

A second, more easily recognized aspect of biological diversity is ***distinct species***. Some species, such as American elk, rainbow trout, and ponderosa pine are

plentiful. Others such as the red cockaded woodpecker, Siler's pincushion cactus, or grizzly bear, have populations that are much reduced or may even face extinction. Conserving biological diversity includes perpetuating native species in numbers and distributions that provide a high likelihood of continued existence.

1.3.2.1 Genetic Diversity

Genetic diversity is the combination of different genes found within a population of a single species, and the pattern of variation found within different populations of the same species. Coastal populations of Douglas fir are genetically different from Sierran populations. Genetic adaptations to local conditions such as the summer fog along the coast or hot summer days in the Sierra result in genetic differences between the two populations of the same species according to Jensen *et.al.* (1990).

1.3.2.2 Species Diversity

Species diversity is the variety and abundance of different types of organisms which inhabit an area. A ten square mile area of Modoc County contains different species than does a similar sized area in San Bernardino County according to Jensen *et.al.* (1990).

According to WRI (1992), species diversity refers to the variety of species within a region. Such diversity can be measured in many ways, and scientists have not settled on a single best method. The number of species in a region - its species "richness" - is one often used measure, but a more precise measurement, "taxonomic diversity", also considers the relationship of species to each other. For example, an island with two species of birds and one species of lizard has a greater taxonomic diversity than an island with three species of birds but no lizards.

1.3.2.3 Ecosystem Diversity

According to Jensen *et al.* (1990), ecosystem diversity encompasses the variety of habitats that occur within a region, or the mosaic of patches found within a landscape. A familiar example is the variety of habitats and environmental parameters that constitute the San Francisco Bay-Delta ecosystem: grasslands,

wetlands, rivers, estuaries, fresh and salt water. According to WRI (1992), ecosystem diversity is harder to measure than species or genetic diversity because the "boundaries" of communities, associations of species and ecosystems are elusive. Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystems, their numbers and distribution can be measured.

1.3.2.3.1 Ecosystem Components

According to Grumbine (1993), ecosystem components refer to the inhabiting species in all their variety and richness. Many different species, gene-pool abundance, and unique populations are what most people think of when they hear the term "biodiversity". But there is much more to consider.

1.3.2.3.2 Ecosystem Structure

According to Grumbine (1993), ecosystem structure refers to the physical patterns of life forms from the individual physiognomy of a thick-barked Douglas-fir to the vertical layers of vegetation from delicate herbs to tree canopies within a single forest stand. An ecosystem dominated by old, tall trees has a different structure than one comprised of short, quaking aspen. And there is more structure in a multilayered forest (herbs, shrubs, young trees, canopy trees) than in a single sagebrush grassland, prairie, or salt marsh.

1.3.2.3.3 Ecosystem Function

According to Grumbine (1993), ecosystem functions are hard to see in action. "You can't hug a biogeochemical cycle," says one ecologist. But without the part of the carbon cycle where small invertebrates, fungi, and microorganisms work to break down wood fiber, the downed logs in an ancient forest would never decay. Natural disturbances also play a role. Wildfires release nutrients to the soil, weed out weak trees, and reset the successional clock. The energy of falling water creates spawning beds for salmon even while it carves a mountain's bones. Plants breathe oxygen into the atmosphere. Ecological processes create landscapes and diverse environmental conditions out of life itself.

Ecosystem components, structures, and functions are all interdependent. To understand biodiversity, one has to think like a mountain and consider not only the biotic elements of plants, animals, and other living beings, but also the patterns and processes that shape volcanoes and forests.

1.3.3 Homestead Agricultural Biodiversity in Bangladesh

Homestead contains multipurpose trees, shrubs, annual crops and various domesticated animals. It is the place where domestication and diversification takes place, management practices develop, and genetic resources are maintained. Home gardens are considered to be one of the most complex agricultural systems. Almost all the homesteads had mixed vegetation with various annual and perennial trees and seasonal vegetables. OFRD (2001) reported that a wide variety of plant species was found in the homesteads at Farming Systems Research (FSR) site, Noakhali. More than 62 useful species were identified in the homesteads among them 30.91% fruits (perennial and annual) 29.09% timber, 34.54% vegetables, and 5.45% were spices. Abedin and Quddus (1990) studied the average tree density in homestead was the highest at Patuakhali and Rangpur (1.5 and 1.4 trees/10 sq. m, respectively) while lowest at Rajshahi (0.7) and Ishurdi (0.8). Such figures indicate that the abundance of trees in the homesteads might be affected by climatic factors, especially by rainfall.

1.3.4 Importance and Management of Homestead Plant Biodiversity

Adegbehin *et.al.* (1990) observed that successful introduction of multipurpose tree species in homestead areas increase the output of homestead production system.

Linda (1990) mentioned that the high diversity of plant species in village home-garden ensures continuous production of fruits and vegetable, fuel wood, timber and medicinal and case crops.

Khandaker (1991) reported that agroforestry system is traditional in the homestead of' moist tropical world including rural areas of' Bangladesh since the establishment of houses. This system could be considered as potential technology for rural poverty alleviation because of its diversified function.

Hossian and Bari (1996) reported that generally wives (39.8%) were more involved than husbands (34.8%) in the application of manure (decomposed leaves, household wastes, cow-dung' etc.) and fertilizers to homestead vegetable garden. However, this pattern was prominent amongst landless and marginal farm categories but husbands were more involved in soil fertility management than wives on small, medium and large farms.

Miah and Hossain (2001) indigenous knowledge on homestead forestry was explored in the areas of plating programmers, (*Azadirachta indica* and *Artocarpus heterophyllus*), forestry products and services, women involvement, spacing of plantation, tending and cultural operations and problems in the homestead forestry. The study revealed some important indigenous management technologies, which may be used along with the scientific management technique to sustainable manage e the homestead forestry resources in Bangladesh.

Nahar (2000) reported that extent of participation of rural women in homestead vegetable cultivation, post harvest activities, poultry raising and goal rearing were 40 percent, 62 percent, 54 percent and 47 percent respectively. Age of the rural women had no significant relationship with their participation in homestead agriculture activities. She also found that majority of the respondents possessed moderate level of knowledge about homestead agriculture, attitude homestead agriculture, innovatieness and extension contact whereas cosmopolitans was found low.

Shrestha (2002) reported that trees retained in the middle of terrace riser and outside terrace on the edge were ranked first and second, respectively for soil conservation, fodder and fuel wood production.

Wani *et.al.* (2002) reported that medicinal and aromatic plants could be a source of sustained income to the inhabitants' of hilly areas, Hakims and Pharmaceutical industries. They also suggested for adopting strategies to improve marketing channels and their impact on socioeconomic condition of the local communities.

Reyes *et.al.* (2005) stated that agro-forestry systems provide approximately double income per capita in comparison to traditional methods. More intensified cash crop cultivation in the highlands of the East Usambara also results in double income compared to that in the lowlands. People are sensitive to risks of changing tanning practices. Encouraging farmers to apply better land management and practice sustainable cultivation of cash crops in combination with multipurpose trees would tie relevant in improving their economic situation in the relatively short term. The markets of most cash crops are already available. Improved agro-forestry methods could ameliorate the living conditions of the local population and protect the natural reserves from human disturbance.

Klein *et.al.* (2006) reported that diversity and parasitism, as a higher tropic interaction and ecosystem service, are enhanced by (i) improved connectivity of agro-ecosystem system with natural habitats such as agro-forestry adjacent to rain foret and (ii) management practices to increase light availability in agro-forestry, which also enhances richness of flowering plants in the under storey.

1.1.1 Homestead Agricultural Biodiversity and Rural Women in Bangladesh

Women are the key operators of household activities. Their involvement in homestead agriculture started from time immemorial. They were pioneers in plant domestication and planned agriculture (Childe, 1971). Actually women are the custodian of biodiversity and caretaker of agriculture and livestock generic resources. The preservation of biological diversity and plant genetic resource is nowwidely recognized as essential to food security. Islam (2005) stated that rural women in Bangladesh play a key role in the sphere of biological diversity as seed selection, biological diversity management at home garden, and keeper of local knowledge of food crops, medicinal plants, wild foods and forest products. The preservation and use of a wide range of wild vegetables by women survive their household during crisis of food. Trees that women plant around their homesteads provide different kinds of capital (physical, financial, etc.) throughout the year. Karim and Wee (1996) mentioned that women were

involved in seed collection, seed storage, water management, fertilizer application, daily maintenance and harvesting. In the case of tribal people, vegetables were growing mostly cared by women. Urban women were also eager to grow vegetables in the homestead.

Women in Bangladesh are highly involved in agricultural activities like sowing, irrigating, mulching, harvesting, storing of seeds, seed testing, sprouting of seeds etc. Moreover, women are sole contributor in the entire post-harvest work up to making grain/crop processed, cooked and made ready as food. Halim (1987) stated that women are potential producer of the homestead agricultural products and through their participation they may contribute in intensive homestead production. Quddus and Bose (1985) reported that the kitchen gardening and home level food processing was satisfactory and profitable and women participation was very high with strengthening extension work and their participation was highly favourable. They also advocated that with existing social system homestead gardening may be considered a major area for women which have both economic and nutritional implications for the rural women particularly for the poor unemployed women.

In most part of the world women provide sustenance to their families and communities through management and use of natural resources. In fact women are closely linked with ecology and environment. Rural women collect tree leaves, twigs, ecological food, fruits and medicinal herbs for family consumption. Women maintain the diversity of their physical ecological needs. But they are the worst victims of environmental degradation by deforestation and commercialization of forests and crops, drying of wetlands, arsenic pollution, shrimp cultivation, soil erosion, riverbank erosion, contamination from agricultural chemicals and changing the ownership patterns of forests and natural disasters such as cyclones, floods and droughts (ADB, 2001; NCBP, 2005).

1.1.2 Homestead Biodiversity and Rural Livelihood in Bangladesh

In the context of Bangladesh, homestead has special significance where about 62 per cent of farmers are landless. Homestead agriculture may be a lifeboat for their survival and existence because of secured supply of food, petty cash, etc. Majority of rural poor in Bangladesh depend on natural resources for their livelihoods. Land, water, forests and livestock are the sources of livelihoods. Miah and Ahmed (2003) stated that homestead production systems contribute about 70% fruits, 40% vegetables, 70% timber and 90% firewood and bamboo requirement of Bangladesh. Farmers benefited from homegarden in several ways. Homegarden act as a "reserve bank" of food and cash for farmers. The income from homegarden was significantly different with in the farm categories. Larger farm categories were getting more income than the smaller farm categories because of having large pieces of land. The annual income derived from each household depending on farm size varies from Tk. 12500 to Tk. 41000. Income from plant species was found more in all farm groups, which was followed by income from poultry and livestock (Alam and Masum, 2005). Ahmed (1999) said that homestead production plays an important role in Bangladesh economy and provides 50 percent cash flow to the rural poor.

According to Miah *et.al.* (1990), homestead contributed about 10 per cent of the total income of the farmers. The ratio of income from homestead did not vary significantly due to farm size or homestead size. However, income from homestead was slightly higher in the smaller farms than in larger one, indicating the possibilities of more cash income from the later farm category. The rural economy thus depends on productivity of the natural resources which is intimately linked with the biodiversity in the ecosystem (Rahman *et. al.*, 2009). The socioeconomic factors including demography, land holding patterns, household income and homestead tree resources of 54 households in one sampled village of Chittagong districts was studied by Akhter *et.al.* (1997). Findings showed that, average

annual income per household was found as taka 49,055 and homestead agroforestry contribute about 22% of that income. A total of 1341 individuals under 37 different tree species including bamboo were recorded in the study area. Among the tree species, *Mangifera indica* was highest in number (mean 6.11/household) followed by *Samanea saman* (mean 5.93/household) and *Areca catechu* (mean 3.28/household). Tree grown in homesteads played significant role, among others, by providing fuel and cash in emergency situation.

1.3.5 Status of Biodiversity in Bangladesh and Surrounding Countries

In a world of increasing globalization and environmental degradation, management of its most valuable living resource, biodiversity, is one of the most important and critical challenges facing mankind today. According to CBD (2000), biodiversity is the resource upon which families, communities, nations and future generations depend. It is the link between organisms, binding each into an interdependent community or ecosystem in which all living creature have their place and role. It is the very web of life. Bangladesh is endowed with a number of natural forest ecosystems including inland Sal forest (*Shorea robusta*), dipterocarp forest, bamboo bushes in the hilly regions and freshwater swamp forests. It also has littoral mangrove ecosystems and swamp forests. In addition to the forests the country also has a very rich aquatic biodiversity (with over 400 species) and bird and plant life. The biodiversity (in the forests and elsewhere) is undergoing threats due to human interventions and fragmentation of habitats, etc. Climate change impacts are adding an extra dimension to these ongoing stresses (NAPA, 2005). Bangladesh possesses a rich biodiversity in fresh water wetland areas. Approximately 5000 species of flowering plants, 750 species of birds (150 species of waterfowls), over 500 species of fish, 120 species of mammals, 124 species of reptiles and 19 species of amphibians found in Bangladesh. About 50 species are nearly extinct and 33 species are seriously threatened of known vertebrates and nearly 250 species of birds are in danger due to rapid depletion of forest according to UNCED (1990).

Alam *et.al.* (1996) studied that village forest in Bangladesh cover an area of 0.27 million hectare while state forests cover 2.25 million hectares. Village forests, mostly private owned are more productive than the government forest and supply about 85% of timber requirements of the country. Both indigenous and exotic trees are the major components of the village forests in Bangladesh. They are represented by about 183 species belonging to 36 genera under 48 families. Floristic elements of this flora consist mostly of native African and New world taxa. About 50 species are exotic and many of them have been neutralized. Exotic species are still being introduced. Most of the village trees in Bangladesh have multiple uses. About 40 are fruit trees and others are timbers, fuel, wood, fodder, tannins and pharmaceuticals importance. Aside from species diversity, genetic variations also exist in the village forests. Homestead tree production system in village is a model of species and genetic conservations for a good number of trees.

IUCN (2000) revealed 54 threatened species of fishes in Bangladesh some of them are Grey feather back (*Notopterus notopterus*), Freshwater eel (*Anguilla bengalensis*), Snakeheads (*Channa marulius, Channa barca* and *Channa orientalis*), Darkina (*Rasbora rasbora*), Bhanga (*Labeo boga*), Olive barb (*Puntius sarana*), Mahashol (*Tor tor*), Baaghair (*Bagarius bagarius*), Bacha (*Eutropichthys vacha*), Tara baim (*Macrognathus aculeatus*), Netani (*Ctenopis noblis*), Napit koi (*Badis badis*) and Bhangan (*Liza tade*) etc. The wetlands of hills of Chittagong (Rangamati) once were rich in varieties of fish, only yielded the Nilotica or Tilapia exotic species by wiping out the local species. Thus conservation of biodiversity of indigenous fish species and socio-economic sustainability and upliftment of the nutritional status, it is need to establish fish sanctuaries in the open waters and traditional and improve fish polyculture system should be incorporated with small indigenous fish species (BSER, 2000).

In case of birds, Khan (2002) reported that, Bhadi hash (white-winged duck) lives in high forest of Chittagong Hill Tracts when there was a plenty of tall tree species diversity *viz.* Civil (*Swintonia floribunda*), Chundal (*Tetrameles*

nodiflora), Uriam (*Mangifera longipes*), Garzan (*Diptocarpus turbinatus*), Chaplish (*Artocarpus chaplasha*), Dhaki jam (*Eugenia grandis*), Shimul (*Bombax ceiba*), Shil koroi (*Albizzia procera*), Chakua koroi (*Albizzia chinensis*), Bandarholla (*Duabhanga sonneratia*) etc. Also there were plenty of bodies that included Kassalong river, many ox-bow lakes and innumerable chars or feebly flowing streams that formed the lifeline of Bhadi hash. With commission Kaptai Hydro-electric Project, increased in the vast quantity of flooding the favourite feeding places of Bhadi hash in chars decline the number of Bhadi hash and about 20 pairs of Bhadi hash in Bangladesh at present. Husain (1979) mentioned that the most dominant or adaptive birds species were several mynahs, kites, crows, magpie-robins, black drongoes, which remain on forest or wood, land edge and used to changes in their environment. The environment of man both near villages and in towns, they adapted profound to feed on man produced seed and wastes as well as natural food (kite, crows, mynahs and house sparrows), insect pests of man's crops (magpie-robin, drongoes). Findlay *et.al.* (2005) described that wetland biodiversity loss in response to road construction by fitting regression models that express species richness of different taxa (birds, mammals, plants, and reptiles) as a function of both current and historical road densities on adjacent lands. The proportion of variation in reptile and bird richness explained by road densities increased significantly when past densities were substituted for more current densities in multiple regression models. Moreover, for vascular plants, birds and reptiles, there were significantly negative effects of historical road densities when the most current densities were controlled statistically. They showed that the full effects road construction on wetland biodiversity might be undetectable in some taxa for decades.

According to Miller (2005), biodiversity loss is a matter of great concern for increasingly disconnecting of people from nature. Broad-based public support for biodiversity conservation in public places is required to promote opportunities for meaningful interactions with the natural world to protect native

species and to enhance human well-being. Alam and Masum (2005) mentioned that increased human population and associated development activities in the last few decades has resulted directly and indirectly in depletion of the natural vegetation which in turn increase the pressure on the homestead forest specially in the developing countries to meet various needs of the human beings. In this circumstances correct inventory and assessment of biodiversity in different habitats is necessary for evolving a long-term strategy for conserving the endangered species and improvement of the existing species.

1.3.6 Plant Biodiversity in Bangladesh

Januzi and Peach (1977) said that moreover, homestead agro-production has special significance in the context of Bangladesh where about 50 per cent of rural households are landless. Haque (1996) said that plant diversity improves the socio-economic condition of the farmers by increasing profitability and security through balanced soil utilization and fertility preservation, it turns to be a constant source of income from trees. So it bears no risk for the farmers. It makes environment favorable for precipitation, increase humidity and minimize the loss of water through transpiration, evapotranspiration and keep the microenvironment colder by absorbing water from deep soil level.

Hossain and Bari (1996) said that the natural vegetation has been declining day by day being replaced by cultivated crops and the intensity of cropping in the cultivated land ‘has been increased to the maximum possible extent. Abedin and Quddus (2001) reported that these human activities have created numerous complexities, both in nature and in human society. For example, deforestation has increased the crises of fuel wood and timber shortage and has hastened soil erosion and degradation of the environment. Depletion of forest has resulted in loss of biodiversity, possible global climate change, degradation of watersheds and desertification. Due to continuous transformation of forest land to agricultural land, aquaculture, homestead and other purposes, 73000 ha of forest land are decreasing per year. Annual deforestation rate is about 8,000 ha and another 99,000 ha of reserved forest land has been subjected to shifting cultivation.

The biodiversity and its conservation have now become a global agenda. It refers to the variety and variability among living organisms, such as plants, animals and micro-organisms. It is usually measured in terms off number of species in an area and encompasses genus, species, economic benefits in terms of food, medicine, industrial raw materials, etc., and in maintaining the balance of the environment and the ecosystems.

Bangladesh is unique in having a wide variety of plant species with enormous genetic diversity. In addition to many valuable timbers and wood tree species, the forests and the village groves have been important source of numerous wild resource species, like fruit and nuts, fuel and fodder, vegetables, medicinal plants, bamboo and many other non-wood forest species. Ali and Ahmed (2001) reported that plant biodiversity in Bangladesh is estimated at over 5,000 species of higher plants, some 158 of which are found in freshwater wetlands and 334 in coastal wetlands. Key components of Bangladesh's plant biodiversity include its globally significant mangrove resources as well as the within-species genetic diversity found in several thousand varieties of rice grown within seasonally flooded areas.

Rahman *et.al.* (2004) a preliminary survey on medicinal plant diversity in the flora of the kingdom of Saudi Arabia. They had been made the survey with seven families; Amaranthaceae, Apocynaceae, Capparidaceae, Euphorbiaceae, Labiatae, Polygonaceae and Solanaceae. As an initial study these families are represented in the flora with 254 species and individually with 27, 7, 29, 66, 76, 22 and 33 species respectively. Of these, 86 species, so far investigate are medicinal, distributed in these seven families as follows: 7, 5, 13, 20, 23, 7, and 12 respectively. The labiatae have the highest number (23) of medicinal plants among them while maximum medicinal plant diversity within the family has been observed with the Apocynaceae.

According UNCED conference (2006) *Ex-situ* conservation means the conservation of components of biological diversity out side their natural habitat. *Ex-situ* conservation of genetic resources is often called gene banks. Living on like botanical gardens, arboreta, or field gene banks.

1.4 Agricultural Adaptation to Climate Change in Bangladesh

A little number of organizations are engaged in studying climatic change in Bangladesh- A project undertaken by the world Bank (2001) entitled 'Bangladesh Climate Change and Sustainable Development' reported on this aspects. This report was a pioneering one and had specific sections on the adaptation. The document represented both; broad sectoral adaptation possibilities and the challenges of adaptation.

Smith and Skinner (2002) reported that most adaptation options are modifications to on-going farm practices and public policy decision-making processes with respects to a suite of changing climate (including variability and extremes) and non-climatic conditions (political, economic and social).

World Bank (2002) reported that it is difficult to determine Bangladesh's potential to adapt to climate change, but several key statistics give some insight as to the state of its infrastructure and social and human capital. In 2000, the World Bank estimated that only 9.5% of Bangladesh's 207,500 km network of roads was paved, putting it well below the average for low income countries of 16.5%, suggesting that its physical infrastructure in general might be less developed than that of low income countries. In the same year, the World Bank reported Bangladesh had only 51 scientists and engineers per million people, a number comparable to that for low income countries in general. Similarly, gross secondary and tertiary school enrollment stood at 47.5% and 4.8%, respectively, in 2000.

1.5 Crop Rotation and Environmental Awareness

Khan (2002) reported that there was adverse effects of rice monoculture on rice fields, air and environment in case of rice cultivation i.e found a highly significant positive relationship of knowledge of farmers on rice cultivation with their awareness on adverse effects of rice monoculture. Sutradhar (2002) revealed that knowledge about crop rotation of the respondents had a significant positive relationship with their awareness on environmental degradation. Roy (2004) found that there was positive significant relationship between knowledge

about crop rotation and environmental knowledge of the farmers. Islam (2008) reported the relationship between knowledge about crop rotation and the environmental awareness as positively significant.Shalehin (2010) found that there was significant relation between the knowledge about crop rotation of the farmers with their environmental awareness.

1.6 Using of Manure and Environmental Awareness

Bishwas and Salam (1993) reported that the combined treatment of organic manure and mulch significantly influenced the soil properties, parameters of growth, yield and quality of carrot. Islam (2003) found that the knowledge about organic manure showed significant and positive relationship with their composite adoption of organic manures. Peigne and Girardin (2004) conducted an experiment and found that the main environment components potentially affected by causing pollution were air and water. Various gases released by composting, such as NH_3, CH_4 and N_2O can impact air quality and are therefore studied because they all have environmental impacts and en be controlled by composting management. Ceotto (2005) focused the efficient use and management of animal waste for curbing the rise of anthropogenic carbondioxide in the atmosphere. The use of animal waste in the crops through farmyard manure possibly enhances the carbon sequestration in the agricultural soils. Islam (2005) observed that the organic farming with cowdung and poultry manure and their combination with inorganic fertilizer showed a significant positive effect on soil moisture, organic matter, total N, available P, exchangeable K and available S but negative effect on soil pH. Rashid (2006) reported that knowledge of using organic manure had significant relationship with the attitude towards the use of chemical fertilizer and organic manure in his study area. Siddique (2007) found a positive relationship between organic manures and soil properties. Sharker (2007) found positive significant relationship between organic manures and yield attribute of soybean.

1.7 Fertilizer Application and Environmental Awareness

Islam (2005) observed that the organic farming with cowdung and poultry manure and their combination with inorganic fertilizer showed a significant positive effect on soil moisture, organic matter, total N, available P, exchangeable K and available S but negative effect on soil pH. Rashid (2006) reported that knowledge of using chemical had significant relationship with the attitude towards the use of chemical fertilizer and organic manure in his study area. Longo and York (2008) found that the mass consumption of manufactured fertilizers by industrialized agricultural systems worldwide threatened human health and the health of ecosystem. Aziz (2010) found that the application of fertilizer of farmers had significant positive relationship with environmental awareness of the farmers.

1.8 Pesticide Application and Environmental Awareness

Hamid (1995) conducted a study on farmers awareness on environmental pollution caused by the use of agro-chemicals in two selected BAUEC villages. The findings of his study revealed that two-thirds (65%) of respondents of less progressive villagers had poor awareness, 9% and 25% of the respondents had no awareness and moderate awareness respectively while only 1% respondent had high awareness on environmental pollution. On the other hand, majority (43%) of the respondents had moderate awareness while 6% and 11% of respondents had no awareness and high awareness respectively. Gandhi and Patel (1997) revealed an impact of pesticide on environment that means positive relationship between awareness on pesticide application and awareness on environment. Hanif (2000) in his study indicated that among the Farmers Field School (FFS) farmers, 100% had high awareness on environmental pollution due to use of pesticides. In case of non FFS farmers 66.67% had poor awareness while 30% had medium and 3.33% had high awareness on environmental pollution due to use of pesticides. Kashem (2001) showed a positive relationship between the awareness on insecticides application and environmental awareness of farmers. Longo and York (2008) found that the mass consumption of

agrochemicals, including pesticides, by industrialized agricultural systems worldwide threatened human health and the health of ecosystem.

1.9 Modern Agricultural Practices in Bangladesh

Parveen (1995) in her study on awareness of farm women on environmental degradation due to use of some selected modem agricultural technologies found that 65% of the farm women had poor awareness, while 29% had medium and 6% had high awareness on environmental degradation.

Hossain (2000) conducted a survey on 105 farmers of four upazila (Sherpur Sadar, Nakia, Nalitabari and Jhinigati) under Sherpur district and he found that in his study on farmers knowledge and perception of Binadhan-6 in the Boro season, 21 % low knowledge and lowest proportion 14% possessed high knowledge.

Uddin (2001) conducted a survey on 69 farmers of two upazila at Khalihati and Ghatail under Tangail district and he found that 0% farmers had low knowledge, 58% farmers had medium knowledge and 42% farmers had high knowledge have taken less care in intensive rice farming and environmental hazards and associated problems *i.e.* knowledge on agrochemicals of BSs had significant relationship with their opinion on environmental hazard and associated problems due to continuous and intensive rice farming.

Sutradhar (2002) revealed that knowledge on the use of modem agricultural technologies of the respondents had a significant positive relationship with their awareness on environmental degradation. Roy (2004) found that there was positive significant relationship between knowledge about use of modem agricultural technologies and environmental knowledge of the farmers. Hasan *et.al.,* (2005) conducted a study and found there was a significant relationships between IPNS knowledge and environmental awareness. Bene (2006) found that there was a significant relationship between the knowledge about agricultural activities of the respondents with their environmental awareness in farm and homestead activities.

