An exploratory study on farmer's vernacular knowledge about the land characteristics, soil quality and crop suitability in Lower Ganga Flood Plain: Bangladesh Perspective

Samsunnahar popy

Dept. of ESD, Banga bandhu Sheikh Mujibur Rahman Science & Technology University, Gopalganj, Bangladesh

Abstract— *Local people and small scale farmer had a broad understanding of their land characteristics and soil quality to choose crop. Though Maximum farmers in our country are illiterate and little educated; they have no enough scientific knowledge about land type, soil quality and crop suitability. But they possess vast indigenous knowledge by living in a same environment for a long period of time. They have developed some strategies that helped them to attain a higher degree of satisfaction in farming. So therefore it is very important to explore the farmer's vernacular knowledge about the land type, soil quality and crop suitability. To address this indigenous knowledge this study investigates the farmer's vernacular knowledge about the land type, soil quality and crop suitability in Lower Ganga Flood Plain in Bangladesh. The information was collected from one Mouza in Nagarkanda upazila, Faridpur district Lower Ganga Flood Plain in Bangladesh. Qualitative and quantitative both data were used in this study. The data were collected from primary sources (such as questionnaire survey, FGD) and secondary data sources (such as books, journals, and published and unpublished research reports). Data were analyzed by exploratory statistics. Graphs and graph tables were created by MS excel. By analyzing the Field data it was investigated that farmers of the study area recognized four elevation levels of land; i). High Land (Vitta) ii). Medium Land (Taner Jomi) iii). Low Land (Nall/Dhop) iv).Very Low (Beel) based on its elevation, flood depth, land use, and crop suitability. The farmers of the study area possess considerable knowledge of the soils quality, moisture conditions of that area. The farmers of the study area distinguish soil into three categories primarily on the basis of color, texture, organic matter content, drainage, and fertility of soils. They use indigenous methods such as visual observation while color, tasting by tongue, feeling, vegetation cover and rubbing with fingers to determine various soil properties. Thus Farmers' knowledge of soils is, therefore, a vast resource we summarized in this paper.*

Keywords— Agriculture, Crop suitability, Farmer, Local Knowledge, Land, Soil.

I. INTRODUCTION

Bangladesh is one of the most densely populated countries in the world with an area of 147,570 sq. kilometers. The economy of Bangladesh primarily is dependent on agriculture [6]. To meet the increasing demand of growing population crop field is used intensively where farm characteristics, soil quality are the main prerequisites for sustainable crop production. The success of maintaining or enhancing land, soil quality and crop suitability depends on our understanding of how the soil responds to agricultural land use and crop pattern. Concern about land type, soil quality and are not limited to agricultural scientists, natural resource managers, and policymakers, but also farmers have a vested interest in land type soil quality crop suitability [1]. Local or indigenous cultures and people hold significant knowledge of soils, land and crop suitability, attained by experience and testing through many generations of living close to the land [10]. The environmental knowledge embedded in local cultures provides a long-term perspective on land use and management not otherwise available. The long-term experience of local cultures with resource use and management, including successes and failures, is embodied in local cultures and can help in evaluating land use in relation to soil quality and sustainable agriculture. (Sandor, 2002). Local soil knowledge is clearly a cross or mix between knowledge and practice, and the two are frequently difficult to separate. A better understanding of the diversity among the farmer's local knowledge of land, soil management and crop suitability is essential to formulate a sustainable national agricultural development policy [2].

Historically, agricultural researchers and policymakers of Bangladesh have neither recognized the importance of farmers' local knowledge of soil management nor integrated them in farming systems research. Therefore, the potential contribution of such a vast resource to achieve sustainability of the country's farming systems remained untapped, and the agricultural researchers have not been very successful in developing a sustainable farming system that is suitable for different environmental conditions. Farmers possess vast knowledge of local soils and land management, and practice multiple cropping under different environmental conditions [2]. The challenge for researchers is to investigate farmer's indigenous knowledge about land characteristics and soil quality for crop suitability to achieve high production.

