Journal of Scientific Agriculture 2017, 1: 79-90
doi: 10.25081/jsa.2017.v1i0.34
http://updatepublishing.com/journals/index.php/jsa

INVITED ARTICLE

Factors associated with agrobiodiversity conservation: A case study on conservation of rice varieties in Barak valley, Assam, India

Nazimur Rahman Talukdar and Parthankar Choudhury*

Department of Ecology and Environmental Science, Assam University, Silchar 788011, India.

Abstract

Agrobiodiversity contributes to food security, increase productivity, economic returns and provides social, cultural and ecological functions. The present study aims to investigate the factors associated with agrobiodiversity conservation, with respect to the rice varieties in the Barak valley of Assam, India. Barak valley has high ecological and genetic diversity, and is one of the important regions of NE India in terms of agricultural productivity. More than 80% of the people of the Valley depend upon agricultural activities for their livelihood. Fieldwork included semi-structured interviews, visit to crop field (inventory) and survey to households to register seed exchange network, socio-economic characteristics and other factors influencing agrobiodiversity conservation. We used correlation analysis to know the association of various factors. Thirty six rice varieties were found to be traditionally conserved. Indegee refers to the number informants inform someone's name when asked about their shareholders. For example, one informant name was informed by five people when asked to list the name of seed givers or receivers, then the informant would have an indegree of five. It was found that Farmers who had higher indegree conserved more traditional varieties than those farmers who had less indegree. It can be hypothesized that conservation of traditional varieties is related with various co-relating factors. Our findings will surely contribute to the conservation of genetic resources. Establishment of seed bank and application of vermicompost technique are suggested to check genetic erosion and fulfill the inadequacy of organic fertilizers.

Key words: Human-wildlife conflict, *In situ* conservation, Socio-economic, South Assam

Introduction

Rice is world most used food crops, specially grown in humid tropical regions of the world, with favorable temperature range of 10-30°C. India harbors a large number of rice species because of its diverse climatic and geographic conditions. Many of the rice varieties are limited to the Gangetic plain of northern part of India. National bureau of plant genetic resources (NBPGR) identified about 2000 local landraces from major rice ecologies from North-Eastern India (Hore, 2005). Local farmers in general, practice traditional varieties based on the knowledge of the quality of rice varieties and their adaptation in various agro-ecological systems (Das and Das, 2014). However, during the latter half of the 20th century, intensive agriculture for increasing crop yields to meet the growing demand for food has led to degradation of the natural resources upon which agriculture depends, viz., soil, water, and natural genetic diversity.

From the last few decades biotechnological solution to increase food production has been increasing tremendously. As a result, farmers are motivated to use hybrid and high-yielding

Received 29 April 2017; Revised 25 May 2017; Accepted 26 May 2017; Published 26 May 2017

*Corresponding Author

Parthankar Choudhury

Department of Ecology and Environmental Science, Assam University, Silchar-788011, India.

Email: parthankar.c@rediffmail.com; parthankar@rediffmail.com

varieties at the cost of traditional varieties. Researchers, therefore, have highlighted the importance of *in situ* conservation as a balancing approach of *ex situ* conservation to tackle genetic erosion (Oldfield and Alcorn, 1987; Brush, 1991). *In situ* conservation not only help in reducing genetic erosion through conservation of varieties but it also increases the germplasm as it allows species to adapt with the environmental change (Altieri and Merrick, 1987). It also makes the sustainable environment as the traditional varieties are less dependent on allochthonus inputs like pesticides and fertilizer (Prescott-Allen and Prescott-Allen, 1982; Altieri and Merrick, 1987). *In situ* conservation of Agrobiodiversity has a tremendous historical and cultural significance (Cox, 2000; Maffi, 2002). Most importantly, it bridges the community through exchange and marketing the seeds and seedlings.

After the Convention on Biodiversity (CBD, 1999) held at Reo De Janeiro, *in situ* Agrobiodiversity conservation is now being incorporated in the governmental policies. Some of the important researches on *in situ* conservation of agrobiodiversity and its role on conservation of plant genetic resources are Agelet et al. (2000), Sunwar et al. (2006), Perrault-Archambault and Coomes (2008), Calvet-Mir et al. (2011), etc. Previous researchers have highlighted the importance of seed exchange in the home-gardens as conservation of plant germplasm (Calvet-Mir et al., 2012). A few researchers have stated that markets can trigger genetic erosion as local varieties are substituted by high-yielding varieties (Bellon, 2004; Stromberg et al., 2010). Previous researches suggest that the seed exchange and knowledge are transmitted together (Acosta-Naranjo and Diaz-Diego, 2008). The present study focuses on conservation and management of traditional rice varieties, and importance of exchanging them, and hypothesizes that traditional varieties conservation depends on various factors. We focus on traditional rice varieties conservation because these varieties are going to less important to study areas and many researchers have highlighted the importance traditional practices that can contribute to conservation of plant genetic resources (Altieri and Merrick, 1987; Oldfield and Alcorn, 1987).

Methodology

Study Area

Assam, state of North East India, lies between 24°8/ N to 28°2/ N latitude and 89°42/ E to 96° E longitude, covering an area of 78 438 km^2. The northern Assam is a part of the Himalayan biodiversity hotspot, while the southern region is a part of the Indo-Burma hotspot, and thus Assam is a home to an extensive exhibit of vegetation, running from tropical and sub-tropical to temperate or near temperate. This is because of the various geology, shifted and rich precipitation and differential climatic and edaphic conditions in the state. The woods are especially plentifully supplied with orchids and various types of medicinal and aromatic plants.

Edaphically, the region of the country is diverse, contributed by hillock, mountain, wetlands, floodplains, grasslands, etc. However, agricultural activities are restricted in this region due to poor agricultural land and irrigation facilities.