Bipasha and Chatterjee (2006) found that there exists a significant relationship between modem technology and food grain production. Among the modem technologies, the impact of HYV seeds followed by fertilizer has the major impact on the food grain production.

Santha and Ramesh (2006) conducted a study was conducted among farmers in Kamarajar district, Tamil Nadu, India, to determine their extent of awareness about environmental pollution due to pesticide application. Findings revealed that there was a positive relationship between knowledge about the use of modern agricultural technologies and environmental degradation.

Ajayi and Banmeke (2007) conducted study farmers' perception and knowledge of environmental problems affecting their food production and found that there was no relation between knowledge about the use of modern agricultural technologies of the farmers and awareness on environmental pollution.

Roy (2007) found that agricultural knowledge had positive significant relationship with their awareness on environment. Haque *et.al.* (2007) revealed that there was significant relationship of knowledge about agricultural activities with environmental awareness of rural people. Longo and York (2008) found that the mass consumption of agrochemicals, including manufactured fertilizers and pesticides, by industrialized agricultural systems worldwide threatened human health and the health of ecosystem. Islam (2008) reported the relationship between knowledge on the use of modern agricultural technologies and the environmental awareness as positively significant.

Bo and LinHai (2010) conducted a study to investigate farmers' awareness of pesticide residues and their behaviours regarding pesticide application and found that positive significant relationship between knowledge about the use of modern agricultural technologies of the farmers with the awareness on environmental pollution. Shalehin (2010) found that there was significant relation between the knowledge about agricultural activities of the farmers with their environmental awareness.

Zaidi *et.al.,* (2011) was conducted a study to determine the levels of knowledge of the farmers on the effect of pesticides on environment in Dawadmi Province. Saudi Arabia and found that knowledge about the use of modern agricultural technologies of the farmers had positive significant relationship with the awareness on environmental pollution.

1.10 Objectives of the Study

1. To asses the impact of agricultural practices on sustainable biodiversity.
2. To find out the constraints faced by the farmers to do good practices on agricultural land.
3. To identify the modern agricultural technologies being used by the farmers.
4. To provide some solutions and recommendations to maintain a sustainable biodiversity on agricultural land.

Chatper 2
Methodology

2.1 Site Selection

There are 9 upazillas present in Rajshahi district. Among them reserch work is done in Puthia Upazilla. Puthia is located at 24.3750^{0}N and 88.8500^{0}E. Six villages were selected for the research purpose. On the basis of two ecosystems, selected area for the research purpose are-

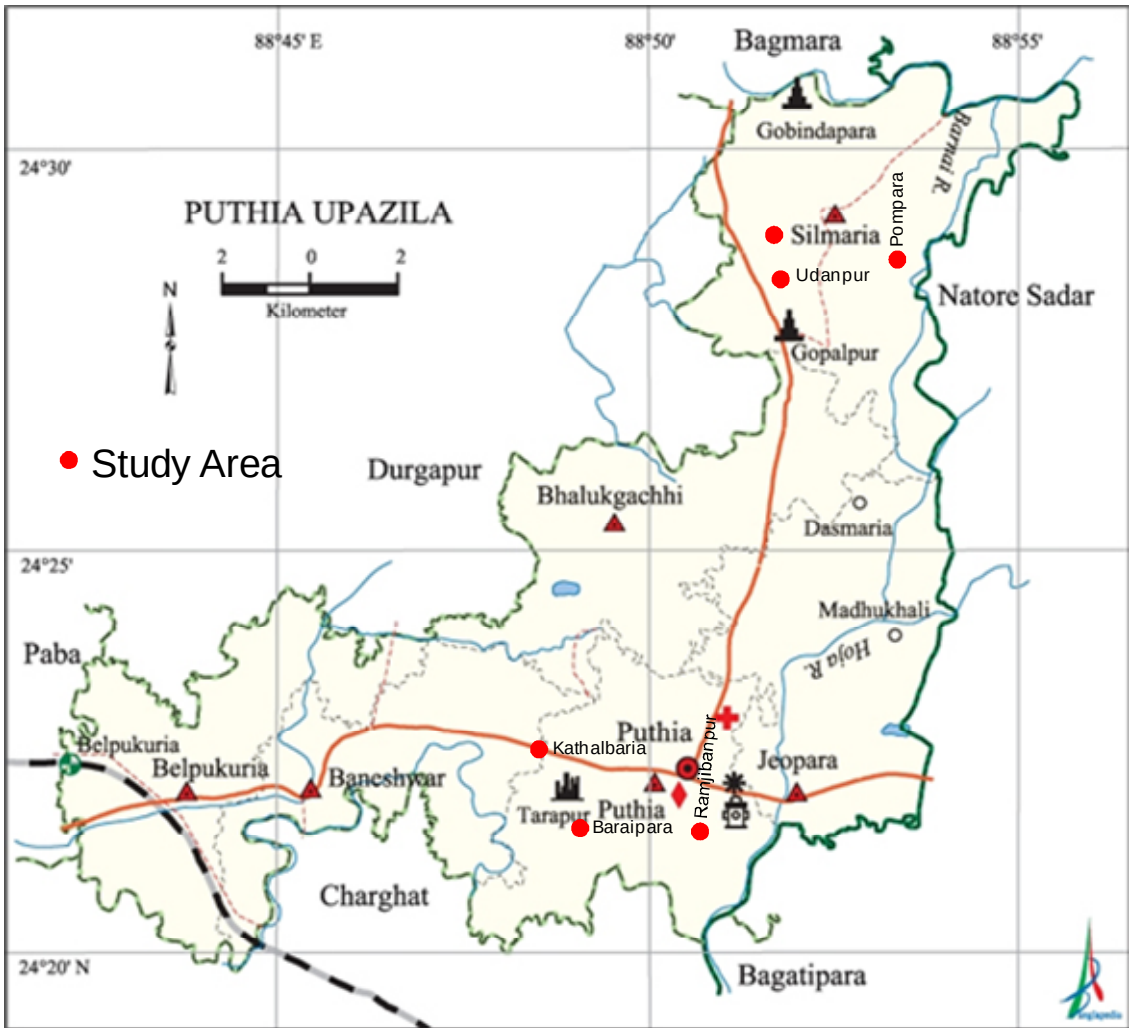
a) Upland not regularly affected by annual flooding or comparatively dry land area with three villages are i) Baraipara ii) Ramjibanpur and iii) Kathalbaria and

b) Low land (Marshy) or "beel" area with three villages are i) Shilmaria, ii) Udanpur and iii) Pompara

2.2 Presenting the Map of the Study Area

Study Area

Source: Banglapaeida.



(● Study Area)

Source: Banglapaeida.

2.3 Sample of the Study

Data were collected from samples, selected following a proportionate stratified random sampling technique. A village-wise list of farmer's households according to the farm categories (*i.e.* medium, small and landless) was prepared first. Then heads of households were selected randomly and proportionately at the ratio of 1:3:4 from medium (1.01-3.00 ha), small (0.21-1.0 ha) and landless (0.01-0.2 ha) farms, respectively, following the prevailing distribution of different farm size categories. There was no large farm (above 3.00 ha) household in any of the six villages. An equal number of samples were taken from each of the six villages. Thus, a total of 144 household heads (24 from each of the six villages) constituted sample of the study (Fig. 2.1).

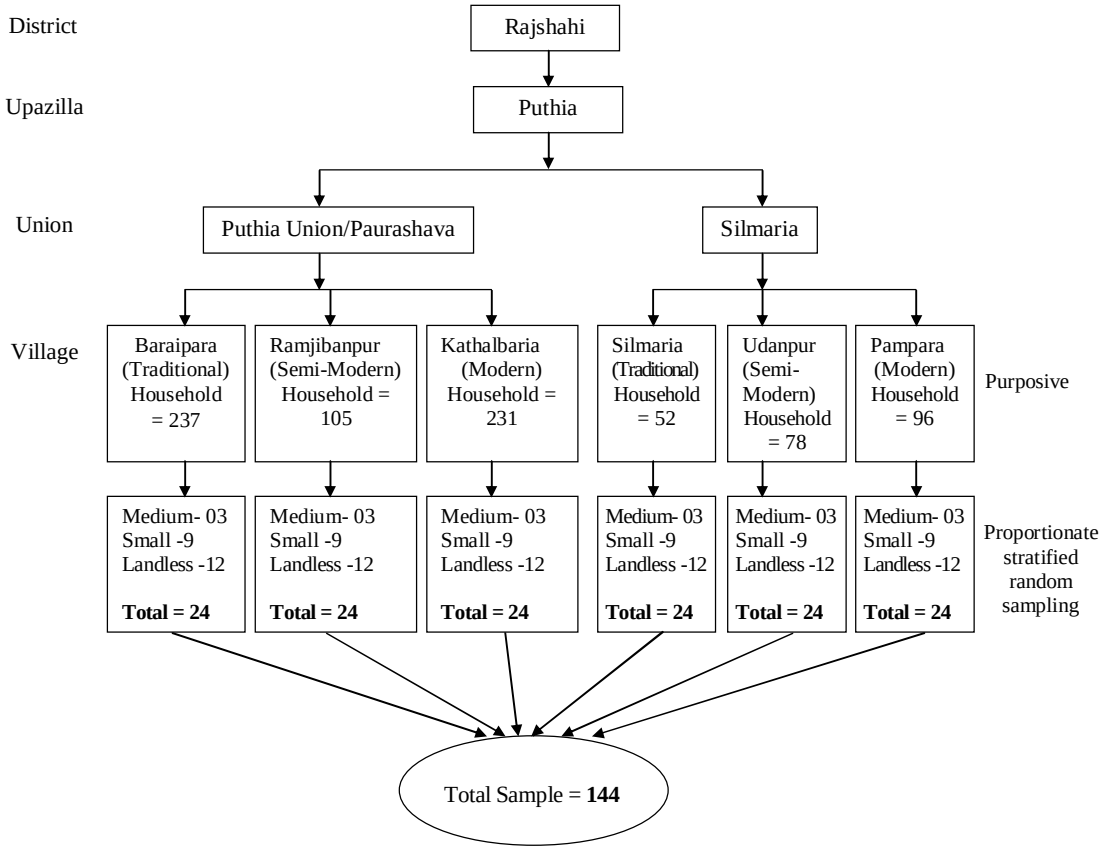


Figure 2.1: Diagrametic Figure of Sampling Design in the Study

2.4 Measurement of Agriculture Practices Impacts on Sustainable Biodiversity

The procedures for measuring the impacts of agriculture practices on sustainable biodiversity over time and the existing biodiversity in the study area were as follows.

2.4.1 Measurement the Impacts of Agriculture Practices on Sustainable Biodiversity over Time

The changes in biodiversity over time were assessed in following two ways:

i) Time trend analysis – for determining the impacts of agriculture practices on sustainable biodiversity over time ; and

ii) Listing lost/rare (threatened) species – for determining changes in biodiversity in the area through making a list of the species which have already been lost from the agriculture and/or from the locality and species which decreased in number drastically and are under threat to be extinct.

The impacts of agriculture practices on sustainable biodiversity over time were measured by “Time Trend” technique. Time trend is carried out with an objective to show qualitative and quantitative changes in one or more issues with time. Amount of crop land, market price of crops, no. of domestic animals, no. of trees, rainfall, population, housing etc. may be the issues of “time trend” analysis (Huda, 2005). Thus, the changes (increase or decrease) in biodiversity in the study area over last two and half decades (1990-2014) were assessed by “Time Trend” technique. It was done through the Focus Group Discussion (FGD) conducted at Six selected villages during study period. Respondents of each village were grouped into four categories such as – (i) 30-39 years, (ii) 40-49 years, (iii) 50-59 years and (iv) 60 years and above and were asked to indicate biodiversity in their locality, respectively for the period of 1990-2014. Each group was consisted of 5 respondents *i.e.* there were 20 respondents in each FGD. Six FGDs were conducted separately at six selected villages. Respondents of each group were asked to mention the name of different types of plants (field crops, fruit, timber, medicinal, ornamental, etc.), domestic animals, wild animals, birds and fishes, etc. in their locality during the period of time specified for respective group. The name of each of the species of plants, animals, birds and fishes was recorded carefully.

The list of plants and animals which had already been lost or their number reduced alarmingly in the study area or in the locality were recorded through interview and FGD. Respondents were asked to mention the name of lost/ rare (threatened) plants, animals, birds, fishes and recorded accordingly. It appears in the question no. 10-12 of the interview schedule in Appendix 1.

2.4.2 Measurement the Impacts of Agriculture Practices on Sustainable Biodiversity with Modernization

Six villages namely, a) Baroipara (traditional village), b) Ramjibonpur (semi-modern village), and c) Khathalbaria (modern village) of Puthia Union and Pouroshova, d) Shilmaria (traditional village), e) Udanpur (semi-modern village), and f) Pompara (modern village) were selected for determining the

impacts of agriculture practices on sustainable biodiversity with degree of modernization. The biotic component of the study area consists of human, plants, animals and birds, fish, micro-organisms, etc. In the present study, sustainable biodiversity was evaluated considering mainly the plants (crops, fruits, timber, medicinal and weeds), animals (wild, domestic and pet), birds and fiehes . Species richness measures was used in determining the biodiversity.

2.4.3 Species Richness

This is the simplest of all the measures of species diversity. Species richness (S) measures the number of species within a homestead. According to Heywood and Watson (1995), species richness measures the number of species within an area, giving equal weight to each species. Thus, each species of plants and animals in each of the selected homesteads of the six villages were recorded for this purpose. It appears in the question no. 10,11,12 of the interview schedule in Appendix 1.

2.5 Instrument for Data Collection

An interview schedule was used as the key instrument for collecting quantitative data from the selected respondents through household survey. The interview schedule was prepared as per objectives of the study. It contained closed form of questions in most cases. The interview schedule was tested in the field prior to final data collection and necessary adjustments were made accordingly. The interview schedule was drafted in English (Appendix 1) initially but for ease of understanding Bangla version of the same was used in the pre-test and final data collection. However, qualitative data was collected using some PRA tools like Direct Observations, Focus Group Discussion (FGD) case study and Photograpy.

2.6 Data Collection

Both quantitative and qualitative methods were used in collecting data for the study. Primary data have been collected from respondents through schedule questionnaire, observation, Focus Group Discussion (FGD) and Case study.

2.6.1 Primary Data

2.6.1.1 Face to Face Interview

The quantitative data were collected through face to face interview.

2.6.1.2 Direct Observations

Observation is an important technique for collecting data when the information is considered sensitive and when a high degree of reliability and accuracy is required (Narayan, 1996).

2.6.1.3 Focus Group Discussions (FGD)

Focus Group Discussions(FGD) refers to group discussion on certain issues involving persons who are associated with that particular issue e.g. group discussion on agriculture with persons involved in agriculture (Huda, 2005).

2.6.1.4 Case Study

Case study strategy have been used as a means of in-depth investigation which allows an investigator to address a broader range of historical, attitudinal and observational multiple sources of evidence. This provides the opportunity to develop the convergence of lines of inquiry and a process of triangulation. How', ´Why' and ´What' type of questions of any research can be addressed with case study strategy. In this study, Case Study strategy is used to gain a deep insight and for scrutinizing of the data collected from the respondents through other techniques.

2.6.2 Secondary Data

i) Data were collected from different organizations.Such as

Department of Agricultural Extension

Department of Livestock and Fisheries

Department of Forestry

Bangladesh Bureau of Statistics (BBS)

Department of Meteorology

ii) From newspaper, journals, different thesis and internet applications.

2.7 Data Analysis

After collection, data were coded, compiled and tabulated in accordance with the objectives of the study by sophisticated statistical tools. Comparison and different information were showed through bar-diagram and line graph.

2.8 Photography

Photographs were taken from different cultivated crops, vegetables, instruments used for cultivation, different use of land for human need, different types of chemical fertilizers and pesticides, application of pesticides, effect of herbicide, organic manure and its use as fuel, some wild animals, birds, fishes etc.

Chatper 3
Results and Discussion

3.1 Agriculture Practices in the Study Area

Agricultural practices are increasing day by day due to high demand of foods, resulting the area of jungle, bush, fellow land and water bodies have been reducing at alarming rate. This Chapter deals with the systematic and logical presentation of results of the study. The findings and discussion have been presented here in line with the objectives of the study. Necessary explanations and interpretations have also been incorporated here on logical basis of the findings.

Puthia has a total land about 192.64 sq.km area with 6 union, 1 Pouroshova and 128 Mouza. It also consists of 19 Agricultural block, 41717 total farmers family, 15052 hectre of cultivable land, 910 hectre of fruit garden, 2500 hectre of hoestead area. Within the total land area cultivable land is about 15052 hectre, which comprises 854 hectre of single cropland, 9708 hectre of double cropland, 26253 hectre of triple crop land and 2372 hectre of more than triple crop land. Cultivable land area are divided into four categories are- (a) High land (9446 hectre) (b) Medium high land (3031 hectre) (c) Medium low land (2346 hectre) and (d) low land (229 hectre). Crop intensity is about 260% (Appendix 2.1).

There are 21 seed dealer of BADC, 08 fertilizer dealer of BCIC, 63 retail fertiflizer seller, 21 pesticide whole seller and 354 relailer of pesticide licese holder, 201 deep tube wells, 8291 shallow tube wells and uncountable submersible pumps present in Puthia Upazilla (Appendix 2.1).

Agriculture practices is mostly done by the farmers, who produced different types of crops such as cereal crops, pulses, oilseed, sugar, spices and vegetables in puthia Upazilla. These crops are produced by the farmers in three seasons.

1. Robi Season (November-March)
2. Kharif-1 Season (March-June)
3. Kharif-2 Sesaon (July-October)

In Robi Season 33 types of crops were grown in the crop fields such as 3 type grains- Boro rice (*Oryza sativa),* Wheat (*Triticum aestivum*), Maize (*Zea mayes*), 3 type Pulses- Lentil (*Lens culinoris*), Pea (*Pisum sativum*), Grass pea (*Lathyrus sativus*), Sugarcane (*Saccharum officinarum*), Mustard (*Brassica Campestris*), 17 items of vegetables- Green pea (*Pisum sativum*), Potato (*Solananum tuberosum*), Cauliflower (*Brassica oleracea var botrytis*), Cabbage (*Brassica oleracea var capitata*), Red amaranth (*Amaranthus gangeticus*), Spinach (*Spinacia oleraceae*), Radish (*Raphanus sativus*), Tomato (*Lycopersicon esculentum*), Brinjal (*Solanm melongena*), Bottle gourd (*Lagenaria sicararia*), Seem (*Dolichos lablab*), String bean (*Vigna Sesquipedalis*), Bitter gourd (*Momordica charantia*), Sweet gourd (*Cucurbita maxima*), Carrot (*Daucus carota*), Cucumber (*Cucumis sativus*) and Cucumber (short) (*Cucumis anguina*) and 6 type of spiecs (onion (bulb, al) (*Allium cepa*), Coriander (*Coriandrum sativum*), Termaric (*Curcuma longa*), Garlic (*Allium sativum*), Black cumin (*Nigella sativa*), Chilli (*Capsicum annum*) in 19674, 21120 and 19665 hactre during 2008-2009, 2013-2014 and 2014-2015 respectively (Appendix 2.3).

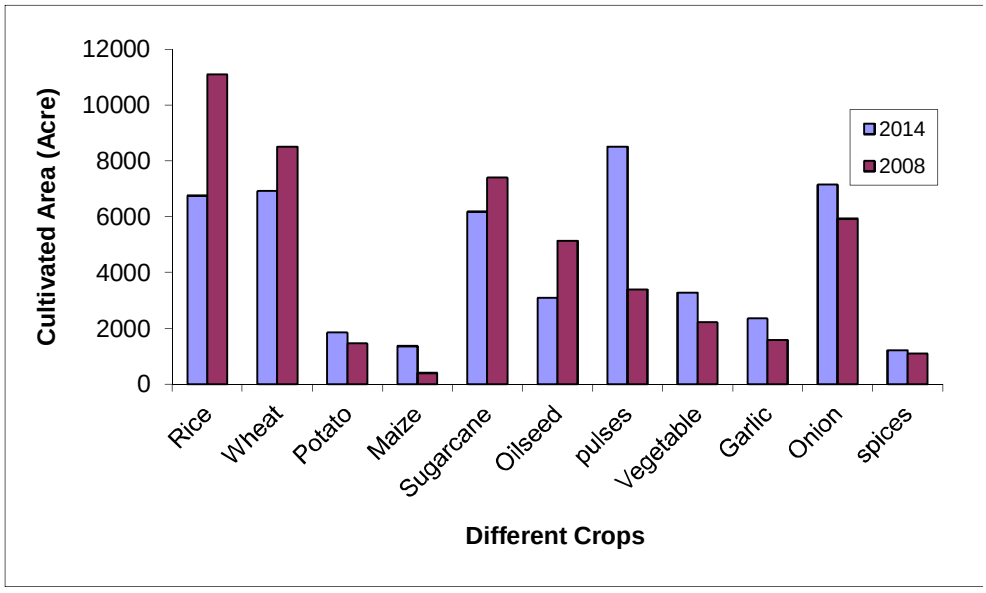


Figure 3.1: Comparative Statement of Different Crops Cultivated Area (Acre) in Robi Season from 2008-2014

It is indicated from the above figure 3.1 that in Robi season crop as Rice, Wheat, sugarcane and oilseed production area were decresed from 2008 to 2014 and Maize, Pulses, Spices, Potato, Garlic, Onion and vegetable production area were increased in 2014 from 2008. So, it can be said, that hybrid, HYV and modern agriculture practices increased for economic gain and the demand of food.

In Kharif-1 Season 24 types of crops were cultived such as 2 types grains- (Aus rice (*Oryza sativa*), Maize (*Zea mays*), Jute (*Corchorus capsularis*)), Pulses- Mung bean (*Vigna radiate*), Sesame (*Sesamum indicum*), 2 types fruits- Papaya (*Carica papaya*), Banana (*Musa sapientum*), Chilli (*Capsicum frutescesns*), 16 types vegetable- Bringal (*Solanum melongena*) , Okra (*Abelmoschus esculentus*), potol (*Trichosanthes diocia*), Bitter gourd (*Momordica charantia*), Ribbed gourd (*Luffa acutagula*), Chichinga (*Trichosanthes anguina*), Wax gourd (*Benincasa hispida*), Sweet gourd (*Cucurbita maxima*), String bean (*Vigna Sesquipedalis*), Red amaranth (*Amaranthus gangeticus*), Indian spinach (*Basella alba*), Stem amaranth (*amaranthus lividus*), Drumstick (*Moringa oleifera*), Eddoe (*Calocasia esculenta*), Cucumber (*Cucumis sativus*), Cucumber (Short) (*Cucumis anguina*) in 5157, 7458, 6021 and 6575 hactre during 2008-2009, 2012-2013, 2013-2014 and 2014-2015 respectively (Appendix 2.4).

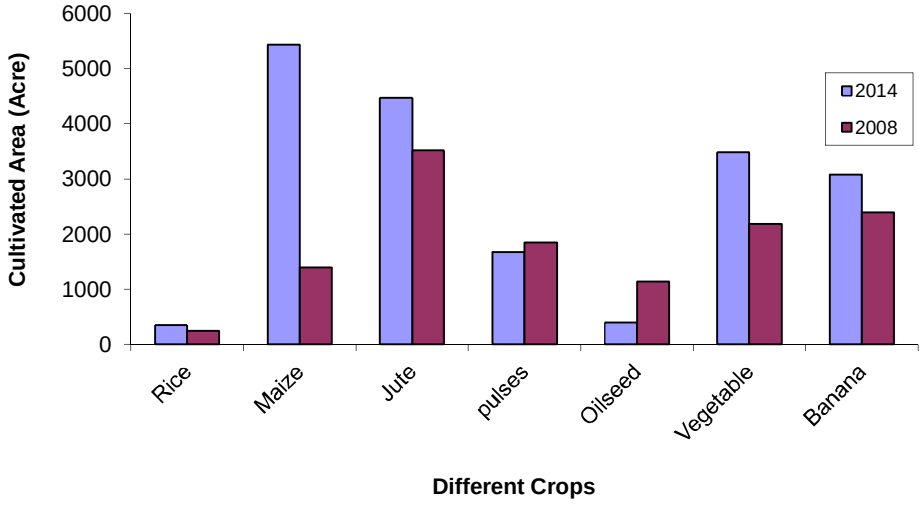


Figure 3.2: Comparative Statement of Different Crops Cultivated Area (Acre) in Khorif 1 Season from 2008- 2014

It is indicated from the above figure-3.2 that in Kharif-1season crop as Rice, Maize, Jute, Banana and Vegetable production area were increased in 2014 from 2008 and only Pulses and Oilseed production area were decreased in 2008 to 2014. So, it can be said, that hybrid, HYV and modern agriculture practices increased for economic gain and the demand of food and fibre.

In Kharif-2 season 4 types of crops were cultivated such as Bro Amon (Hybird, Upshi, Local) (*Oryza sativa*), Black gram (*Vigna mungo*) in 4890, 3350, 4100 And 4140 hectre during 2008-2009, 2013-2014, 2014-2015 and 2015-2016 respectively (Appendix 2.5).

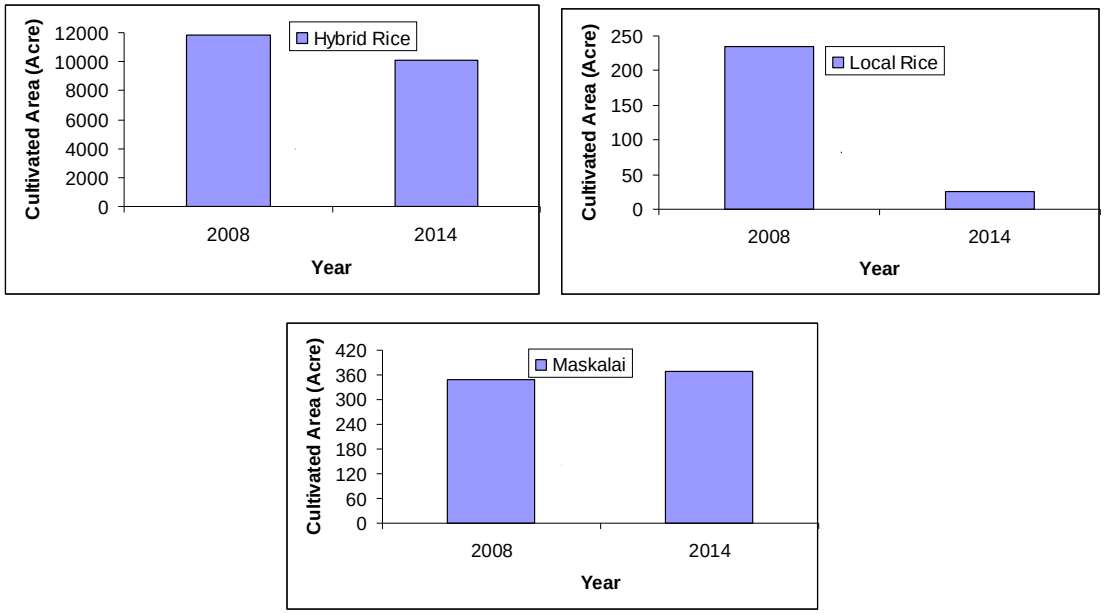


Figure 3.3: Comparative Statement of Crops Cultivated Area (Acre) in Khorif 2 Season from 2008-2014

It is indicated from the above figure 3.3 that in Kharif-2 season crop as hybrid Rice and local rice production area were decreased in 2008 to 2014 and black gram production area were same in 2008 to 2014. So, it can be said, that hybrid, HYV and modern agriculture practices increased for economic gain and the demand of food.