Several participatory approaches have been developed to involve farmers in an interdisciplinary approach to agricultural research. These give greater attention to actual farming practices, farmers' needs and farmers' knowledge. Although many studies have investigated the indigenous knowledge of farmers to improve agricultural sustainability, but there were no in-depth investigation in lower Ganga flood plain in Bangladesh. This study attempt to explore the farmer's vernacular knowledge about the land characteristics, soil quality and crop suitability in Nagarkanda Upazila (Lower Ganga Flood Plain) in Bangladesh.

II. LOCATION OF THE STUDY AREA

The study was conducted in four villages of Nagarkanda Upazila of Faridpur district in Lower Ganga Flood Plain in Bangladesh. The latitudinal extension of the study site is from 23°19´ North to 23°24´ North and longitudinally it stretches from 89°43´ East to 89°56´ East (Figure 1). Nagarkanda Upazila (Faridpur district) with an area of 379.02 sq km, is bounded by Faridpur sadar and char Bhadrasan upazilas on the north, Muksudpur and Boalmari upazilas on the south, Bhanga and Sadarpur upazilas on the east, Char Bhadrasan upazila on the northeast and Boalmariupazila on the west [19]. My study area is consisted of 17 union parishad. Data were collected from four villages (Boronaudubi, Poradia bazar, Suturkanda and Balia) of kachail union. In that area about 80% people depends on agriculture. The whole area of the study site is plain land and lies in the recent flood plain physiographic unit of Bangladesh. Total land area of my study area is 15444 acres. And here high land is 1403 acres which remain 9% of the total area, medium land is11938 acres and it occupies 77% of the total area which indicates that the study area is a medium high land dominated flood plain area .The low land of my study area is 2103 acres (14%) of the total area [6].