The Barak valley region, covering an area 6 922 km^2, is located in the southern part of the state of Assam in India, (24°48/N, 92°45/E) and is particularly rich in biodiversity. The Barak river, originating in the Barail range (Assam-Nagaland border), flows through the Cachar district with a 40-50 km wide valley and enters Bangladesh. The region is named after the Barak River. The study was conducted in Kurtigaon (24°48/083//N, 92°23/570//E) in the Karimganj district of Barak valley, Assam India (Fig. 1).

The vegetation in the valley is for the most part tropical evergreen and there are vast tracts of rainforests in the northern and south-eastern parts of the valley, which are rich wildlife however with a considerable amount disappearing because of human attack and environment damages. Rare species found are Hoolock gibbon *Hoolock hoolock*, Phayre's leaf monkey *Trachypithecus phayrei*, Pig-tailed macaque *Macaca nemestrina*, Stump-tailed macaque *Macaca arcoides*, Masked Finfoot *Heliopais personatus*, White-winged Wood Duck, *Asarcornis scutulata* etc. (Choudhury, 1989, 1997).

J. Sci. Agric. 2017, 1: 79-90
http://updatepublishing.com/journals/index.php/jsa

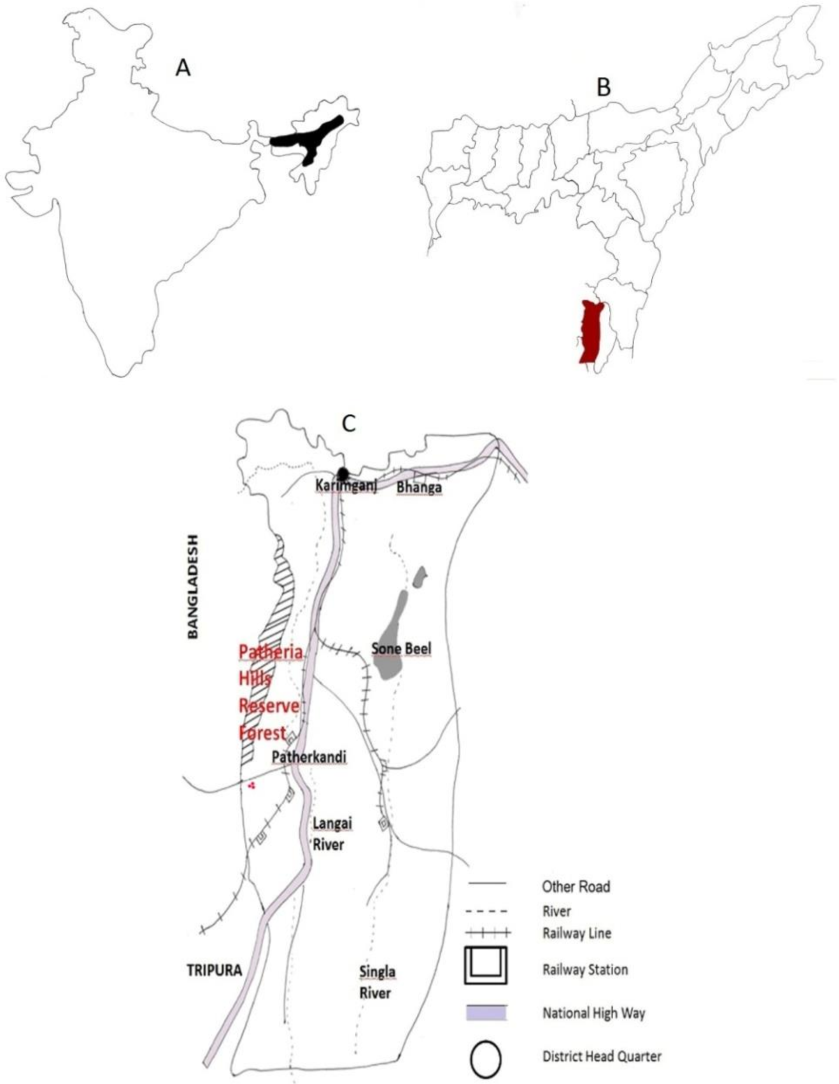

Fig. 1. Map of Study Area. A: Map of India highlighting the state of Assam. B: Map of Assam highlighting Karimganj district. C: Map of Karimganj District highlighting where red dot indicates the exact location of study site. Map by @ Nazimur Rahman Talukdar

Sampling design and data collection

Sampling Design

At first we did a pilot survey in south Assam and then selected two villages depending on both potentialities of agriculture and forested area. Data collection from those selected villages included the inventory of 100 households, and a survey conducted with farmers (100) whose primary occupation is farming. We excluded those farmers who occasionally do farming. Since, we selected villages after preliminary observation of the villages (pilot survey), the sampling is realistic for our objectives. Also, our objective was what are those factors influencing the traditional varieties conservation, not how much influencing, so, selected 100 farmers for seed exchange network is not an underestimation or an overestimation.

Data were collected from the two villages. We tried to reach every farmers household so that seed exchange network could be identified. The study was carried out from June 2015 to April 2016. Data collection included semi-structured interviews, field inventories and structured interviews.

Semi-structured interviews

We interviewed with selected 100 farmers belonging various age groups. We asked the traditional rice varieties which were cultivated, their source of seedlings, conservation practices, and size of crop field on which they cultivated paddy.

Inventory

The agricultural fields were visited in all the seasons of paddy cropping, *Kharif* (April-June) and *Rabi* season (November-January), and observed the rice varieties which were cultivated. The farmers were asked to accompany and tell the vernacular name of the species. Photographs documentation of the species were made. Vouchers of all species were deposited in the herbarium centre of the Environmental studies, Udhay Group of Institution, Hailakandi, India.

