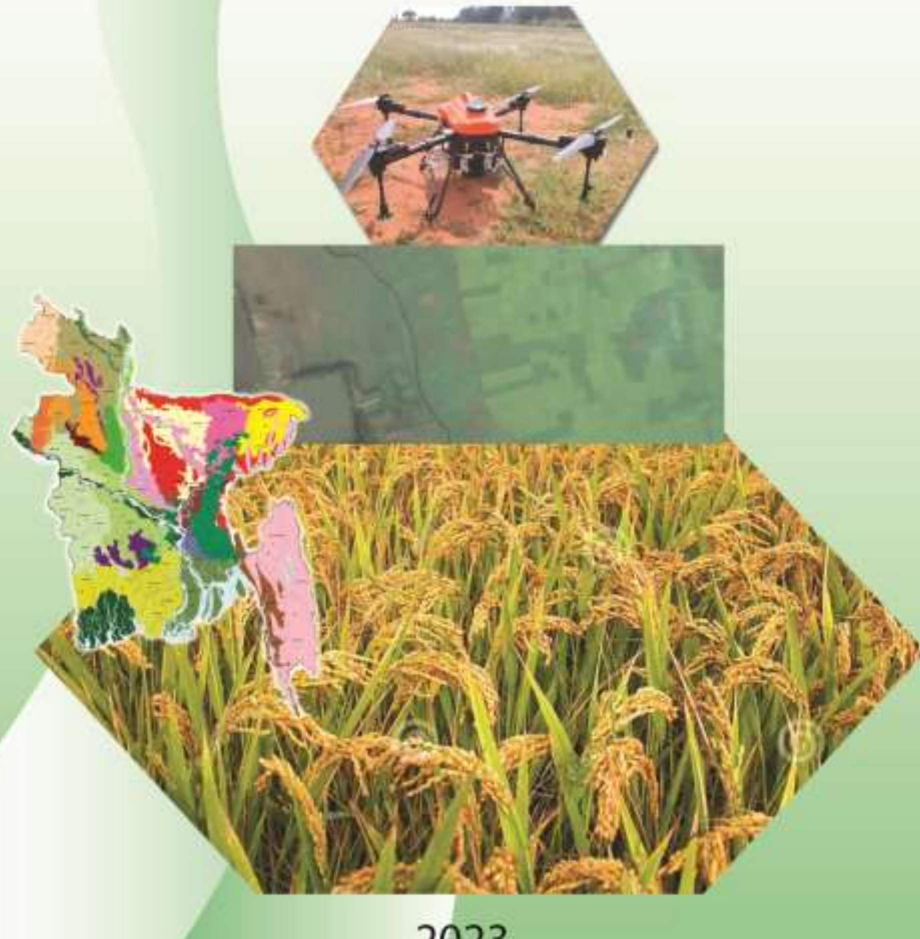
ANNUAL REPORT

2022-2023



2023

SOIL RESOURCE DEVELOPMENT INSTITUTE

MINISTRY OF AGRICULTURE

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Government of the people’s Republic of Bangladesh

ANNUAL REPORT
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SOIL RESOURCE DEVELOPMENT INSTITUTE
MINISTRY OF AGRICULTURE

Foreward

One of the vital activities of SRDI is to publish annual report based on all activities performed during the fiscal year. Accordingly, this report covers the achievement against target of Annual Performance Agreement (APA) for 2022-2023.

Being a NARS organization SRDI has the mandate to develop inventories on soil and land resources, ensure sustainable soil health management, and innovate technologies for problem soil management. All these ventures have a common goal- sustainable agricultural development.

Conducting semi detailed soil survey and preparation of Upazilla Nirdheshika is one of the core works of SRDI. It is a unique tool developed for local level agricultural planning. The Nirdeshika comprises all land and soil related data, information including soil fertility and agro climatic features. It is prepared for developing local level agricultural planning by Upazila level DAE official including SAAOs as it provides all sorts of local level land, soil and agro climatic data base. Upazila Nirdeshika has multiple uses. Among them, assessment of crop suitability, land use and recommendation of balanced fertilizer are of worth mentioning. Apart from Upazila Nirdeshika SRDI also prepares Union Shahayika as a tool for developing agricultural planning at grass root level. Except for its planning advantage, it is also used as a guiding tool for fertilizer recommendation. To popularize balanced fertilizer use practice among farmers SRDI has initiated and operating number of programmes, like conducting research trial and distribution of fertilizer recommendation cards and organizing discussion meeting on minimizing wastage of chemical fertilizers through farmers gathering.