Rice: A large number of local rice varieties were grown prior to 1990, before the introduction of the high yielding varieties and hybrid varieties (these local varieties, selected by local farmers, adapted to local soil and flood condition

have been totally eliminated now from the study area). This monoculture of rice resulted in loss of the crop species and their local varieties from the study area according to respondents of the FGDs and interview.

Total rice land area are decreased but other crop area increased in the study areas during the period 1990-2014. This reduction in crop diversity and replacement of traditional cropping system by HYV- fertilizer package had severe effect on soil fertility, pest abundance and other ecosystem functions. Boro varieties were not cultivated during 1990s but now the area under Boro is increasing. Local Aush and Aman are not grown in the study area at present time.

Wheat: Wheat is the second most important cereal crop in Bangladesh and its production is expanding rapidly. However, wheat production is very sensitive to environmental production conditions and managerial practices. It was realized that though about 80 percent of the total cropped area of Bangladesh is devoted to rice cultivation, rice alone could not meet the food requirement of the country. Wheat was therefore chosen as an alternate food crop in the winter season, which remains mostly free from natural calamities. The common cultivated varieties are locally known as Sonalika, Kanchan, Balaka, Ananda, Akbar, Barkat, and Aghrani mentioned respondents during FGDs and interviews.

Maize: Maize is an attractive crop for Bangladeshi farmers for several reasons, the demand from producers of poultry and fish feed who purchase approximately 90% of maize produced in the country in particular. Only the remaining portion is used for human consumption. Furthermore, maize has at least double the yield potential of rice and wheat and thus provides greater returns for lower production costs. Recenty maize cultivated area increased mentioned by FGDs and interviews.

Vegetables: According to the Department of Agricultural Extenstion 17 types of vegetables were grown in the period 2008-2014 (Appendix 2.3), but an increasing trend was observed for vegetables cultivation area and types both were increased recently mentioned respondents during FGDs and interviews.

Potato: Potato is suitable as a security crop in times of rice shortages due to its high carbohydrate content contributing to improved food security. It is also used as a vegetable by various income groups of the country. Since it is a short duration crop. It is an alternative food of rice and wheat. Potato eassily can reduce the pressure on main food as rice and wheat. Now potato production area and production increased in the study area.

Pulses: The pulses of Bangladesh comprise of six major crops, namely, lentil, khesari, blackgram, mungbean, chickpea and pigeon pea. Pulses are considered as "the meat of the poor" because still pulses are the cheapest source of protein. Lentil is the most nutritious of all pulses containing high protein in their seeds. It is known as '**masur dal**' in Bangladesh. Among the pulses grown in Bangladesh, lentil holds the second position in respect of both total area and cultivation just after cultivation. The cropped area and production of these pulses have been on the decline over the past few years mainly because of the increased emphasis on HYV rice and wheat. But pulses are very important because of their protein supply to the human diet and nitrogen fixation for soil nutrition. Pulses production decreased as well as production area are reduced.

Spices: According to Department of Agricultural Extenstion 6 types of spices were grown in puthia Upazilla in 1990-2014. There was no such change in the spieces over time but area under cultivation of spices decreased remarkably as mentioned by the respondents during FGDs and interview.

Sugarcane: It is one of the most important cash crops of the country. A sugarcane plant has prominently jointed stalks, each bearing two ranks of sword-shaped but gracefully arching leaves. It is an annual crop, sugarcane keeps the land occupied throughout the year. Consequently, some farmers are inclined to cultivate other profitable crop rather than sugarcane. This has resulted in a decline in crop acreage as well as the production of the commodity in recent years. Soem farmer are not interest for sugarcane farming. Those famer convented to another short time duration economic viable crop.

Jute: Jute is the major fibre crop of the country. Despite the relative decline in importance of jute in agriculture, potential still exists for the fibre to increase its contribution to the economy through productivity increases and diversification. The share of raw jute and jute goods in the total exports of the country has been declining but still remains significant. In this situation, government has taken special measures to encourage farmers to further intensify jute production in order to satisfy domestic and export demand. To enable jute to compete with synthetics, emphasis has given to jute goods utilization.

The result of the study supported by Rahman (2015) and he said in his study that the number of local varieties of varieties crops is steadily declining due to 'the Promotion and economic consideration of only a few selected varieties, especially of the High Yeld Varities (HYV) of rice and wheat and other crops. This is causing of irreparable loss to the genetic diversity of our crop plants and their wild relatives.

3.2 Cultivated and Irrigated Land in the Study Area

Table 3.1 shows that in 1990, total cultived land was 36157 acre and irrigation land area was only 4514 acre (12.5%). But in 2014, total cultivable land is about 36481 acre and irrigation area were same (100%). Now a days, the pattern of croppiong and cultivable crops are charging in the fields. Irrigation is an essential tools for crop production now. Figure 3.4 also shows cultivated and irrigation land area of 1990 and 2014.

Table 3.1: Total Cultivated and Irrigation Land (Acre) of Puthia Upazila 1990-2014

1990		2014	
Cultivated	**Irrigation**	**Cultivated**	**Irrigation**
36157	4514	36481	36481

Source: Official record of DAE, Puthia

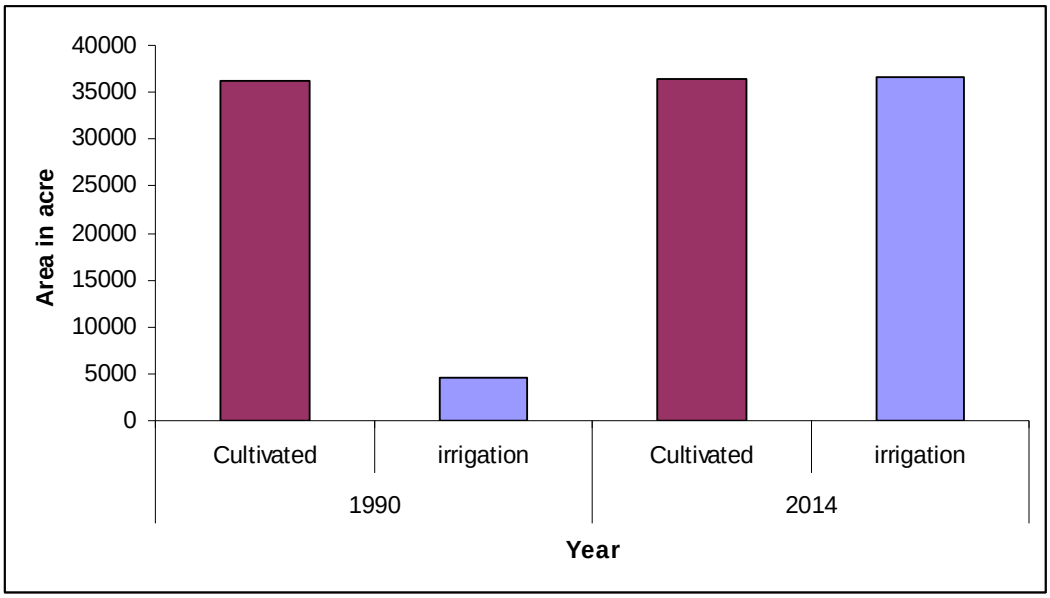


Figure 3.4: Cultivated and Irrigated Land (Acre) of Puthia Upazilla 1990 - 2014

Before 1970, all irrigation was done using surface water from beels and ponds, by 1980s a number of shallow tube wells and in 1990s deep tube wells were introduced. The number of tube wells increased rapidly, currently most of the irrigation water comes from the ground water. Recently, Sub-mersible pump are using for irrigation in cultivated land and also for drinking water. Figure-3.4 shows that 100% land under irrigation.

Table 3.2: Cultivated and Irrigated Land (Acre) of Different Villages in the Study Area from 1990-2014

Villages	1990		2014	
	Cultivated	Irrigation	Cultivated	Irrigation
Baraipara	469	45	471	471
Ramjibanpur	132	7	134	134
Kathalbaria	456	24	458	458
Silmaria	46	10	40	40
Udanpur	83	25	86	86
Pampara	108	22	113	113

Source: Official record of DAE, Puthia

Table 3.2 shows that six study villages cultivable and irrigated land area in 1990-2014. We found that in 1990 irrigated area were only, Baraipara (9.5%), Ramjibanpur (5%), Kathalbaria (5%), Silmaria (21.7%), Udanpur (30%) and Pampara (20%). But in 2014 year, 100% cultivated land are under irrigation. The result of this study supported by Aminul *et. al.,* (2012) and said that labour and irrigation costs together normally account for two- thirds of the total cost of production. Mandol (2006) also supported this finding.

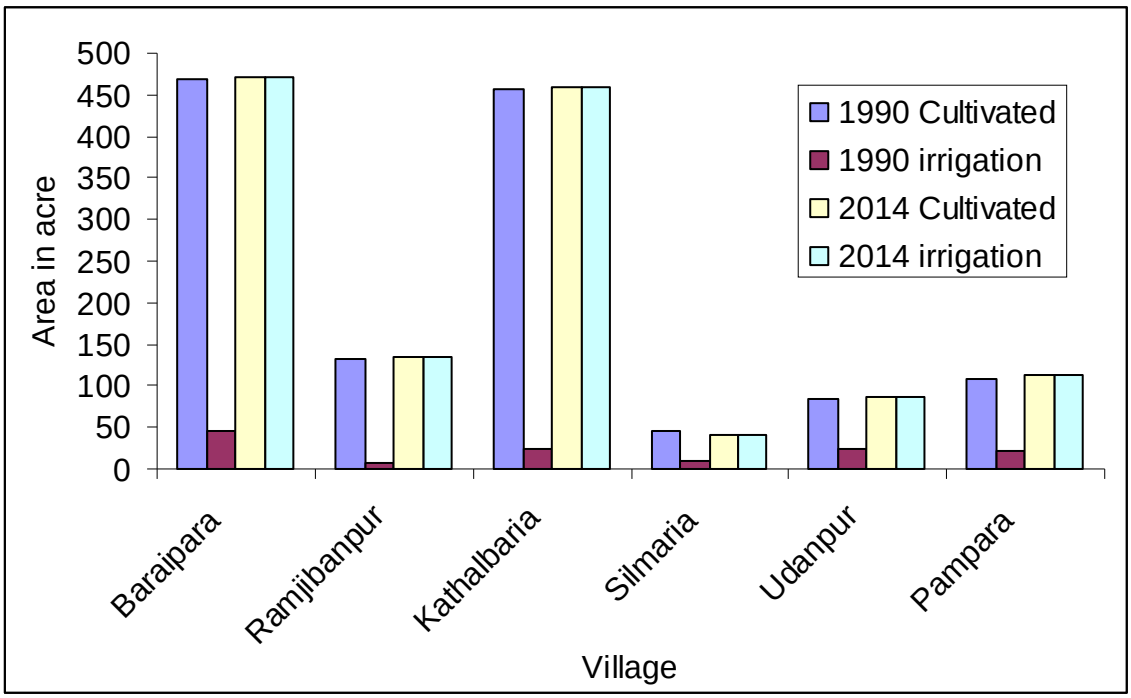


Figure 3.5: Cultivated and Irrigated Land of the Study Area from 1990 - 2014

Individual cultivable land area increases during the period 2014 in the six study villages.The total cultivated land during the period 1990-2014 has mostly taken place with the adoption of modern agricultural technologies eg. High yielding varieties, chemical fertilizers, irrigation by ground water and pesticides.

During the period 1990-2014, fallow land has decreased significantly and local farmers have converted into crop land or used for other purposes. About 98% of the fallow land has been converted into crop land both the upland and lowland areas during this period from FGDs.

3.3 Wetland Degradation in the Study Area

Bangladesh is a land of wedlands. More than two thirds of the country may be classified as wetland according to the definition enunciated in the Ramsar convention. The wetlands of Bangladesh support awide varity of floral and faunal diversity, some of which are globally as well as locally endangered. However these aquatic resources have been subjected to repid degradation due to the increasing population pressure, habitat destruction and other anthropogenic as well as natural causes. About 28 numbers of beels present in puthia, Kantar beel, udonpur beel, ratowal beel, ruiar beel, pomparar beel, goriar beel, sukpara beel, matchpara beel are the largest beel among the rests. The total land area of beel is about 1821 hectre. Cultivable land within beel area in about 1739 hectre. In 1990, 931 hectre of beel area was stagnant and 890 hectre was used for cultivation. But in 2014 for more demand of food, 1739 hectre of beel area are using for cultivation. In the present study, wedland biodiversity are depletion dramatically (Appendix 2.6).

The wetlands area are the most biologically diverse ecosystems on earth. After 1990s, the local people observed a rapid decrease in the wetland. For more economic gain, a trend has been started to digging pond in beel area (Plate 3.3). All these were converted into crop fields and ponds. Local people reported that available migratory birds are found in the winter season in the beels but those birds are totally absent. Cultivated land increased and natural biodiversity described in the study area during 1990-2014 which indicate a substantial decrease in natural habitats. Resulting wetland biodiversity is decreasing at alraming rate. Most of the wetland flora and fauna are going to disapper from this area (Plate 3.1).

The local fishermen reported the reduction in abundance of local fish species by 25% to 85%. The local people mentioned over fishing, beel area converted into crop fields and ponds, obstacles in fish migration due to flood control devices and lack of reproductive ground of local non-migratory fish species for this decline. Open-water fishes are seriously affected, the abundance of indigenous fish species

greatly reduced, but the cultivated fish abundance in ponds increased, though most of the species being exotic, Silver carp, Big head carp, Mirror carp, Grass carp, Black carp,Thai pangus, Talapia etc. The result of the study supported by Khondoker *et. al.*, (2014). They said that once Beel Bakar was rich in biodiversity and important for local fisheries. The result of the study also supported by Azhar *et. al.*, (2013) and they said that wetlands are being continuously lost or degraded primarily because of various recent developments, such as shrimp culture, which reflect a lack of community awareness of wetland functions and values. Ramamasy and Baas (2007) also support are above findings.

Some people has established brick field on their cultivable land (Plate 3.5). As a result, crop land degradation and air pollution increased day by day. Some crops are damaged by the natural calamities like flood and drought (Plate 3.2 & 3.6). Changing in agriculture practices has been occur from past to till date. Manual practices with land, ploughing with cow has been replaced by ploughing with tractor, power triller etc. (P late 3.7 and Plate 3.8).

To meet up the food demand of over population different hybrid crops and vegetables and high yielding variety (HYV) crops are now cultivated in the crop fields (Plate 3.10). Hybrid varity required a less space but provide more production. But due to cultivation of selected crops and vegetables, native varity are disappearing day by day.

Due to population increase, peoples are using land more and more. Wild vegetation or fallow land of a house is absent now (Plate 3.11). Even fallow land beside their homestead are now using for cultivation purpuses (Plate 3.12). Cattle and goat were seen in grazing was a common matter in past (Plate 3.13 and 3 .14). Now residential buildings are constructed on crop fields (Plate 3.15). Filling of pond due to human demand (Plate 3.16). As a result, all these activities creates a pressure on natural biodiversity in the study area and geometrically decrease of biodiversity.

Plate 3.1: Udonpur Perennial Water Bodies in the Study Area

Plate 3.2: Water Logging in Crop Land due of Natural Canal Distruction

Plate 3.3: Distruction of Beel Wetland in the Study Area

Plate 3.4: Plantation of Banana After New Artificial Upland

Plate 3.5: Crop Land Degradation and Air Pollution due to Brick Field

Plate 3.6: Effect of Draught on Fruits Plant

A. Ploughing by Weeding Hook **B. Ploughing by COW**

Plate 3.7: Traditional Practices in the Crop Land

C. Ploughing by Tractor **D. Ploughing by Powertiller**

Plate 3.8: Modern Practices in the Crop Land

A. Rice Cultivation Area **B. Crop Land Converted to Maize Cultivation Land**

Plate 3.9: Cultivated Land with Crops

A. Use of over doses Urea in the Rice (*Oryza sativa)* Field

B. Hybrid Pumpkin (*Cucurbita maxima*) Culture in the Study Area

C. Hybrid Korola (*Momordica charantia*) Culture in the Study Area

D. Over Practices in the Land 3-4 Times in a Season eg. Lal Shak (*Amaranthus gangeticus*)

E. Hybrid Cucumber (*Cucumisn sativus*) Culture in the Study Area

F. Over Practices in the Land 3-4 Times in a Season eg. Okra (*Abelmoschus esculentus*)

Plate 3.10: Some Hybrid Crops and Vegetables

Plate 3.11: Wild Vegetation Decreased Day by Day

Plate 3.12: Homestead Cropping Practices by Home to Home

Plate 3.13: Grazing Land Reduce Day by Day (Image a Cow Grazing)

Plate 3.14: Grazing Land Reduce Day by Day (Image a Goat Grazing)

Plate 3.15: Decreasing of Cultivable Land due to Residential Construction and Urbanization

Plate 3.16: Filling of Pond due to Human Demand

3.4 Agriculture Practices in the Study Area

Cultivation method is an important compenent in agricultural production. In the study area the respondents followed traditional (by cow, buffalo) and modern (by tractor, power tiller) method of cultivation. Table 3.3 indicates that method of cultivation was changed according to year in 2014 most of the farmers 75% followed modern method, while in 1990, 60.2% fermers follwed only traditional method. Traditional method has also desreased from the previous years. Ploughing is a pre-requisite to mineralize and facilitate decomposition of crop residues, green manure and other organic manures and help relase of nutrients. It was necessary to remove stiff roots, stubbles, root stocks and stamps. More over deep ploughing facilitates easy uptake of water as well as nutrient by roots from the deeper soil depths efficiently and consequently increased the root growth. The result of the study supported by Raisuddin (2001), he reported that on average, about 28 percent of cultivated land was plowed with power tillers and tractors in 1996. It seems that progress in the application of power tillers/ tractors in Bangladesh was rapid in the1990s.

Table 3.3: Method of Cultivation According to Year

Sl. No.	Methods of Cultivation	Use in 1990 (%)	Use in 2014 (%)
1.	Traditional method (cow/buffallo)	60.2	10
2.	Modern method (Tractor/Powertiller)	20.3	75
3.	Both	19.5	15

Source: FGDs and interview (% indicate respondents mention)

3.5 Fertilizer Practices in the Study Area

Fertilizer is any substance used to add nutrients to the soil to promote soil fertility and increase plant growth. Almost all farmers reported that the changes in soil fertility and soil structure during the period 1990-2014. They said that use of chemical fertilizer and ground water irrigation has resulted in the decline of

soil fertility. Trend in fertilizer use indicates less use of organic manure (Table 3.5). Cowdung, compost and green manure use decreased during the period 1990-2014. Poultry waste and other inorganic fertilizer (Mn, Zn, S, Br, Ni etc.) use increased now (2014). Though cowdung use increased in the upland areas but declined in the lowland areas. Extensive rice cultivation and narrowing of crop diversity was reported to reduce natural soil fertility. Above all these were observed during study and mentioned by the respondents while conducting FGDs and interviews.

Feed crisis and lack of grazing land were reported as the major factor responsible for decline the number of cattle in the study area during the period 1990-2014. Most of the animal dung is used as dry fuel (Plate 3.18) as well as farmer turn into chemical fertilizer (Case study 3).

Table 3.4: Practices of Organic Manure (%) in the Study Area between 1990-2014

Area	Village	1990					2014					Changes				
		Cow dung	Compost	Green manure	Poultry dust	Others	Cow dung	Compost	Green manure	Poultry dust	Others	Cow dung	Compost	Green manure	Poultry dust	Others
Upland	V1	72.5	1.6	2.8	2.1	21	55	6.6	0	0.8	37.6	-17.5	+5	-2.8	-1.3	16.6
	V2	76.6	0	0.8	0	22.6	45	0	0	1.6	53.4	-31.6	0	-0.8	+1.6	30.8
	V3	92.5	0.8	0.3	1.1	5.3	92.5	0	0.8	2.5	4.2	0	-0.8	+0.5	+1.4	-1.1
Lowland	V1	95	0	0	1.6	3.4	61.6	0	0	15	23.4	-33.4	0	0	+13.4	20
	V2	90	0	2.8	0.5	6.7	78.3	0	0	1.6	20.1	-11.7	0	-2.8	+1.1	13.4
	V3	77.5	0	0	0.8	21.7	65	0	0	0.8	34.2	-12.5	0	0	0	12.5

Source: FGDs and interview

[Upland V_1= Baraipara, V_2=Ramjibanpur, V_3= Kathalbaria and Low land V_1= Shilmaria, V_2=Udanpur, V_3= Pompara]

Organic manure practices decreased for low availability and use of chemical fertilizer increased for easy supply and higher demand for hyrid, HYV and higher yield of crops. This study supported by Hossain and Tanveer (2012). They said that application of bio-products in order to ensure better and safe environment without any reduction in yield of crops.

Table 3.5: Practices of Chemical Fertilizers During 1990-2014

Year	Village	1990				2014			
Upland		Urea (%)	TSP (%)	MOP (%)	Others (Br, Zn, Mn, S, Mg,etc.) (%)	Urea (%)	TSP (%)	MOP (%)	Others (Br, Zn, Mn, S, Mg, etc.) (%)
	V1	80	70	60	5	100	100	100	45
	V2	80	65	45	-	100	100	95	40
	V3	80	66	50	10	100	100	95	35
Loland	V1	75	55	45	-	100	100	90	30
	V2	68	50	40	7	100	100	85	30
	V3	72	60	55	-	100	100	80	25

Source: FGDs, (% respondent mentioned)

[Upland V_1= Baraipara, V_2=Ramjibanpur, V_3= Kathalbaria and Low land V_1= Shilmaria, V_2=Udanpur, V_3= Pompara]

Use of modern agricultural practices in farming is pertinent to increase farm out put. It is considers as useful means in field crops production. However, the adoption of modern practies and their management in field crop production is difficult. Distribution of farmers according to their use of chemical fertilizer is presented in Table 3.5.

In principle, balanced fertilization is indispensable to avoid crop yield decline on cultivated land and to supplement nutrient loss from the soil ecosystem. Balanced fertilization ensures high productivity in accordance with nutrient demand by individual crops and for individual nutrient elements without causing harm to the environment.

Table 3.6: Amount of Chemical Fertilzier (M. Ton) Used in the Study

1990			2014				Changes			
Urea	**TSP**	**MOP**	**Urea**	**TSP**	**DAP**	**MOP**	**Urea**	**TSP**	**DAP**	**MOP**
2500	800	600	8000	2200	2000	2700	+5500	+1400	+2000	+2100

Source: BCIC dealer

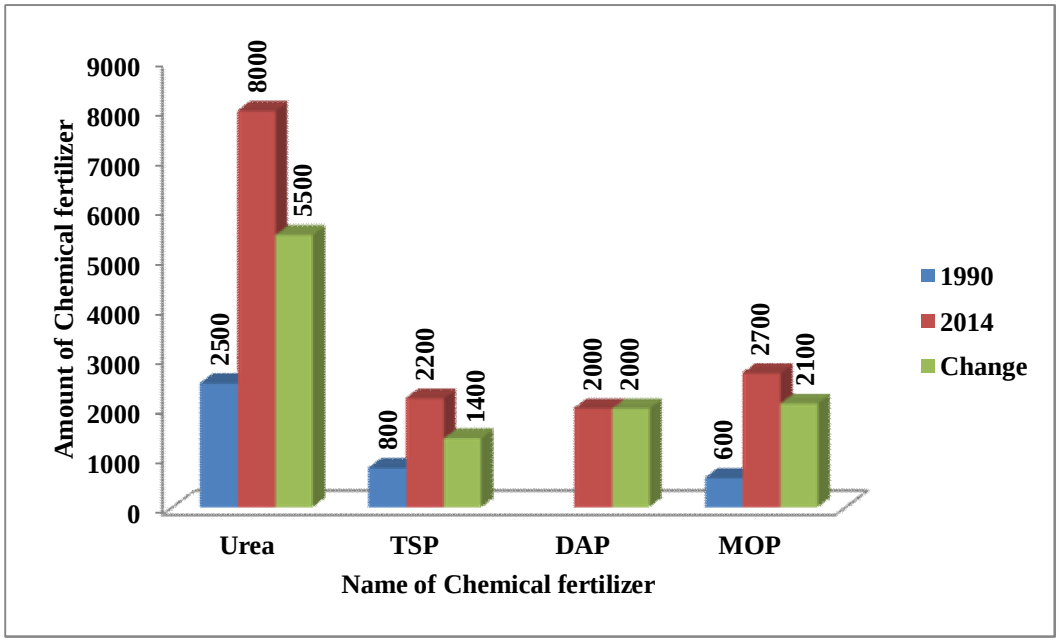


Figure 3.6: Comparative Statement of Chemical Fertilizer Used the Study Area from 1990-2014

Like all over Bangladesh, the use of chemical fertilizers was started during Mid-1980s. Before that, the local farmers used animal manure and organic fertilizers for cropping. During recent years, the farmers have to use more and more fertilizers to maintain higher yield of crops. During 1990-2014, the amount of chemical fertilizer used per unit crop land had increased many folds (Table 3.5 and 3.6). Form the Table 3.6 it is evident that in 2014, Urea 68.75%, TSP 63.7%, DAP 100% and MOP 77.8% used as higher while in 1990 Urea 2500 m.ton TSP 800 m. ton and MOP 600 m.ton were used only. There was no use of DAP found in 1990, but in 2014, the use of DAP is about 2000 m.ton (Table 4.6). This result of the study supported by Tilman (1999) and Tilman *et al.* (2002). They reported that the past 35 years have seen a 6.87 fold increase in nitrogen fertilization and a 3.48 fold increase in phosphorus fertilization within intensive agricultural systems. This study also supported by Hossain and Tanveer (2012). They said that the cost of agriculture has increased manifold with declining yield levels and growing dependence on market for purchase of chemical fertilizers and pesticides.

3.6 Pesticide Practices in the Study Area

Agriculture has been highly susceptible to crop pest attacks and diseases. The incidence of pest occurs either sporadically or in out breaks every year throughout the country. Conservative estimates of annual crop losses are in the range of 10-15% without any direct intervention. In their defense, farmers have begun to use more toxic chemicals for pest control that have reputations of speed and effectiveness. The Government of Bangladesh also promotes the use of pesticides to expand its agricultural frontiers and increase output per acre of land. As a result, pesticide use in general is increasing. At present 123 generic pesticides with 2570 trade names have been registered in Bangladesh (Annon, 2011) to combat against these pests and diseases.