Survey and data analysis

We conducted a questionnaire with those selected100 farmers. In Barak valley, farmers perform agricultural activities either on their own land or others on lease basis. Most of the land owners are unaware of the varieties grown in their fields, which are actually done by the farmers. Therefore, our target group for the questionnaire was farmers. The questionnaire was performed followed Calvet-Mir et al. (2011). The questionnaire was divided into four sections. In the first section, we compiled information about the socio-economic status of the farmers, including age, gender, and number of years they have been farming. In the second section, we asked about sources of seeds and seedlings. In the third section, we asked about the seed and seeding exchange network. In that effort, we asked farmers about their seed exchange network. Specifically, we asked the farmers the name of persons to whom they share seeds and also persons from whom they obtain seeds (Calvet-Mir et al., 2012). After all the names were listed, we asked informants to furnish other details the sex, age, and place of residence of all the people listed. In the last section we asked about the use of fertilizer.

Socio-economic status among the farmers is assessed on the basis of criteria such as land size, number of cattle owned and number of literate in the family, roofing pattern (Das and Das, 2014). The informants were asked about the uses of fertilizers. Rice production was classified as organic and inorganic. Organic rice was that in which was produced by using manure or other organic products as the main fertilizers and use of physical and mechanical techniques to control weeds and pests. Inorganic rice was those where chemical fertilizers were the input. The farmers were classified into small scale farmers (cultivating five or less than five acre), medium scale farmers (greater than five but less than ten acre) and large scale farmers (greater than ten acres). We then calculated four network measures: (1) size, or number of actors in the network; (2) number of components, (4) network centralization index, or the tendency of a few actors in the network to have many links (expressed in percentage) and (1) indegree of a seed exchange network. Indegee refers to the number informants inform someone's name when asked about their shareholders. For example, one informant name was informed by five people when asked to list the name of seed givers or receivers, then the informant would have an indegree of five (Calvet-Mir, 2012)

To measure the seed exchange network, centrality and indegree, we created a column in questionnaire as shareholder (seed receiver or seed donor). The informants respond was written numerically from the serial number of informant's name. For example, we surveyed hundred households and their name were written serially. The informant responds for other seed receiver or donor from the serial number were written as their serial number. We used Spearman Rank order correlation to test the association among different variables.

Results

It has been found that agrobiodiversity conservation is associated with many factors (Fig. 2). In Spearman correlation analysis, we found a positive association between organic farming and traditional varieties conservation but it was to a certain extent. When size of the crop field increased more than five-six acres, the numbers of traditional varieties were almost same as were cropped in five-six acres. Though the number of traditional varieties were same but organic farming practices declined with increase the size of crop fields ($r = -0.54$).

It was found that organic farming practitioners were mainly subsistence farmers with an average land size 2.3 acres (SD= 0.90). With the increasing size of the crop land, farmers reduced organic farming ($r = -0.54$) and they used either both organic and chemical fertilizer ($r = 0.58$) or only chemical fertilizers ($r=0.77$).

Fig. 2. Factors affecting traditional agrobiodiversity conservation.

It was found 82% of the respondents had either small or large paddy land or farming as their primary or secondary occupation, 89% of the households had one or more educated member (Fig. 3). Among them, class one to eighth standard represented 79%, eight to tenth standard is represented by 11%, 5 % members studied up to higher secondary and only 3% are graduates. Majority of household's (65%) annual income is between the 20000-50000 Indian rupees (Fig. 3). Farmers in the study area cultivate rice as it is the major food crops in the valley. They are less dependent on high yielding varieties. A total of 36 traditional rice varieties documented in the study site (Table 1), which is higher than other study of the region (Das and Das, 2014). The landraces are morphologically although similar but genetically different (Saxena and Singh, 2006) and they are also adapted to different agro-ecological conditions (Das and Das, 2014). On an average one farmer cultivates 3.04 traditional rice varieties (SD =4.8; SEM=0.13). At most, eight varieties were cultivated by one farmer, whereas lowest number of rice varieties under cultivation is one. Among the randomly selected informants, 74% were small, 21% were medium and only 5% were large scale farmers.

Table 1. Traditional rice varieties documented from the study area.

Sl. No.	Rice varieties in local name	Sl. No.	Rice varieties in local name
1.	Aijong	19.	Kushal
2.	Aush Joria	20.	Koia- Borua
3.	Bahadur	21.	Lal Biroin
4.	Balam	22.	Lal Kartika
5.	Balijira	23.	Latoi / Latma / Lata
6.	Chandmoni	24.	Lushai biroin
7.	Chanmoni	25.	Maloti
8.	Chhatoki	26.	Mayamati
9.	Chhoeamara	27.	Moniraj
10.	China Kaberi	28.	Mulashail/Moinahaal/Monoharshail
11.	Dinnath	29.	Najira
12.	Disang	30.	Paijento
13.	Eri	31.	Pankaj
14.	Gondi biroin	32.	Terabali
15.	Guwaroi	33.	Saada kartika
16.	Joria	34.	Sornomoshari
17.	Kaalijira	35.	Swarnabh
18.	Krishnabuk	36.	Khonkosh

