Studies on the Environmental and Agroforestry Systems of the Entisol Order soils of Bangladesh

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Abstract: **The conducted studies on the Environmental and Agroforestry Systems of the Entisol Order soils of Bangladesh were with the objective of identifying the agroforestry systems in favor of environment covering entisols of northern Bangladesh. The areas of studies covered three major Districts and ten Upazilas. The technical type investigations were conducted involving agroforestry tree species and ecological components. It has been found that the national level respondents give more importance to several modern fruit trees but the local respondents show significantly less interest for those fruit species. The fruit species domination among them in descending order are lemon, mango, coconut, date palm, papaya and jujube as preferred by the farmer consumers. The Community Forest Tree Species domination show in descending order neem, bamboo, sisso and betelnut. The less dominant tree is jarul. The major trees domination in the char suitable for land and soil conservation arein descending order bamboo, neem, acacia, eucalyptus and palmyra palm. The less dominant tree is alder. The major crops domination in the char good for soil conservation arein descending order rice, wheat, arhar, kaon, blackgram, grasspea, maize and sungrass. The less dominant crops are data and okra. The major trees in the char dominated in homestead are indescending order bamboo, neem, banana, mango and mahogoni. The less dominant trees are alder, gliricidia and pitraj. The major trees in the char dominated in embankments are in descending order acacia, neem, sisso, eucalyptus and mahogoni. The less dominant trees are pitraj, betelnut, pummelo and chatim. The results found domination percentage in Agroforestry systems show that the Agro-Sylviculture (74%) and Agro-Sylvi-pastoral systems (81%) are more preferred by the consumer farmers and recommended as well in consideration of production sustainability.**

Keywords: **Environment, Agroforestry Systems, Entisols**

I. INTRODUCTION

The circumstances, objects, or conditions by which one is surrounded and the complex of physical, chemical, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival is known as environment i.e. the surroundings or conditions in which a person, animal, or plant lives or operates. To divide environments' sorts, we can mention 3 kinds of environment-natural, industrial and social environment. Natural environment includes water, light, land, air and all organisms that live in nature.

An environmental system is an interacting biotic and abiotic component connected in such a way that a change in one part of the system affects one or more other parts of the system. Environmental Systems are systems where life interacts with the various abiotic components found in the atmosphere, hydrosphere and lithosphere. It also involves the capture, movement, storage and use of energy. Environmental systems can be split broadly into three categories such as hydrological, ecological and climatic.

Agroforestry is the management and integration of trees, crops and/or livestock on the same plot of land and can be an integral component of productive agriculture. It may include existing native forests and forests established by landholders there is need to enthusiastically agroforestry a promising approach of land use system that address the integration of variety of tree species with herbaceous crops and animal in some form of special arrangement (Sobolaetal.,2015).

Agroforestry is a land use management system in which trees or shrubs are grown around. It provides opportunities for income generation with substantial benefits to resource poor farmers and female farmers (Alam & Sarkar, 2011). Agroforestry systems are land management practices in which trees and shrubs are produced on the same land area as agricultural crops or livestock (Michael. A. G. 2016). Therefore, agroforestry systems combine trees, crops, or livestock to increase diversity, productivity, profitability, and environmental stewardship (Oke, D.O., 2008). In agroforestry systems, woody and herbaceous perennials are grown on land that also supports agricultural crops or animals. The mixture of these components, in the form of spatial arrangement or temporal sequence, enhances ecological stability and production sustainability.

There are several types of agroforestry systems: Agrosilvicultural systems are a combination of crops and trees, such as alley cropping or home gardens and charlands (Karim, M. A. 2014). Silvipastoral systems combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm, Protein Bank, a live fence of fodder trees and hedges, trees and shrubs on pasture. Agrosilvipastoral systems are home gardens, woody hedgerows, live fence, shelterbelt, alley farming, taungya system, improved fallow agroforestry systems and are solution for protective to environmental systems (Sobolaetal., 2015).

Entisols are soils of recent origin, the central concept is soils developed in unconsolidated parent material with

usually no genetic horizons except an A horizon and are soil of an order comprising mineral soils those have not yet differentiated into distinct horizons. These are sandy mineral soils low in organic matter, natural fertility, and water holding capacity (Weil and Brady, 2015). These have weak or no diagnostic subsurface layers and are well to excessively well drained (Obreza and Collins, 2008). Entisols are commonly found at the site of recently deposited materials (alluvium), or in parent materials resistant to weathering (sand). These soils also occur in areas where a very dry or cold climate limits soil profile development.