Table 3.7: Pesticide Practices in the Study Area (1990-2014)

Farmers name	Age	Total land (bigha)	Using pesticides	
			1990	2014
Abdus Salam Mondol	72	25	Cypermethrine, Carboforan, Diazinone, Metalexyl, Sulphate, Hexaconazole, Cartap	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Cartap/Diosulfan, Thiamethoxam 25 WG, Carbondazim, Carbofuran, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart
Orun kumar Datto	60	18	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Diazinone, Fosfamidon, Mencozeb	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Cartap/Diosulfan, Thiamethoxam 25 WG, Dimethoate, Carbendazim Dicloran, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart

Farmers name	Age	Total land (bigha)	Using pesticides	
			1990	2014
Masudur Rahman	50	15	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Diazinone, Carbendazim	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Carbendazim Cartap/ Diosulfan, Thiamethoxam 25 WG Fenvelerate, Emidoclocide 200 SL, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart
Md. Rafikul Islam	45	7	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Diazinone	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Carbendazim Cartap/Diosulfan, Thiamethoxam 25 WG Abamectine, PGR, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart
Md. Altab Hossain	56	12	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Diazinone, Fosfamidon, Nogos	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Carbendazim Cartap/ Diosulfan, Thiamethoxam 25 WG Propiconazole, Deltamethine 2.5 EC, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart
Md. Abu Syem	39	9	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Diazinone, Carbofurn, Cartap	Cypermethrine, Metalexyl, Sulphate, Hexaconazole, Profenophos, Mencozeb, Diazinone, Cartap/Diosulfan, Thiamethoxam 25 WG Carbodazim, Carbofurn, Carbosulfer, Lamda Cylothrin, Amamectin benzoit, Abamectin, Hexaconazole, emidaclopid, Pratilaclore, paracoart

Source: Interview of respondents

During the survey, local farmers of the area reported that the use of pesticides has increased rapidly with the introduction of HYVs. The villagers used no insecticides/ pesticides during 1980s, but since 1990s the attacks of diseases and pests intensified and more and more amounts of different pesticide have to be used (Table 3.7). Many pests and diseases were reported to become uncontrollable even with available pesticides and new diseases and pests are appearing in recent years.

The farmers reported that even after the use of pesticides, a significant proportion of crop ranging from 20% to 50 % were lost every year due to diseases and pests. This problem of crop loss due to pests and diseases has been escalating every year. Many different types of insects became very problematic causing huge damages every year. But by using of insecticides, some useful insects are facing a harmful effects and resulting depletion of biodiversity. Now herbicide are used for control weeds of crop fields which also causes native biodiversity loss.

Along with the use of fertilizers, the use of pesticides, mostly insecticides, has increased more than 10 items in 2014 in the study area mentioned respondents during FGDs and interview (Table 3.7, Plate -3.19 and 3.20). But in 1990, only a few types of insecticides used in cultivated land. The result of the study supported Longo and York (2008) found that the mass consumption of agrochemicals, pesticides, by industrialized agricultural systems worldwide threatened for human and ecosystem health. This study also supported by Ramaswamy (1992) and Jackson (1991). They said that several studies of farmers have shown that inadequate product labeling and farmers' lack of information have led to widespread overuse or misuse of dangerous pesticides. A substantial body of anecdotal evidence also suggests that pesticide poisonings and ecological damage have become commonplace in Bangladesh. This study also supported by Halim, *et al.,* (2013) and they said that chemical fertilizers, pesticides and insecticides etc. are using for cultivation which is a cause of extinction of some environment friendly faunal species.

Plate 3.17: In this Time, so Rare Using of Cowdung as Organic Manure

Plate 3.18: Using of Cowdung as Fuel for Crisis of Natural Fuel

Plate 3.19: Different Types of Chemical Fertilizer Store in the Study Area

Plate 3.20: Different Types of Pesticides Store in the Study Area

Plate 3.21: Over Doses Spraying of Harbiside in a Banana Garden

Plate 3.22: Negative Effects of Herbicides on Cropland

3.7 Rainfall in the Study Area

Rainfall is the primary factor affecting crop production in rain-fed agriculture Godwin (1990). The impact of raindrops on the soil surface results in temporary capping of the soil and lowered infiltration rate, thus generating runoff. The crop production potential of granitic sandy soils is low, but if adequate fertilisers are applied, average yields can be achieved. However, the fertiliser application is very much dependent on rainfall, so that rainfall becomes the most important factor influencing crop production. Rainfall distribution becomes an important factor if the effect of mid-season droughts is to be minimized.

Table 3.8: Statement of Monthly Rainfall During 2012, 2013, 2014, 2015, 2016 of Puthia Upazilla

Sl. No.	Name of Month	2012 Amountof Rainfall (m.m.)	2013 Amountof Rainfall (m.m.)	2014 Amountof Rainfall (m.m.)	2015 Amountof Rainfall (m.m.)	2016 Amountof Rainfall (m.m.)
1.	January	-	5	00	05	36
2.	February	-	17	35	18	00
3.	March	6	12	09	25	07...
4.	April	90	25	55	146	
5.	May	26	110	166	175	
6.	June	103	204	292	395	
7.	July	131	132	256	348	
8.	August	76	206	324	274	
9.	September	135	226	321	187	
10.	October	96	197	17	39	
11.	November	66	-	0	11	
12.	December	-	-	0	03	
Total		**729**	**1134**	**1475**	**1626**	

Source: DAE, Puthia

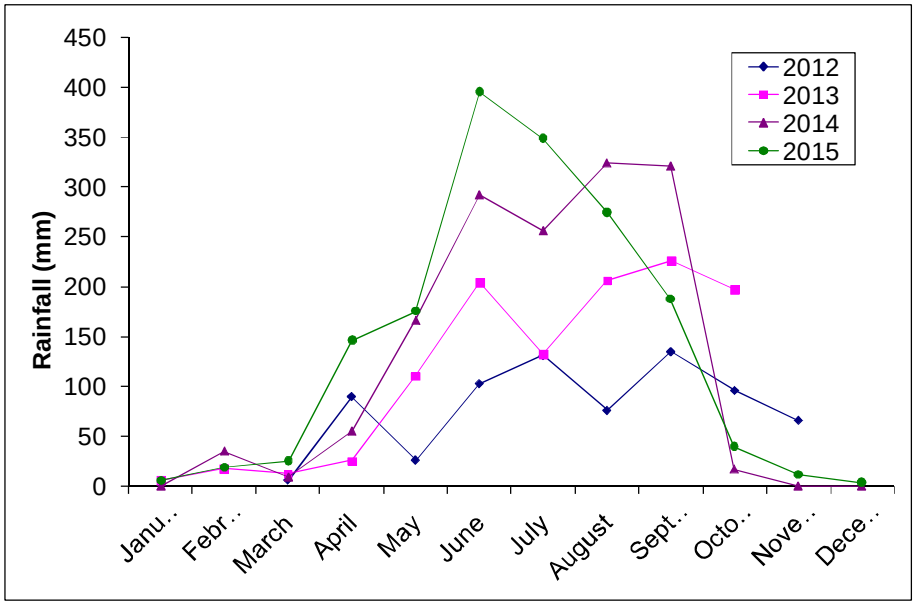


Figure 3.7: Monthly Variation of Rain Fall from 2012-2015

Table 4.12 shows the rain fall data over time (2012-2015). Though a definite trend can not be traced, the variability of rainfall during the dry season (November-May) is remarkable (Figure 3.7).

It is not possible to establish a trend in the rainfall, wide variation was the rule. Figure 3.7 indicates December month was rainless and November, January, February and March months had little amount of rainfall. May-October was the heavy rainfall in the study area during 2012-2015.

The timing of the first rainfall of the end of the dry season also reported to vary widely. This is important because too early rain fall damages Boro paddy (Plate 3.2) and Rabi crops while too late rain fall induces strong drought.

Generally paddy cultivation in the area was not possible in lowland areas due to flooding during August to September. Because, heavy rainfall during this period cause to flood and the low land became flooded by rain water.

The people of the study area build their homesteads in elevated lands to escape flood and remain unaffected except extreme floods like in the 1988. But the low lying crop fields are much more damaged by annual floods. Guava, Jujube,

banana gardens also were damaged by water logging due to irregular rainfall and drought which causes unexpected loss in the study area (case study 1).

3.8 Ground Water Depletion in the Study Area

The number of days per year where tube wells in the study area failed to supply water due to static lebel of water is given in Table 3.10. Increase in number of dry period for tube wells indicates prolonged unavailability of water.

The minimum level has sunk and a number of wells become dry during the summer months. Many of the hand tube wells become dry and remain dry for longer periods during the summer months in the last decade. Also, the irrigation wells (shallow tube wells) fail to supply water, many of these have to be resunk in deep pits for lifting water. The local people and well operator informed that level of ground water table sinks rapidly during the dry season. Hand tube wells failed to supply water during the dry season.

Table 3.9: Level of Ground Water Table (Static Level) During 1990- 2014

1990		**2014**	
Wet Season (ft.)	**Dry Season** (ft.)	**Wet Season** (ft.)	**Dry Season** (ft.)
14-17	26-28	16-20	30-32

Source: Official record of DPHE, Puthia

Table 3.10: Underground Water Crisis in the Study Area

No. of Tube Wells (%)	**Running Dry (Days)**
90-95	60-90 (March-May)
30-35	90-60 (May-June)

Source: Officilal record of DPHE, Puthia

The duration of annual periods of drought in the study area ranges from mid February to mid May as reported by the villagers. In years like 1995, 1996 and 1997 the drought lasted for 3 months; but in like 1994 the drought lasted only for one

month. In recent years, the numbers of dry tube wells and shallow pumps became the major cause of drought and water crisis in the area according to FGDs. Now a days, mainly sub-mersible pump are using for drinking water.

Plate 3.23: Underground Water Crisis in the Study Area

The number of shallow, deep and hand- tube wells has increased in the study area during 1990-2014. The use of ring well and surface water for drinking and domestic use has declined. In recent years, only deep wells supply water during dry season reported DPHE, Puthia and FGDs.

Irrigation from surface water bodies where ground water is not available and when tube wells run dry became less and less available during 2000 onwards. Even during droughts when tube well water is unavailable, pond water is used for domestic and drinking. The local community reported that some ponds do not become dry, but availability of safe water becomes a serious problem, especially in upland villages. The report of the study supported by Rahman and Mahbub (2012) and they reported that agricultural pattern, cropping intensity (262% in Tanore upazilla and national intensity is 180%), methods of cultivation, crop variety and yields all show a positive change after starting of

groundwater irrigation in mid 1980s, but water level is continuously lowering at the rate of 1.37 ft/y in wet season and 0.72 ft/y in dry season. Water is the main input for agriculture but successive depletion of groundwater level can be a serious problem for water stressed of Barind Tract.

3.9 Pond Number and Area are Increased in the Study Area

The number of ponds has increased (Table 3.11) during the period 1990-2014. Total number of ponds increased both in the areas and the rate of increase in the ponds was more in lowland than upland during the period 1990-2014. The new ponds were excavated to meet the surface water needs, modern fish culture and also to elevate lands for homestead too. Though the number of ponds increased slightly (Table 3.11), but availability of water during the dry season decreased substantially. The increase in population and demand of water resource are emphasized by the local community.

Table 3.11: Number of Ponds in Upland and Lowland During 1990-2014

Land use	Area	Village	1990	2014	Changes
Perennial water bodies	**Upland**	V1	12	14	+2
		V2	4	5	+1
		V3	13	11	-2
		Total	29	30	+1
	Lowland	V1	5	9	+4
		V2	8	17	+9
		V3	12	23	+11
		Total	25	49	+24

Source: Official Record of DoF, Puthia

[Upland V_1= Baraipara, V_2=Ramjibanpur, V_3= Kathalbaria and Low land V_1= Shilmaria, V_2=Udanpur, V_3= Pompara]

Sources of above ground water, amount and quality has been declined in the study area during 1990-2014. The ponds and canals, which are man-mode and the beel area, are important sources for storage and availability of surface water. Respondent mentioned that both amount and quantity changed during the period (1990-2014). This study also supported by Halim, *et. al.*, (2013) and they reported that water bodies are the most common phenomenon in Rajshahi

district. Water bodies have increased than previous especially the numbers of pond have increased due to more profit. Chemical fertilizers, pesticides and insecticides etc. are using for cultivation which is a cause of extinction of some environment friendly faunal species.

Table 3.12: Changing Pattern of Fish Farming During 1990-2014

		Upland		Lowland	
Year	**Village**	**Indigenous**	**Culture**	**Indigenous**	**Culture**
1990	V1	8	4	5	0
	V2	4	0	7	1
	V3	10	3	9	3
	Total	**22**	**7**	**21**	**4**
2014	V1	0	14	0	9
	V2	0	5	0	17
	V3	0	11	0	23
	Total	**0**	**30**	**0**	**49**

Source: Official record of Dof, Puthia and FGDs

[Upland V_1= Baraipara, V_2=Ramjibanpur, V_3= Kathalbaria and Low land V_1= Shilmaria, V_2=Udanpur, V_3= Pompara]

The result of the study supported by Joadder, *et. al.* (2013). They said that fish farmers are adopting scientific technologies instead of ancient culture methods. Saha (2003) also supported the results of this study.

3.10 Changes in Biodiversity from 1990-2014.

The changes in biodiversity of the study area was assessed and described under following heads:

i) Time trend analysis:
ii) List of lost/ rare (threatened) species

3.10.1 Time Trend Analysis

Data regarding different species of plants and animals in Rajshahi district over long period of time were not available. Hence, the time trend analysis was done through focus group discussion and interview to assess the change in biodiversity over a period of 24 years (1990-2014). Species richness was considered for evaluating the change in biodiversity over time.

However, the changes in species diversity of different categories of plants (Fruit, Timber, weeds, vegetables, medicinal), animals, birds and fishes over last two and half decades (1990-2014) are presented in following two broad heads:

i) Changes in plant-biodiversity (1990-2014)
ii) Changes in animal-biodiversity (1990-2014)

3.10.1.1 Changes in Plant Biodiversity in the Study Area (1990-2014)

The changes in plant biodiversity was assessed by grouping the plants into several categories such as: 'Timber tree', Fruit trees', 'Medicinal plants', 'Vegetables' and 'Species'. Findings of the time trend analysis are discussed below.

3.10.1.1.1 Different Fruit Plants Diversity in the Study Area

According to the respondents of the FGDs, there were 31 fruit species common during 1990s such as: Lichu (*Litchi chinesis*), Peyara (*Psidium guajava*), Boroi/kul (*Zizyphus mauritiana*), Lebu *(Citrus Spp.),* Amra (*Spondias pinnata*), Ata *(Anona Spp.),* Dalim *(Punica granatum*), Bel *(Aegle spp.*) Sopheda *(Manilkara achras*), Kola *(Musa spp.),* Papaya (*Corica papaya*), Dawaya *(Artocarpus lakoocha*), Karamcha (*Caesalpinia crista*), Kathal (*Artocarpus heterophyllus*), Dhapar (*Flacouritia ramontchi*), Kalojaam *(Syzygium cuminii*), Narikel *(Cocos nucifera*), Khejur *(Phoenix sylvestris*), Taal *(Borassus flabellifer),* Tetul *(Tamarindous indica*), Dumur (*Ficus hispida*), Supari *(Areca catechu*), Jamrul *(Syzygium samarangense*), Kamranga *(Averrhoa camrambola*), Bag borie *(Zizyohus oenoplea*), Jangle Jackfruit (*Artocarpus lekucha*), Kathbel *(Ferornia lizmonia*), Gab (*Diospyros peregrine*), Jambura *(Citrus grandis*), Chalta *(Dillenia indica),* Bel *(Aegle mermelos*); list has been presented also in Appendix 3.1. The number of species was somewhat decreased in the following decades and 10 species Amra, Dalim, Sopheda, Dawya, Karamcha, Tetul, Jamrul, Kamranga Chalta and Gab were recorded rare (threatened) in 2014. Dhapar, Bag borie and Jangle Jackfruit which were lost or not present in the study area none of the respondents in FGDs mentioned these species for the period of 2014. These species were also not observed or recored during the course of interview.

Table 3.13: Different Fruit Plants Diversity in the Study Area During 1990-2014

Sl.	Common 1990		(%)*	Rare 2014	(%)*
	Local Name	**Scientific name**		**Local Name**	
1	Lichu	*Litchi chinensis*	100		
2	Peyara	*Psidium guajava*	100		
3	Boroi/kul	*Zizyphus mauritiana*	100		
4	Lebu	*Citrus sp.*	100		
5	Amra	*Spondias pinnata*	85	Amra	95
6	Ata	*Anona sp.*	87		
7	Dalim	*Punica granatum*	82	Dalim	60
8	Bel	*Aegle sp.*	98		
9	Sopheda	*Manilkara achras*	76	Sopheda	85
10	Kola	*Musa* spp.	100		
11	Papaya	*Corica papaya*	100		
12	Dawya	*Artocarpus lakoocha*	75	Dawya	75
13	Karamcha	*Caesalpinia crista*	72	Karamcha	90
14	Kathal	*Artocarpus heterophyllus*	100		
15	Dhapar	*Flacouritia ramontchi*	63	Dhapar	100
16	Kalojaam	*Syzygium cuminii*	100		
17	Narikel	*Cocos nucifera*	100		
18	Khejur	*Phoenix sylvestris*	100		
19	Taal	*Borassus flabellifer*	98		
20	Tetul	*Tamarindous indica*	90	Tetul	65
21	Dumur	*Ficus hispida*	89		
22	Supari	*Areca catechu*	100		
23	Jamrul	*Syzygium samarangense*	95	Jamrul	55
24	Kamranga	*Averrhoa camrambola*	88	Kamranga	70
25	Bag borie	*Zizyohus oenoplea*	70	Bag borie	100
26	Jangle Jackfruit	*Artocarpus lekucha*	68	Jangle Jackfruit	100
27	Kathbel	*Ferornia lizmonia*	95		
28	Gab	*Diospyros peregrine*	72	Gab	95
29	Jambura	*Citrus grandis*	100		
30	Chalta	*Dillenia indica*	82	Chalta	90
31	Bel	*Aegle mermelos*	100		

Source: FGDs and interview (* % Respondents mention)

The result of this study supported by Mannan (2000), he identified 34 fruit species in the rural homesteads of Gazipur district. Another researcher Rafiqul (2012) identified 30 fruit species in the rural homesteads of Gazipur district.

Caste Study : One

A permanent resident of Baroipara village, Md. Tozrul Islam is a young well-to-do farmer. Only 40 years old, he is very active and always try to adopt new ideas. When watched a television programme on "Apple kul", a high yielding variety of jujube, he became interested and decided to invest 2 areas of his 5 acres of land for jujube cultivation.


Md. Tozrul Islam (40)

He borrowed Tk 50 thousand and spend it to prepare land and buy 300 jujube seedlings from Rajshahi Agricultural Farm. He established the jujube field in 2010 took care of the cuttings and had to invest another 10 thousand Taka. He started getting fruits during 2011-2012 seasons and during the two seasons he earned about 21 thousand Taka.

He was expecting a better crop during 2013-2014 season but the plants shoed no sings of bloom till late in the season. Only a few plants had some flowers but they dropped off. When reported to the local Thana Agricultural Officer, he said that untimely rainfall and unfavorable temperature were responsible for lack of flower and flower damage this year.

Less than expected return and complete damage of crop compelled Mr. Sarker to abandon jujube, he has decided to cut down all his jujube plants and cultivate other more profitable and regular bearing crop.

3.10.1.1.2 Different Timber Plants Diversity in the Study Area

During 90s (1990-2000), there were as much as 29 timber species in the study area as mentioned by the respondents in FGDs, which were such as: Khayer (*Albizia procera*), Babla (*Acacia nylotica*), Nem (*Azadirachta indica*), Sathim (*Alstonia scholaris*), Bot (*Ficus benghalensis*), Hizul (*Barringtonia acutangula*), Kadam

(*Anthocephalus cadamba*), Badorlathi (*Cassia fistula*), Meghoni (*Swietenia mahagoni*), Sissoo (*Dulbergia sissoo*), Debdaru (*Polyalthia longifolia*), Arjun (*Terminalia arjuna*), Bola (*Kleinhovia hospital*) Khoksa (*Ficus hispida*), Pipul (*Piper longum*), Akashmoni (*Acacia moniliformis*), Eucalyptus (*Eucalyptus citriodora*), Epilepil (*Leucaena leucocephala*), Baet (*Calamus* spp.), Tamal (*Diospyros cordifolia*), Krishnachurra (*Delonix regia*), Bash (*Bambusa* spp.), Simul (*Gossypium herbaceum*), Jiga (*Lagerstroemia flos reginae*), Mander (*Erythrina inidca*), Gamar (*Gmelina arborea*) Horitoki (*Terminalia chebula*) Ashok (*Saraca asoca*) and Pycor (*Ficus comosa*); a list has also been presented in Appendix 3.2. Number of species gradually decreased over time and 11 species such as: Babla, Sathim, Sishu, Arjun, Bola, Beat, Simul, Jiga, Mander Asok and Gamar were recorded rare (threatened) in 2014. Khayer, Hizul, Badorlathi, Tamal and Horitoki were not present or lost form the study area as none of the respondents in FGDs mentioned these species for the period of 2014. These species were also not observed or recorded during the course of interview.

Table 3.14: Different Timber Plants Diversity in the Study Area During 1990-2014

Sl. No.	Common 1990		(%)*	Rare 2014	(%)*
	Local Name	Scientific Name		Local Name	
1	Khayer	*Albizia procera*	95	Khayer	100
2	Babla	*Acacia nylotica*	86	Babla	95
3	Nem	*Azadirachta indica*	98		
4	Sathim	*Alstonia scholaris*	95	Sathim	90
5	Bot	*Ficus benghalensis*	98		
6	Hizul	*Barringtonia acutangula*	86	Hizul	100
7	Kadam	*Anthocephalus cadamba*	95		
8	Badorlathi	*Cassia fistula*	85	Badorlathi	100
9	Meghoni	*Swietenia mahagoni*	100		
10	Sissoo	*Dulbergia sissoo*	100	Sisso	90
11	Debdaru	*Polyalthia longifolia*	95		
12	Arjun	*Terminalia arjuna*	82	Arjun	98
13	Bola	*Kleinhovia hospital*	95	Bola	98
14	Khoksa	*Ficus hispida*	100		
15	Pipul	*Piper longum*	90		
16	Akashmoni	*Acacia moniliformis*	95		

17	Eucalyptus	*Eucalyptus citriodora*	88		
18	Epilepil	*Leucaena leucocephala*	100		
19	Baet	*Calamus spp*	95	Baet	*96*
20	Tamal	*Diospyros cordifolia*	82	Tamal	100
21	Krishnachurra	*Delonix regia*	100		
22	Bash	*Bambusa* sp.	100		
23	Simul	*Gossypium herbaceum*	95	Simul	85
24	Jiga	*Lagerstroemia flos reginae*	95	Jiga	88
25	Mander	*Erythrina inidca*	98	Mander	85
26	Gamar	*Gmelina arborea*	90	Gamar	95
27	Horitoki	*Terminalia chebula*	85	Horitoki	100
28	Pycor	*Ficus comosa*	78		
29	Ashok	*Saraca asaca*	85	Ashok	89

Source: FGDs and interview (* % Respondents mention)

The result of this study supported by Rafiqul (2012), he identified identified only 17 timber species in the rural homesteads of Gazipur district. Another researcher Rahman (2015) also supported the result of the study and said in his study that more than 85 percent of Modhupur forest has been cleared in last 40 years. In most of the areas the age of sal forest is not more than 10 to 15 years.

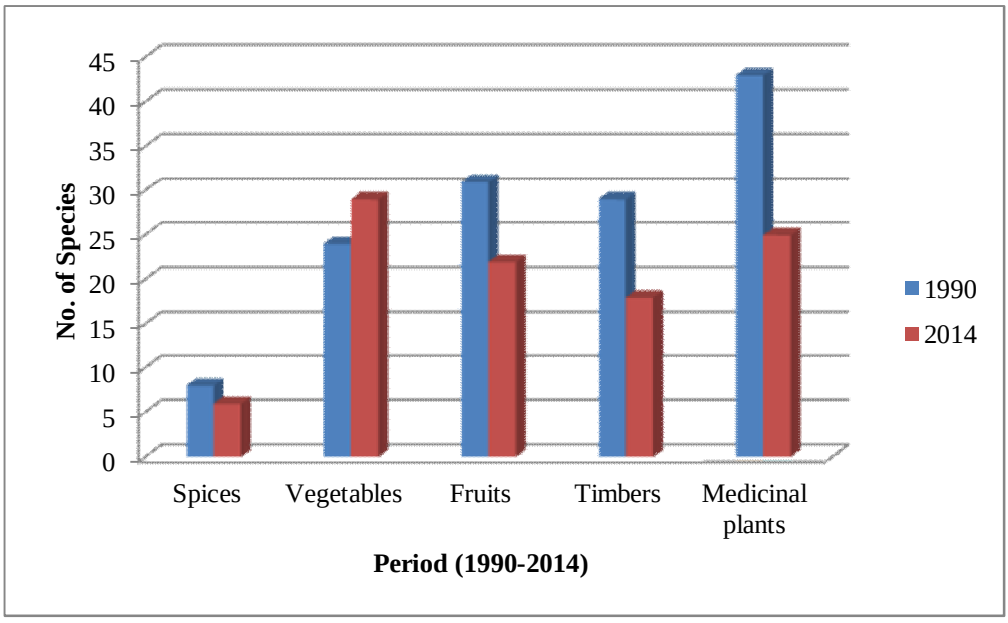


Figure 3.8: Changes in Plant Biodiversity (Species Richness) in the Study Area (1990-2014)

3.10.1.1.3 Depletion of Medicinal Plants Diversity in the Study Area

Local peoples and some selected 'Kabiraj' reported that many people in the study area used traditional medicine for their common diseases during 1970s, these medicinal plants were found local ecosystem and were available in the study area. In the FGDs for time trend analysis, a total of 43 medicianl plants were recorded for the period of 1990 such as; Tulshi (*Ocimum santum)*, Durba (*Cynodon dactylon),* Duttura (*Datura metel),* Akanda (*Calotropis procera*), Apang (*Achyranthes aspera*), Neem (*Azadirachta indica*), Kochu (*Colocasia esculenta*), Bashok (*Adhatoda vasica*), Bael (*Aegle spp.)* Jaam (*Syzygium cumini*), Shorisha (*Brassica napus*), Varenda (*Ricinus communis),* Hatishur (*Heliotropium indicum*), Katanate (*Amaranthus spinosus*), Jostimodhu (*Glycerrhiza glabra),* Dhonia, (*Coriandrum sativum*), Thankuni (*Holorhena antidysenterica*), Biskhatalee (*Cinnamomum tamala*), Paddo *(Nelumbo nucifera*), Anantomul (*Hemidesmus indicus*), Panimorich (*Polygonum hydropiper*), Begun (*Solanum melogena),* Peyaj (*Allium cepa*), Rosun *(Allium sativum*), Greetokumari (*Aloe indica*) Lebu *(Citrus spp.*). Arjun (*Terminalia arjuna*) Sorpogondha (*Rauwolfia serpentine),* Kamranga (*Averrhoa carambola*), Satomuli (*Asparagus racemosus)* Shimul (*Bombax ceiba*), Mukta Jhuri (*Acalypha indica*), Golmorich (*Piper nigrum*), Kalomegh (*Andrographis paniculata*), Kuinien (*Cinchona officinalis*), Dadmordon (*Cassia alata*), Babla (*Acacia nylotica*), Kolkosunda *(Cassia sophera*), Mehedi (*Lawsonia inermis),* Kadam (*Anthocephalus cadamba*), Ashok (Saraca asoca), Horitoki *(Terminalia chebula)* and Bohera (*Terminalia berica)* (Appendix 3.3). Downward trend was observed in this case also. The number of species descreased over time and 9 species such as: Tulshi, Akanda, Paddo, Arjun, Kamranga, Satomuli, Golmorich, Babla, Ashok and Simul were rare (threatened) as the respondents FGDs and interviews mentioned. None of the respondents in FGDs mentioned that Sorpogondha, Bohera, Horitoki, Bashok and Kuinien these 5 species were lost or not present or eliminated from the study area during 2014. These species were also not observed or recored during in the course of interviews.