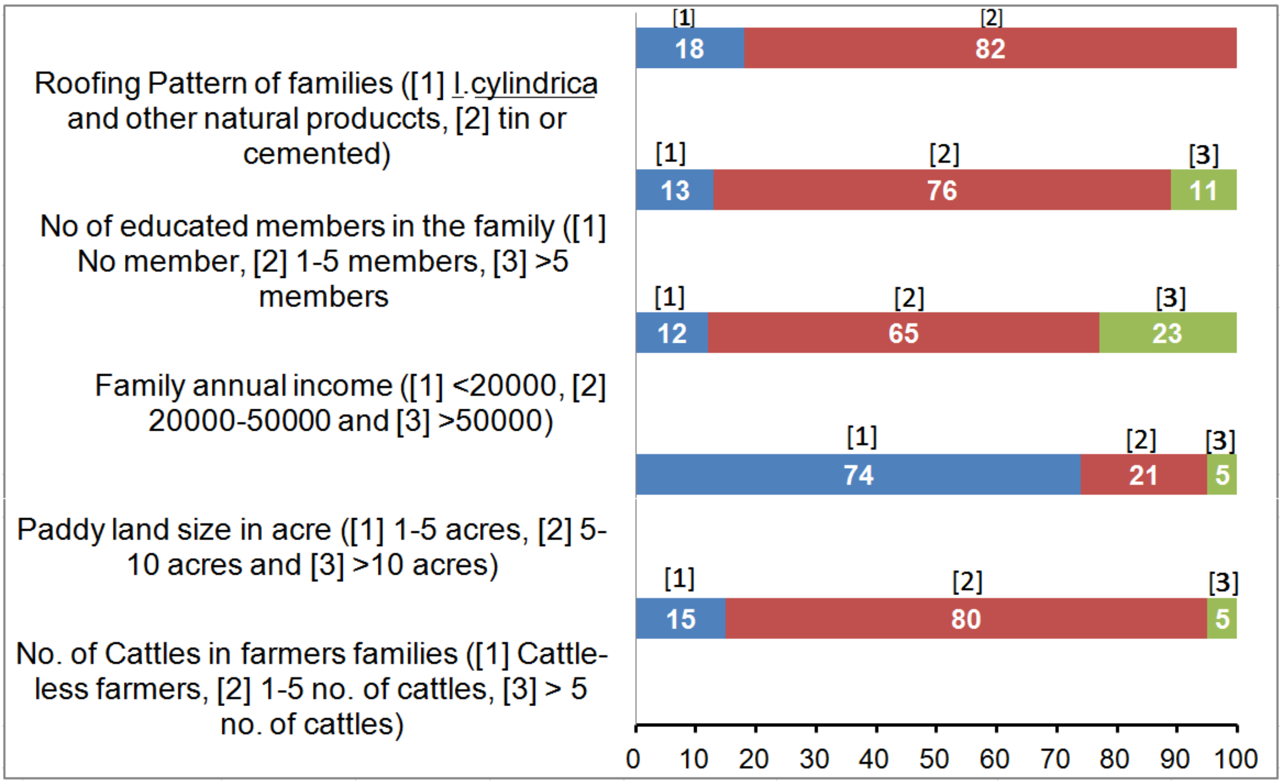

Fig. 3. Socio-economic characteristics of farmers.

Out of 100 farmers, all of them were directly related to seed exchange network (Fig. 4). On an average, each informant named 3 persons as seed giver or receivers (SD =1.92; SEM= 0.12). About 76% of the farmers practice in their own land while the remaining 24% were landless farmers. Seventeen farmers were found who has no cattle. Two subsistence farmers, although had one cattle each, did not use the manure in the paddy fields. Among the farmers, 34% used organic fertilizer and 49% (majority) of the lands were cultivated by using mixture of organic and inorganic fertilizers. However, 17% farmers used chemical fertilizers extensively in the agricultural fields.

The seed exchange network of selected farmers had a centralization index of 4.54% as compare with pure star network, which will have a centralization index of 100%, meaning that the degree of concentration of seed varieties in the network among the actors was quite low. The network had three independent components (Fig. 4). That is, farmers were connected with each other in three isolated networks. The largest component included 46% of the actors, followed by 39%, and 15% of the actors. It has been found that the farmers average in degree of 2.9. The farmer who had higher indegree also more seed varieties than those farmers who had lower in degree.

Discussion

Four major findings come out from the present study: (i) Seedling exchange and marketing is active in the valley, (ii) Traditional varieties have positive correlation with organic farming, (iii) Organic farming relies on size of the crop fields, availability of fertilizers, and purpose of cultivation, and (iv) Traditional varieties conservation is influenced by many factors (Fig. 2).

a) Seed and Seedling exchange

Documentation of seed exchange network is complex (Badstue et al., 2007), as it is difficult for the informants to state the entire name of shareholders during their lives. They can share only those shareholders who are engaged in seed exchanging in recent years. So, seed exchange network drawn (Fig. 4) does not reflect the actual existence of it. Interaction with the farmers it was found that due to unavailability of traditional rice seeds and seedling in the markets, seed exchange network although still active in area, is being fragmented like in other findings (Bodin and Crona, 2008; Calvet-Mir et al., 2012). The fragmentation may be due to farmer's preference for high yielding varieties. The seed exchange helping endemic varieties conservation in the study area, as the local varieties are limited access to farmers. Exchanging seed helps endemic varieties has been shown in others studies too (Ban and Coomes, 2004; Badstue et al., 2007, Stromberg et al., 2010). The establishment of market has made the farmers less dependent on each other for seeds and other propagules. It was found from the study that farmers exchange seeds among themselves within the villages or from neighboring villages or from relatives. People shared that reliance between farmers for seeds has been declining with the emergence of high yielding varieties.

Seed exchange network was found as decentralized (4.54%) which is very low compared to other related study (Calvet-Mir et al., 2012). It implies maximum farmers conserve the rice varieties which they need to plant to subsequent years. Since the population density of the study area is more, majority of the farmers were involved in seed exchange network. The average in degree of farmers was more compared to other research works (Calvet-Mir et al., 2011), and thus conservation status is still not bad.