Analysis of soil, fertilizer, plant & water is another vital activity of SRDI. These services are provided mainly by Divisional and regional laboratories having permanent infrastructures. Beyond that another type of farmers' service is given through Mobile Soil Testing Laboratories (MSTL). It is mainly a motivational programme run with the objective of creating mass awareness among farmers on use of balanced fertilizer on the basis of soil test data.

Soil and water salinity monitoring is another prime activity of SRDI which is devoted to generating database for improved management of saline soils and also for programme planning.

SRDI also conducts research through Soil Conservation and Watershed Management Centre (SCWMC) at Banderban and Salinity Management and research Centre (SMRC) at Batiaghata, khulna. Both the centres are devoted to conduct research and develop sustainable soil management technologies on problem soils, viz. hill soils and saline soils.

Aside from these, SRDI extends support services to DAE, NARS organization, educational institutions and other GO and NGOs by providing data through its rich data base.

Divisions and sections of SRDI head office have significant contributions to achieve the annual targets other than their other valuable jobs.

I believe that the information and findings covered by this report will be helpful for all concerned.

I would like to extend my heartiest thanks and gratitude to all officers and staffs of field offices, laboratories, research centers and head offices who are involved in implementing the annual programme 2022-2023 with sincere efforts.

My thanks also go for project directors and programme directors for their contribution in achieving annual target.

Finally members of the annual report preparation committee also deserve thanks for their valuable efforts to prepare the annual report.

(Md. Sabbir Hossain)
Director General

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Executive Summary

Sustainable use of land resources and promoting soil health management are the two vital Sustainable Development Goals (SDG) relating to agricultural development in Bangladesh. Ensuring food security for booming population through squeezing land and soil resources is the main challenge in achieving these goals. SRDI's all-out efforts and functions are concentrated to achieve the goals amidst harsh reality.

As a government and NARS organization under Ministry of Agriculture (MoA) Soil Resource Development Institute (SRDI) is responsible for making inventory on land and soil resources, conducting research on hill soils and salinity affected area. Besides, SRDI provides soil and fertilizer testing services through static laboratories. It also renders motivational soil testing services at grass root level through Mobile Soil Testing Laboratory (MSTL). The Institute is also liable to conduct research on crucial soil and environment related problems. Providing advisory services to divergent stakeholders is another salient job of SRDI.

Updating of "Upazila Nirdeshika" through semi-detailed soil survey is a core programme of SRDI. In the fiscal year 2022-23, updating soil survey programme was carried out in 50 Upazilas. Field level information on significant changes in land use, land type, fertilizer use and other relevant data as well as composite soil samples were collected for each and every case. Inclusion of vegetable and fruits as high value crop has been noticed in some places. A number of thirty-five (35) Upazila Nirdeshika were published in the year. The findings of published Upazila Nirdeshika reveal that there is significant increase in transformation of agricultural land into non-agricultural land due to urbanization, industrialization and rural settlements. Data also reveal that homestead forest covers a significant area under rural settlements of coastal area. Change in land type classes has been observed in some cases. Soil pH as well as soil nutrient status have been decreasing or almost similar in different parts of the country. Reasons of declining soil pH or soil acidification are excessive and/ inappropriate use of nitrogenous fertilizers and removal of crop residues. Soils of intensive cropped area are found to be more exhausted in respect of soil fertility which is mainly due to unbalanced use of fertilizers along with minimum or without use of organic inputs.

Union based Land, Soil and Fertilizer Recommendation Guide (Union Sahayika) is being used as a local level tool for agricultural development planning and for advisory services. A number of 234 Union Sahayikas were prepared and published in the fiscal year 2022-23.

SRDI has launched Online Fertilizer Recommendation System (OFRS) since 2009. The system aims at providing faster and easier delivery of fertilizer recommendation service which is a part of sustainable soil management. In FY 2022-23, about 9024 farmers/beneficiaries were served through OFRS software. Number of farmers served on the basis of Upazila Nirdheshika and soil test are 6843 and 707respectively.