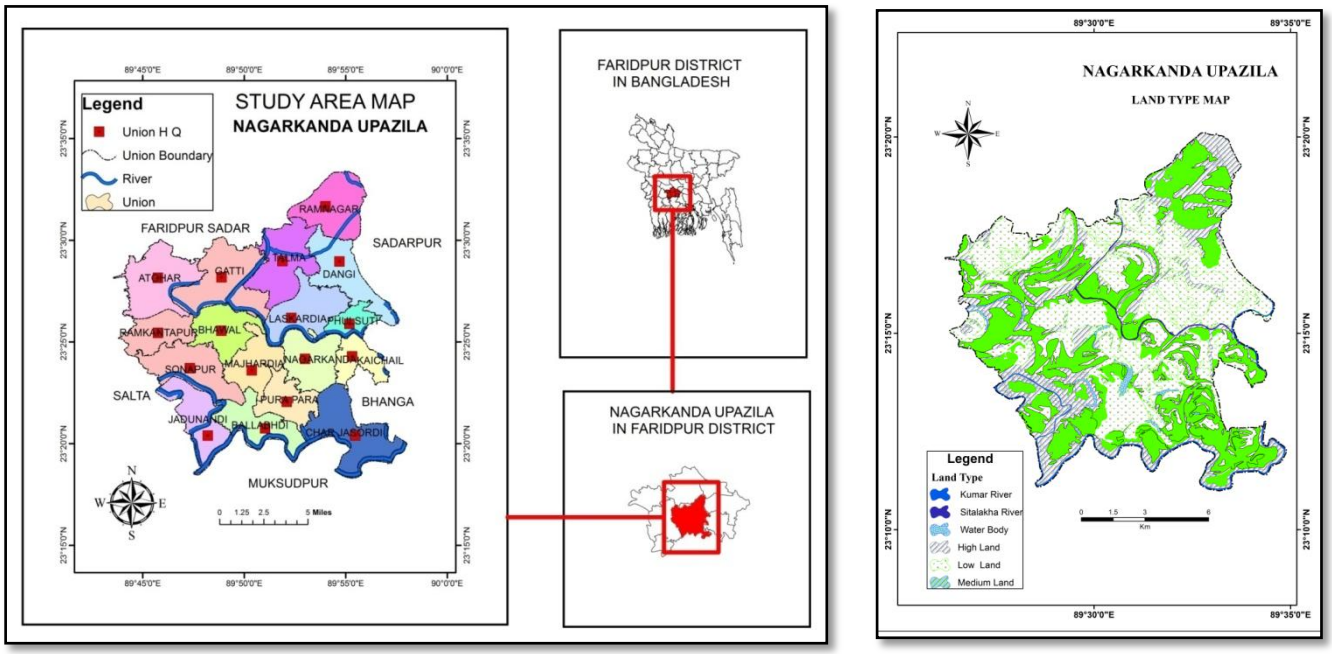

FIGURE 1: Location, Land type of the study Area
Sources: SRDI Report, 1999, complied map by author

Two main river Kumar and Shitalaka flow through this area and causing flood during the rainy season**.** Soils of this region are silt loams and silty clay loams on the ridges and silty clay loam to heavy clays on lower sites. General soil types predominantly include calcareous dark grey and calcareous brown floodplain soils. Annual average temperature varies from maximum 35.8c to minimum 12.6c and annual rainfall is 1546 mm [19].

III. DATA AND METHODOLOGY FOR STUDY

Farmer's local knowledge about land type of area are the main sources of information for this research. In addition, the research utilizes different types of secondary data, including land type of Bangladesh, land type of the study area, land characteristics, floodibility of land; crop suitability etc. information are obtained from different secondary sources. A detail in-depth Questionnaires were finalized to collected the field data. Observation techniques were also adopted to understand the farmer knowledge about the land type. Focus group discussions were conducted with the farmers to know about cropping patterns, land type and soil quality for cultivation. Firstly, the Upazila Nagarkanda, Faridpur were selected where maximum people are directly and indirectly involved in agriculture. A total of 100 farmers' were selected from 4 villages (4 villages

from). From each of a village 20-30 farmers' were sampled and data were collected for the study. Among the selected farmers, there were mixed groups of marginal, poor farmers and day laborers different age. The local knowledge about their agriculture is known from them through focus group discussions, in this regard key informants' were interviewed. Besides, local govt. (UP-Chairman & members) and officials (AEO) were also interviewed. Questionnaires were finalized after field test. Observation techniques were also adopted to understand the farmer's local knowledge about the land type. Focus group discussions were conducted with the farmers to know about cropping patterns, land type and soil quality for cultivation. Their thinking about the problems they face in cultivation and the way they are planning for solution of their problems were also addressed in this study. Data were collected from rice and non-rice crops growing farmers of the villages using questionnaire. There are many secondary data sources that are collected from various books, articles, thesis, reports and news article. The collected data was manually coded according to the objective of the study. All the collected data were summarized and scrutinized carefully. Data were analyzed by exploratory statistics. Graphs and graph tables were created by MS excel.

IV. RESULTS AND DISCUSSION

4.1 Land Type of Study Area

Nagarkanda Upazila (Faridpur district) lies in lower Ganges River Floodplain region which comprises the eastern half of the Ganges river floodplain. The land is low-lying and the area has a typical meander floodplain landscape of broad ridges and basins [19]. Whole area is a medium high land area which is most suitable for agriculture.

TABLE 1
LAND USE AND LAND CONTROL OF THE STUDY AREA

Cultivable land 92%	Percentage of land	Land control: Among the peasants	Percentage of peasants
Single crop	30%,	Landless	35%
Double crop	60%	Small	30%
Treble crop	10%;	Intermediate	25%
land under irrigation	80%.	rich	10%

Sources: BBS, District Statistics (2011).

4.2 Farmer's indigenous knowledge about land evaluation

Adequate knowledge of land elevation is required to make land use decisions. From interviews and group discussions, it appears that farmers of these villages possess considerable knowledge of the village land type, climate condition, cropping pattern. Though they have no scientific knowledge but they have much local and practical knowledge about land type, soil quality and crops suitability. They got this knowledge by living in this village environment for some period of time. This Local knowledge is very important for the agriculture of our country. All farmers recognized the occurrence, duration, and possible impacts of floods caused by high monsoon rainfall. The farmers of the study site consider the land elevation, floodibility, and land use pattern, to classify land categories. Farmers recognized four elevation levels; i).High Land (Vitta); ii).Medium Land (Taner Jomi); iii).Low Land (Nall/Dhop); iv).Very Low (Beel); in reference to Flood depth, elevation from river bank.