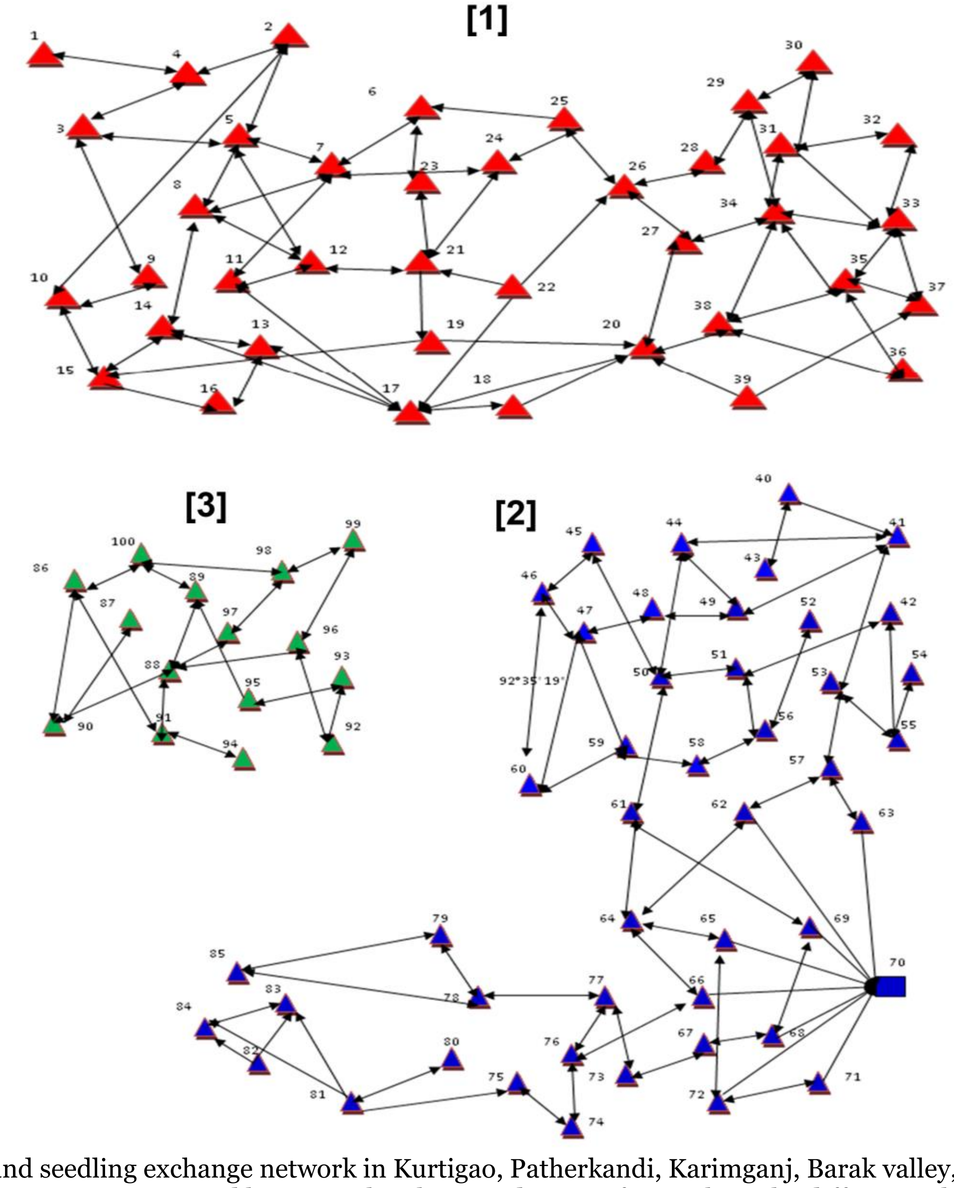

Fig. 4. Seed and seedling exchange network in Kurtigao, Patherkandi, Karimganj, Barak valley, Assam. India. Farmers' houses are represented by triangular shape and square for market. The different colors to indicate different seed change network existed within the two villages. The houses were marked serial numbers. Edges arrow represents the direction of the nomination.

b) Seed Bank

Seed bank plays a great role to conserve traditional varieties. Seed bank helps to supply traditional variety which is vital for sustainable subsistence farming (Pratap and Sthapit, 1998). Centralization helps to conserve both agrobiodiversity and its associated knowledge (Calvet-Mir et al., 2012). Surprisingly, there had not been no initiative to establish seed bank throughout the valley. Though agricultural offices are available in the study area, but they were not found for conserving traditional varieties. Instead, they the demotivate farmers on traditional varieties. In order to conserve traditional varieties nurturing of traditional seed varieties in the seed bank need to be preferred. The farmer's awareness is also another factor to make the seed bank functional.

c) Organic Farming

Organic farming improves the soil quality besides contributing to agrobiodiversity conservation (Hole et al., 2005; Scialabba, 2003; Scialabba, 2013). It can be considered that organic farming has good association with size of the crop fields, as has been reported in other studies (Chamango, 2001; Mekuria and Waddington, 2002). It was observed that majority of the farmers (66%) use mixture of organic and chemical fertilizers. However, inadequate amount of organic fertilizers for the large crop fields forced them to use chemical fertilizers also. Since, organic fertilizers were not available in the local market, the farmers could not maintain the fertilizer corresponds to their cropping areas and hence they were restricted to use chemical fertilizers to increase the yield. Although organic fertilizer users are less (29%) but it is far better than the other group (5%) who used only chemical fertilizers. Most of the organic fertilizer users were subsistence farmers. Zant (2010, 2014) found that subsistence farmers in African countries specially use organic fertilizers and also prefer to cultivate traditional varieties. It clearly supported the farmers above views which are also proved from the present study. Thus, it can be assume that the organic fertilizers have a good association with both traditional varieties and size of the crop fields.

Organic manures were the only organic fertilizers in the valley. Since amount of manure is proportional to cattle's availability (Elzaki et al., 2005; Zant, 2010), along with organic manure, other organic fertilizers (vermicompost, crop residues and intercropping) need to be made available. Thus, there is need to aware among farmers for vermicompost techniques and intercropping, which needs support from government.

d) Size of the field

As already mentioned, the amount of organic fertilizers used is related to number of livestock of a farmer. It was found that small scale farmers had a few livestock and hence easy for them to use organic fertilizers in their cultivated land. Similar results also have shown in rural areas different regions (Zant, 2010). Conversely, for obvious reason, large holder could not get the desired quantum of the organic manure in their cultivated land.