Entisols or Charlandsin Bangladesh have been distributed into five sub-areas: the Jamuna, the Ganges, the Padma, the Upper Meghna and the Lower Meghna rivers (Alam & Sarkar, 2011). There are other areas of riverbed chars in Bangladesh, along the Tista and the old Brahmaputra rivers (Karim et al., 2017). The flow of old Brahmaputra and the Tistariver always shift from their own course. The chars or river meander areas are formed on further deposition layers established by new siltation with course sand & clay. Newly accreted areas (chars) are born with course sand & clay mixed. The water table is very shallow there. Water is essential for crop production. It is collected by digging well or sinking tube well. Char dwellers always shift their habitats with shifting of land reclamation (Hasan et al., 2008). There are 6,66,000 hectare char land in 65 Upazilla under 17 districts in Bangladesh (Karim et al., 2017). The land is the most valuable part of dwellers life, because they become landless by the river's action. So, they use these scarce lands in a way as to get best productions as much as possible by using their knowledge and experiences in this regard. The population living in char areas maintains their livelihood through char based farming systems. There are over 12 million people who live in char lands and always struggle against the floods and associated river bank instability (Hooper, 2001). The char based farming systems initially not expected as good or sound healthy environment for agriculture production. Many of the chars are not stable. A char land which is too sandy too wet or too exposed to the risk of bank erosion or floods may cause damage to crops to be grown at any time of the year. Flood causes change in fertility and chemical properties of the soils of chars. The feasibility of permanent reclamation with suitable crops and their production sustainability is yet to be determined though people living there have their own culture and crop production systems consisting diversification intends with unique environmental system. Stability of char needs an environment for suitability of production activity. The environment for agriculture production or appropriate land use is a vital factor of development of char dwellers and chars.It's a hard task to choose sustainable production system for the char land for the present time, so that land use pattern complies with the future planning, to establish a healthy environment for stability of accreted new entisol land by applying appropriate technology and production utility. In new char entisol land production systems are agriculture based but it is observed that intercropping of tree species can play an environmental role for non- shifting of sands, use as wind break, shelter of soil stability and improve soil structure with vertical land use. In general, these types of activities can be performed through adopting agroforestry systems.

Char dweller also practice agroforestry systems in their own traditional way and select the tree and agricultural crops on their choice. Actually, it is needful to establish scientific environmental safety prioritize agroforestry species selection for proper and productive land use pattern in char Entisol land. Present less productive agroforestry models needs to be identified and should be prescribed highest yield productive model for betterment on livelihood of char dwellers. In the dominant agroforestry systems tree species are driven for progressive land use pattern of char Entisol land and which will cover environmental factors for establishment of soil improvement, increasing water holding capacity, act as wind break and cover life security of char dwellers at incidental emergent in flash flood.

Adedire, 2004 suggested that the integration of trees in the farming system could go a long way to help reclaim environmental systems problems: creating of microclimates favorable for crop growth and enhancing the recycling of minerals to establish a more complete ground cover which could substitute to protect soil from erosion and adverse temperatures, this would be providing wood food and/or animal products. Evans, 1992 stated that agroforestry contribution is very significant through its economic, environmental and social stability to the sustainable development. He further mentioned that agroforestry has proven criteria of sustainable development that has no adverse impact on the environmental systems.

The productivity systems in chars and allied land are agro-based with profound culturing of trees where potential of its development with rearing of animals is possible and feasible. The present study has been taken with the objectives to explore the agroforestry and environmental systems, optimizing land use with the priority of tree and crop species in favour of environmental safety in the Char Entisol Lands of Bangladesh.

II. METHODOLOGY

This research study is descriptive-cum-empirical as well as suggestive in nature. The study is survey type. The present study has been included secondary sources consisting of books, newspapers, periodicals, articles from national and international level. Internet sources have been used for the research. Attempts have been made to include the latest information whenever available. At the same time primary data have been collected through interview with respective respondent.

Tools of Data Collection

The nature of the study requires combining analytical and empirical approaches in the methodology. The study relied on four main data collection tools namely: in-depth interview guideline/checklist; observation of respondent, cross checking

of data collected from field using mobile/telephone and review of related documents. All these tools are closely related. Accordingly, both qualitative and quantitative information and required data were collected; therefore, both primary and secondary data sources were utilized for the accomplishment of study. Data were also analyzed, the findings were presented through the use of necessary figures/charts, tables, and narrative way.

Methods of Data Collection

Researcher conducted the face to face interview with the respondents of the study areas. As per the plan for data collection the researcher communicated the concerned officials by emails, telephone/ mobile phone for appointment with the respective respondents. The researcher took help of his colleagues and friends during conducting data collection.

Data analysis and presentation

Collected data were tabulated and analyzed by using computer program Microsoft Excel. Then data were presentedin adequate tables and graphs.

Variables

A. Site

1. Kurigram- Jamalpur– (Upazila–Roumari, Rajibpur and Sarishabari) AEZ 2- Active Tista Floodplain, AEZ 7- Active Brahmaputra - Jamuna Floodplain and AEZ 8 - Young Brahmaputra and Jamuna Floodplain.
2. Sirajganj-Tangail – (Upazila – Kazipur, Chouhali and Bhuapur) AEZ 7- Active Brahmaputra - Jamuna Floodplain and AEZ 8 - Young Brahmaputra and Jamuna Floodplain.
3. Pabna-Manikganj, Shariatpur - (Upazila - Bera, Sujanogor, Shibaloy and Naria) AEZ 7 - Active Brahmaputra – Jamuna Floodplain, AEZ 8 - Young Brahmaputra and Jamuna Floodplain, AEZ 10 - Active Ganges Floodplain and AEZ 12 - Lower Ganges River Floodplain.