TABLE 2
FARMERS' CLASSIFICATION OF LAND BASED ON ELEVATION, FLOODIBILITY AND LAND USES

Local name	SRDI name	Amount of land	Floodibility by flood types	Flood depth	Land use
Vitta	High Land	1403 (9%)	Flood free	Flood free	Rural settlement, gardening, livestock farming, manmade forest
Taner Jomi	Medium Land	11938(77%)	inundated for 2/3 months	highest 180cm (6feet)	robi crop (Rice, onion,garlic Wheat) and kharip(jute).
Nall/Dhop	Low Land	1503(10%)	inundated 5/6 months	180cm to 275cm (6feet-9feet)	Ropa aman, mixed aush, fish pond
Beel	Very Low Land	600 (4%)	inundated 9/10 months	more than 275cm (9feet)	Bona aman, fish pond

Source: Field survey, 2015

The high land locally called Vitta, is relatively high land from the riverbanks and cannot hold waters during monsoon. It extends 1403 acres (9%) area of the study site. These land mainly used for rural settlement, livestock farming, gardening, and

manmade forest. The high land (vitta) is also used in agriculture purpose where three crops are cultivated in a year by irrigation. This land is most suitable for cultivating sugarcane, Banana, and different types of fruit. Next, elevation level is medium land which locally called Taner Jomi. Taner Jomi occupies 11938 acres (77%) area, are frequently flooded up to 180cm (6feet). This land mainly used as cropland (khet) and sometimes it remains fallow (patitha). This land is inundated for 2/3 months in the rainy season. So two crops are cultivated in a year in this land which is robi crop (Rice, onion Wheat) and kharip (jute).).The third level, dhop/nallis the low land covers 1503 acres (10%) area. And in the dhop land which is inundated 5/6 months in a year and flood depth extends180cm to 275cm (6feet-9feet) during the monsoon season. Only one crop (Ropa aman) is cultivated here in a year. Beel that occupies 600 acres or 4% of the study site is regularly flooded and this land is used to cultivate Bona aman, fish farming. Human-induced changes in land levels are prominent in that village. Over the years farmer migrate rice cultivation to fish farming. They dig so many (dighi) large ponds in the crop land for fish farming.

4.3 Soil of Nagarkanda Upazila

Soils of this region are silt loams and silty clay loams on the ridges and silty clay loam to heavy clays on lower sites. General soil types predominantly include calcareous dark grey and calcareous brown floodplain soils [19]. Organic matter content is low in ridges and moderate in the basins. General fertility level is medium. According to this sense Nagarkanda Upazila is a develop area by its Soil and land quality. According to SRDI Nagarkanda Upazila was divided into nine categories according to its land Type, soil quality and possibility of agriculture development. Broad soil classification of Nagarkanda Upazila in 2008 is shown in (table: 3) and figure (3).

TABLE 3
SOIL TYPES OF NAGARKANDA UPAZILA

Lower ganga Flood Plain-12				
S. No:	**Soil Name**	**Area**	**(%) of area**	**Soil Group**
1	Lower ganga Alluvium Soil-1	1702hec.	4.5%	Sara, Gopalpur,Ishirdi
2	Lower ganga Alluvium Soil-2	441hec.	1.2%	Sara,Gopalpur,Ganga polol.
3	Lower ganga Alluvium Soil-3	2279hec.	6.0%	Sara,Gopalpur,Ishirdi
4	Lower ganga Alluvium Soil-4	1495hec.	4%	Gopalpur, Ishirdi
5	Lower ganga Alluvium Soil-5	2634hec.	7%	Ishirdi, Ghieor.
6	Lower ganga Alluvium Soil-6	9709hec.	25.7%	Ishirdi, Ghieor.
7	Lower ganga Alluvium Soil-7	8006hec	21.2%	Ishirdi, Ghieor.
8	Lower ganga Alluvium Soil-8	4763hec.	12.6%	Ishirdi, Ghieor.
9	Lower ganga Flood Plain Soil-9	1545hec.	4%	Ghieor, Ramdia.