Table 3.15: Depletion of Medicinal Plants Diversity in the Study Area During 1990-2014

Sl. No.	Common 1990		(%)*	Rare 2014	(%)*
	Local Name	Scientific name		Local Name	
1	Tulshi	*Ocimum santum*	97	Tulshi	85
2	Durba	*Cynodon dactylon*	100		
3	Duttura	*Datura metel*	95		
4	Akanda	*Calotropis procera*	92	Akanda	62
5	Apang	*Achyranthes aspera*	90		
6	Nem	*Azadirachta indica*	98		
7	Kochu	*Colocasia esculenta*	100		
8	Bashok	*Adhatoda vasica*	85	Bashok	100
9	Bel	*Aegle sp.*	100		
10	Jam	*Syzygium cumini*	100		
11	Shorisha	*Brassica napus*	100		
12	Varenda	*Ricinus communis*	100		
13	Hatishur	*Heliotropium indicum*	100		
14	Katanate	*Amaranthus spinosus*	100		
15	Jostimodhu	*Glycerrhiza glabra*	93		
16	Dhonia	*Coriandrum sativum*	94		
17	Thankuni	*Holorhena antidysenterica*	95		
18	Biskhatalee	*Cinnamomum tamala*	90		
19	Paddo	*Nelumbo nucifera*	94	Paddo	73
20	Anantomul	*Hemidesmus indicus*	92		
21	Panimorich	*Polygonum hydropiper*	95		
22	Begun	*Solanum melongena*	100		
23	Peyaj	*Allium cepa*	100		
24	Rosun	*Allium sativum*	100		
25	Greetokumari	*Aloe indica*	92		
26	Lebu	*Citrus sp*	100		
27	Arjun	*Terminalia arjuna*	82	Arjun	98
28	Sorpogondha	*Rauwolfia serpentine*	82	Sorpogondha	100
29	Kamranga	*Averrhoa carambola*	88	Kamranga	70
30	Satomuli	*Asparagus racemosus*	92	Satomuli	90
31	Shimul	*Bombax ceiba*	95	Shimul	85
32	Mukta Jhuri	*Acalypha indica*	98		
33	Golmorich	*Piper nigrum*	82	Golmorich	98
34	Kalomegh	*Andrographis paniculata*	94		
35	Kuinien	*Cinchona officinalis*	78	Kuinien	100
36	Dadmordon	*Cassia alata*	98		
37	Babla	*Acacia nylotica*	86	Babla	95
38	Kolkosunda	*Cassia sophera*	93		
39	Mehedi	*Lawsonia inermis*	90		
40	Kadam	*Anthocephalus cadamba*	95		
41	Ashok	*Saraca asoca*	85	Ashok	89
42	Bohera	*Terminalia berica*	80	Bohera	100
43	Horitoki	*Terminalia chebula*	85	Horitoki	100

Source: FGDs and interview (* % Respondents mention)

The result of this study supported by Rafiqul (2012), he identified identified 16 medicinal plant species in the rural homesteads of Gazipur district. Rahman *et. al.,* (2008) were recorded 49 species of medicinal plant in Rajshahi city. Rahman and Sarker (2015) were documted 143 medicinal plants with their uses for the cure of more than 109 diseases in Katakhali Pouroshova, Rajshahi. Rahman *et. al.,* (2013) were recorded 102 species of medicinal plant in Naogaon district. Rahman and Keya (2015) were recorded 119 species of medicinal plant in Bogra district.

3.10.1.1.4 Vegetables and Spices Diversity of the Study Area

Vegetables Diversity: An increasing trend was observed in case of vegetables species (Fig. 4.8) According to respondents of the FGDs, there were 24 vegetable species during the period 1990 same species was also recorded for the period 1990-2014 (Fig. 4.8). Thes species were Chalkumra (*Benincasa hispida),* Karola (*Momordica charantia*), Begun (*Solanum meloggenan*), Lau (*Leginaria vulgaris*), Badha kopi (*Brassica oleracea var. capitata*), Ful Kopi (*Brassica oleracea var. botrytis*), Seem (*Dolichos lablab*), Shosa (*Cucumis sativus*), Sajina (*Moringa oleifera*), Mankachu *(Alocasia indica*), Pui shak (*Basellam alba*), Dherosh (*Hibiscus esculantus*), Mula (*Raphanus sativus*), Lal shak (*Amaranthus tricolor*), Jhinga (*Luffa acutangula*), Chichinga (*Trychosanthes anguina*), Palong shak (*Spinacia oleraceae*), Dhundul (*Luffa cylindrical*), Data (*Amaranthus lividus*) Misti kumra (*Cucurbita moschata),* Mukhi kachu (*Colocasia esculenta*), Tomato (*Lycopersicon esculentum*), Kakrol (*Momordica diocia*), Borboti (*Vigna unguieulata*); a list appears in Appendix 3.4. During the following two and half decades (1990-2014) some vegetables like Kalmi shak (*Ipomoea reptans),* Badha kopi (*Brassica oleracea var. capitata)* and Ful kopi (*Brassica oleracea var. botrytis*) were recorded which might be introduced throught the DAE and NGOs. The result of this study supported by Alam and Masum (2005), they found country bean, ash gourd, sweet gourd, tomato, brinjal, cabbage, amaranth and radish in higher percent of homesteads of sandwip upazilla in Chittagong. Another researcher Mannan (2000) found sweet gourd, country bean, stem amaranth,

Indian spinach, ash gourd, sponge gourd and brinjal in higher percent of the homesteads in Gagipur. Rafiqul (2012) identified 28 vegetables species in the rural homesteads of Gazipur district.

Spices Diversity: The number of spcies as recorded in the FGDs for the period of 1990-2014 were the same and the species were: chilli (*Capsicum annum)*, coriander (*Cariandrum stivum)*, garlic (*Allium sativus)*, onion *(Allium cepa)*, ginger (*Zingiber*), turmeric (*Curcuma longa)*, anise (*Pinpinella anisum)*, Black cumin (*Nigella sativa)* and bay leaf (*Cinnamum tamala*) (Appendix 3.4). There was no such change in the species of spcies over time (Fig. 3.8) but area under cultivation of spices decreased remarkably as mentioned by the respondents. Among the above mentioned species, anise and bay leaf were not found during the period 2014. The result of this study supported by Mannan (2000) and he recorded turmeric, chili, ginger, bay leaf and cinnamon respectively in 46, 24, 8, 6 and 2 percent of the homesteadsvat Bandarban; while turmeric, bay leaf, chili and cinnamon respectively in 22, 8, 4 and 2 percent of the homesteads in Niamatpur. Another researcher Rafiqul (2012) identified 6 species of spices in the rural homesteads of Gazipur district.

Case Study: Two

A class five passed house wife of village Ramjibanpur, Shela Begum, only 32 years old, has been living in this home since her childhood. She is married to a local small farmer of the same village and has two children. Her husband owns only about 1 bigha of agricultural land and a very small homestead.


Shela Begum (32)

From childhood she with her fellow playmate used to gather leafy vegetables from fallow lands and crop fields. As children from poor marginal farmers, they had little money to buy vegetables. These wild leafy vegetables used to grow around their little homesteads, used to meet their daily demand.

When asked, she said that many different kinds of wild vegetables were easily available near their homes in the past. To meet the need, she said that she had to spend only half an hour before or after school, to collect enough leaves for daily consumption of her family. When asked to mention a few, she named kanta nate (*Amaranthus spinosus*), kalmi (*Ipomoea aquatica*), kachu (*Colocasia esculenta*), Helencha (*Alternanthera sp*.), Nate (*Amaranthus viridis*), Bathua (*Chenopodium sp*.), Telakuch (*Coccianea cordifolia*), Dheki (ferns), and Shapla or Shaluk (*Nymphea sp*.) etc.

But she said with a tone sadness and despair, very little wild leafy vegetables are available now. "You have to spend hours and walk miles to collect only a handful of leaves", she said. Sreemoti Das also said, "we seldom go out to gather these now-a-days".

3.10.1.1.5 Abundance of Plant Species

Changes in natural vegetation directly affected the abundance of plant and tree species in the study area during 1990-2014. The spots of fallow lands and jungles had been removed after 1990s; the low lying wetland and grass lands were drained off and converted into crop lands during 1990s and recently converted into Ponds. Most of the aquatic weed and grass species including terrestrial plant species totally disappeared during this period. The villagers and old poor women reported that they used leafy wild plants as vegetables. These vegetables support them economically and provided nutrition. Upland villagers used most of the vegetables during 1990s but their availability has been decreased during 2014. In the lowland villages leafy wild vegetables were also reduced. Maximum family used these vegetables and due to lack of availability their used decreased during 2014 (case study 2). The result of this study supported by OFRD (2001), reported that a wide variety of plant species was found in the homesteads at Farming Systems Research (FSR) site, Noakhali. More than 62 useful species were identified in the homesteads among them 30.91% fruits (perennial and annual) 29.09% timber, 34.54% vegetables, and 5.45% were spices. Another report supported the result of the study by Alam and

Masum (2005) identified 142 plant species belonging to 61 families in the homesteads of an offshore island, of which 76 species were recorded as tree species, 25 shrub species and 41 herb species. Diversity and abundance of fruit species was found higher in all homestead.

3.10.1.2 Changes in Animal Biodiversity in the Study Area (1990-2014)

The animals in the study area were grouped into several categories such as livestock, poultry, pet animals, wild animals, birds and fishs for assessing the changes in animal-biodiversity over last two and half decades (1990-2014). Findings of the time trend analysis are discussed below.

3.10.1.2.1 Livestock, Poultry and Pet Animal's Diversity in the Study Area

Livestock Diversity: Cattle (*Bos primigenius taurus*), buffaloes (*Bubalus bubalis*), goat (*Capra aegagrus hircus*) and sheep (*Ovis aries*) were the common species in the study area during the period of 80s and 90s. But the number of buffalo and sheep decreased and there was no buffalo and sheep during the period of 2014 (Fig. 3.9) (Appendix 3.6). Number of goat was also decreasing as mentioned by the respondents. Lack of grazing field, lack of feeds and fodder might be the reasons for extinction of buffaloes from this area. The number of cattle also decreased in the area for similar reasons. Introduction of power tiller during 90s onward might be an important reason for decrease in cattle population. It should be noted that rearing of improved breed and cross-breed cow has increased in the area since 90s due to expansion of artificial insemination programme and also due to government and NGO initiative for providing loan for this purpose. It was observed during the course of interview that rearing of local breed of chicken reduced in the area mainly due to avoid conflict with neighbours. Rearing of duck and pegion might also reduce for similar reason. However, rearing of improved breed of chicken has been flourishing in Rajshahi district since late 90s, but a few households were there in the study area having improved breed of chicken or improved poultry farms. This study supported by Rafiqul (2012), he identified 4 livestocks species in the rural homesteads of Gazipur district.

Poultry Diversity: It included chicken (*Gallus domesticus*), duck (*Anas platyrhyncha*), goose (*Anser cygnoides*) and pigeon (*Columbia livia*). According to the respondents of FGDs, all these species were available during 90s but their number decreased in 2014 (Fig. 3.9) (Appendix 3.6). Respondents of the FGDs for the period of (1990-2014) did not mention about goose. This one species was also not found in any household during the interview. This study supported by Rafiqul (2012), he identified 3 poultry species in the rural homesteads of Gazipur district.

Pet animals diversity: During the period of 1990, there were different pet animals in study area like cat (*Felis catus*), dog (*Canis lupusfamiliaris*), hare (*Oryctolagus cuniculus*), Tia (*Psittacula krameri manillensis*), dove (*Streptopelia chinesis*), and house-myna (*Acridotheres tristis*); a list appears in Appendix 3.6. The number of species decreased in the following decades and only two species *i.e.* dog and cat were recorded during the period of 2014 (Fig. 4.9). Once, having a pet animal particularly birds like mynah, parrot, cockatoo, etc. was considered as part of aristocracy. During the pre-liberation period (60s and back) and also in early 70s, pet animals like birds, dogs, cats were being reared by all classes of people particularly by rich and middle class families. Collecting and rearing different types of birds, dogs, cats, etc. was a good item of recreation to children and young generation. During the period after liberation (*i.e.* 1971 onwards), lifestyle of people has changed gradually to cope with destructed economy of the country during liberation war, political instability, natural calamities, crisis of food, abrupt increase in cost of living and also in adoption of modern technologies like cassette/CD player, TV, satellite channel, computer, etc. Actually TV and VCD become major items of recreation to young generation and children since 2000s onward both in urban and rural areas. In the recent years, computer has become the major item of recreation and as such children

and young generation getting detached from the nature which might be one of the important reasons for decrease in pet animals. Above all, unavailability of such bird species like mynah, parrot, cockatoo, dove etc. due mass destruction of trees in the locality might be an important reason in this regard. This study supported by Rafiqul (2012), he identified 2 pet animal species in the rural homesteads of Gazipur district.

Case Study: Three

Md. Harun-or-Rashid is an old farmer of village Ramjibanpur. He is 85 Years Old. A head of household with 13 members, he inherited about 4 acres of land from his father.

Md. Harun-or-Rashid (85)

When young, he had 4 cows, 2 buffalos, 4 goats, more than one dozen chicken and 2/3 dozens ducks. He never had problem in the past to look after these domestic animals because there as plenty of falow land around his home and the water bodies were rich in feed. He's children of the house and women folk looked after these animals.

But now he has only 1 cow, 2 goats and 6 chickens in his home. When asked why, he replied that there is no fallow land around his house, so it became difficult to keep animals. The goats and chicken damage crops and vegetables in nearby fields and kitchen garden. The neighbors complain about such incidents so he had to sell off his goats. There is no water bodies for ducks so numbers were reduced. There is no land for cattle to graze; he had to feed his cows buying hey and other animal food from the market. He felt sorry that he does not get pure milk to drink and is deprived from the income out for his domestic animals.

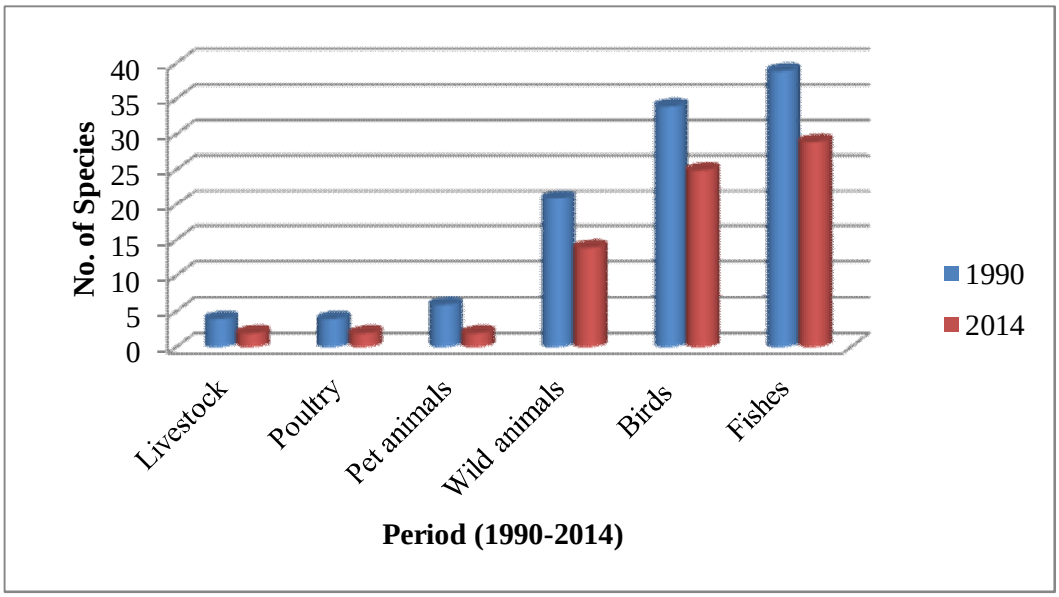


Figure 3.9: Changes in Animal Biodiversity (Species Richness) in the Study Area (1990-2014)

3.10.1.2.2 Wild Life Diversity

A total of 21 wild animals species recoreded during the FGDs for the period 1990 were such as Sheal (*Vulpus spp.)*, Begi (*Herpestes* spp.), Ban biral (*Felis* spp.), Mecho Bagh (*Neofelis nebulosa*), Casshop (*Testudo* spp.) Guisap (*Varanus* spp.), Sona bang (*Rana tigrina)*, Gecho bang (*Rhacophrous* spp.), Badhur (*Pteropus giganteus*), Chamcika (*Pipestrellus coromandallanus)*, Katberali (*Funumbulus pennanti*), Edur (*Mus musculus, Rattus rattus, Bandicoota* spp.), Khorgos (*Lepus nigricollis reficaudatus*), Goma (Ghokra) (*Naza* spp.) Bora (*Vipera ruselli*), Daras (*Ptyas muscosus*), Dumukho (*Bungarus fasciatus*), Kaklas (*Calotis versicolor*) and Onjony (*Mabua carianta)*. The number of wild animals species descresed and 7 species such as Sheal, Begi, Casshop, Guisap, Goma (Ghokra), Bora, Daras and Dumukho were rare (thretened) in the study area during 2014 metioned the respondents in FGDs and interviews. Ban biral, Mecho bagh, Gecho bang, Sona bang and Khorgos were lost or not present in the study area in 2014. These species were also not observed or recorded during the courses of interview.

Table 3.16: Depletion of Wild Life Diversity During the Period 1990-2014 in the Study Area

Sl. No	Common 1990		(%)*	Rare 2014	(%)*
	Local Name	Scientific name		Local Name	
1	Sheal	*Vulpus* sp.	100	Sheal	65
2	Begi	*Herpestes* sp.	100	Begi	60
3	Ban biral	*Felis* sp.	85	Ban biral	100
4	Mecho bagh	*Neofelis nebulosa*	60	Mecho bagh	100
5	Casshop	*Testudo* sp.	68	Casshop	90
6	Guisap	*Varanus* sp.	70	Guisap	68
7	Sona bang	*Rana tigrina*	75	Sona bang	100
8	Gecho bang	*Rhacophrous* sp.	72	Gecho bang	100
9	Badur	*Pteropus giganteus*	100		
10	Chamcika	*Pipestrellus coromandallanus*	100		
11	Katberali	*Funumbulus pennant*	98		
12	Edur	*Mus musculus*	100		
13		*Rattus rattus*	100		
14		*Bandicoota* sp.	100		
15	Khorgos	*Lepus nigricollis reficaudatus*	68	Khorgos	100
16	Goma (Ghokra)	*Naza* sp.	90	Goma (Ghokra)	88
17	Bora	*Vipera ruselli*	85	Bora	83
18	Daras	*Ptyas muscosus*	88	Daras	95
19	Dumukho	*Bungarus fasciatus*	65	Dumukho	97
20	Kaklas	*Calotis versicolor*	100		
21	Onjony	*Mabua carianta*	100		

Source: FGDs and interview (* % Respondents mention)

The result of the study supported by Rahman (2015), his study in his study that Already, 12 wildlife species have become extinct from Bangladesh. In addition, Mammals 40, birds 41, reptiles 58 and amphibians 8 have listed in red data book of threatened animals of Bangladesh. Anthropogenic pressures, uncontrolled

dredging, hydrological intervention, pollution, chemical fertilizers are directly effect on habitat, biodiversity and aquifer.

3.10.1.2.3 Birds Diversity

A total of 34 wild bird species recorded during the FGDs for the period of 1990 such as: Nishi Bok or Wakk (*Nycticorax nycticorax*), Shamuk Bhanga/ Khol (*Anastomus oscitans*), Kath-thukra (*Picoidespubescens*), Pankowri (*Phalacrocorax*), Majhari Bok (*Mesophoyx intermedia)*, Ghugu (*Streptopelia* spp.), Doel (*Copsychus saularis*), jathua or Boro Sada Bok (*Casmerodius albus*), Shama (*Copsychus malabaricus*), Shalic (*Acridotheres tristis)*, Majhari Pankowri (*Phalacrocorax fuscicollis*), Go-shalic (*Pied Myna*), Bulbuli (*Phconotus cafer*), Choto Sada Bok (*Egretta garzetta*), Gobok (*Bubulcus ibis*), Fingey (*Dicrurus macrocercus*), Kana Bok (*Ardeola grayii*), Charui (*Passer domesticus*) Bau Katha Kao (*Cuculus micropterus*), Brihot Pankowri (*Phalacrocorax carbo*), Machranga (*Halcyon smyrnensis*), Tia (*Psittacula krameri manillensis*), Kokil (*Eudynamys scolopaceus*), Baz (*Aviceda leophotes*), Holde kutum (*Orilus capensis)*, Patikak (*Corvus splendens*), Dar kak (*Corvus corax*), Tuntuni *(Orthotonus sutorius*), Pecha (*Nocturnolis strigiformes*), Chill (*Milvus migrans*), Shankho Chill (*Halastur indus*), Dahuk (*Amaurornis ponniurus)*, Kayem (*Porphyrio porphyrio*), Kadakhocha (*Gallinago gallinago)*; detail list in Appendix 3.8. The number of species as mentioned by the respondents decreased in the following decades (Fig. 4.9) and only 12 species such as: Kath-thukra, Doel, Bulbuli, Gobok, Nishi bok or Wakk, Pecha, Gabok, Chill, Dahuk, Machranga, Bau Katha kao and Holde Kutum mentioned were rare (threatened) in the study area during 2014 mentioned the respondents in FGDs and interviews. Kayem, Kadakhocha, Tia, Baz and Shama were lost or not present in the study area during 2014. These species were also not observed or recoreded during the course of interview.

Table 3.17: Some Local and Migratory Birds' Diversity in the Study Area.

Common in 1990				(%)*	Rare in 2014	(%)*
Local name	**English Name**	**Scientific Name**	**Residence status**		**Local name**	
Nishi Bok or Wakk	Black-crowned Nigh heron	*Nycticorax nycticorax*	Resident and migratory	75	Nishi Bok or Wakk	65
Shamuk Bhanga/ khol	Asian Openbill/ Open billed stork	*Anastomus oscitans*	Resident and migratory	62		
Kath-thukra	Woodpecker	*Picoides pubescens*	Resident	75	Kath thukra	82
Pankowri	Little cormorant	*Phalacrocorax*	Resident	88		
Majhari Bok	Intermediate Egret	*Mesophoyx intermedia*	Resident and migratory	90		
Ghughu	Dove	*Streptopelia* sp.	Resident	95		
Doel	Magpie	*Copsychus saularis*	Resident	98	Doel	94
Jathua or Boro Sada Bok	Great Egret	*Casmerodius albus*	Resident and migratory	85		
Shama	Shama	*Copsychus malabaricus*	Resident	95	Shama	100
. Shalic	Common Myna	*Acridotheres tristis*	Resident			
. Majhari Pankowri	Intermediate Cormorant	*Phalacrocorax fuscicollis*	Resident and migratory	82		
. Go-shalic	Pied Myna	*Sturnus contra*	Resident	90		
. Bulbuli	Red Bulbul	*Phconotus cafer*	Resident	95	Bulbuli	92
. Choto Sada Bok	Little Egret	*Egretta garzetta*	Resident and migratory	85		
. Gobok	Cattle Egret	*Bubulcus ibis*	Resident	78	Gobok	93
. Fingey	Blck drongo	*Dicrurus macrocercus*	Resident	90		
. Kana Bok	Pond heron	*Ardeola grayii*	Resident and migratory	85		
. Charui	House sparrow	*Passer domesticus*	Resident	100		
. Bau Katha Kao	Indian cuckoo	*Cuculus micropterus*	Resident	85	Bau Katha Kao	78
. Brihot Pankowri	Great cormorant	*Phalacrocorax carbo*	Resident and migratory	72		
. Machranga	Kingfisher	*Halcyon smyrnensis*	Resident	92	Machranga	78
. Tia	Parrot	*Psittacula krameri manillensis*	Resident	100	Tia	100
. Kokil	Asian koel	*Eudynamys scolopaceus*	Resident	100		
. Baz	Baza	*Aviceda leophotes*	Resident	95	Baz	100
. Holde kutum	Black capped oriole	*Orilus capensis*	Resident	88	Holde kutum	90
. Patikak	House crow	*Corvus splendens*	Resident	100		
. Dar kak	Raven	*Corvus corax*	Resident	90		
. Tuntuni	Tailorbird	*Orthotonus sutorius*	Resident	95		
. Pecha	Owl	*Nocturnolis strigiformes*	Resident	100	Pecha	68
. Chill	Pariah Kite	*Milvus migrans*	Resident	95	Chill	90
. Shankho Chill	Brahminy Kite	*Halastur indus*	Resident	85		
. Dahuk	White Breasted Waterhen	*Amaurornis ponniurus*	Resident	90	Dahuk	85
. Kayem	Purple Moorhen	*Porphyrio porphyrio*	Resident	75	Kayem	100
. Kadakhocha	Fantil Snipe	*Gallinago gallinago*	Resident	70	Kadakhocha	100

Source: FGDs and interview (* % Respondents mention)

The result of this study supported by UNCED (1990), they identified nearly 250 species of birds are in danger due to rapid depletion of forest. Another researcher Rafiqul (2012) identified 21 birds species in the rural homesteads of Gazipur district.