SRDI's activities also involve GIS based data processing and map preparation. This endeavor employed for utilizing GIS in storage, retrieval as well as visualization of land and soil related maps. Under this programme, Proposed upazila for soil suvey (semi-deyail soil survey of SRDI) map, Agroecological Zone (AEZ) map of Bangladesh, Agroecological Zone of Chapainawabganj District were prepared in 2022-23 fiscal year. The digitized maps depict the updated scenario of nutrient deficiency, degraded soil area, flood prone area, physiography as well as AEZ related features throughout the country.

SRDI initiated Soil Test Based (STB) Fertilizer Recommendation System through Mobile Soil Testing Laboratories (MSTL) since 1996. At present, SRDI operates 10 MSTL for providing farmers service through soil analysis at the user's end in two seasons (Rabi & Kharif) of the year. In 2022-2023, 5081 farmers of 80 Upazilas were given soil testing service and fertilizer recommendation cards through this programme.

SRDI is conducting salinity monitoring in coastal area of the country to observe short term and long-term trend of salinity fluctuation. Data disclose that soil and water salinity was much higher in south western part of the country than rest other parts. It is due to the non-functional river system because of reduced upstream flow. In Khulna Division severe sanity affected Districts are Bagerhat, Satkhira and Khulna. In Barishal Division mainly onshore areas are affected by salinity. Accordingly higher degree of soil and water salinity was recorded in Barguna, Patuakhali, Bhola & Pirojpur Districts. Barishal Division is naturally more advantaged because of its active river network as well as affluent river flow. In recent years Baleshwar River lost its upstream flow. Consequently, sea water intrusion occurs up to Pirojpur Sadar Upazila in dry season which means extension of saline area along the river Baleshwar and scarcity of irrigation water. In Bhola District, saline soils are easily managed because of its loamy texture. These coarse textured soils have low CEC. As a result, they can't hold salt elements with their poor electrostatic charge. This is the reason why desalinization happens in these soils during monsoon through rain flashing if drainage provision is satisfactory. Soils of Hatiya and Swandip under Noakhali and Chittagong District as well as offshore part of Feni District also have the similar advantage. In Barishal Division saline soils could be more easily managed utilizing plentiful dry season river flow. Sweet water needs to be stored in October-November and utilized through buried pipe irrigation network. This could be achieved through modern polder management. In Cox's Bazar District farmers use their lands as salt bed because of higher return. This practice is detrimental to soil health and eventually may accelerate soil salinization. River water salinity of Noakhali and Bhola district is less than that of Khulna, Bagerhat and Satkhira districts. In Satkhira, river water salinity was found highest in May/June whereas in Noakhali and Barishal it was highest in April/May. River water remains saline during April-June as rainfall is low during this period. During the dry season most of the DTW and STW water remains saline. Generally, Barisal experiences lower rainfall during November to March. In Patuakhali, both soil and water salinity start to increase in January/February, attains its peak in March and starts to decrease in June/July at the onset of monsoon. In Chittagong and Cox's bazar soil salinity starts to increase in December, attains its peak in March and then gradually decreases at the start of monsoon. Water salinity starts to increase in January, attains its peak in April/May.

Salinity Management and Research Centre (SMRC), Batiaghata, Khulna has developed number of technologies for saline soil management which have been found to be very effective in farmer's field. These technologies are: top soil carpeting technology for vegetable production on shrimp-gher bund, farm-pond technology, pitcher irrigation, dibbling and transplanting of maize under zero tillage, single and double layer mulching, flying bed culture for vegetable cultivation, and screening of suitable crop varieties for saline soils. Proper dissemination of these technologies is needed for crop intensification through optimum soil and water management in coastal area of Bangladesh.

Soil Conservation and Watershed Management Centre (SCWMC), Meghla, Bandarban has developed some advanced technologies for hill soil management, among these hedge row technology, staggered trenching, half-moon trenching, slash and mulch system of agro-forestry and Natural Vegetative Strips (NVS) for controlling soil erosion in hill slopes are noteworthy. These technologies need to be disseminated through DAE for sustainable soil management in hill area.