Sources: SRDI Report, 1999.

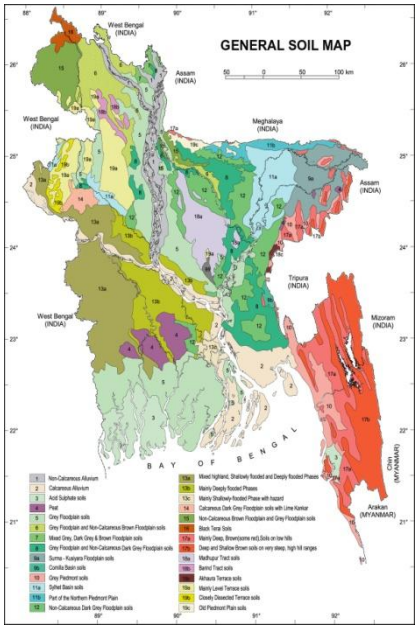

FIGURE 2: General soil map of Bangladesh
Sources: Banglapedia

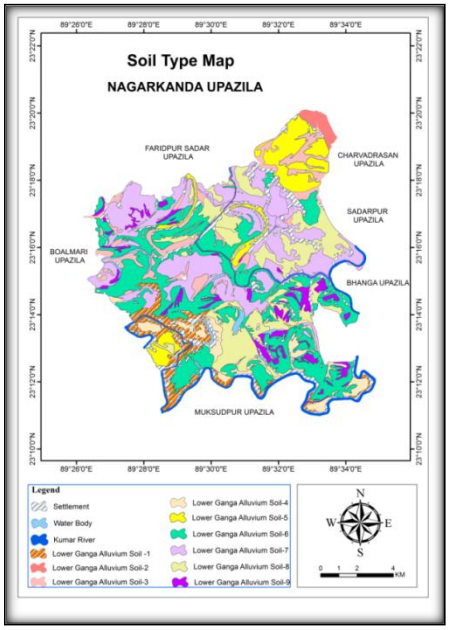

FIGURE 3: Soil map of Nagarkanda Upazila
Sources: SRDI Report, complied map by author

4.4 Farmers' indigenous knowledge about Soil Quality assessment

From the study it was explore that farmers of the study area possess considerable knowledge of the soils quality, moisture conditions of that area. Farmers' measurements of soil properties are rather qualitative than quantitative except for soil. The farmers of the study area were only concerned with the top soil as they use this part of the soil profile for agricultural purpose. They distinguish soil types primarily on the basis of color, rubbing, texture, vegetation, and fertility of soils. They use indigenous methods such as visual observation while tilling, tasting by tongue, feeling and rubbing with fingers to determine various soil properties. Then there they found different types of soil where sand, silt, clay and sandy loam are most. First, Farmers take handfuls of soil and feel the presence of sand, stones (kankar), silt, and clay to distinguish soil textures and classify soils into three broad types: Baila mati (sandy), Jharjara mati (silty), and Athaila mati (clayey). At the same time, they look for the presence of organic matter by color. In general dark soil is considered as fertile soil where light soil is less fertile based on their organic matter content. Black soil which is more fertile and contains relatively high levels of organic matter and light soil is less fertile and it contains less organic matter. They rub soil between two finger to assess whether it is sandy, clay, loamy and silt. They investigate how fast water penetrates into soil to determine soil drainage. Farmers taste soil by tongue to recognized acidity and salinity. They categorize on the basis of taste into salty for salinity, sour and irritating for acidity. Some farmer smell soil to determine whether it is good or bad soil. Finally, farmers use dark green vegetative growth of plants and high crop yields as the key indicators of soil fertility.