3.10.1.2.4 Fish Diversity

A total of 39 fish species were recorded for the period for the period of 1990 such as: Koi (*Anabas testudineus*), Shing (*Heteropneustes fossilis*), Magur (*Clarius batrachus*), Tengra (*Mystus tengara),* Gulsha (*Mystusgulio*), Mola (*Amblypharyngodon mola*), vedha (*Vandus nandus*), Showl (*Channa striatus*), Puthi (*Puntisu sophore*), Khalsha (*Colisa fasciatus*), Taki (*Channa punctatus),* Chanda (*Chanda ranga*), Chingry Echa (*Marobrachium lamarrei)*, Chang (*Chacca chaca*), Chittal *(Notopterus chitala)*, Pholi *(Notopteru natopturus),* Goalchanda (*Chanda basculis*), Kuchia (*Monopterus cuchia*), Titputhi (*Puntus ticto*), Dhela (*Rohtee cotio*), Darkina (*Esomus darrious*), Bele (*Glossogobius giuris)*, Namachanda (*Chanda nama*), Baim (*Mastacembelus armatus)*, Catol (*Catla catla*), Rui (*Labeo rohita*), Mrigel (*Cirrhinus cirrhosus*), Kalibaus (*Labeo calbasu)*, Bata (*Labio bata*), Silver carp (*Hypophthalmichthys molitux)*, Bighead (*Hypophthalmichthys nobilis*), Grass (*Ctenopharyngodon idella*), Black carp (*Mylopharyngodon piceus*), Japani (*Cyprinus carpio)*, Hungari (*Cypinus* spp.), Pangus (*Pangasius pangasisus)*, Talapia (*Oreochromis* spp.), Khorsula (*Rhinomugil corsula)* and Gajar (*Channa marulius*); detail list in Appendix 3.7. The number of fish species decreased in subsequent decades and only 13 species such as: Gulsha, Mola, Showl, Chanda, Khalsha, Chingry/Echa, Dhela, Bele, Khorsula, Namachandra, Titputhi, Pholi and Chital mentioned these species by the respondents in FGDs were recorded rare (threatened) in 2014. These 4 species such as: Vedha, Baim, Kuchia and Gajar were lost or not present in the study area as none of the respondents in FGDs mentioned the period in 2014. These species were also not observed or recoded during the course of interview.

Table 3.18: Past and Present Fish Diversity in the Study Area

Common in 1990			Cultured and Rare in 2014			
Local name	**Scientific Name**	**Residence status**	**(%)***	**Cultured**	**Rare in 2014**	**(%)***
1. Koi	*Anabas testudineus*	Resident and Exotic	100	Thi Koi/ Viet Koi		
2. Shing	*Heteropneustes fossilis*	Resident	100	Shing		
3. Magur	*Clarius batrachus*	Resident	100	Magur		
4. Tengra	*Mystus tengara*	Resident	100	Tengra		
5. Gulsha	*Mystusgulio*	Resident	100	Gulsha	Gulsha	72
6. Mola	*Amblypharyngodon mola*	Resident	100	Mola	Mola	85
7. Vedha	*Nandus nandus*	Resident	80		Vedha	100
8. Showl	*Channa striatus*	Resident and Exotic	95		Showl	75
9. Puthi	*Puntius sophore*	Resident	100			
10. Khalsha	*Colisa fasciatus*	Resident	98		Khalsha	78
11. Taki	*Channa punctatus*	Resident	100			
12. Chanda	*Chanda ranga*	Resident	100		Chanda	70
13. Chingry/ Echa	*Macrobrachium lamarrei*	Resident	100		Chingry / Echa	75
14. Chang	*Chaca chaca*	Resident,	100			
15. Chittal	*Notopterus chitala*	Resident	95		Chittal	55
16. Pholi	*Notopteru natopterus*	Resident	95			
17. Goalchanda	*Chanda baculis*	Resident	90			
18. Kuchia	*Monopterus cuchia*	Resident	85		Kuchia	100
19. Titputhi	*Puntus ticto*	Resident	98			
20. Dhela	*Rohtee cotio*	Resident	85		Dhela	95
21. Darkina	*Esomus darrious*	Resident	100			
22. Bele	*Glossogobius giuris*	Resident	85		Bele	90
23. Namachanda	*Chanda nama*	Resident	95		Namachanda	68
24. Baim	*Mastacembelus armatus*	Resident	75		Baim	100
25. Catol	*Catla catla*	Resident	100	Catol		
26. Rui	*Labeo rohita*	Resident	100	Rui		
27. Mrigel	*Cirrhinus cirrhosus*	Resident	100	Mrigel		
28.Kalibaus	*Labeo calbasu*	Resident	100	Kalibaus		
29. Bata	*Labio bata*	Resident	100	Bata		
30. Silver carp	*Hypophthalmichthys molitux*	Exotic	100	Silver carp		
31. Bighead	*Hypophthalmichthys nobilis*	Exotic	90	Bighead		
32. Grass carp	*Ctenopharyngodon idella*	Exotic	100	Grass carp		
33. Black carp	*Mylopharyngodon piceus*	Exotic	65	Black carp		
34. Japani	*Cyprinus carpio*	Exotic	100	Japani		
35. Hungari	*Cypinus* sp.	Exotic	100	Hungari		
36. Pangus	*Pangasius pangasius*	Exotic	100	Pangus		
37. Talapia	*Oreochromis* sp.	Exotic	100	Talapia		
38.Khorsula	*Rhinomugil corsula*	Resident	86		Khorsula	82
39.Gajar	*Channa marulius*	Resident	65		Gajar	100

Source: FGDs and interview (* % Respondents mention)

The result of the study supported by Rahman (2015). A total of 81 fish species were recorded from Chalan Beel including 72 indigenous fish species and nine exotic species. Nodoi (*Nandus nandus*), Sarpoti (*Puntius sarana*), Bacha (*Eutropiichthys muriu*), Bata (*Bangana ariza*), Pangas (*Pangasius pangasius*) and Pabda (*Ompok pabda)* are becoming extinct. Even the water animals like Ud Biral (*Lutra lutra*), Mesobagh (*Felis viverrina*) have also become non-existent.

From the above findings and discussions it might be concluded that, biodiversity *i.e.* the species richness (both plants and animals) in the study area of Puthia Upozilla of Rajshahi District had decreased over last two and half decades. The decrease in plant species was much higher than that of animal species. Increase in population, fragmentation of homesteads, unplanned cutting of trees, decrease in livestock grazing fields, filling-up of ponds and ditches, establishment of huge number of institutions/organizations, industries, and other infrastructures, utilization of old trees for furniture and housing or sold for money, plantation of a few selected species and above all mass destruction of forests area might be the reasons for decrease in biodiversity in the area. The result of this study supported by Alam and Masum (2005). They identified a total of 24 species of cultured fishes under 14 families and recorded poultry (64%) was the major livestock component of each household followed by goat (12%), cattle (10%), buffalo (8%) and sheep (6%). This study supported by another research of UNCED (1990), identified approximately 5000 species of flowering plants, 750 species of birds (150 species of waterfowls), over 500 species of fish, 120 species of mammals, 124 species of reptiles and 19 species of amphibians found in Bangladesh. About 50 species are nearly extinct and 33 species are seriously threatened of known vertebrates and nearly 250 species of birds are in danger due to rapid depletion of forest.

3.10.2 List of Lost/Threatened Species

A list of lost and threatened species of plants and animals of a locality is an important indicator for understanding the change in biodiversity. Attempt was made to record the rare (threatened)/lost or not present or absent species of plants and animals in the study area through interview and FGDs. A list of lost/threatened species as mentioned by the respondents is presented in Table 3.19. The result of the study supported by Rahman (2015), in his study that unfortunately, many plant and animal species on Earth are facing severe threats to their survival and are disappearing at alarming rates. And human actions are the cause behind this biological degradation. Biodiversity is affecting due to deforestation, forest exploitations, agriculture and industrial pollution, irrigation and flood control developments, shifting land use and over exploitation of biological resources.

Table 3.19: List of Plants and Animals Under Threat or Lost from the Study Villages of Puthia Upozilla of Rajshahi Distrcit.

Sl.	Bengali/local name	Scintific name
	A. Plant	
1	Amra	*Spondias pinnata*
2.	Dalim	*Punica granatum*
3.	Karamcha	*Caesalpinia crista*
4.	Dhapar*	*Flacouritia ramontchi*
5.	Bag Borie*	*Zizyohus oenoplea*
6.	Jangle Jackfruit*	*Artocarpus lekucha*
7.	Gab	*Diospyros peregrine*
8.	Chalta	*Dillenia indica*
9.	Khayer*	*Albizia procera*
10.	Babla	*Acacia nylotica*
11.	Sathim	*Alstonia scholaris*
12.	Dawya	*Artocarpus lakoocha*
13.	Hizul*	*Barringtonia acutangula*
14.	Badorlathi*	*Cassia fistula*
15.	Sishu	*Dulbergia sissoo*
16.	Arjun	*Terminalia arjuna*
17.	Bashok	*Adhatoda vasica*
18.	Baet	*Calamus* spp.
19.	Simul	*Gossypium herbaceum*

20	Jiga	*Lagerstroemia flosreginae*
21.	Mander	*Erythrina inidca*
22.	Gamar	*Gmelina arborea*
23.	Sopheda	*Maniklkara achras*
24.	Bola	*Kleinhovia hospital*
25.	Tetul	*Tamarindous indica*
26.	Anise	*Pinpinella anisum*
27.	Bay leaf	*Cinnamum tamala*
28.	Satomuli	*Asparagus racemosus*
29.	Golmorich	*Piper nigrum*
30.	Kuinien*	*Cinchona officinalis*
31.	Jamrul	*Syzygium samarangense*
32.	Kadam	*Lawsonia inermis*
33.	Bohera*	*Terminalia berica*
34.	Ashok	*Saraca asoca*
35.	Tulshi	*Ocimum santum*
36.	Bashok*	*Adhatoda vasica*
37.	Arjun	*Terminalia arjuna*
38.	Sorpogondha*	*Rauwolfia serpentine*
39.	Tamal*	*Diospyros cordifolia*
40.	Horitoki*	*Terminalia chebula*
41.	Akanda	*Calotropis procera*
42.	Paddo	*Nelumbo nucifera*
B. Animal		
43	Buffaloes	*Bubalus bubalis*
44	Sheep	*Ovis aries*
45	Khorgos	*Oryctolagus*
46	Shama*	*Copsychusmalabaricus*
47	Tia*	*Psittacula krameri manillenis*
48	Kath-thukra	*Picoidespubescens*
49	Baz*	*Aviceda leophotes*
50	Holde kutum	*Orilus capensis*
51	Dahuk	*Amaurornis ponniurus*
52	Kayem*	*Porphyrio porphyrio*
53	Kadakhocha*	*Gallinago gallinago*
54	Nishi Bok or Wakk	*Nycticorax nycticorax*
55	Doel	*Copsychus saularis*
56	Bulbuli	*Phconotus cafer*
57	Gobok	*Bubulcus ibis*
58	Bau Katha Kao	*Cuculus micropterus*
59	Machranga	*Halcyon smyrnensis*
60	Pecha	*Nocturnolis strigiformes*
61	Chill	*Milvus migrans*

62	Sheal	*Vulpus* sp.
63	Begi	*Herpestes* sp.
64	Guisap	*Varanus* sp.
65	Ban Biral*	*Felis* spp.
66	Mecho Bagh*	*Neofelis nebulosa*
67	Casshop	*Testudo* spp.
68	Sona bang*	*Rana tigrina*
69	Gecho bang*	*Rhacophrous* spp.
70	Khorgos*	*Lepus nigricollis reficaudatus*
71	Goma (Ghokra)	*Naza* spp.
72	Dumukho	*Bungarus fasciatus*
73	Bora	*Vipera ruselli*
74	Daras	*Ptyas muscosus*
75	Chingry\Echa	*Marobrachium lamarrei*
76	Kuchia*	*Monopterus cuchia*
77	Dhela	*Rohtee cotio*
78	Baim*	*Mastacembelus armatus*
79	Gajar*	*Channa marulius*
80	Vedha*	*Vandus nandus*
81	Gulsha	*Mystusgulio*
82	Mola	*Amblypharyngodon mola*
83	Showl	*Channa striatus*
84	Khalsha	*Colisa fasciatus*
85	Chanda	*Chanda ranga*
86	Chittal	*Notopterus chitala*
87	Bele	*Glossogobius giuris*
88	Namachanda	*Chanda nama*
89	Khorsula	*Rhinomugil corsula*

* Were not found in 2014.

A total of 89 species (42 plants and 47 animals) mentioned by the respondents which either were lost from the area, endangered or near threatened. Among 42 plant species, 12 were not found in the study area in 2014 while others 30 were rare or threathened. Out of 47 animal species, 12 were not found in the study area in 2014 while others 35 were rare or threatened (Table 3.19). It indicates that animals are more vulnerable compared to plants. Animals are in some way or other dependent on plants for food and shelter. Thus mass destruction of forest areas, removal of large and old trees for the establishment of human habitats, industries and other infrastructures might be the reasons for decrease or extinction of the animal species as mentioned above.

So, it may be said that the overall biodiversity in the Puthia Upozilla in Rajshahi District has decreased remarkably over last two and half decades (1990-2014) mainly due to agricultural practices or human interventions. The biodiversity in the study area is also decreasing gradually with increase in modernisation of the villages *i.e.* through the process of urbanization. Increase in population, construction of houses and roads, establishment of other infrastructures negatively affecting biodiversity in the area. Proper conservation of plants of the area; plantation of threatened/lost plant species in the homesteads, roadside waste lands and also in the premises of school/ colleges, institutions/ organizations, etc.; rearing different types of animals and birds in different forest areas and in the homesteads; and poly-culture of different fish species might help improve biodiversity in the area.

3.11 Plant Species Richness in the Study Area

The existing biodiversity in the study area of selected six villages of Puthia Upazilla in Rajshahi District are described under Species richness diversity.

Almost all the villages of the study area contained mixed vegetation of various annual and perennial plants including field crops, medicinal plants, trees, shrubs and herbs. There were different types of domestic and pet animals, wild animals, birds and also fishes in the ponds but not present in all the villages of the study area. Findings of the study showed that there were wide variety of plant and animal species in the study area and their number varied from one homestead to another and also varied among the six study villages. A total of 184 plant species were identified in the six study Villages. Among the 184 plant species, 45% weed species, 15% vegetable, 12% fruits species, 10% timber species, 14% medicinal plants and 4%spices species (Table 3.20).

The highest number (170) of species was found in Pompara village of Puthia Upozilla and the lowest (148) in the modern village Khathalbaria (Table 3.20). It indicates that number of species decreased with increase in modernization of the villages. Particularly the number of weed spoecies decreased remarkably in the

modern village. However, the richness of other species *i.e.* fruits, timber, medicinal, vegetable and spcies were more or less same in the six selected villages. However, the richness of different categories of plant species is discussed below.

3.11.1 Fruit Trees Richness in the Study Area

Findings presented in Table 3.20 show that the number of fruits species was higher in the study area compared to other category of plant species except the weeds. Fruit species covered about 12 percent of the total vegetation of a study area. A total of 22 fruit species was recorded in Pampara while there were 21species in Kathalbaria and equal 20 species in Ramjibanpur and in Silmaria, another equal 19 species in Baraipara and in Udanpur villages were recored. The common species in all six villages were: Lichu (*Litchi chinesis*), Peyara (*Psidium guajava*), Boroi/kul (*Zizyphus mauritiana*), Lebu (*Citrus* spp.), Ata (*Anona* spp.), Dalim *(Punica Granatum*), Kola (*Musa* spp.), Papaya (*Corica papaya*), Kathal (*Artocarpus heterophyllus*), Kalojaam *(Syzygium cuminii*), Narikel (*Cocos nucifera*), Khejur (*Phoenix sylvestris*), Taal (*Borassus flabellifer*), Dawaya *(Artocarpus lakoocha*), Tetul (*Tamarindous indica*), Supari (*Areca catechu*), Jamrul (*Syzygium samarangense*), Jambura (*Citrus grandis*) and Bel (*Aegle mermelos*). However, the number of fruit species also varied widely from one village to another.

3.11.2 Timber Trees Richness in the Study Area

The plant group ‘timber’ occupied fifth position with respect to average number of species and covered 10 percent of the total vegetation of study area. Highest number of timber 17 species were recorded Baraipara (traditional), Kathalbaria and Pompara and lowest 14 species in Silmaria, 15 species in Ramjibanpur and second highest 16 species in Udanpur were recored and the 13 comman species were: Nim (*Azadirachta indica*), Bot (*Ficus benghalensis*), Meghoni (*Swietenia mahagoni)*, Debdaru (*Polyalthia longifolia*), Pipul (*Piper longum*), Akashmoni (*Acacia moniliformis*), Eucalyptus (*Eucalyptus citriodora*), Epilepil (*Leucaena leucocephala*), Krishnachurra (*Delonix regia*), Bash (*Bambusa* spp.) Kadam (*Anthocephalus cadamba)* Khoksa (*Ficus hispida*) and Simul (*Gossypium*

herbaceum). Jiga and Mander was found at Kathalbaria and Udanpur while the species Bola was found only at Pampara. In Udanpur the species like Babla, Khayer, Arjun, and Gamar were not found.

3.11.3 Medicinal Plants Richness in the Study Area

A total of 25 species were identified from six selected villages. (Table- 3.20). These were mainly trees, shrubs and herbs such as: Durba (*Cynodon dactylon),* Duttura (*Datura metel),* Akanda (*Calotropis procera*), Kochu (*Colocasia esculenta*), Bel (*Aegle* spp.) Varenda (*Ricinus communis),* Hatishur (*Heliotropium indicum*), Katanate (*Amaranthus spinosus*), Dhonia, (*Coriandrum sativum*), Thankuni (*Holorhena antidysenterica*), Begun (*Solanum melogena),* Lebu (*Citrus* spp.). Mukta Jhuri (*Acalypha indica*), Dadmordon (*Cassia alata*) and Kolkasunda (*Cassia sophera*) were comman in six villages. In addition, Shimul (*Bombax ceiba*), Mehedi (*Lawsonia inermis*) and Tulshi (*Ocimum santum*) were common in three villages Baraipara, Udanpur and Kathalbaria. Babla (*Acacia nylotica*) were common in Ramjibanpur and Pampara. Apang (*Achyranthes aspera*) and Jostimodhu (*Glycerrhiza glabra)* were recorded in four villages Silmaria, Ramjibanpur, Pampara and Udanpur. Arjun (*Terminalia arjuna*) and Sorpogondha (*Rauwolfia serpentine)* were recorded in Kathalbaria only.

Table 3.20: Species Richness of Different Plant Groups in the Study Area of Puthia Upazila in Rajshahi Disctirct.

Villages	No. of species						Total
	Weeds	Vegetables	spices	Fruit	Timber plants	Medicinal plants	
Baraipara	74	25	5	19	17	22	162
Ramjibanpur	82	24	4	20	15	15	160
Kathalbaria	68	20	4	21	17	18	148
Silmaria	70	23	5	20	14	21	153
Udanpur	75	26	4	19	16	23	163
Pampara	78	24	6	22	17	23	170
Average	74	24	5	20	16	20	159
All	84 (45)	27 (15)	8 (4)	22 (12)	18 (10)	25 (14)	184 (100)

Source: Field visit FGDs and Interview
Figures in parentheses indicate percent

3.11.4 Vegetables and Spices Richness in the Study Area

Vegetables Richness: With respect to average number of species vegetables occupied Second position among the plants groups covered 15 persents of the total vegetation of the study area. (Table 3.20) a total of 27 vegetable (field crops) species were identified of which 18were common at all six selected villages wich were Potato, Cauliflower, Cabbage, Lal shak, Mula, Tomato, Begun, lau, Seem, Misti Kumra, Khira, Jhinga, Chille, Maize, Wheat, Rice, Lentil and Pea. Three other vegetables not recoreded at Silmaria were Borboti, Karola and Jhinga but this vegables were present in Kathalbaria, Baraipara and Pampara

Spices Richness: Only eight species of spices were identified of which six were common over six selected villages and these were: chilli, coriander, garlic, ginger, onion and turmeric (Appendix 3.4). Anise was found only in one homestead at Baraipara while Bay leaf was found in three homestead at Pampara and Kathalbaria.

3.11.5 Weeds Richness in the Study Area

A total of 84 weed species were identified (Table 3.20) from six selected villages (Appendix 3.5). Highest (82) number of weed species found at Ramjibanpur, 2nd highest (78) number of weeds was recorded at Pampara and 3rd highest (75) number of weeds was recorded at Udonpur. The lowest (68) number of weeds was recorded at Kathalbaria and 2nd (70) number of weeds was recorded at Silmaria. Lowest and the last (74) number of weeds was recorded at Baraipara. Among the identified weeds species, 62 found common in six villages which were as: Bon holud, Malancha, Durba, Bon begun, Ghagra, Ulu, Nunia, German lata, Ulatkambal, Swanalata, Kenduli, Bathua, Dheki sak, Shushni, Katahenchi, Jagatmadan, Akanda, Chhagalgacha, Biralkarani, Chapra, Choto helencha, Bhat, Kanta begun, Thankuni, Amrul, Telakucha, Dhutura, Pteris, Lantana, Dandakalash, Kuni ghas, Premkata, Mati chech, Baro dudhia, Mutha, Katanotey, Apang, Khetpapri, Choto dudhia, Roktodron, Benajoni, Anguli ghas, Chanchi,

Chela ghas, Shialmutra, Bishkatali, Kanaibashi, Kanainala, Halud nakful, Arail, Bon dhonia, Bon tamak, Nalkhagra, Hurhur, Lajjabatim, Chech Jhanjhani, Bon masur, Kalmi, Keshraj/Keshuti, Hatishur, Bon sarisha and Bon mator.

3.12 Animal Species Richness in the Study Area

3.12.1 Livestock, Poultry and Pet Animal Richness

Livestock Richness Two livestock species *i.e.* cattle and goat were found in the homesteads of all six study villages. In the case of cattle, exotic or cross breed was found in many cases along with local breed. Black Bengal goat was the only species of goat (Table 3.21).

Poultry Richness: Three poultry species as chicken, duck and pigeon were availablein the study villages (Table 3.21). Some exotic breed was found in case of chicken only.

Pet Animal Richness: Only two pet animals e.g. dog and cat of local breed were found in some homesteads of all six villages.

3.12.2 Wild Life Richness

A total of 14 wild animals species were mentioned by the respondents which observed in the study area during last one year in 2014. These species were as: Sheal (*Vulpus* spp.), Begi (*Herpestes* spp.), Guisap (*Varanus* spp.), Badhur (*Pteropus giganteus*), Chamcika (*Pipestrellus coromandallanus*), Katberali (*Funumbulus pennanti*), Edur (*Mus musculus*), Edur *(Rattus rattus*), Edur *(Bandicoota* spp.), Goma (Ghokra) (*Naza* spp.), Bora (*Vipera ruselli*), Daraj (*Ptyas muscosus*), Kaklas (*Calotis versicolor*), Onjony (*Mabua carianta).* More or less smiliar species were recorded in the six study villages. The higest equal number (20) of species was recorded both at Pampara and Ramjibanpur while lowest number (17) was recorded at udanpur village.

Table 3.21: Species Richness of Different Animal Groups in the Study Area of Puthia Upazila in Rajshahi District

Villages	No. of Species						Total
	Livestock	Poultry	Pet Animals	Wild Animals	Birds	Fishes	
Baraipara	2	3	2	12	21	24	64
Ramjibanpur	2	3	2	13	18	22	60
Kathalbaria	2	3	2	11	21	25	64
Silmaria	2	3	2	14	17	26	64
Udanpur	2	3	2	10	22	28	67
Pampara	2	3	2	12	24	25	68
Average	2	3	2	12	21	25	65
All	2 (3)	3 (4)	2 (3)	14 (19)	25 (33)	29 (38)	75 (100)

Source: Field visit, FGDs and Interview
Figures in parentheses indicate percent

3.12.3 Birds Richness

In this case, respondents were asked to mention name of different birds as they observed in their homesteads and their locality last one year 2014. As much as 25 bird species (Table 3.21) as mentioned by the respondents were: Shamuk Bhanga/ Khol (*Anastomus oscitans*), Kath-thukra (*Picoides pubescens*), Pankowri (*Phalacrocorax auritus*), Majhari Bok (*Mesophoyx intermedia*), Ghugu (*Streptopelia* spp.), Doel (*Copsychus saularis*), jathua or Boro Sada Bok (*Casmerodius albus*), Shalic (*Acridotheres tristis)*, Majhari Pankowri (*Phalacrocorax fuscicollis*), Go-shalic (*Pied myna*), Bulbuli (*Phconotus cafer*), Choto Sada Bok (*Egretta garzetta*), Gobok (*Bubulcus ibis*), Fingey (*Dicrurus macrocercus*), Kana Bok (*Ardeola grayii*), Charui (*Passer domesticus*) Bau Katha Kao (*Cuculus micropterus*), Brihot Pankowri (*Phalacrocorax carbo*), Machranga (*Halcyon smyrnensis*), Kokil (*Eudynamys scolopaceus*), Dar kak (*Corvus corax*), Tuntuni *(Orthotonus sutorius*), Chill (*Milvus migrans*), Shankho Chill (*Halastur Indus*) and Pecha (*Nocturnolis strigiformes*); detail list in Appendix 3.8. More or less similar species were recorded at Udanpur, Silmaria and Baraipara and lowest (22) species were recorded at Kathalbaria.

3.12.4 Fishes Richness

Among the animals found in the study area, species richness was high in case of fishes. A total of 29 fish species were mentioned by the respondents which they observed recently in their ponds while catching fish. The species were as: Koi (*Anabas testudineus),* Shing *(Heteropneustes fossili),* Magur *(Clarius batrachus),* Tengra (*Mystus tengara),* Mola *(Amblypharyngodon mola),* Showl *(Channa striatus),* Puthi (*Puntius sophore),* Chanda *(Chanda ranga),* Chingry/Echa (*Macrobrachium lamarrei),* Chang *(Chaca chaca),* Chittal (*Notopterus chitala),* Pholi (*Notopteru natopterus),* Goalchanda (*Chanda baculis),* Darkina (*Esomus darrious),* Bele (*Glossogobius giuris),* Namachanda *(Chanda nama),* Catol (*Catla catla),* Rui (*Labeo rohita),* Mrigel *(Cirrhinus cirrhosus),* Kalibaus (*Labeo calbasu),* Bata (*Labio bata),* Silver carp (*Hypophthalmichthys molitux),* Bighead (*Hypophthalmichthys nobilis),* Grass carp (*Ctenopharyngodon idella),* Black carp (*Mylopharyngodon piceus),* Japani (*Cyprinus carpio),* Hungari *(Cypinus* sp.), Pangus (*Pangasius pangasius),* and Talapia (*Oreochromis* sp.) a list also given in Appendix 3.7. The highest number (28) of species was recoreded at Udonpur and the lowest (22) at Ramjibanpur.