Government has to pay a cosmic amount of money for subsidy in fertilizers. It is an extra pressure on our national economy. For proper utilization of government support or incentive it is necessary to use balanced fertilizers by farmers. Farmers should be motivated for rational and balanced use of fertilizers. Minimum wastage of fertilizers is expected with respect to economic and soil health and environmental perspective. With a view to fulfilling the objective, SRDI has initiated adaptive trial programme to popularize balanced fertilizer use among farmers. Basis of the fertilizer recommendation was direct soil test value and soil fertility data of Upazila Nirdeshika. This programme has been implemented throughout the country to visualize superiority of balanced fertilization over farmers' assumed dose. Besides yield increase balanced fertilization help to maintain soil health and good environment. Altogether 62 adaptive trials were set up in the year 2022-23. The yield data of Adaptive Trial plots revealed that farmers got 1.06%-28% higher yield in different crops and varieties in comparison to farmers' practices in different locations.

Chemical analysis of soil, fertilizer, plant and water sample is one of the core functions of SRDI. This programme has been aimed at evaluating soil fertility status for updating of soil chemical databases of SRDI's Upazila Nirdeshika and recommendation of balanced fertilizer doses for different crops. Another objective of the programme is to analyze fertilizer samples for the purpose of quality control and to analyze water and plant samples for research needs of SRDI and other Government and non-Government organizations. During 2022-23 Static Laboratories conducted soil analysis for both physical and chemical parameters, plant and water analysis for chemical parameters and fertilizer samples analysis under different programmes. In Static Laboratories (Central and Regional Laboratories) 25,051 soil samples, 423 water samples, 365 plant samples and 4,744 fertilizer samples were analyzed. Central Laboratory conducted research on various aspects of soil and fertilizer management, sludge management, nutrient management and so on. In addition, 5,081 soil samples were analyzed by 10 MSTLs.

Building up resourceful manpower to cope with upcoming challenges SRDI is implementing good deal of training programmes throughout the year. As a part of this, training was imparted to the officers and scientists of SRDI, DAE on chemical analyses of soil and fertilizers, Identification of adulterated fertilizers at field level, Soil sample collection technique and Use of balanced fertilizer. Training was given to the Officers of SRDI/DAE on the use of Upazila Nirdeshika along with various aspects of soil management/capacity building & skill development and the Officers of SRDI on application of GIS Technology in Preparing maps, skill development on remote sensing, innovation in public service, E-filing, laboratory equipment maintenance and methodology, use of computer and software; farmers/fertilizer dealers/ SAAO's/entrepreneurs of Union Information Center on the use of Upazila Nirdeshika/soil sample collection technique & use of balanced fertilizer/identification of adulterated fertilizer.

To mobilize field and laboratory activities SRDI has three projects and three programmes. The projects are “Strengthening of Soil Research and Research Facilities (SRSRF)”, “Construction of building and Capacity Building of SRDI (CCBS)” and “Gopalganj- Khulna- Bagerhat- Satkhira- Pirojpur Agricultural Development (GKBSP)”. The programmes are “Acidic soil management and sustainable crop production & improvement of soil fertility by practicing climate smart agriculture in Barind area”, “Assessment of Cultivated Land Area for Different Crops Using Remote Sensing and Upazila Nirdeshika”, “Strengthening of Three Newly Created Laboratories”. Significant progress has been made with respect to yearly achievement of the institution. The activities performed by the projects and programmes have been included in this report precisely.

Chapter 1: SRDI at a glance

1.1 Brief Introduction of Soil Resource Development Institute (SRDI)

Soil Resource Development Institute (SRDI) is a designated organization for soil resource inventory as well as soil research for sustainable soil and land management with a view to ensuring food security. SRDI is an attached department to Ministry of Agriculture which was originated in 1961 as the East Wing Directorate of the Soil Survey Project of Pakistan with the assistance of FAO/UNDP. The institute aimed at quick inventory of soil and land resources to develop a sound database of soil and land especially for- Extension, Irrigation and drainage, Soil conservation and reclamation & soil fertility investigation and identification of problem soils.