TABLE 4
SOIL CLASSIFICATION CRITERION

Criterion	Method of determination	Frequency by Percentage (%)
Color	Look the presence of organic matter	21
Rubbing	Rub soil between two finger	34
Vegetation cover	High crop yields indicates of fertile soil	27
Drainage	How fast water penetrates into soil	9
Salinity and acidity	Taste soil by tongue	5
smell	Bad smell indicates high organic matter	4

Source: Field survey, 2015.

TABLE 5
FARMER'S CLASSIFICATION OF SOIL BASED ON COLOR, DRAINAGE, AND VEGETATION COVER

Soil name	Local Name	SRDI Name	Total area (acres)	Frequency by Percentage (%)
Sany Loam	(Baila mati)	Bele Doash	0	0%
Silty Loam	(Jharjara mati)	Atel Doash	30127	90%
Clay Loam	(Athaila mati)	Poli Doash	3136	10%

Source: Field survey, 2015

Above table (5) shows the soil classification of study area. It represents that silty loam soil (Atel Doash mati) covering 30127 acres land of the study area is the dominant soil type of that area and local people called this soil as (jharjara mati). Clay loam soil (Poli Doash mati) locally called athaile mati remains 3136 acres land Occupying 33% land is another dominant soil type of this study area. Sandy loam (Bele Doash mati) is found very little amount in my study area, local people called this soil (Baile mati). Baile mati contains more sand and less silt and clay. This type of soil is light dark grey in color and contains less moisture. And found near the river bank area. Fertility of Soil varies from one land to another land. Normally Fertility of a land is decreasing by cultivating regularly. But now a days by using different fertility development strategies the fertility of maximum soil are increasing and few amount of soil fertility are decreasing for the lack of different fertility development strategies.

4.5 Cropping pattern of my study area

Crop suitability is a function of crop requirements for soil and land characteristics. Matching the land characteristics with the crop requirements gives the suitability. Eleven agro-edaphic factors (Soil: Soil Permeability, Effective Soil Depth, Available Soil Moisture, Nutrient Status, Soil Reaction (pH), Soil Salinity, Soil Consistency, Drainage; Inundation: Depth of inundation, Flood hazards; and Landform: Slope) were considered for land suitability analysis[20]. Highland may be suitable for kharif or perennial dry land crops if the soils are permeable. Impermeable soils may be suitable for transplanted Aus and/or Aman paddy. Medium Highland is suitable for crops which can tolerate shallow flooding, such as broadcast or transplanted Aus paddy, jute and transplanted Aman paddy. Lowland is flooded too deeply for broadcast Aus or transplanted Aman to be grown. Dry land rabi crops can only be grown if floodwater recedes before December. Very Lowland generally

is too deeply flooded for even deep water Aman to be grown .Where cultivated, very Lowland is generally used for irrigated Boro paddy, either HYV or local varieties.

In this region main crop is rich, jute, wheat, onion, garlic and different types of pulse and oil seeds. My study area is a part of lower ganga flood plain region. Its land is very fertile. According to local agro climatic zone the most suitable and medium suitable crops list are given (table 6) below.

TABLE 6
SUITABLE CROPS OF THE STUDY AREA

Most suitable crops:	Rice, Pulses, Potatoes, Jute, Onion, Sugarcane, vegetable, Lemon, Nut, Mustard.
Medium suitable crops:	Wheat, Jute, maize, Oat, Barley, Chena, Soabin, Ginger, Turmeric, Papaya, Banana.

4.6 Farmers' indigenous knowledge about Crop suitability assessment

The farmers of the study area had a better understanding of the effect of land and soil type for different crops. They know the relief and environmental conditions in which various crops thrive well, and the soil, water, and nutritional needs of those crops. They consider drainage status, soil depth, land elevation, fertility to choose crop. First, they consider the elevation of the land then the presence of sand, silt, and clay. Second, they look for the presence of organic matters (doash meaning loam) and further classify each textural class into two subtypes: soils with low or no organic matter and those with high organic matter content. Farmers know that the aus rice, a kharif crop, grows well on flood-free danga land containing bele maati (sandy) and bele–doash maati (sandy loam soils). It can neither thrive in severe drought or high flood, nor can it tolerate high compactness, salinity, and acidity that characterize most of the village soils. It is not a common crop in the village. Jute is also a kharif crop that grows well with floodwater.