e) *Type of cultivation:* Subsistence Versus Commercial

It was found that the small scale farmers cropped mainly for consumption purposes in their own land whereas medium and large farmers cropped either their own land or on leased land for both consumption and commercial purposes. Several other results (Arriaga-Jordan and Pearson, 2004; Zant, 2010) also showed traditional rice varieties are cultivated mainly by subsistence farmers. When farmers take land as lease, their sole intention is to increase production. It was found that maximum agricultural households in the study area were identified as small scale farmers and they were engaged in traditional varieties for their consumption and not aimed to exploit their products. Though use of inorganic fertilizers and pesticides in the valley had been increasing at an alarming rate due to inadequate amount of organic fertilizers, however, farmers in the valley still prefer organic fertilizers as they think organic products are better than their inorganic counterparts. Besides, being economically challenged, most of the farmers were unable to buy chemical fertilizers.

f) Soil

Soil plays a major role for traditional varieties conservation. Continuous use of soil and inadequate management degrade the soil, changes its structure and reduces fertility (Barrios, 2007 Blum, 2013, DeLong et al., 2015). As a result, the soil which supported a variety is now not supporting. For example, in the study area, *Chhoeamara*, a local rice variety had been cultivated since long, but recently farmers avoid using the variety as the species is not grown well and thereby product is limited. The reason is that excess anthropogenic pressures in the form of deforestation in the hilly areas make soil erosion to the cultivated land which changes the composition, especially increases the sand percentage in the soil.

g) Culture

Cultures also play a diverse role to conserve traditional agrobiodiversity (Ji et al., 2000; Nautiyal et al, 2008; Das and Das, 2014). The people of Barak valley use *Biroin, Kalijira* (local rice varieties) to make special delicious food for the guest and relatives as feast during social festival. It was found that most of the farmers cultivate those species at sizeable amount (Table 1). They also used traditional rice varieties as breakfast food. So, extinction of traditional varieties implies both genetic and cultural erosion at the same time (Negri et al, 2009; Negi and Maikhuri, 2013).

h) Population density

The most important factor associated with agrobiodiversity conservation is population explosion. Every year 70 million new people are born throughout the world (Folke et al., 2005), and is projected to grow by approximate 65% in next 50 years (Wallace, 2000; Sauer et al., 2008) putting an extra pressure on natural resources (Alexandratos et al., 2006). For providing food to all, it's necessary to increase the production to three-four times (Bruinsma, 2003). The government of India started Green Revolution in the early 1960. As part of this program, the government provided free high yielding varieties and chemical fertilizers at the first phase. This made farmers to cultivate crop with high yielding varieties using chemical fertilizers, instead of traditional varieties and organic farming. But the negative effects of agriculture of chemical fertilizers are already established (Folke et al., 2005; Singh, 2012).

It was found from the study that the areas where human population density was more, the farmers land size was small and they were cultivating both traditional varieties and high yielding varieties. They cultivated at least few areas for culturally important traditional and the remaining areas for high yielding varieties. Except cultural varieties, tendency of traditional variety cultivation is being declined. Farmer desire is to get maximum output from the small land. They think only use of high yielding varieties can achieve this goal. It is the need of the hour to aware them about traditional varieties and necessity of their conservation, and for this to keep in place, proper incentives from government side should also be made available.

i) Human-Wildlife Conflict

Human-Wildlife Conflict is an important threat to conserve traditional agrobiodiversity. Though it does not occur in every area, but is a crucial problem in areas where mega herbivore like rhinoceros, elephant etc. occur and raid crop. The crop damaged by elephants is a major factor in Asia and African countries. The study area is blatant example where farmers have developed a bent of mind not to cultivate paddy because of wild elephant and pig. Wild elephant often come out at night hours from the Patharia Hills reserve forest and damage the crops (Talukdar and Choudhury, 2017). Wild pig also affects rice in the area although but this is not to a large extent. Elephants migrate from Patharia Hills reserve Forest to Tilbhum reserve forest and adjoining areas of Bangladesh. Especially they damage rice when it is about to harvest. As a result, farmers often keep their land as barren and therefore, traditional varieties are going to local extinction. This is in practice in the study area since last four to five years (Fig. 5).

a) Socio-economic condition

Traditional varieties and size of the cultivated fields were found to be related with socio-economic condition of families. Small Poor families have less paddy land, or subsistence farmers and practiced traditional varieties with organic fertilizers (Fig. 3). Larger families cultivated large paddy land (either their own land or lease land), practicing both organic and inorganic; mostly both. Thus, social–ecological linkages function as co-emergent properties of changes in both traditional high agrobiodiversity, land use and along with modern cropping intensification and commodity production (Negi and Maikhuri, 2013; Zimmerer, 2013). Majority of households were roofed with tin, though a few use *Imperata cylindrica*, *Vetiveria zizanoides* and bamboo as their roofing material.