After emergence of Bangladesh, the then East wing office of the Central Soil Resource Institute started functioning as Department of Soil Survey under Ministry of Agriculture and Forest, Government of the People's Republic of Bangladesh. In 1983, Soil Resource Development Institute (SRDI) was established under the Ministry of Agriculture and Forest by reorganizing the then Department of Soil Survey. From 1986 onwards through successful completion of several projects the activities of SRDI have increased manifold. An important landmark in the development of the Institute was the recent creation of 33 regional offices as well as 23 regional laboratories to flourish soil management services up to grass root level. It is now prepared to face the challenges of future to make breakthrough in crop production through improved soil and nutrient management in Bangladesh.

1.1.1 Vision of SRDI:

SRDI has the vision to ensure judicious and profitable use of the land and soil resources of the country and to protect soil health.

1.1.2 Mission of SRDI:

The mission of SRDI is to make inventories of soil and land resources, classify them according to their potentiality, prepare user-friendly guidelines and manuals for their optimum utilization, investigate and manage problem soils and develop and implement sustainable plans for increased crop production in Bangladesh.

1.2 Functions of SRDI

The functions of the Soil Resource Development Institute are as follows:

a) Reconnaissance Soil Survey of the whole country based on aerial photo interpretation and field survey and laboratory investigation of soils;
b) Semi-detailed soil survey for the preparation of Upazila Nirdeshika;
c) Detailed/Semi-detailed soil surveys of development project areas and research farms for various beneficiary agencies;
c) Soil surveys to evaluate command areas for irrigation and for cropping potentials;

d) Soil surveys for locating areas of problem soils (e.g., saline, alkaline, acidic soil or peat soils) and polluted soils (contaminated by toxic elements and heavy metals), soil degradation and erosion (in watershed region) for planning reclamation or watershed management;
e) Correlation of soils collected through various surveys;
f) Conducting chemical, physical, mineralogical and microbiological study. Chemical analysis of soil, water and plant samples to verify and clarify the field observation;
g) Analysis of chemical and organic fertilizers to ensure the quality of fertilizers for legal action and policy support.
h) Interpretation of satellite imageries through GIS and remote sensing tools for soil and land use surveys;
i) Preparation of various maps and reports on the above-mentioned surveys for publication;
j) Providing services to the development agencies with the help of basic data on soils, land capability and crop suitability for preparation of both short and long-term agricultural development plans;
k) Coordination with the beneficiary agencies at local, regional or national levels regarding planning and execution of land use development programmes;
l) Guiding with respect to sustainable soil management and agricultural development possibilities for each upazila for agricultural extension and research workers;
m) Provision of soil data for planning irrigation, drainage and reclamation projects;
n) Identification of research need and selection of suitable sites for specific research/development activities;
o) Imparting in-service training to the newly recruited technical officers on soil survey, land use planning, cropping potential, etc. and refreshers training to keep the technical officers of the department apprised and acquainted with the up-to date knowledge;
p) Training of agricultural extension and research workers of various levels on proper utilization of soil survey information. Imparting basic training on various aspects of soils to the students of the agricultural institutions. (Source: Gazette Notification, October, 1983);
q) Render services to farmers and others by analyzing soil, plant, water and fertilizer samples and recommend location specific fertilizer doses on the basis of soil testing and crop requirements;
r) Provide assistance in regular monitoring of soil fertility and land productivity activities throughout the country;
s) Study in soil moisture characteristics to ascertain irrigation needs of different crops;
t) Launch a regular programme for the training of field level extension workers on the use of Upazila Nirdeshika to make them enable for preparing local level sustainable agricultural plan and to make recommendation of fertilizers on the basis of soil analytical data;
u) Investigate soil fertility degradation problem, nutrient related problems of crops, soil moisture stress and constraints in crop production etc.