B. Respondent: As Service/ Consumer/ Technical;Literate employees, FarmersProfessionals

C. level: National/ Regional/ Local.

Sample Population: 100 samples were taken from each site balancing other variable criteria with sufficient diversity.

Study Sites

Kurigram

Nageswari

Roumari

Char Rajibpur

Sarishabari

Kazipur- Shirajgonj

Choihali

Choihali Punorbason

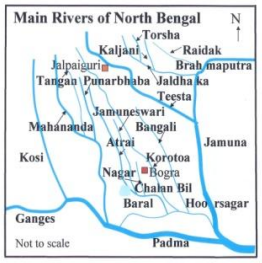
Bhuapur

Bera

Sujanagar

Sibaloy - Manikganj

Naria



Feeding River Systems

Char homestead agroforest

Char homestead agroforest

III. RESULTS AND DISCUSSION

The results obtained from the research studies are presented as follow. The collected data processed and analyzed before presentation. The results are interpreted and illustrated in both Tables and Graphs. The recommendations from the findings are thus formulated and presented separately. The results are arranged as per site variables described in the methodology.

Fruit species now dominating the char lands

Table 1: Fruit species domination percentage by level

Species	National level	Regional level	Local level	Mean
Pineapple	18	24	22	21.3
Watermelon	27	29	23	26.3
Coconut	75	48	36	53.0
Date palm	55	46	55	52.0
Guava	61	32	19	37.3
Lemon	73	53	42	56.0
Orange	15	20	23	19.3
Banana	24	11	70	35.0
Papaya	34	52	64	50.0
Mango	58	56	49	54.3
Litchi	40	52	46	46.0
Wood litchi	31	41	35	35.7
Amlaki	46	43	36	41.7
Grape	15	16	13	14.7
Jujube	52	46	36	44.7
Dragon	18	24	26	22.7
Lotkon	25	31	24	26.7
Bel	38	29	27	31.3
Amra	22	27	23	24.0
Jalpai	40	41	40	40.3
Daowa	17	23	27	22.3
Chalta	25	32	33	30.0
Mean	36.8	35.3	35.0	35.7

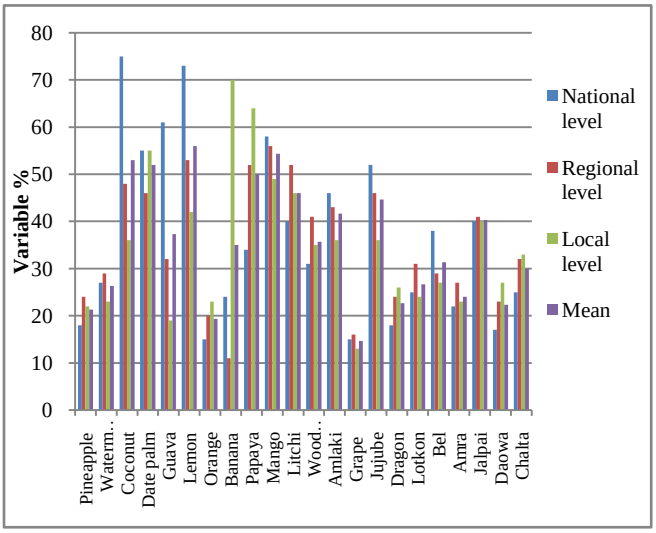


Fig.1: Fruit species domination percentage by level

The results given in table 1 and figure 1 found domination percentage by level show the fruit species domination, among them lemon national level is 73% but local level 42%, coconut national level is 75% but local level 36%, jujube national level is 52% but local level 36% and papaya 64%, banana 70% are preferred by the local level.

Table 2: Fruit species domination percentage by functional beneficiaries in char lands

Species	Servicem an Literate	Consumer Farmer	Tec person Professional	Mean
Pineapple	22	21	21	21.3
Watermelon	24	24	31	26.3
Coconut	46	64	49	53.0
Date palm	49	59	48	52.0
Guava	40	39	33	37.3
Lemon	48	67	53	56.0
Orange	18	13	27	19.3
Banana	34	39	32	35.0
Papaya	51	53	46	50.0
Mango	48	64	51	54.3
Litchi	51	38	49	46.0
Wood litchi	43	19	45	35.7
Amlaki	39	41	45	41.7

Grape	20	5	19	14.7
Jujube	38	54	42	44.7
Dragon	27	10	31	22.7
Lotkon	23	20	37	26.7
Bel	37	29	28	31.3
Amra	22	28	22	24.0
Jalpai	39	40	42	40.3
Daowa	20	24	23	22.3
Chalta	25	35	30	30.0
Mean	34.7	35.7	36.5	35.7