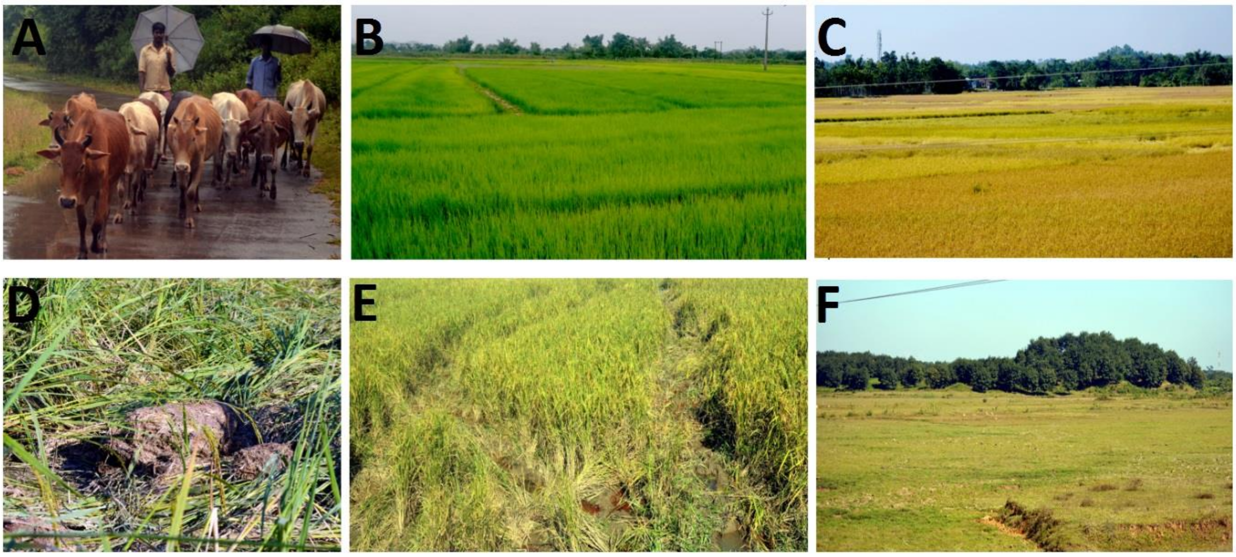

Fig. 5. A) Farmers are returning with cattle. B) Different varieties of Seedling in the field, C) Paddy in the field, D) Excreta of elephant in the field E) Paddy damaged by elephants, and F) Barren land resulted by Human–Elephant conflict.

Conclusion

Our findings conclude that conservation of traditional varieties depend upon many correlated factors which must be taken care for conservation of genetic resources. However, limitation in like seed banks and declining seed exchange network, ever-increasing demand for higher food production, human-wildlife conflict was found to be the key factors that may lead to genetic erosion of the rice varieties. Thus, government and non-governmental organizations should come forward to conserve this high agrobiodiversity of the region by creating seed banks, mass awareness programs on use of vermicompost organic manures and inter cropping on the field. Since Barak valley is one of the largest valleys of NE India, has immense potential for agricultural activities, and harbors high cultural and ethnic diversity, and since no such study on the agrobiodiversity of the region has been undertaken yet, the present study is of immense significance.

Acknowledgement

A lot of people helped during fieldwork and data collection. Field works would not be completed without the help of them. The authors expressed their gratitude to many people especially, Somir Uddin, Helal Uddin, Altaf Hussain, Ashiqur Rahman Talukdar, Nazrina Akthar Barbhuiya, AS Masum Ahmed Barbhuiya, Abdul Aziz Choudhury, Thck. Suchitra Devi and many others for helping during the data collection. The authors thank to wildlife conservation Laboratory and all its members namely, Anisur Rahman, Biswajit Singh, Rofik Ahmed Barbhuiya, Amir Sohail Choudhury. The author also thanks to Mohammed Khairuzzaman Mazumder, President of Uday Group of Studies (an NGO), Hailakandi, Assam, for helping throughout the work. The department of Ecology and Environmental Science, Assam University, Silchar is thankful for supporting and co-operating throughout the study.

Author Contribution

Both NRT and PC contributed to the overall design of the study as well as conception of the idea. NRT contributed to the field survey and drafting while PC finally approved the manuscript.

References

Acosta-Naranjo, R., & Diaz-Diego, J. (2008). Y en sus manosla vida. Los cultivadores de las variedades locales de Tentudía, First edition, Centro de Desarrollo Comarcal de Tentudía, Tentudía-Extremadura, Spain.

Agelet, A., Bonet, M. À., & Vallés, J. (2000). Homegardens and their role as a main source of medicinal plants in mountain regions of Catalonia (Iberian Peninsula). *Economic Botany*, *54*(3), 295-309.

Alexandratos, N., Bruinsma, J., Bödeker, G., Schmidhuber, J., Broca, S., Shetty, P., & Ottaviani, M. G. (2006). World agriculture: Towards 2030/2050. Interim report. Prospects for food, nutrition, agriculture and major commodity groups.

Altieri, M. A., & Merrick, L. (1987). In situ conservation of crop genetic resources through maintenance of traditional farming systems. *Economic Botany*, *41*(1), 86-96.

Arriaga-Jordán, C. M., & Pearson, R. A. (2004). The contribution of livestock to smallholder livelihoods: the situation in Mexico. *BSAS Occasional Publication*, 99-116.

Badstue, L. B., Bellon, M. R., Berthaud, J., Ramírez, A., Flores, D., & Juarez, X. (2007). The dynamics of farmers' maize seed supply practices in the Central Valleys of Oaxaca, Mexico. *World Development, 35*(9), 1579-1593.

Ban, N., & Coomes, O. T. (2004). Home gardens in Amazonian Peru: diversity and exchange of planting material. *Geographical Review*, 94(3), 348-367.

Barrios, E. (2007). Soil biota, ecosystem services and land productivity. *Ecological Economics, 64*, 269-285.

Bellon, M. R. (2004). Conceptualizing interventions to support on-farm genetic resource conservation. *World Development 32*(1), 159–172.

Blum, W. E. (2013). Soil and land resources for agricultural production: general trends and future scenarios-a worldwide perspective. *International Soil and Water Conservation Research*, *1*(3), 1-14.

Bodin, Ö., & Crona, B. I. (2008). Management of natural resources at the community level: Exploring the role of social capital and leadership in a rural fishing community. *World development*, *36*(12), 2763-2779.

Bruinsma, J. (2003). World agriculture: towards 2015/2030 –A FAO Perspective, FAO.

Brush, S. B. (1991). A farmer-based approach to conserving crop germplasm. *Economic Botany 45*, 153–165.

Calvet-Mir, L., Calvet-Mir, M., Molina, J., & Reyes-García, V. (2012). Seed exchange as an agrobiodiversity conservation mechanism. A case study in Vall Fosca, Catalan Pyrenees, Iberian Peninsula. *Ecology and Society*, *17*(1), 29.

Calvet-Mir, L., Calvet-Mir, M., Vaqué-Nuñez, L., & Reyes-García, V. (2011). Landraces in situ Conservation: A Case Study in High-Mountain Home Gardens in Vall Fosca, Catalan Pyrenees, Iberian Peninsula. *Economic Botany*, *65*(2), 146–157.