TABLE 7
CROP SUITABILITY BASED ON LAND AND SOIL CHARACTERISTICS

Name of crop	Land	Soil
Aush	Taner Jomi	Sand, Silty loam, Sandy Loam
aman	Taner Jomi, Nall	Silt, clay
Boro	Taner Jomi, , Nall	Silt, Silty Loam, clay
Wheat	Vetta, Taner Jomi	Silt, Loam clay
Jute	Taner Jomi,, Nall	Silt, clay
Onion	Vetta, Taner Jomi	Silt, Silty Loam, clay
Oil seeds	Vetta, Taner Jomi	Silt, SiltyLoam
Pulse	Vetta, Taner Jomi	Silt,Loam, clay
Nut	High land	Loam
Potato	Vetta, Taner Jomi	Loam, Clay Loam

Source: Field survey, 2015.

The suitability of some main crop in respect to land type and soil quality is identified. Here according to land type and soil characteristics the crop suitability is classified into three categories (Table 8) Suitability of Different crops are shown in (Table: 9) .They are:

TABLE 8
CROP SUITABILITY CODE

Crop Suitability	Code
Suitable	1
Medium suitable	2
Not Suitable	3

TABLE 9
CROP SUITABILITY CODE ACCORDING TO LAND TYPE, SOIL TEXTURE, SOIL COLOR, SOIL MOISTURE AND IRRIGATION TYPE

Crop name	Land type			Soil texture			Soil color			Soil moisture			Irrigation type		
	High land	Medium land	Low land	Sand	Silt	clay	dark grey	moderate grey	light grey	High	medium	low	good	medium	low
Aush	1	1	3	3	1	1	1	2	3	1	2	3	3	2	1
aman	2	1	1	3	1	1	1	2	3	1	3	3	3	2	1
Boro	3	1	1	3	1	1	1	2	3	1	3	3	3	2	1
Wheat	1	1	3	3	2	1	1	2	3	1	2	3	1	2	3
Jute	1	1	3	3	1	1	1	2	3	1	3	3	1	2	3
Onion	1	1	3	3	1	1	1	2	3	1	3	3	1	2	3
Oil seeds	1	1	2	3	1	1	1	2	3	1	2	3	1	2	3
Pulse	1	1	2	3	1	1	1	2	3	1	2	3	1	2	3
Nut	2	2	3	1	2	3	1	2	2	2	2	2	1	2	3
Potato	2	2	3	1	2	3	1	2	2	2	2	2	1	3	3

V. CONCLUSION

Farmers' knowledge of land is inherited, acquired through generation-long in situ practical experience and is reflective of their close interaction with the physical environment. Despite their lack of scientific knowledge about topology, physiography and land characteristics of the study area, the farmers are highly knowledgeable in various land type of the study area. Thus, the farmers' knowledge of land has greater utility toward the sustainability of agriculture in the village. Farmer assessment about the soil quality, soil fertility is very much important in agriculture spatially cropping pattern of my study area. Though their local knowledge about soil is much different from scientific research, Farmers' interest in soils is to sustain higher yield of crops of their choice; hence they classify soils on the basis of topsoil conditions. They have traditional local knowledge about the crop suitability of that area. Depending on their local knowledge they cultivate different types of food and cash crops. Though their local knowledge about crop suitability is not wrong but if we can add scientific knowledge with their local knowledge then this knowledge will be better than the local knowledge. So from the above discussion it can be said that combined knowledge (local and scientific) is more suitable and useful than local knowledge.

ACKNOWLEDGEMENTS

The Authors wish to express sincere thanks to the Head of the Department of Geography and Environment, Jahangirnagar University, savar Dhaka-1342 for providing all necessary institutional support also Bangladesh Soil Research Development Institute (SRDI) for providing soil data.