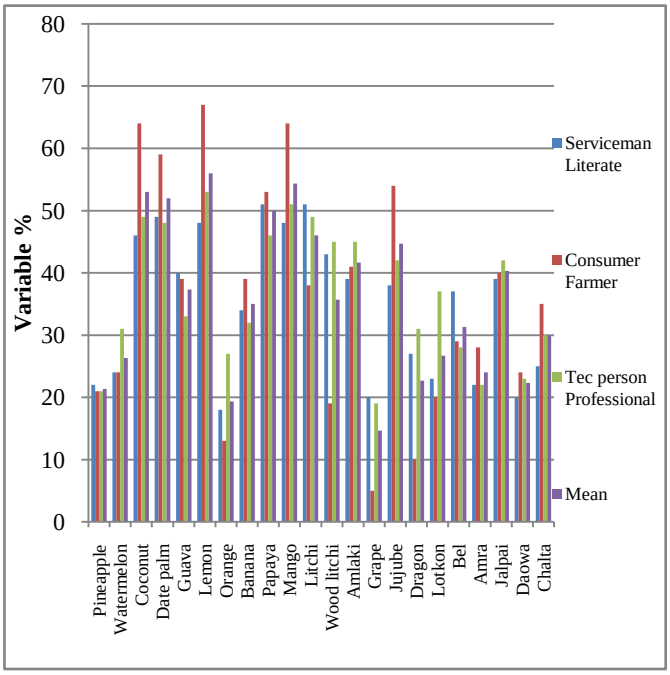


Figure 2: Fruit species domination percentage by functional beneficiaries in char lands

The results given in table 2 and figure 2 found domination percentage by functional beneficiaries show the fruit species domination, among them lemon (67%), coconut (64%), date palm (59%), papaya (53%), jujube (54%) and mango (64%) are preferred by the farmer consumers.

The results given in table 1& 2 and figure 1 & 2 show the fruit species domination mean percentage, among them lemon (56%), coconut (53%), date palm, papaya, jujube and mango are preferred by the farmer consumers. It has been found that the national level respondents give more importance to several modern fruit trees but the local respondents show significantly less interest for those fruit species.

Community Forest Tree Species (CFTS) now dominating the char lands

Table 3: CFTS domination percentage by functional beneficiaries in char lands

Tree	Serviceman Literate	Consumer Farmer	Tec person Professional	Mean
Mander	30	20	21	23.7
Cassia	36	21	20	25.7
Kapok	16	17	15	16.0
Bamboo	65	70	59	64.7
Jarul	5	4	8	5.7
Pitraj	11	13	16	13.3
Gliricidia	13	15	21	16.3
Sisso	63	67	66	65.3
Coconut	18	22	19	19.7
Betelnut	63	63	69	65.0
Neem	68	75	74	72.3
Palmyra Palm	27	26	27	26.7
Telikadom	21	26	29	25.3
Mahogoni	42	39	48	43.0
Date palm	12	16	12	13.3
Mean	32.7	32.9	33.6	33.1

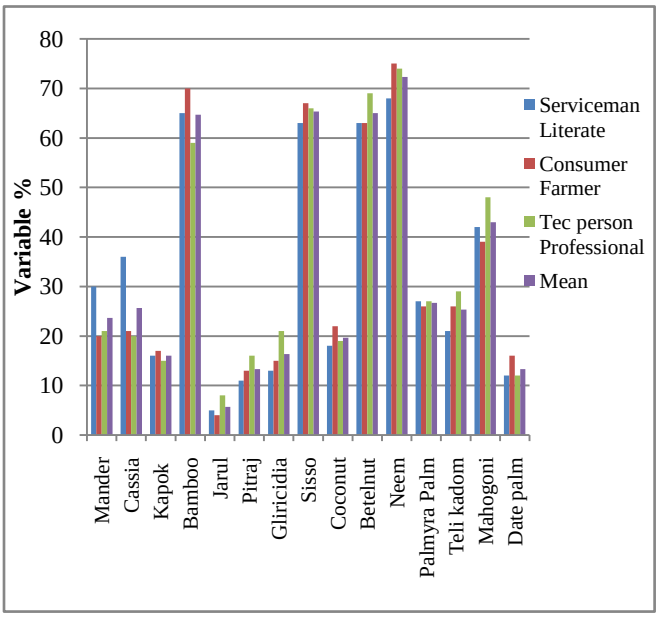


Fig.3: CFTS domination percentage in char lands

The results given in table 3 and figure 3 found domination percentage by functional beneficiaries the Community Forest Tree Species domination show neem (75%), bamboo (70%), sisso (67%), betelnut (63%) are preferred by the farmer consumers.