Chamango, A. M. Z. (2001). Improving grain yield of smallholder cropping systems: A farmer participatory research approach with legumes for soil fertility improvement in central Malawi, seventh eastern and Southern Africa regional maize conference.

Choudhury, A. U. (1989). Primates of Assam: their distribution, habitat and status, PhD Thesis, Guwahati University, 300pp + maps.

Choudhury, A. U. (1997). Checklist of the Mammals of Assam, Revised 2nd Edn. Gibbon Books & ASTEC, Guwahati.

Cox, P. A. (2000). Will tribal knowledge survive the millennium? *Science, 287*, 44–45.

Das, T., & Das, A. K. (2014). Inventory of the traditional rice varieties in farming system of southern Assam: A case study. *Indian Journal of Traditional Knowledge 13(1)*, 157-163.

DeLong, C., Cruse, R., & Wiener, J. (2015). The soil degradation paradox: Compromising our resources when we need them the most. *Sustainability*, *7*(1), 866-879.

Elzaki, R. M., Ahmed, A., Hassab, S. E., Elbushra, A. A., & Ahmed, B. W. E. (2010). Impact of Livestock Biodiversity in Poverty Reduction and Welfare Change in Rural Sudan.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, *30*, 441-473.

Hole, D. G., Perkins, A. J., Wilson, J. D., Alexander, I. H., Grice, P. V., & Evans, A. D. (2005). Does organic farming benefit biodiversity? *Biological Conservation, 122* (1), 113-130.

Hore, D. K. (2005). Rice diversity collection, conservation and management in northeastern India. *Genetic Resources and Crop Evolution*, *52*(8), 1129-1140.

Ji, L. J., Peng, K., & Nisbett, R. E. (2000). Culture, control, and perception of relationships in the environment. *Journal of Personality and Social Psychology, 78* (5), 943.

Maffi, L. (2002). Endangered languages, endangered knowledge. *International Social Science Journal, 54*, 385–393.

Mekuria, M., & Waddington, S. R. (2002). *17 initiatives to encourage farmer adoption* *of soil-fertility technologies for maize-based cropping systems in southern Africa. Natural resources management in Africa Agriculture* No. CIS-3411. CIMMYT.

Nautiyal, S., Bisht, V., Rao, K. S., & Maikhuri, R. K. (2008). The role of cultural values in agrobiodiversity conservation: a case study from Uttarakhand, Himalaya. *Journal of Human Ecology*, *23*(1), 1-6.

Negi, V. S., & Maikhuri, R. K. (2013). Socio-ecological and religious perspective of agrobiodiversity conservation: issues, concern and priority for sustainable agriculture, Central Himalaya. *Journal of Agricultural and Environmental Ethics, 26* (2), 491-512.

Negri, V., Maxted, N., & Veteläinen, M. (2009). European landrace conservation: an introduction. *European Landraces: on-Farm Conservation, Management and Use*, 1-22.

Oldfield M. L., & Alcorn, I. B. (1987). Conservation in traditional agro ecosystems. *Bioscience, 37*, 199–208.

Perrault-Archambault, M., & Coomes, O. T. (2008). Distribution of agrobiodiversity in home gardens along the Corrientes River, Peruvian Amazon. *Economic Botany, 62* (2), 109-126.

Pratap, T., & Sthapit, B. (1998). The challenges of managing the agrobiodiversity of the Hindukush Himalayan region: An overview of issues, In: Managing agrobiodiversity, Famers perspective and institutional response in the Hindukush Himalayan region, edited by T. Pratap and B. Sthapit, (International Centre for integrated mountain development) pp.1-30.

Prescott-Allen, R., & Prescott-Allen, C. (1982). The case for in situ conservation of crop genetic resources [wild species]. *Nature and Resources (UNESCO)*, *231*, 5–20.

Sauer, T., Havlík, P., Kindermann, G., & Schneider, U. A. (2008). Agriculture, Population, Land and Water Scarcity in a Changing World—The Role of Irrigation. In *Congress of the European Association of Agricultural Economists, Gent, Belgium*.

Saxena, S., & Singh, A. K. (2006). Revisit to definitions and need for inventorization or registration of. *Current Science*, *91*(11).

Scialabba, N. E. (2003). Organic agriculture: The challenge of sustaining food production while enhancing biodiversity united nations thematic group sub-group meeting on wildlife, biodiversity and organic agriculture Ankara, Turkey.

Scialabba, N. E. (2013). Organic Agriculture's Contribution to Sustainability, Crop Management.

Singh, A., 2012. Green revolution in India: Its Environmental and health Effects-world of Science. www.world of science.in

Stromberg, P. M., Pascual, U., & Bellon, M. R. (2010). Seed systems and farmers' seed choices: The case of Maizein the Peruvian Amazon. *Human Ecology*, *38*(4), 539-553.

Sunwar, S., Thornström, C. G., Subedi, A., & Bystrom, M. (2006). Home gardens in western Nepal: opportunities and challenges for on-farm management of agrobiodiversity. *Biodiversity and Conservation*, *15*(13), 4211-4238.

Talukdar, N. R. & Choudhury, P. (2017). Population structure of wild Asiatic elephant in Patharia Hills Reserve Forest, Karimganj, India: A plea for Conservation. *Journal of Entomology and Zoology Studies, 5(2)*, 1493-1498.

Wallace, J. S. (2000). Increasing agricultural water use efficiency to meet future food production. *Agriculture Ecosystems & Environment, 82*, 105-119

Zant, W. (2010). Is organic fertilizer going to be helpful in bringing a green revolution to sub-Saharan Africa? Economic Explorations for Malawi Agriculture.

Zant, W. (2014). Do organic inputs in african subsistence agriculture raise productivity? Evidence from plot data of Malawi household surveys. TI 2014-114/V Tinbergen Institute Discussion Paper.

Zimmerer, K. S. (2013). The compatibility of agricultural intensification in a global hotspot of smallholder agrobiodiversity (Bolivia). *Proceedings of the National Academy of Sciences*, *110*(8), 2769-2774.