1.3 Organogram of SRDI

Soil Resource Development Institute (SRDI) is a government organization under Ministry of Agriculture (MoA) which is working as a member of NARS system under the umbrella of Bangladesh Agricultural Research Council (BARC). The institute operates its functioning with 2 wings, 2 divisions and 11 sections. Field Services Wing consists of 7 divisional offices and 33 regional offices. Analytical Services Wing includes 7 divisional laboratories, 23 regional laboratories and central laboratory. Survey and land management division consists of 3 sections namely (i) soil survey and land classification section (ii) land use planning section (iii) land evaluation and soil correlation. Training & Communication Division consists of 3 sections namely (i) Cartography section (ii) DPS & ICT section (iii) Human resource development section and (iv) Publication and record section. Central Laboratory consists of 3 sections namely i) Soil physics and Mineralogy ii) Soil chemistry iii) Soil Microbiology and Biochemistry. SRDI's Two research centres namely (i) Soil Conservation and Watershed Management Center (SCWMC), Meghla, Bandarban and (ii) Salinity Management and Research Center (SMRC), Batiaghata, Khulna are controlled by central administration. Centrally controlled administration section includes: administrative branch, accounts branch and store branch. Besides, Upazila Nirdeshika Cell is directly controlled by Director General`s office.

Soil Resource Development Institute is headed by Director General. Field Services Wing, Analytical Services Wing are headed by director. The divisions of head office, divisional offices, divisional laboratories and central laboratory are headed by Chief Scientific Office (CSO) and the sections of head office, regional offices, regional laboratories and research center are headed by Principal Scientific Officer (PSO). Cartography Section is headed by Senior Cartographer, Publication and Record Section is headed by Publication & Liaison Officer.

1.3.1 Functions of Survey and Land Management Division

Planning, co-ordination and supervision of all technical programmes and activities of the component sections. Review and/or editing of all technical reports prepared by the component sections. Co-ordination with allied Government, Autonomous/other agencies in national programmes on soil and land resource evaluation and land utilization planning. Correlation of soils and soil and land classification surveys at national level. Responsible for overall technical progress of the Division. Field investigation of soil problems. Assistance to the Director in general and technical administration of the division. This division has three sections.

1.3.1.1 Functions of Survey and Classification Section

Planning and supervision of soil surveys. Updating of earlier surveys on soils, land use and land capability. Development of advanced methodology for soil surveys. Trials on adoption of latest global technology for soil survey, i.e., use of satellite image for preparing field maps through using remote sensing technique. Editing of soil survey reports.

1.3.1.2 Functions of Land use Planning Section

Planning, supervision and execution of soil survey data interpretation activities. Providing basic data on soils, land capability and crop suitability. Interpretation of soil data for locating areas suitable for extension and introduction of various crops. Processing of soil survey data for land use planning.

1.3.1.3 Functions of Land Evaluation and Soil Correlation Section

Planning and execution of annual targeted programme. Managing correlation of soil series, organizing monoliths. Maintenance of uniform standard of methodology for soil survey. Development and maintenance of the Soil Museum with global experiences.

1.3.2 Functions of Training and Communication Division

Organizing all central training programme and coordinating other trainings of field offices and laboratories. implementing other services through three component sections under this division. Coordination among the sections and administrative functions. Assisting Director General on various technical and administrative issues. This division comprises of four sections.

1.3.2.1 Functions of Human Resource Development Section

Planning and execution of in-service training programmes. Organizing refresher courses. Organizing training programmes related to land, soil, water resources. Developing training modules. Preparation and collection of training materials. Planning, organizing and facilitating overseas training and higher Studies.

1.3.2.2 Functions of DPS and ICT Section

Planning and execution of annual targeted programme. Review and/or editing all technical reports and maps prepared by using base materials and GIS technology. Storage, analyses and regular updating of soil and land resource database. Maintenance and up scaling of Online Fertilizer Recommendation System (OFRS) and Website management. Responsible for overall technical progress of the division.

1.3.2.3 Functions of Cartography Section

Planning and execution of annual targeted cartographic activities. Procuring, managing and distributing all kinds of maps and aerial photographs. Liable for being a custodian of aerial photographs including base maps of different types.

1.3.2.4 Functions of Pubication and Record Section

Collection of relevant books, journals, periodicals and management of SRDI library. Helping authority to conduct publication related activities is another responsibility of the section.

1.3.3 Functions of Field Services Wing

Planning, coordination and supervision of all technical programmes and activities of the divisional and Regional Offices under the wing. Assisting allied government and autonomous bodies and NGOs for implementing local and national level programme on agricultural development. Assisting Director General on technical and administrative issues.