Table 4: CFTS domination percentage by level in char lands

Tree	National level	Regional level	Local level	Mean
Mander	23	23	25	23.7
Cassia	25	22	30	25.7
Kapok	11	18	19	16.0
Bamboo	59	65	70	64.7
Jarul	7	8	2	5.7
Pitraj	11	16	13	13.3
Gliricidia	15	13	21	16.3
Sisso	68	66	62	65.3
Coconut	26	15	18	19.7
Betelnut	70	65	60	65.0
Neem	74	69	74	72.3
Palmyra Palm	30	26	24	26.7
Telikadom	26	27	23	25.3
Mahogoni	44	44	41	43.0
Date palm	15	14	11	13.3
Mean	33.6	32.7	32.9	33.1

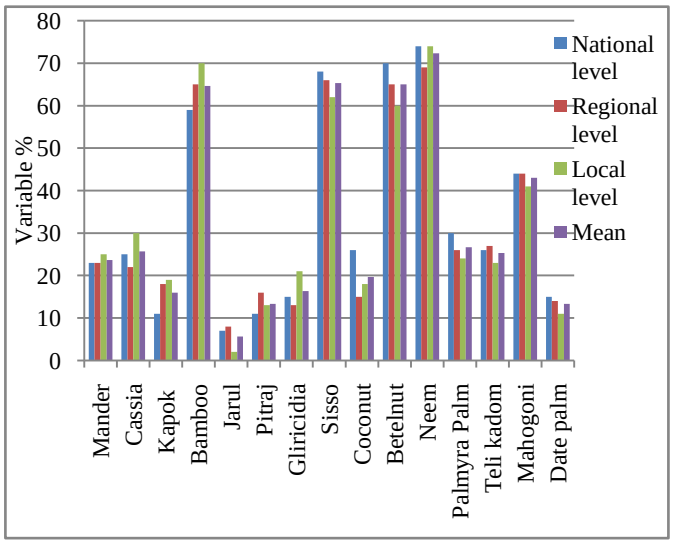


Fig. 4: CFTS domination percentage by level in char lands

The results given in table 4 and figure 4 found domination percentage by level the Community Forest Tree Species domination show neem (74%),bamboo (70%), sisso (62%), betelnut (60%) are preferred by the local level, but sisso (68%) &betelnut (70%) significantly high interest by national level.

The results given in table 3 & 4 and figure 3&4 found the Community Forest Tree Species domination mean percentage show neem (72%), bamboo, sisso, betelnut (65%). The less dominant tree is jarul (6%).

Trees are most suitable for land & soil conservation in charlands

Table 5: Tree domination percentage by functional beneficiaries in char lands suitable for land & soil conservation

Tree	Serviceman Literate	Consumer Farmer	Tec person Professional	Mean
Alder	0	4	5	3
Eucalyptus	69	77	69	71.7
Acacia	73	75	79	75.7
Kapok	37	30	36	34.3
Bamboo	86	86	86	86.0
Jarul	54	61	52	55.7
Coconut	39	34	42	38.3
Betelnut	55	49	48	50.7
Pummelo	28	31	35	31.3
Neem	88	81	89	86.0
Lambu	34	43	43	40.0
Banana	33	25	37	31.7
Palmyra Palm	61	58	62	60.3
Hijal	32	31	30	31.0
Mean	49.2	48.9	50.9	49.7

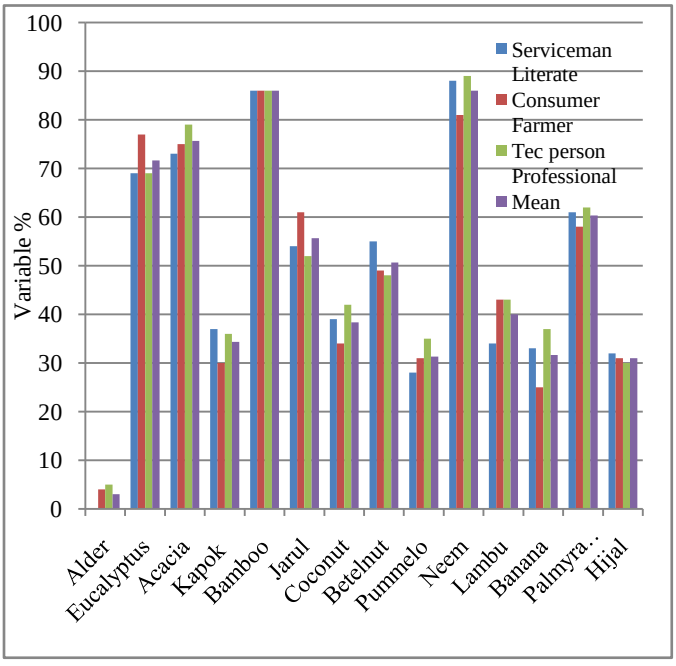


Figure 5: Tree domination percentages for land & soil conservation in char lands

The results given in table 5 and figure 5found that the major domination mean percentage trees in the char suitable for land & soil conservation show bamboo, neem (86%), acacia (76%), eucalyptus (72%) and palmyra palm (60%). The less dominant tree is alder (3%).