From the above findings and discussions it might be concluded that, biodiversity *i.e.* the species richness (both plants and animals) in six villages of Puthia upazila had decreased over last two and half decades. The decrease in plant species was much higher than that of animal species. Increase in population, fragmentation of homesteads, unplanned cutting of trees, decrease in livestock grazing fields, filling-up of ponds and ditches, establishment of huge number of institutions/organizations, roads, and other infrastructures, utilization of old trees for furniture and housing or sold for money, plantation of a few selected species, modern agriculture practices and above all mass destruction of forests area might be the reasons for decrease in biodiversity in the area.

Plate 3.24: Positive Impacts of Roadside Plantation with Native Date Plant (Khajur)

Plate 3.25: Crop Land and Forest Land Convented to Mango Orchard

Plate 3.26: Negative Impacts of Roadside Plantation with Exotic Plant (Mehogoni)

Plate 3.27: Crop Land and Forest Land Convented to Guava Garden

Plate 3.28: Intercropping for People Demand

Plate 3.29: Natural Land Convented to Jujube Garden

A. Once upon a Time Sona Bang is a Common Frog in the Study Area Now it is a Uncommon Frog due to Wetland Destruction

D. Common Bird Doel. It Population Density Decreased Day by Day to Natural Food Shortage

B. Rare Wild Animal (Ban Biral) in the Study Area due to Forest Destruction

E. Holde Kutum Rarely Found in the Study Area

C. Goma (Ghokra) Rarely Found in the Study Area due to Habitat Distruction

F. Tia Rarely Found in the Field due to Plant Destruction

Plate 3.30: Some Rare Wild Animals and Birds

Plate 3.31: Vhada (*Nandus nandus*) not Found from the Study Area due to Wetland Destruction

Plate 3.32: Exotic Fish (Pangus (*Pangasius pangasius*), Talapia (*Oreochromis* sp.)) Farming in the Study Area

Plate 3.33: Polyculture Fish Farming in the Study Area

Table 3.22: Causes of Biodiversity Depletion

Villages	Cultivation/Land used Pattern (%)	Use of Chemical Fertilizer (%)	Use of Pesticide etc. (%)	Irrigraion (%)	Hybrid, HYV and Exotic Plant (%)	Use of Modern Agriculture Technology (%)	Habitat Distruction (%)	Road Constration and Urbanization (%)	Others (%)	Total (%)
Baraipara	50.78	9.73	15.02	3.78	4.89	5.86	3.64	4.29	2.01	100
Ramjibanpur	49.68	9.06	17.08	3.98	4.90	5.77	3.48	3.39	2.66	100
Kathalbaria	48.52	8.98	16.35	4.31	4.12	6.01	2.99	3.56	5.16	100
Silmaria	51.04	8.83	15.84	4.55	4.47	5.46	3.28	4.12	2.41	100
Udanpur	49.89	9.97	16.19	5.17	4.23	4.16	3.31	9.68	2.4	100
Pampara	50.36	9.14	16.05	4.66	4.76	5.02	3.83	4.56	1.62	100
Avarage	50.00	9.2	16.00	4.4	4.5	5.2	3.4	4.7	2.6	100

Source: FGDs and interview. (% of respondents mention)

Table 3.22 indicate that the loss of biodiversity is occurring day by day in many ways. The findings of causes of biodiversity loss in the study area of six villages as Baraipara, Ramjibanpur, Kathalbaria, Silmaria, Udanpur and Pampara in Puthia Upazila due to some parameters. These are cultivation (land use pattern), use of chemical fertilizer, use of pesticide, irrigation, hybrid and exotic plant, use of modern agriculture technology, habitat destruction, road construction and urbanization and some other reasons. To fulfill the research objective, the peoples perception for the causes of biodiversity loss are about 48-51% for cultivation (land use pattern), 15-17% for use of pesticide, 8-10% for use of chemical fertilizer, 4-6% for use of modern agriculuture technology, 4-5% for Hybrid, HYV and exotic plant, 3-10% for road construction and urbanization, 3-5% for irrigation, 2-4% for habitat destruction and 1-3% for other reasons.

Table 3.23: Impacts of Agriculture Practices on Sustainable Biodiversity in the Study Area

Item	Change	Possible Impacts	
		Positive	Negative
1. Cultivated land	Increased	**Higher production**	Negative impacts on ecosystem
2. Perennial water bodies vs ponds	Increased	**Increase surface water reserver**	Natural water body
3. Natural vegetation	Decreased	–	Negative impacts on Indigenous vegetation
3. Tree diversity (Fruits and Timber)	Decreased	–	Negative impacts on wild animals
4. Indigenous plant diversity	Decreased	–	Negative impacts on biodiversity
5. Exotic plants	Increased	**Economic gain**	Impacts on indigenous biodiversity
6. Soil fertility	Decreased	–	Negative impact on agricultural production
7. Organic matter	Decreased	–	Negative impacts on soil fertility
8. Cattle dung	Decreased	–	Negative impacts on organic manure
9. Open water fishery	Decreased	–	Indigenous fish diversity decreased
10. Indigenous Fish diversity	Decreased	–	Negative impacts on health of local low income peoples
11. Exotic fish diversity	Increased	**Higher production**	Negative impacts on ecosystem of indigenous fish diversity
12. Natural water resources	Declined	–	Crisis of surface water
13. Water availability in dry season	Declined	–	Over extract of ground water
14. Rain water	Increased	**Increased water level**	But season shift, Negative impacts on agricultural ecosystem
18. Wildlife species diversity	Decreased	–	Negative impacts on food chain and food pyramid
19. Habitat destruction	Wide spread	–	Environmental degradation
21. Crop diversity	Decreased	**Higher production**	Negative impacts on local and indigenous crops diversity
22. Hybrid crops	Increased	**Higher production**	Distruction of local ecosystem
23. Medicinal plants	Decreased	–	Negative impacts on local community peoples health
24. Culture fish	Increased	**Economic gain**	Fish diversity decrease
25. Chemical fertilizer, pesticide, herbicide, insecticide uses	Increased	**Higher production and economic gain**	Negative impacts on aquatic and terrestrial ecosystem

From the following table we can observed that the changes of some parameters in the study area. Some of them are increased and some are decreased. Some parameters causes positive impacts to the national economy but ultimately negative impacts on environment. Due to demand of food the cultivated land area are increased and resulting a higher production. But it causing a great negative environmental impacts and ultimately biodiversity is decreased. Due to habitat destruction, abundance of flora and fauna are declined and creates negative environmental impacts. Some practices for economic gain like culture of different types of fishes, hybrid crops and monoculture of exotic plant, a large number of native biodiversity is dramaticaly decreased. Due to over doses of chemical fertilizer, pesticide, herbicides were used for but consequently negative impacts on soil and water and depletion of biodiversity day by day.

3.13 Conclusion

Agriculture is the backbone of the country and is synonymous to the food security of the country. Attaining self sufficiency by 2013 along with ensuring food to all is adopted in the, Vision 2021 of the Government of Bangladesh. Pressure for increased crop production is triggered by the rapid population growth and it is the most important challenge. For these reasons, the government has put top most priority to the agriculture sector.

Moreover agriculture and environment have a close relationship and have got interact with each other in such a way that the health of agriculture depends on the proper functioning of environmental process and the health of environment depends on a respectful agriculture. Due to lack of proper knowledge of environment is degrading day by day very quickly which directly affects agriculture and thereby causes serious damage to lives on earth. In Bangladesh farmers use land through out the year for continuous production of food grain. Agriculture has repeatedly been identified as one of the largest contributors to the loss of biodiversity world-wide. This is because of the large land area

devoted to this activity as well as the high degree of physical manipulation and inputs of pesticides and fertilizers inherent in our current way of farming. Preserving the quantity and quality of soils is one of the main objectives of current efforts to make agriculture more ‘Sustainable’. Although current efforts to protect the agricultural resource base may have a possitive influence on environmental quality and by extension, on the wild biota in agricultural landscapes, this is no guarantee that biodiversity is being preserved. If we are to be serious about our commitment to conserve biodiversity, we will need to fully consider the effects of common agricultural practices, such as tillage, drainage, intercropping, rotation, grazing, pesticide and fertilizer use, irrigation, hybrid, HYV, monocropping, unpland tree cutting and convertion of wetlands, on wild flora and fauna. Practices such as drainage are fundamentally of odds with wildlife conservations; the conservation of wetlands has become a critical issue in Rajshahi as elsewhere. Management tools for other agricultural practices, such as intercropping and rotation to reduce pesticide use, assessment of the severity of pest. Species competition priod to pesticide use, fertilizer application linked to no-till methods or nutrient budgets and re-seeding improved pastures with native vegetation may successfully benefit agriculture and preserve the quality of habitat for wildlife. Loss of biodiversity caused by agriculture to farm environment due to intensive land use, introduction of high yielding varieties, monocropping practices, inadequate and unbalanced use of chemical fertilizers and pesticides. For the above reasons, land degradation, losses of soil fertility and microorganisms, air and water pollution, health hazards of people and so on problem occurred in farm environment.

Overall, creating agricultural systems with lower impact on offside biodiversity and maintenance of high levels of inside biodiversity will require us to utilize all available technologies while simultaneously encouraging appropriate farmer practices. This also means that agricultural and conservation policy should work together in order to develop sustainable biodiversity.

Additionally agricultural impacts on sustainable biodiversity afford and opportunity scientist to make future researches, particularly about the condition in which diverse species will flourish.

3.14 Recommendations

The following recommendations are formulated to maintain positive impacts of agriculture practices on sustainable biodiversity.

1. Designing of suitable biodiversity which must be in harmony with the farmer's resource base, available technology, goals and performances.
2. Research priority should be given in order to maintain biodiversity of plants and animals for sustaining productivity, ecological replenishment and ecosystem restoration.
3. Massive and relevant training programme should be providing for farmers to upgrade their awareness and understandings of the knowledge about climate change, ensure proper agricultural practices, increase afforestation programme.
4. Department of Livestock, Department of Forestry and Department of Fisheries has to take all necessary steps to conserve endangered species of animals, birds and fishes.
5. Awareness building program should be ensured from school level to mass people and create alertness to all to maintain a sustainable biodiversity for our future generation.
6. More research are needed in the field of agricultural practices and their impacts to maintain a sustainable biodiversity.

Chatper 4
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Appendices

Appendix-1

Questionnaire

English Version of the Interview Schedule
Institute of Environmental Science
Rajshahi University
Interview schedule for collection of data to determine An Interview Schedule of Farmers' on the "Impacts of Agriculture practices on sustainable biodiversity in Rajshahi District"

Serial No:.....Date.....

Name of respondent.....

Village.....Union.....Thana.....

1. Age.....
2. Sex (a) male
   (b) Female
3. Family size

   Total no of family members.....
   Male.....Female.....
4. Farm size
5. Cropping pattern in the study area

Cropping pattern	
Single crop	
Double crop	
Multiple crop	

6. Corpping pattern in the study area

Robi season	
Khorif season-1	
Khorif season-2	

7. Agricultural farming practices
   a) Field crops

Name	Total production	Year

   b) Fruits crops

Name	Total production	Year

   c) Pluses crops

Name	Total production	Year

d) Oil seed crops

Name	Total production	Year

e) Vegetables

Name	Total production	Year

8. Information about use of Agricultural Technologies
   a) Organic fertilizer

Name	Year
Cowdung	
Compost	
Green manure	
Poultry waste	
Crop residuce	
Household waste	

   b) Chemical fertilizer

Name	Year
Urea	
TSP	
MOP	
Others (Zn, S, Mn, Mg, Br, etc.)	

9. Pesticide use

Name	Year

10. Animals in the study area-
    a) Domestic
    b) Wild animals

Name	Found in the year	
	1990	2014

    c) Birds

Name	Found in the year	
	1990	2014

11. Fishes-

Types	Found in the year	
	1990	2014

12. Plants of the study are- 1990-2014

Name	Fruits	Multi	Wood	Medicinal plants

13. Knowledge about biodiversity-
    1. Yes 2. No
14. Do you think that is there any impacts of agricultural practices on sustainable biodiversity?
15. Do you think that biodiversity conservation is necessary?
16. What is your opinion to learning and gathering knowledge about good agriculture practices?
17. What is your recommendation to ensure sustainable biodiversity in your living area?

Appendix-2

Appendix 2.1: Agricultural Information of Puthia Upazilla

Sl. No.	Description		
1.	Area (Sq. km)		192.64
2.	Upazilla No.		01
3.	Union No.		06
4.	No. of pourashova		01
5.	No. of Mouza		128
6.	No. of Agricultural block		19
7.	No. of seed dealer (BADC)		21
8.	No. of fertilizer dealer (BCIC)		08
9.	No. of retail fertilizer seller		63
10.	No. of seed selling centre (BADC)		21
11.	Seed selling centre (General)		45
12.	Total Farmers Family		41717
13.	Landless		14557
14.	Marginal		11835
15.	Small		10730
16.	Medium		4192
17.	Big		403
12 = (13+14+15+16+17)			-
18.	Total land area (Hectre)		19264
19.	Cultivable land (Hectre)		15052
20.	Cultivated barren field (Hectre)		-
21.	No. of Char		-
22.	Charland (Hectre)	Cultivated Char	-
		barren Char	-
23.	Moorland (Pond, Puddle)		757
24.	Forest (Hectre)		-
25.	Fruit garden (Hectre)		910
26.	Brick kiln and field (Hectre)		45
27.	Homestead (Hectre)		2500
18 = (19+20+21+22+23+24+25+26+27)			-

Sl. No.	Description		
28.	Total cultivable land		15052
29.	Single crop land (Hectre)		854
30.	Double crop land (Hectre)		9708
31.	Triple crop land (Hectre)		26253
32.	More then triple crop land (Hectre)		2372
Total Crops land (Hectre)			39187
Crops Intensity (%)			260
33.	High land (Hectre)		9446
34.	Medium high land (Hectre)		3031
35.	Medium low land (Hectre)		2346
36.	Low land (Hectre)		229
37.	Very low land (Hectre)		-
Total			15052
38.	No. of Buffer storage		-
39.	Capacity of Buffer storage		-
40.	No. of cold storage		03
41.	Capacity o cold storage (m. ton)		41700
42.	No. of Rice Mills	Auto Rice mills	-
		Rice mills	52
43.	Horticulture centre	Number	-
		Area (Hectre)	-
44.	No. of nursery by forest Department		01
45.	Private Nursery		21
46.	Total population (2010-11)		207490
47.	Total population (2014-15)		217975
48.	Total demand of food (m. ton)		32750
49.	Net yield of crop (m. ton)		48760
50.	Net production of food (m. ton)		43153
51.	Net surplus food (m. ton)		16010
52.	No. of deep tube well	Diesel	01

Sl. No.	Description		
		Electricity	200
53.	Shallow tube well	Diesel	8177
		Electricity	114
54.	LLP	Diesel	-
		Electricity	-
Total Pump (52+53+54)			8492
55.	No. of LCC		275
56.	No. of Tructor		19
57.	No. of Power Tiller		750
58.	No. of Brick wet machine		01
59.	No. of Soil Minilab		-
60.	Granular Urea Appling machine		21
61.	AIZ-11 (The flood plains of the Ganges)		19264
62.	Pesticide license	Whole seller	21
		Retailer	354

Source: Official Record of DAE, Puthia

Appendix 2.2: Crops Rotation (Sasyabinyas) and under Crop Rotation (Sasyabinyas) Land Area (in Hectre) of Puthia Upazila

Serial No.	Crop rotation (sasyabinyas)			Land (Hectre)	%
	Robi	Khorif-01	Khorif-02		
1.	Mustard + Boro	Fellow	Ropa Amon	860	5.71
2.	Mustard + Boro		Fellow	250	1.66
3.	Boro	Fellow	Fellow	430	2.86
4.	Boro	Fellow	Ropa Amon	1050	6.97
5.	Vegetable/ Mustard + Boro	Aus	Fellow	140	0.93
6.	Potato/onion/maize	Maize	Ropa Amon	750	4.98
7.	Potato/onion/Garlic/ Wheat/ Lentil	Maize/ Fellow	Ropa Amon/ Fellow	2800	18.60
8.	Wheat/onion/Garlic/ Lentil	Jute/Fellow	Ropa Amon/ Masakalai	2600	17.27

Serial No.	Crop rotation (sasyabinyas)			Land (Hectre)	%
	Robi	Khorif-01	Khorif-02		
9.	Wheat	Sesame	Ropa Amon/ Masakalai	160	1.06
10.	Lentil/wheat	Mung	Ropa Amon	650	4.32
11.	Wheat	Dhainca	Ropa Amon	50	0.33
12.	Vegetable	Vegetable	Vegetable	1200	7.97
13.	Sugarcane+Lentil/ Garlic/Onion/Coriander /Black cumin	Sugarcane	Sugarcane	1900	12.62
14.	Sugarcane	Sugarcane	Sugarcane	100	0.67
15.	Onion/Termeric/ Lentil/potato/ vegetable	Onion/ Mung/ vegetable	Guava	400	2.66
16.	Guava	Guava	Guava	100	0.67
17.	Banana	Banana+ Termeric/ Mung/ vegetable	Banana	775	5.15
18.	Banana	Banana	Banana	100	0.67
19.	Betel	Betel	Betel	87	0.58
20.	Papaya+Lentil/ Vegetable	Papaya	Papaya	150	1.00
21.	Termeric	Termeric	Termeric	150	1.00
22.	Others			350	2.32
			Total =	15052	100

Source: Official Record of DAE, Puthia

Appendix 2.3: Crop Production of Robi Season During 2008-09, 2013-14, 2014-15 and 2015-16 of Puthia Upazilla

Sl. No.	Name of Crop	Scientific name	2008-09		2013-14		2014-15		2015-16
			Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)
1.	Boro	*Oryza sativa*	4630	32837	2730	11820	2735	18300	2800 (continue)
2.	Wheat	*Triticum aestivum*	3450	8350	2660	31920	2800	9520	2900
3.	Potato	*Solananum tuberosum*	595	14219	755	22650	750	18000	1000
4.	Mustard	*Brassica campestris*	2085	1772	1070	1070	1250	1500	1150
5.	Lentil	*Lens culinoris*	1225	1347	3200	4480	3400	4080	3500
6.	Pea	*Pisum sativum*	22	28	30	30	40	48	-
7.	Khesari	*Lathyrus sativus*	131	144	20	50	10	10	-
8.	Chickpea	*Pisum sativum*	-	-	-	-	-	-	-
9.	Onion bulb	*Allium cepa*	390	4095	605	6050	650	7150	720
10.	Onion al	*Allium cepa*	2010	28395	2200	33000	2250	36350	2600
11.	Garlic	*Allium sativum*	640	2192	910	5915	950	11400	1250
12.	Chilli	*Capsicum annum*	72	65.5	70	70	90	108	100
13.	Coriander	*Coriandrum sativum*	108	102	110	110	65	65	65
14.	Termaric	*Curcuma longa*	244	3279	350	5250	325	4875	-
15.	Sugarcane	*Saccharum officinarum*	3000	131220	3000	132000	2500	105000	2000
16.	Maize	*Zea mayes*	160	800	2200	14300	550	3575	650 (Continue)
17.	Cauliflower	*Brassica oleracea var botrytis*	41	607	45	720	35	560	35
18.	Cabbage	*Brassica oleracea var capitata*	44	970	45	1350	35	1050	35
19.	Lalshak	*Amaranthus gangeticus*	120	618	105	630	120	720	150
20.	Spinach	*Spinacia oleraceae*	104	676	65	455	40	280	25

21.	Raddish	*Raphanus sativus*	85	1708	150	3450	160	3680	150
22.	Tomato	*Lycopersicon esculentum*	43	662	65	1300	65	1300	65
23.	Brinjal	*Solanm melongena*	228	2952	350	5250	420	6300	450
24.	Cucurbit	*Cucurbita maxima*	45	90	60	1140	75	1425	65
25.	String Bean	*Vigna sesquipedalis*	50	290	75	488	70	455	60
26.	Cowpea	Vigna unguiculata	15	94	20	140	30	210	15
27.	Korola	*Momordica charantia*	40	405	25	250	40	400	25
28.	Khira	*Cucumis anguina*	25	375	25	250	15	150	20
29.	Pumpkin	*Cucurbita maxima*	28	480	55	825	40	800	45
30.	Carrot	*Daucus carota*	08	51	-	-	-	-	-
31.	Black cumin	*Nigella sativa*	17	10	25	18	10	7.5	15
32.	Cucumber	*Cucumis sativus*	4	37	20	200	15	150	25
33.	Green Peas	*Pisum sativum*	15	75	80	400	130	650	80

Source: Official Record of DAE, Puthia

Appendix 2.4: Crop Production of Khorif Season-1 During 2008-09, 2012-13, 2013-14 and 2014-15 of Puthia Upazilla

Sl. No.	Name of Crop	2008-09		2012-13		2013-14		2014-15	
		Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)
1.	Aus (*Oryza sativa*)	100	224.6	150	383 rice	141	338 rice	90	216
2.	Maize (*Zea mays*)	566	2619	1450	8700	2200	14300	1800	11700
3.	Jute (*Corchorus capsularis*)	1425	340	1900	4560	180	4344	1900	4180
4.	Mung bean (*Vigna radiate*)	750	815	880	1056	680	816	630	756
5.	Sesame (*Sesamum indicum*)	460	384	255	255	160	160	165	165
6.	Chilli (*Capsicum frutescesns)*	20	16	90	90	95	95	100	100
7.	Papaya (*Carica papaya*)	95	2090	140	3500	160	3680	150	3750
8.	Banana (*Musa sapientum*)	970	27160	1515	37875	1250	35000	700	-
9.	Bringal (*Solanum melongena*)	200	2830	390	7800	490	19750	510	20400
10.	Okra (*Abelmoschus esculentus*)	42	222	47	470	40	440	40	440
11.	Pointed gourd (*Trichosanthes dioica*)	85	680	65	715	70	700	70	700
12.	Karola (*Momordica charantia*)	20	145	35	525	30	450	35	525
13.	Jhinga (*Luffa acutangula*)	20	160	17	204	20	240	15	-
14.	Chichinga (*Trichosanthes anguina)*	16	112	17	170	40	480	20	240
15.	Chal kumra (*Benincasa hispida*)	40	400	45	720	25	400	40	640
16.	Pumpkin (*Cucurbita maxima*)	40	480	71	1775	75	1875	35	875

17.	Barbati (*Vigna sesquipedalis*)	10	30	23	230	20	200	05	50
18.	Lalshak (*Amaranthus gangeticus*)	80	350	103	824	100	840	80	680
19.	Puishak (*Spinacia oleraceae*)	50	300	59	1475	55	1485	40	1080
20.	Data Shak (*Amaranthus lividus*)	100	420	106	1060	80	1200	60	900
21.	Shojina (*Moringa oleifera*)	8	25	15	300	20	400	15	300
22.	Mukhi Kachu (*Calocasia esculenta*)	28	504	24	360	15	225	10	150
23.	Cucumber (*Cucumis sativus*)	22	132	25	300	40	400	25	250
24.	Khira *(Cucumis anguina)*	10	120	36	432	35	420	20	240

Source: Official Record of DAE, Puthia

Appendix 2.5: Crop Production of Khorif 2 Season During 2008-09, 2013-14, 2014-15, 2015-16 of Puthia Upazilla

Sl. No.	Name of Crop		2008-09		2013-14		2014-15		2015-16	
			Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)	Cultivation (hectre)	Production (m. ton)
1.	Boro Amon (*Oryza sativa*)	Hybride	-	-	50	175 rice	-	-	-	-
		Upshi	4795	16782	3270	10464	4090	13088	4125	13200
		Local	95	171	30	60	10	16	15	27
		Total	4890	16953	3350	10699	4100	13104	4140	13227
2.	Masakalai (*Vigna mungo*)	Upshi	141	127	450	450	150	140	100	100

Source: Official Record of DAE, Puthia

Appendix 2.6: Stagnant and Cultured Area of Beels of Puthia Upazilla

Sl. No.	Name of Beel	**Area (Hectre)** Total area: 1821			
		1990		**2014**	
		Stagnant	**Cultivated**	**Stagnant**	**Cultivated**
1.	Sholtapuri Beel	10	10	1	19
2.	Patildoba Beel	5	2	1	6
3.	Tonapara Beel	52	30	4	78
4.	Jokar Beel	25	15	2	38
5.	Jabra Beel	16	17	1	32
6.	Doldolia Beel	33	30	4	59
7.	Kantar Beel	85	55	5	135
8.	Dub Beel	7	8	1	14
9.	Rangamatia Beel	13	11	1	23
10.	Bodopara Beel	19	14	1	32
11.	Udonpur Beel	68	62	6	124
12.	Udonpara Beel	45	28	2	71
13.	Ratowal Beel	73	67	8	132
14.	Badasher Beel	17	10	1	26
15.	Ruiar Beel	64	66	7	123
16.	Varoi Beel	40	21	1	60
17.	Pomparar Beel	54	76	7	123
18.	Garar Beel	42	38	2	78
19.	Krishnobati Beel	21	29	2	48
20.	Gobtolar Beel	27	26	1	52
21.	Goriar Beel	50	56	5	101
22.	Taltolar Beel	22	28	1	49
23.	Shukpara Beel	53	77	6	124
24.	Joshopara Beel	10	8	1	17
25.	Boalkoli Beel	19	41	2	58
26.	Matchparar Beel	52	56	6	102
27.	Modhukhalir Beel	5	3	1	7
28.	Chak polashir Beel	4	6	2	8
Total Area of Beel		**931**	**890**	**82**	**1739**