REFERENCES

[1] Arfin, A. et al., 2011, Study on Existing Status of Farm Environment and Awareness in a Farming Community of Dinajpur District, J. Environ. Sci. & Natural Resources, 4(2): 151-15, Department of Environmental Science Bangladesh Agricultural University, Mymensingh – 2202.

[2] Ali, A.M.S., 2002, Farmers' knowledge of soils and the sustainability of agriculture in a saline water ecosystem in Southwestern Bangladesh, Geoderma 111 (2003) 333–353, Department of Social Sciences, The University of Texas at Tyler, Tyler, TX 75799, USA.

[3] Ashby, J.A., 1987, The effects of different types of farmers participation on the management of on-farm trials, Agricultural Administration and Extension 24, 234– 252.

[4] Benbrook, C.M., 1991, Sustainable Agriculture Research and Education in the Field, National Research Council, Washington, DC.

[5] Biggs, S.D., 1988, Research by Farmers: The Importance of Informal Agricultural R and D Systems in Developing Countries, Institute of Development Studies, Sussex, England.

[6] BBS, 2013, District Statistics 2011,Faridpur: Bangladesh Bureau Of Statistics

[7] Bodley, J., 1990, A Methodology for Adaptive Agricultural Research, Agricultural Administration (Research and Extension) Network Discussion Paper 23, Overseas Development Institute, London.

[8] Brammer, H., 1986. Classification of the Soils of Bangladesh in the Legend for the FAO/UNESCO Soil Map of the World. Soil Resource Development Institute (SRDI), Dhaka.

[9] Brammer, H. (2002), Land Use and Land Use Planning in Bangladesh, The University Press Limited, Dhaka, ISBN 9840515659.

[10] Das, T. and Das, A.K., 2004, Local soil knowledge of smallholder rice farmers: A case study in Barak Vally, Assam Indian Journal of traditional knowledge vol.4(1) Department of Ecology and Environmental Science, Assam university, Silchar 788011, Assam.

[11] Food and Agricultural Organization (FAO), 1988a. Land Appraisal of Bangladesh for agricultural development. Report 2: Agroecological Regions of Bangladesh. FAO, Rome.

[12] Mustafa, A. A. et al., 2011, Land Suitability Analysis for Different Crops: A Multi Criteria Decision Making Approach using Remote Sensing and GIS1Water Technology Center, 2 Division of Agricultural Physics, 3Division of Soil Science and Agricultural Chemistry Indian Agricultural Research Institute, New Delhi-110 012.

[13] Osbahr, H. and Allan, C., 2002, Indigenous knowledge of soil fertility management in southwest Niger, Geoderma 111 (2003) 457–479 , Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK .

[14] Oudwater, N. and Martin, A., 2002, Methods and issues in exploring local knowledge of soils, Geoderma 111 (2003) 387–401, Livelihoods and Institutions Group, Natural Resources Institute, University of Greenwich, Chatham Maritime, Chatham, UK

[15] Prakash, T.N. (2003)Land suitability analysis for agricultural crops: A fussy multicriterias decision making approach international instituted for geo information science and earth observation enschede, Netherlands.

[16] Payton, R.W., 2000. Combining Systematic and Participatory Approaches for Developing and promoting strategies for Sustainable Land and Water Management. Final Report, European Commission DGXII INCO-DC Research Project ERBIC18CT960107. Centre for Land Use and Water Resources Research. University of Newcastle upon Tyne, Newcastle upon Tyne, UK.

[17] Rasul, G. & Thapa, G. B., 2003, Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives, Rural and Regional Development Planning, School of Environment, Resources and Development, Asian Institute of Technology, PO Box 4, Klong Luang, Pathumthani 12120, Thailand.

[18] Zuberi, M.I. et al., 2002, Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh, Geoderma 111 (2003) 355–386, Department of Agricultural and Environmental Science, University of Newcastle upon Tyne, Newcastle upon Tyne, UK.

[19] http://en.banglapedia.org/index.php?title=Nagarkanda_Upazila

[20] http://cropzoning.barcapps.gov.bd/homes/intro.