Crop now dominating the char lands good for soil conservation

Table 6: Crop domination percentage by functional beneficiaries in char lands good for soil conservation

Crop	Serviceman Literate	Consumer Farmer	Tec person Professional	Mean
Rice	91	90	92	91
Wheat	89	86	95	90
Maize	73	75	75	74
Ginger	36	41	37	38
Termeric	25	36	22	28
Chili	68	71	61	67
Kaon	82	87	90	86
Cheena	70	74	70	71
Blackgram	77	80	89	82
Grasspea	72	78	88	79
Sungrass	69	70	78	72
Sugarcane	55	36	42	44
Arhar	86	86	93	88
Okra	17	7	18	14
Data	21	26	21	23
Brinjal	45	41	44	43
Mean	61	62	63	62

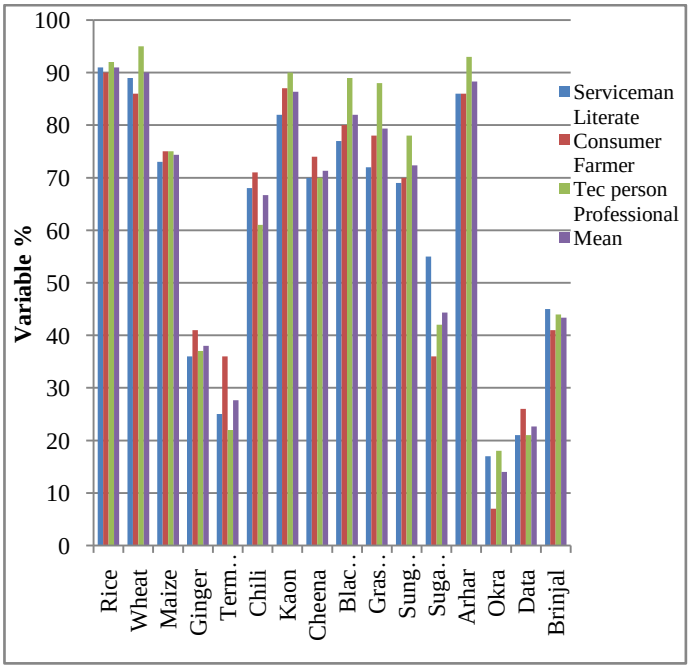


Figure 6: Crop domination percentage good for soil conservation in char lands

The results given in table 6 and figure 6found that the major crops domination mean percentage by functional beneficiaries in the char good for soil conservation show rice (91%), wheat (90%), arhar (88%), kaon (86%), blackgram (82%), grasspea (79%), mize (74%) & sungrass (72%).The less dominant cropsare data (23%) & okra (14%).

Tree now dominating the char lands homestead

Table 7:Tree domination percentage by functional beneficiaries in char lands homestead

Tree	Serviceman Literate	Consumer Farmer	Tec person Professional	Mean
Alder	0	4	5	3
Bamboo	83	90	87	86.7
Jarul	32	46	44	41
Pitraj	6	10	17	11
Gliricidia	0	4	4	2.7
Sisso	56	74	55	61.7
Coconut	26	19	30	25.0
Betelnut	42	41	42	41.7
Pummelo	33	29	34	32.0
Neem	88	80	89	85.7
Banana	85	82	83	83.3
Palmyra Palm	20	12	23	18.3
Mahogoni	65	66	64	65.0
Jiga	65	52	48	55.0
Bet	14	22	20	18.7
Mango	71	62	63	65.3
Mean	42.9	43.3	44.3	43.5

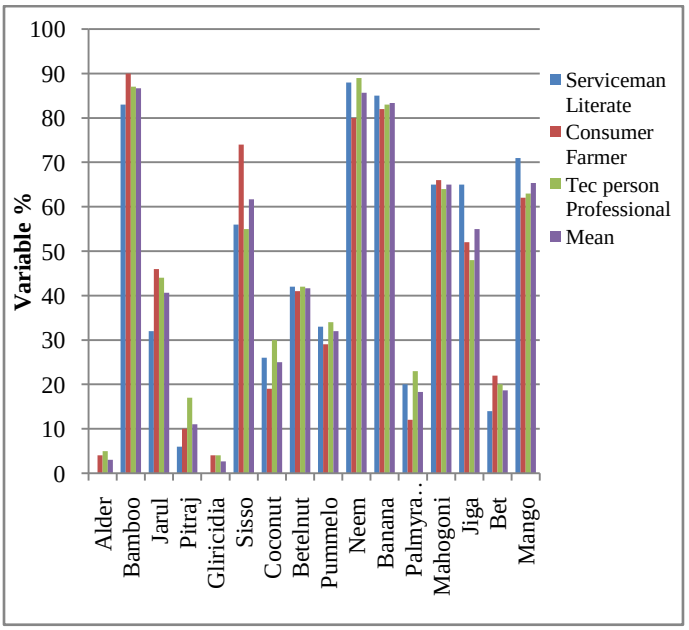


Figure 7: Tree now dominating percentage the char lands homestead

The results given in table 7and figure 7found that the major trees in the char dominated mean percentage by functional

beneficiaries in homestead show bamboo (87%), neem (86%), banana (83%), mango and mahogoni (65%). The less dominant trees are alder, gliricidia (3%) and pitraj (11%).