Source: Official Record of DAE, Puthia

Appendix 3

Appendix 3.1: List of Fruit Species as Recorded During the FGD and/or Identified in the Study Villages of Puthia Upazilla, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
1	Banana	Kola	Musaceae	*Musa* spp.
2	Black berry	Jam	Myrtaceae	*Eugenia jambolana*
3	Betel nut	Supari	Arecaceae	*Areca catechu*
4	Bullock‟s heart	Ata	Annonaceae	*Annona reticulata*
5	Cluster fig	Jagdumur	Moraceae	*Ficus glomirata*
6	Coconut	Narikel	Arecaceae	*Cocos nucifera*
7	Custard apple	Sharifa	Annonaceae	*Annona squamosa*
8	Date palm	Khejur	Arecaceae	*Phoenix sylvestris*
9	Elephant apple	Chalta	Dillenaceae	*Dillenia indica*
10	Fever nut	Karancha	Leguminosae	*Caesalpinia crista*
11	Fig	Dumur	Moraceae	*Ficus racemosa*
12	Guava	Peyara	Myrtaceae	*Psidium guajava*
13	Hog plum	Amra	Punicaceae	*Spondias mangifera*
14	Indian gooseberry	Amloki	Euphorbiaceae	*Emblica officinalis*
15	Jackfruit	Kathal	Moraceae	*Artocarpus heterophyllus*
16	Jujubee	Kul	Rhamnaceae	*Zizyphus jujum*
17	Lemon	Lebu	Rutaceae	*Citrus lemon*
18	Lime	Kagzi lebu	Rutaceae	*Citrus aurantifolia*
19	Litchi	Lichu	Sapindaceae	*Litchi chinensis*
20	Mango	Aam	Anacardiaceae	*Mangifera indica*
21	Monkey jack	Dawya	Moraceae	*Artocarpus lakoocha*
22	Olive	Jolpai	Elaeocarpaceae	*Elaeocarpus robustus*
23	Palmyra palm	Tal	Palmae	*Borassus flabellifer*
24	Papaya	Papay	Caricaceae	*Carica papaya*
25	Pine apple	Anaros	Bromeliaceae	*Ananas sativus*
26	Pome granate	Dalim	Anacardiaceae	*Punica granatum*
27	Pomelo	Jumbura	Rutaceae	*Citrus grandis*
28	River ebony	Deshi gab	Ebenaceae	*Diospyros peregrina*
29	Rose apple	Golap jam	Myrtaceae	*Syzygium jambo*
30	Sapota	Sofeda	Sapotaceae	*Manilkara achras*
31	Star gooseberry	Arobaroi	Euphorbiaceae	*Phyllanthus acidus*
32	Star fruit	Kamranga	Avoraceae	*Averrhoa carambola*
33	Stone apple	Bael	Rutaceae	*Aegle mermelos*
34	Tamarind	Tetul	Leguminosae	*Tamarindus indica*
35	Valvet apple	Bilati gab	Ebenaceae	*Diospyros discolor*
36	Wax jambu	Jamrul	Myrtaceae	*Syzygium samarangense*
37	Wood apple	Kathbel	Rutaceae	*Feronia limonia*

Source: Field visit

Appendix 3.2: List of Timber Species as Recorded During the FGDs and/or Identified in the Study Villages of Puthia Upazila, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
1	Auri	Akashmoni	Mimosaceae	*Acacia auriculiformis*
2	Arjuna	Arjun	Combretaceae	*Terminalia arjuna*
3	*Bhalku* bamboo	Bhalka bash	Gramineae	*Bambusa balcooa*
4	Mangium	Belgium	Leguminosae	*Acacia mangium*
5	Cane	Baet	Arecaceae	*Calamus* spp.
6	Chaplaish	Chambal	Moraceae	*Artocarpus chaplasha*
7	Coral tree	Mander	Leguminosae	*Erythrina indica*
8	Eucalyptus	Malaria	Myrtaceae	*Eucalyptus camaldulensis*
9	Hairy fig	Khoksa	Moraceae	*Ficus hispida*
10	Indian Ash tree	Badhi	Anacardiaceae	*Lannea coromandelica*
11	Ipil-ipil	Ipil-ipil	Leguminosae	*Leucaena leucocephala*
12	Ivy-rue	Bajna	Rutaceae	*Zanthoxylum rhetsa*
13	Kadam	Kadam	Rubiaceae	*Anthocephalus cadamba*
14	Kamela	Raini/Sinduri	Euphorbiaceae	*Mallotus philippinensis*
15	Kassod tree	Minjiri	Leguminosae	*Cassia siamea*
16	*Makal* bamboo	Mahal bash	Gramineae	*Bambusa nutuns*
17	Mahogany	Mehogani	Meliaceae	*Swietenia mahogany*
18	Microcos	Datoi	Tiliaceae	*Microcos paniculata*
19	*Muli* bamboo	Muli bash	Gramineae	*Melocanna bambuoides*
20	Neem	Nim	Meliaceae	*Azadirachta indica*
21	*Ora* bamboo	Ora bash	Gramineae	*Dendrocalamus longispathus*
22	Paper tree	Gamar	Verbenaceae	*Gmelina arborea*
23	*Pecha* bamboo	Pechajali bash	Gramineae	*Dendrocalamus hamiltoni*
24	Pitali	Pitali	Euphorbiaceae	*Trewia polycarpa*
25	Prickly acacia	Babla	Leguminosae	*Acacia nilotica*
26	Pride of India	Jarul	Lythraceae	*Lagerstroemia flos reginae*
27	Raintree	Raintree	Fabaceae	*Samanea saman*
28	Sal	Shal	Dipterocarpaceae	*Shorea robusta*
29	Sandpaper tree	Akashi	Dilleniaceae	*Dillenia scabrella*
30	Shisham	Sissoo	Fabaceae	*Dalbergia sissoo*
31	Silk cotton	Shimul	Malvaceae	*Gossypium herbaceum*
32	Teak	Segun	Verbenaceae	*Tectona grandis*
33	Tooth brush tree	Sheora	Uricaceae	*Sterblus asper*
34	Wavy-leaved fig	Pakur	Moraceae	*Ficus infectoria*
35	White siris	Sil koroi	Fabaceae	*Albizia procera*
36	Wodier	Jiga	Anacardiaceae	*Odina wodier*

Source: Field visit

Appendix 3.3: List of Medicinal and Ornamental Plants Recorded During the FGDs and/or Identified in the Study Villages Puthia Upazila Rajshahi District

Sl.	English name	Bangla/local name	Family	Scientific name
1	Arjuna	Arjun	Combretaceae	*Terminalia arjuna*
2	Ashoka	Ashok	Leguminosae	*Saraca asoca*
3	Basil	Tulshi	Labiatae	*Ocimum tenuiflorum*
4	Beleric myrobalan	Bohera	Combretaceae	*Terminalia berica*
5	Black myrobalan	Horitoky	Combretaceae	*Terminalia chebula*
6	Cape jasmine	Gandharaj	Rubiaceae	*Gardenia jasminoides*
7	China rose	Jaba	Malvaceae	*Hibiscus rosa-sinensis*
8	Chinese box	Kamini	Rutaceae	*Murrya exotica*
9	Crepe jasmine	Tagor	Apocynaceae	*Tabernaemontana coronaria*
10	Devil tree	Chhatim	Apocynaceae	*Alstonia macrophylla*
11	Flame of the forest/ Parrot tree	Polash	Fabaceae	*Butea frondosa*
12	Garden balsam	Gouri phool	Balsaminaceae	*Impatiens balsamina*
13	Golden shower	Sonalu	Leguminosae	*Cassia fistula*
14	Henna	Mehedi	Lythraceae	*Lawsonia inermis*
15	Joy perfume tree	Swarna champa	Magnoliaceae	*Michelia champaca*
16	Jungle flame	Rangan	Rubiaceae	*Ixora coccinea*
17	Kadam	Kadam	Rubiaceae	*Anthocephalus cadamba*
18	Love-lies-bleeding	Morogful	Amaranthaceae	*Amaranthus caudatus*
19	Marigold	Ganda	Compositae	*Tagetes erecta*
20	Medlar	Bakul	Sapotaceae	*Mimusops elengi*
21	Neem	Neem	Meliaceae	*Azadirachta indica*
22	Night blooming jasmine	Hasnahena	Solanaceae	*Cestrum nocturnum*
23	Night flowering Jasmine	Sheuli	Oleaceae	*Nyctanthes arbortristis*
24	Paper flower	Baganbilash	Nyctaginaceae	*Bougainvillea glabra*
25	Periwinkle	Nayantara	Apocynaceae	*Vinca rosea*
26	Pigeon wings	Aparajita	Fabaceae	*Clitoria ternatea*
27	Rangoon creeper	Madhobilata	Combretaceae	*Quisqualis indica*
28	Red sandalwood	Chandon	Fabaceae	*Adenathera pavonina*
29	Rose	Golap	Rosaceae	*Rosaceae rosa/ Rosa alba*
30	Royal poinciana	Krishnachura	Leguminosae	*Delonix regia*
31	Tuberose	Rajanigandha	Agavaceae	*Polianthes tuberose*
32	Water lily	Shapla	Nymphaeaceae	*Nymphaea nouchali*
33	Yellow flame tree	Radhachura	Fabaceae	*Peltophorum pterocarpum*
34	Yellow oleander	Kolke phool	Apocynaceae	*Thevetia peruviana*

Source: FGDs, Interview and Field visit

Appendix 3.4: List of Vegetable and Spices Recorded During the FGDs and/or Identified in the Study Villages of Puthia Upazila, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
Vegetables				
1	Ash gourd	Chalkumra	Cucurbitaceae	*Benincasa hispida*
2	Bitter gourd	Karola	Cucurbitaceae	*Momordica charantia*
3	Brinjal	Begun	Solanaceae	*Solanum melonggenan*
4	Bottle gourd	Lau	Cucurbitaceae	*Leginaria vulgaris*
5	Cabbage	Badha kopi	Cruciferae	*Brassica oleracea var. capitata*
6	Cauliflower	Ful kopi	Cruciferae	*Brassica oleracea var. botrytis*
7	Country bean	Seem		*Dolichos lablab*
8	Cucumber	Shosa		*Cucumis sativus*
9	Drum stick	Sajina		*Moringa oleifera*
10	Giant taro	Mankachu		*Alocasia indica*
11	Indian spinach	Pui shak		*Basellam alba*
12	Kang kong	Kalmi shak		*Ipomoea reptans*
13	Okra	Dherosh	Malvaceae	*Hibiscus esculantus*
14	Plantain	Kachkola	Musaceae	*Musa paradisiaceae*
15	Radish	Mula		*Raphanus sativus*
16	Red amaranth	Lal shak	Amaranthaceae	*Amaranthus tricolor*
17	Ribbed gourd	Jhinga		*Luffa acutangula*
18	Snake gourd	Chichinga	Cucurbitaceae	*Trychosanthes anguina*
19	Spinach	Palong shak	Chenopodiaceae	*Spinacia oleraceae*
20	Sponge gourd	Dhundul		*Luffa cylindrical*
21	Stem amaranth	Data	Amaranthaceae	*Amaranthus lividus*
22	Sweet gourd	Misti kumra	Cucurbitaceae	*Cucurbita moschata*
23	Sweet potato	Mitha alu		*Ipomea batatus*
24	Taro	Mukhi kachu	Araceae	*Colocasia esculenta*
25	Tamato	Tomato	Solanaceae	*Lycopersicon esculentum*
26	Teasel gourd	Kakrol	Cucurbitaceae	*Momordica diocia*
27	Yam	Mete alu	Cucurbitaceae	*Dioscorea esculenta*
28	Yard-long bean	Borboti	Fabaceae	*Vigna unguieulata*
Spices				
1	Bay leaf	Tejpata	Lauraceae	*Cinnamum tamala*
2	Chilli	Morich	Solanaceae	*Capsicum annum*
3	Coriander	Dhonia	Umbelliferae	*Coriandrum sativum*
4	Garlic	Rasun	Liliaceae	*Allium sativum*
5	Ginger	Ada	Zingiberaceae	*Zingiber officinale*
6	Turmeric	Halud	Zingiberaceae	*Curcuma longa*
7	Anise	Mouri	Apiaceae	*Pimpinella anisum*
8	Onion	Piaj	Liliaceae	*Allium cepa*
9	Mint	Pudina	Lamiaceae	*Melissa officinalis*

Source: FGDs, Interview and Field visit

Appendix 3.5: List of Weed Species Identified in the Study Villages of Puthia Upazila, Rajshahi District

Sl.	English Name	Bangla/local name	Family	Scientific name
1	Achiote	Bon holud	Bixaceae	*Bixa orellana*
2	Alligator weed	Malancha*	Amaranthaceae	*Alternanthera philoxeroides*
4	Asian watergrass	Janglidal/ Futki*	Graminae	*Hygroryza aristata*
5	Batoko plum	Buch	Flacourtiaceae	*Flacourtia sepiaria*
6	Bermuda grass	Durba*	Graminae	*Cynodon dactylon*
7	Black nightshade	Bon begun	Solanaceae	*Solanum nigrum*
8	Bind weed	Bindalata*	Convolvulaceae	*Convolvulus arvensis*
9	Bitter dock	Bon palong	Polygonaceae	*Rumex maritimus*
10	Clammy ground cherry	Foska begun	Solanaceae	*Phsalia heterophylla*
11	Coat buttons	Tridhara/Tunaki*	Compositae	*Tridax procumbens*
12	Cocklebur	Ghagra	Compositae	*Xanthium italicum*
13	Coffee weed	Kofi agacha	Leguminosae	*Daubentonia punicea*
14	Cogon grass	Ulu	Graminae	*Imperata cylindrica*
15	Common purslane	Nunia	Portulacaceae	*Portulaca oleracea*
16	Corn spurge	Hazardana*	Euphorbiaceae	*Phyllanthus niruri*
17	Christmas bush	German lata	Asteraceae	*Eupatorium odoratum*
18	Crow foot grass	Kakpaya	Graminae	*Dactyloctenium aegyptium*
19	Dense rush grass	Ailabena	Graminae	*Sporobolus indicus*
20	Devil‟s cotton	Ulatkambal*	Sterculiaceae	*Abroma agustus*
21	Dodder	Swanalata*	Convolvulaceae	*Cuscuta reflexa*
22	Dove weed	Kenduli	Commelinaceae	*Murdania nudiflora*
23	Fathen	Bathua*	Chenopodiaceae	*Chenopodium album*
24	Fern	Dheki sak	Polypodiaceae	*Dryopteris filix-mas*
25	Four-leaved water clover	Shushni*	Marsileaceae	*Marsilea quadrifolia*
26	Fringed false Pimpernel	Katahenchi*	Scrophulariaceae	*Lindernia ciliata*
27	Gandarusa	Jagatmadan	Acanthaceae	*Justicia gendarussa*
28	Gigantic swallow-wort	Akanda*	Asclepiadaceae	*Calotropis gigantea*
29	Goat weed	Chhagalgacha*	Compositae	*Ageratum conyzoides*
30	Gosmore	Biralkarani	Compositae	*Hypochaeris radicata*
31	Goose grass	Chapra	Graminae	*Elusine indica*

32	Green fox tail	Sabuj shial leja	Graminae	*Setaria viridis*
33	Harkuch	Choto helencha*	Compositae	*Enhydra fluctuans*
34	Hill glory bower	Bhat	Verbenaceae	*Clerodendrum viscosum*
35	Horse nettle	Kanta begun*	Solanaceae	*Solanum carolinense*
36	Indian pennywort	Thankuni	Umbelliferae	*Hydrocotyle asiatica*
37	Indian sorrel	Amrul*	Oxalidaceae	*Oxalis europea*
38	Ivy gourd	Telakucha*	Cucurbitaceae	*Cephalandra indica*
39	Jersey cudweed	Bon kopi	Compositae	*Gnaphalium affine*
40	Jimson weed	Dhutura*	Solanaceae	*Datura stramonium*
41	Joint grass	Gitla ghas	Graminae	*Paspalum distichum*
42	Keteli	Keteli	Compositae	*Cirsium arvense*
43	Ladder brake	Pteris*	Pteridaceae	*Pteris vittata*
44	Lantana	Lantana*	Verbenaceae	*Lantana camara*
45	Leptochloa grass	Fulka ghas	Graminae	*Leptochloa chinensis*
46	Lesser fimbristylis	Joyna	Cyperaceae	*Fimbristylis miliaceae*
47	Leucas	Dandakalash*	Labiatae	*Leucas aspera*
48	Love grass	Kuni ghas	Graminae	*Eragrostis unioloides*
49	Love thorn	Premkata	Graminae	*Chrysopogon aciculatus*
50	Low kyllinga	Sethgothuri*	Cyperaceae	*Kyllinga monocephala*
51	*Matichech*	Mati chech	Cyperaceae	*Fimbristylis dipphylla*
52	Mazus	Tutra	Phrymaceae	*Mazus rugosus*
3	Milk weed	Baro dudhia*	Euphorbiaceae	*Euphorbia hirta*
53	Miracle Leaf	Patharkuchi*	Crassulaceae	*Kalanchoe pinnata*
54	Nut sedge	Mutha*	Cyperaceae	*Cyperus rotundus*
55	Pale persicary	Agrha*	Polygonaceae	*Polygonum lapathifolium*
56	Para grass	Para ghas	Graminae	*Brachiaria mutica*
57	Pig weed	Noteshak	Amaranthaceae	*Amaranthus viridis*
58	Prickly amaranth	Katanotey	Amaranthaceae	*Amaranthus spinosus*
59	Prickly chaff flower	Apang*	Amaranthaceae	*Achyranthes aspera*
60	Prostate false pimernel	Khetpapri	Linderniaceae	*Lindernia procumbens*
61	Prostate spurge	Choto dudhia	Euphorbiaceae	*Euphorbia parviflora*
62	Red verticilla	Roktodron*	Labiatae	*Leonurus sibiricus*
63	Rush grass	Benajoni	Graminae	*Sporobolus diander*
64	Scrab grass	Anguli ghas	Graminae	*Digitaria sanguinalis*
65	Sessile joyweed	Chanchi	Amaranthaceae	*Alternanthera sessilis*
66	Sickle pod	Araich	Caesalpinaceae	*Cassia tora*
67	Sheand grass	Chela ghas	Graminae	*Parapholis incurva*

68	Malay blumea	Shialmutra	Asteraceae	*Blumea lacera*
69	Smart weed	Bishkatali	Polygonaceae	*Polygonum orientale*
70	Spider wort	Kanaibashi	Commelinaceae	*Commelina benghalensis*
71	Spreading day flower	Kanainala	Commelinaceae	*Cyanotis axillaris*
72	Southern Rockbell	Halud nakful	Campanulaceae	*Wahlenbergia marginata*
73	Swamp rice grass	Arail	Graminae	*Leersia hexandra*
74	Sweet broomweed	Bon dhonia*	Scrophulariaceae	*Scroparia dulcis*
75	Tex-Mex tobacco	Bon tamak	Solanaceae	*Nicotiana plumbaginifolia*
76	Thatch grass	Nalkhagra	Graminae	*Saccharum spontaneum*
77	Tickweed	Hurhur*	Capparidaceae	*Cleome icosandra*
78	Touch-me-not	Lajjabati	Leguminosae	*Mimosa pudica*
79	Umbrella sedge	Chech	Cyperaceae	*Cyperus iria*
80	Velvate leaf	Jhanjhani*	Malvaceae	*Abutilon theophrasti*
81	Vetch	Bon masur	Leguminosae	*Vicia sativa*
82	Water spinach	Kalmi*	Convolvulaceae	*Ipomoea aquatica*
83	White eclipta	Keshraj/Keshuti*	Compositae	*Eclipta prostrata*
84	Wild clary	Hatishur*	Boraginaceae	*Heliotropium indicum*
85	Wild mustard	Bon sarisha	Cruciferae	*Brassica kaber*
86	Wild pea	Bon mator	Papilionaceae	*Desmodium heterophyllum*
87	Wild rice	Buno dhan	Graminae	*Oryza rufipogon*
88	Winged water primrose	Panilong	Ongraceae	*Jussiaea decurrens*

Source: FGDs, Interview and Field visit * Medicinal plants

Appendix 3.6: List of Animals and Birds in the Recorded During the FGDs and/or Identified in the the Study Villages Puthia Upazila, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
Domestic animals/birds				
1	Cattle	Garu	Bovidae	*Bos taurus*
2	Buffalo	Mahish	Bovidae	*Bubalus bubalis*
3	Goat	Chhagal	Bovidae	*Capra aegagrus hircus*
4	Sheep	Bhera	Bovidae	*Ovis aries*
5	Chicken	Morog/Murgi	Phasianidae	*Gallus gallus domesticus*
6	Duck	Pati hash	Anatidae	*Anatidae anseriformes*
7	Goose	Rajhash	Anatidae	*Anser cygnoides*
8	Guinea fowl	Titir	Numididae	*Numida meleagris*
9	Pegion	Kabutar	*Columbidae*	*Columba livia*
Pet animals/birds				
1	Horse	Ghora	Equidae	*Equus ferus caballus*
2	Dog	Kukur	Canidae	*Canis lupus familiaris*
3	Cat	Biral	Felidae	*Felis catus*
4	Hare	Khorgos	Leporidae	*Lepus spp.*
5	Indian ringneck Parrot Tia		Psittacidae	*Psittacula krameri manillensis*
6	Mynah	Moyna	Sturnidae	*Gracula religiosa intermedia*
7	Cockatoo	Kakatua	Cacatuidae	*Cacatua alba*
8	House myna	Shalik	Sturnidae	*Acridotheres tristis*
9	Dove	Ghughu	Columbidae	*Streptopelia chinesis*

Source: FGDs and Interview

Appendix 3.7: List of Fish Species Recorded During the FGD and/or Interview at Study Villages of Puthia Upazila, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
1	Badis dwarf	Napit koi	Badidae	*Badis badis*
2	Banded gourami	Khailsa	Osphronemidae	*Colisa fasciata*
3	Bata	Bata	Cyprinidae	*Labeo bata*
4	Bronze featherback	Foloi	Notopteridae	*Notopterus notopterus*
5	Catla	Katol	Cyprinidae	*Catla catla*
6	Chanda	Chanda	Ambassidae	*Chanda nama*
7	Climbing perch	Koi	Anabantidae	*Anabas testudineus*
8	Clown knifefish	Chital	Notopteridae	*Chitala chitala*
9	Common carp	Common carp	Cyprinidae	*Cyprinus carpio carpio*
10	Corsula	Khorsula	Mugilidae	*Rhinomugil corsula*
11	Day's mystus	Tengra	Bagridae	*Mystus bleekeri*
12	*Dhela*	Dhela	Cyprinidae	*Osteobrama cotio*
13	Finescale razorbelly minnow	Chela	Cyprinidae	*Salmostoma phulo*
14	Flying barb	Darkina	Cyprinidae	*Rasbora rasbora*
15	Indian potasi	Batasi	Schilbeidae	*Neotropius atherinoides*
16	Jamuna ailia	Banspata	Cyprinidae	*Ailia punctata*
17	Wallago	Boal	Siluridae	*Wallago attu*
18	Small prawn	Chingri	Penaeidae	*Palaemon* spp.
19	Indian river shad	Chapila	Clupeidae	*Gudusia chapra*
20	Great snakehead	Gajar	Channidae	*Channa marulius*
21	Indian glassy fish	Golchanda	Ambassidae	*Parambassis ranga*
22	Grass carp	Grass carp	Cyprinidae	*Ctenopharyngodon idella*
23	Orange-fin labeo	Kalibaus	Cyprinidae	*Labeo calbasu*
24	Walking catfish	Magur	Clariidae	*Clarias batrachus*
25	Mrigal	Mrigel	Cyprinidae	*Cirrhinus cirrhosus*
26	Mirror carp	Mirror carp	Cyprinidae	*Cyprinus carpio*
27	Mola carplet	Mola	Cyprinidae	*Amblypharyngodon mola*
28	Mozambique tilapia	Telapia	Cichlidae	*Oreochromis mossambicus*
29	Mud perch	Royna/Bheda	Nandidae	*Nandus nandus*
30	Olive barb	Sarputi	Cyprinidae	*Puntius sarana*
31	Puntio barb	Puti	Cyprinidae	*Puntius puntio*
32	Rohu	Rui	Cyprinidae	*Labeo rohita*
33	Snakehead murrel	Shol	Channidae	*Channa striata*
34	Silver carp	Silver carp	Cyprinidae	*Hypophthalmichthys molitrix*
35	Spotted snakehead	Taki	Channidae	*Channa punctata*
36	Stinging catfish	Singhi	Heteropneustidae	*Heteropneustes fossilis*
37	Tank goby	Bele	Gobiidae	*Glossogobius giuris*
38	Ticto barb	Titputi	Cyprinidae	*Puntius ticto*
38	Yellowtail catfish	Pangas	Pangasiidae	*Pangasius pangasius*
40	Zig-zag eel	Baim	Mastacembelidae	*Mastacembelus armatus*

Source: FGDs, Interview and Field visit

Appendix 3.8: List of Bird Species Recorded During the FGD and/or Interview in the Study Villages of Puthia Upazila, Rajshahi District

Sl.#	English name	Bangla/local name	Family	Scientific name
1	Asian koel	Kokil	Cuculidae	*Eudynamys scolopaceus*
2	Baya weaver	Babui	Ploceidae	*Ploceus philippinus*
3	Baza	Baz	Accipitridae	*Aviceda leophotes*
4	Black capped oriole	Holde kutum	Oriolidae	*Oriolus capensis*
5	Black cormorant	Pankouri	Phalacrocoracidae	*Phalacrocorax sulcirostris*
6	Black drongo	Fingey	Dicruridae	*Dicrurus macrocercus*
7	Brahminy kite	Shankha chil	Accipitridae	*Haliastur indus*
8	Cattle egret	Sada bok	Ardeidae	*Bubulcus ibis*
9	Common myna	Shalik	Sturnidae	*Acridotheres tristis*
10	Cockatoo	Kakatua	Cacatuidae	*Cacatua alba*
11	Eagle	Eagle	Accipitridae	*Haliaeetus leucoryphus*
12	Green bee-eater	Banspaati	Meropidae	*Merops orientalis*
13	House crow	Pati kak	Corvidae	*Corvus splendens*
14	House sparrow	Charui	Ploceidae	*Passer domesticus*
15	Hawk-cuckoo	Chokh gelo	Cuculidae	*Hierococcyx varius*
16	Indian cuckoo	Bau katha kao	Cuculidae	*Cuculus micropterus*
17	Jungle babler	Chhatare	Timaliinae	*Turdoides striatus*
18	Kingfisher	Machranga	Alcidinidae	*Halcyon smyrnensis*
19	Large pied wagtail	Sada khanjan	Motacillidae	*Motacilla maderapatensis*
20	Magpie robin	Doyel	Turdinae	*Copsychus saularis*
21	Munia	Munia	Ploceidae	*Lonchura vana*
22	Mynah	Moyna	Sturnidae	*Gracula religiosa intermedia*
23	Owl	Pecha	Strigidae	*Nocturnalis strigiformes*
24	Pariah kite	Chil	Accipitridae	*Milvus migrans*
25	Parakeet	Tia	Psittacidae	*Psittacula krameri manillensis*
26	Peacock	Mayur	Phasianidae	*Pavo cristatus*
27	Pied myna	Go-shalik	Sturnidae	*Sturnus contra*
28	Pond heron	Kani bok	Ardeidae	*Ardeola grayii*
29	Raven	Dar kak	Corvidae	*Corvus corax*
30	Red whiskered bulbuli	Bulbuli	Pycnonotidae	*Pycnonotus jocosus*
31	Rufous treepie	Hanrichacha	Timaliimae	*Dendrocitta vagabunda*
32	Spotted dove	Ghugu	Columbidae	*Streptopelia chinesis*
33	Sun bird	Moutusi	Nectarniidae	*Nectarinia zeylonica*
34	Tailor bird	Tuntuni	Cisticolidae	*Orthotomus sutorius*
35	Vulture	Shakun	Accipitridae	*Gyps fulvus*
36	White-breasted waterhen	Dahuk	Rallidae	*Amaurornis phoenicurnus*
37	Wood pecker	Katthokra	Picidae	*Picoides pubescens*
38	Yellow footed green pigeon	Hariyal	Columbidae	*Treron phoenicoptera*

Source: FGDs, Interview and Field visit