1.3.3.1 Divisional Offices

Implementation of the central technical programme through regular supervision and coordination with subordinate regional offices. Carry out administrative functions within the jurisdiction. Maintaining liaison with the partner agencies like NARS institutes, DAE, BADC etc. Contribute as a member of Regional Agricultural Technology Extension committee for developing agricultural development plan by providing soil and related data and information. Conducting training programme for SAAOs, farmers, entrepreneurs, fertilizer dealers and NGOs' field worker. Providing advisory services to GOs/NGOs. Support also given to university and college students to fulfill their academic needs. Preparing reports on crop damage caused by, flood, cyclone, flash flood, drought etc.

1.3.3.2 Regional Offices

Implementing technical activities under the guidance and supervision of head office and divisional office. Preparation of updated Upazila Nirdeshika through semi detailed soil survey, providing useful information on land and soil resources which is a tool for local level agricultural development planning. Delivering farmers service through OFRS and Upazila Nirdeshika and soil test-based fertilizer recommendation. Technology transfer through block demonstration. Assisting beneficiary agencies like DAE, NARS institutes, BADC etc. by providing information and advisory services required for sustainable use of land and soil resources. Contribute as a member of District Agricultural Technology Extension Committee, District Agricultural Rehabilitation Committee and District Development Coordination Committee laying down information on soil and land resources for agricultural and other development planning. Conducting training programme for SAAOs, farmers, entrepreneurs, fertilizer dealers and NGOs' field worker. Assistance given to university and college students to fulfill their educational needs. Preparing reports on crop damage caused by disasters like flood, cyclone, flash flood, drought etc.

1.3.4 Functions of Analytical Services Wing

Planning and implementation of annual programme through central laboratory, divisional laboratories and regional laboratories. Coordinating and supervising the activities of all laboratories. Managing support services including instrument maintenance and supply of chemicals, glassware etc. Planning and execution and coordination of Mobile Soil Testing Laboratory (MSTL) programme. Fulfilling research needs of SRDI and other research organizations through central and other laboratories. Assisting Director General on various technical and administrative issues.

1.3.4.1 Function of Central Laboratory

Central laboratory of SRDI has been mandated to perform multiple functions under soil chemistry, soil physics and clay mineralogy and soil microbiology section. The activities performed by soil chemistry section includes, quality control of analytical work of different Laboratories of SRDI; quality testing of imported fertilizers, registration of new fertilizer brand, renewal of fertilizer registration; analysis of plant and water samples received from different organizations; helping DAE through analyzing fertilizer samples in order to control adulteration of fertilizers and conducting research on contemporary soil and environmental issues. Soil physics and clay mineralogy section has performed determination of physical characteristics of Barind Tract soils that undergone natural soil degradation process named ferro lysis. Soil microbiology section has launched a programme to conduct benchmark study on microbial population under different agroecological regions of Bangladesh. Under the assistance of PARTNER project SRDI is going to establish a modern microbiological laboratory under the umbrella of central laboratory.

1.3.4.2 Functions of Divisional Laboratory

Implementation of annual targeted programme under the guidance and supervision of Analytical Services Wing. Analyses of soil, water and plant samples to evaluate soil fertility, diagnosis of salinity, acidity, nutrient mining for the purpose of providing services and research supports. Analysis of fertilizer sample for the purpose of quality control. Distributing Fertilizer Recommendation Cards (FRC) among farmers on the basis of soil test results. Managing soil testing and fertilizer recommendation services by both static and Mobile Soil Testing Laboratory (MSTL). Coordinating functions of regional laboratories and Mobile Soil Testing Laboratory (MSTL). Generating chemical data for updating Upazila Nirdeshika. Providing research supports to research organizations and educational institutions. Conducting training programme for farmers, entrepreneurs, fertilizer dealers, NGOs field workers.

1.3.4.3 Functions of Regional Laboratory

Analyses of soil samples and providing fertilizer recommendation cards among farmers. Soil analytical services are also given to different organizations like, DAE, NARS organizations and educational institutions. Assisting divisional laboratory for achieving annual target. Participate in execution of Mobile Soil Testing Laboratory programme. Supporting regional offices of SRDI through soil and water analysis. Conducting training programme for farmers, entrepreneurs, fertilizer dealers, NGOs field workers.