Tree now dominating the Char Land road embankments

Table 8: Tree domination percentage by functional beneficiaries in char lands road embankments

Tree	Serviceman Literate	Consumer Farmer	Tec person Professional	Mean
Eucalyptus	61	60	26	49.0
Acacia	79	75	77	77.0
Bamboo	9	16	14	13.0
Jarul	33	32	30	31.7
Pitraj	1	0	3	1.3
Sisso	57	50	54	53.7
Coconut	10	13	19	14.0
Betelnut	1	5	1	2.3
Pummelo	0	2	0	0.7
Neem	75	66	77	72.7
Kalicoroi	27	31	33	30.3
Babla	26	21	34	27.0
Palmyra Palm	29	26	29	28.0
Jam	17	15	25	19.0
Chatim	3	0	2	1.7
Kodom	15	19	20	18.0
Mahogoni	41	48	53	47.3
Jiga	10	16	5	10.3
Mean	27.4	27.5	27.9	27.6

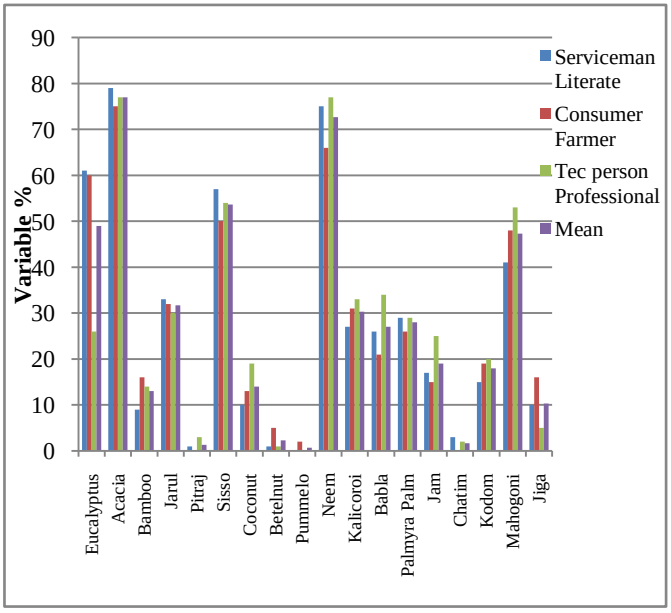


Figure 8: Tree domination percentage in char lands road embankments

The results given in table 8 and figure 8 found that the major trees in the char dominated percentage by functional beneficiaries in road embankments show acacia (77%), neem (77%), sisso (54%), eucalyptus (26%) and mahogoni (53%) preferred by Technical Professional but Consumer Farmer preferred all along with eucalyptus (60%). Mean percentage Show acacia (77%), neem (73%), sisso (54%), eucalyptus (49%) and mahogoni (47%). The less dominant trees are pitraj (1%), pummelo (1%), betelnut (2%) and chatim (2%).

Agroforestry (AF) systems dominating the char lands

Table 9: AF systems domination percentage by functional beneficiaries in char lands

Systems	Service man literate	Consumer Farmer	Tech person professional	Mean
Agro- Sylviculture system	76	78	69	74.3
Agro-horti-sylviculture system	44	37	46	42.3
Agro-Sylvi-pastoral systems	81	84	79	81.3
Horti-sylvicultural system	30	33	41	34.7
Horti-pastoral systems	21	34	25	26.7
Three Layer Model (Tree-herb-pasture)	22	10	24	18.7
Two Layer Model (Big tree-small tree)	20	19	16	18.3
Mean	42.0	42.1	42.9	42.3

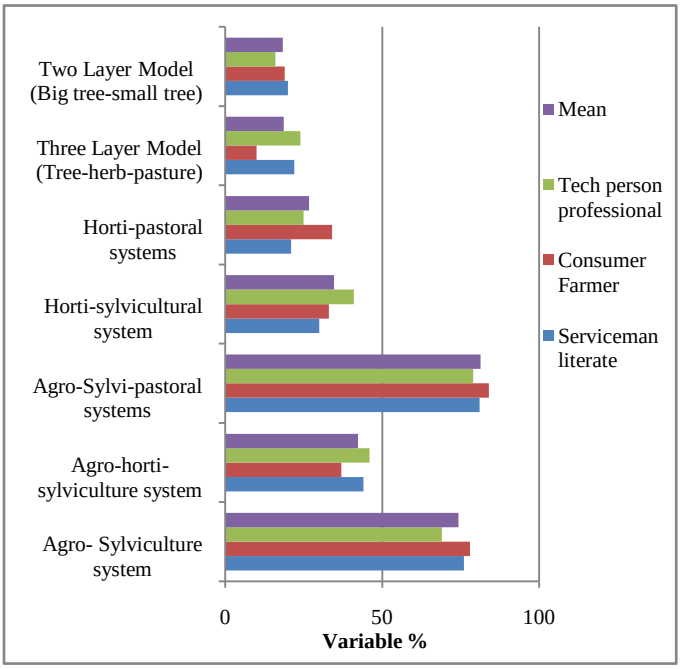


Figure 9: Agroforestry systems domination percentage in char lands

The results given in table 9 and figure 9foundthat the Agroforestry systems show that the Agro-Sylviculture and Agro-Sylvi-pastoral systems are more preferred by the Consumer farmers.

IV. FINDINGS

The fruit species lemon, coconut, date palm, papaya, jujube and mango are preferred by the farmer consumers. The Community Forest tree Species dominant are neem, bamboo, sisso and betelnut. The less dominant tree is jarul.The major trees in the char suitable for land and soil conservation are bamboo, neem, acacia, eucalyptus and palmyra palm. The less dominant tree is alder. The major crops in the char good forsoil conservation are rice, wheat, arhar, kaon, blackgram, grasspea, mizeand sungrass. The less dominant cropsare data and okra. The major trees in the char dominated in homestead are bamboo, neem, banana, mango and mahogoni. The less dominant trees are alder, gliricidia andpitraj. The major trees in the char dominated inroad embankments are acacia, neem, sisso, eucalyptus and mahogoni. The less dominant trees are pitraj, pummelo, betelnutand chatim. Agroforestry systems show that the Agro-Sylviculture and Agro-Sylvi-pastoral systems are more preferred by the consumer farmers.

V. RECOMMENDATIONS

1. The system of agroforesry is preferably recommended for the studied slowly developing entisols of northernBangladesh.
2. In case of agroforestry agro-silvi-pastoral system is likely to be promising and have better potential for adoption for production system in char Entisol land of Bangladesh.
3. The agroforestry technical package should be formulated considering the local agro-ecological aspects.
4. Various sociocultural dimension as well as the gender issuesare to be studied and considered for the better introduction of agroforestry production systems in char Entisol land.

REFERENCES

[1] Adedire, M. O. 2004. Environment protection. The Agroforestry option. Nig. J. Forestry. 34(1): 16

[2] Alam, M. and Sarkar, S. K. 2011. Homestead Agroforestry in Bangladesh: Dynamics of Stand Structure and Biodiversity, *Journal of Sustainable Forestry*, Vol. 36 No. 6, pp. 584-599.

[3] Evans, H. J. 1992.Plantation Forestry. In: The Tropics. 2nd Edn. Clarendon Press. Oxford, pp 300.

[4] Hasan, M. K., Ahmed, M. M., Miah, M. G. 2008. Agro- Economic Performance of Jackfruit-Pineapple Agroforestry System in Madhupur Tract. *J Agric Rural Dev*. 6 (1 & 2): 147-156.

[5] Hooper, A.G. 2001. Coping with river floods in Bangladesh. In: Carpenter TG, editor. The Environmental Impacts of Constructions. New York: John Wiley & Sons. pp. 213–223.

[6] Karim, M. A. 2014. Upscaling Mungbean - Rice Pattern in the Charlands of Kurigram. Pilot Project Final Report. Krishi Gobeshona Foundation - World Bank. Bangladesh Agricultural Research Council Complex (Dhaka) pp. 1-47.

[7] Karim M. A. et al. 2017. Challenges and Opportunities in Crop Production in Different Types of Char Lands of Bangladesh: Diversity in Crops and Cropping, Trop. Agr. Develop. 61 (2): 77-93.

[8] Michael. A. G. 2016. Agroforestry, Encyclopedia Britannica Online. Encyclopedia Britannica, Inc.

[9] Obreza, T.A. and M.E. Collins. 2008. Common soils used for citrus production in Florida. Extension Publication SL 193. Florida Cooperative Extension Service, University of Florida, Gainesville.

[10] Oke, D.O., 2008. The Changing Cocoa Agroforests of Ondo State, Nigeria: Implications for Environmental Stability, Food Security and Biodiversity Conservation. In Research for development in forestry, forest products and natural resources management, Onyekwelu.

[11] Rana, et. al., 2017. Performance of sweet gourd under fruit tree based agroforestry practices in char land ecosystem. J. Agrofor. Environ. 11 (1 & 2): 165-170.

[12] Sobola, O. O., Amadi, D. C., Jamala, G. Y. 2015. The Role of Agroforestry in Environmental Sustainability, IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), Volume 8, Issue 5 Ver. I , PP 20-25

[13] UNDP/ FAO. 1988. Land Resources appraisal for agricultural development in Bangladesh. Report 2. Agro-ecological regions, Rome.

[14] Weil, R. R and Brady, N.C.2015. The Nature and Properties of Soils. 15th edition, pp 96-98.

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