1.3.5 Research Centers

1.3.5.1 Soil Conservation and Watershed Management Center (SCWMC):

Soil Conservation and Watershed Management Center is located at Meghla, Bandarban. SCWMC is responsible for generating technology on soil conservation and watershed management in sloping lands of Hilly areas through conducting research in hill area. Organizing training programmes for SAAOs, farmers and NGOs field workers for technology dissemination. Providing support to university students fulfilling their academic needs.

1.3.5.2 Salinity Management and Research Center (SMRC):

Salinity Management and Research Center is located at Batiaghata, Khulna. SMRC is responsible for generating database on soil and water salinity, identifying potential sources of irrigation water, screening of soil tolerant varieties of different crops, innovation and validation of saline soil and water management technologies. Conducting training of SAAOs, farmers and NGOs field workers for technology dissemination. Supporting research organizations and educational institutions fulfilling their research needs.

Chapter 2. Activities of Different Sections of Head Quarters

2.1 Soil Survey and Management Division

Soil Survey and Land Management Division consists of 3 (three) sections viz Soil survey and classification section, Land use planning section, Land evaluation and correlation section. The core function of the Soil Survey and Land Management Division is to plan, coordinate and supervise all technical programmes and activities of the component sections.

2.1.1 Soil Survey and Classification Section

Piloting of block level detailed soil survey for preparation sustainable soil management hand book

Objectives:

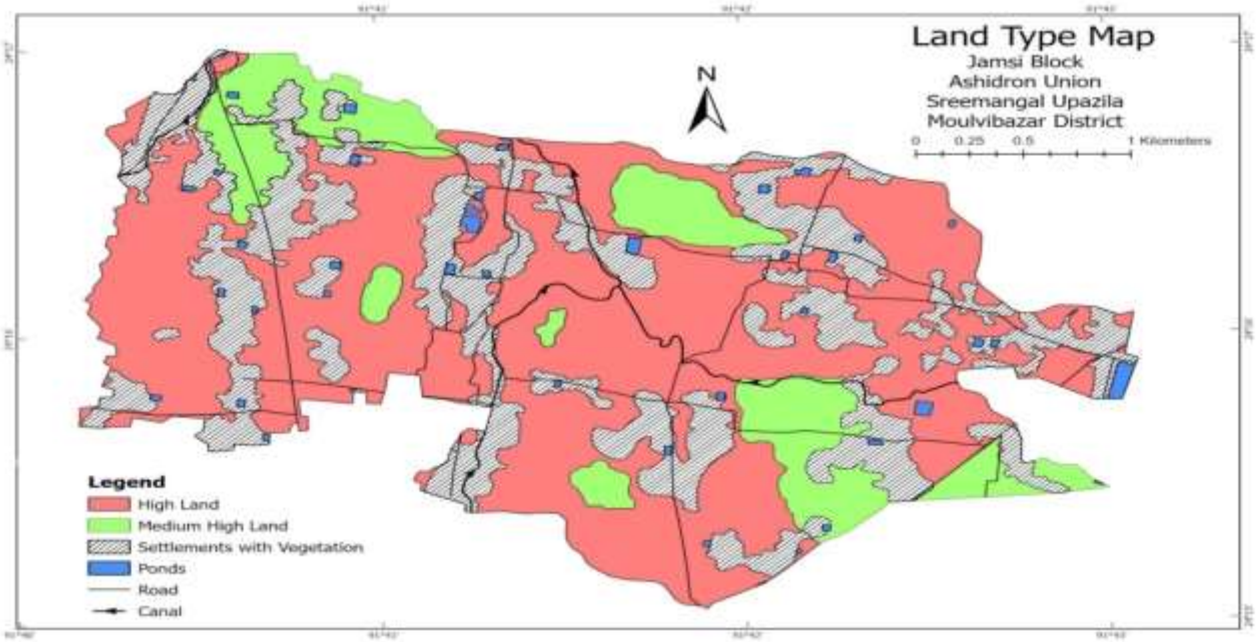
1. Preparation of Block level soil, land and crop related data base for resource-based bottom-up planning
2. Fertility assessment for sustainable soil management
3. Providing Fertilizer Recommendation System through online and offline
4. Preparation of sustainable soil management handbook for grass root level agricultural extension workers (SAAOs)
5. Evaluating affectivity of handbook for further extension of piloting programme

Methodology:

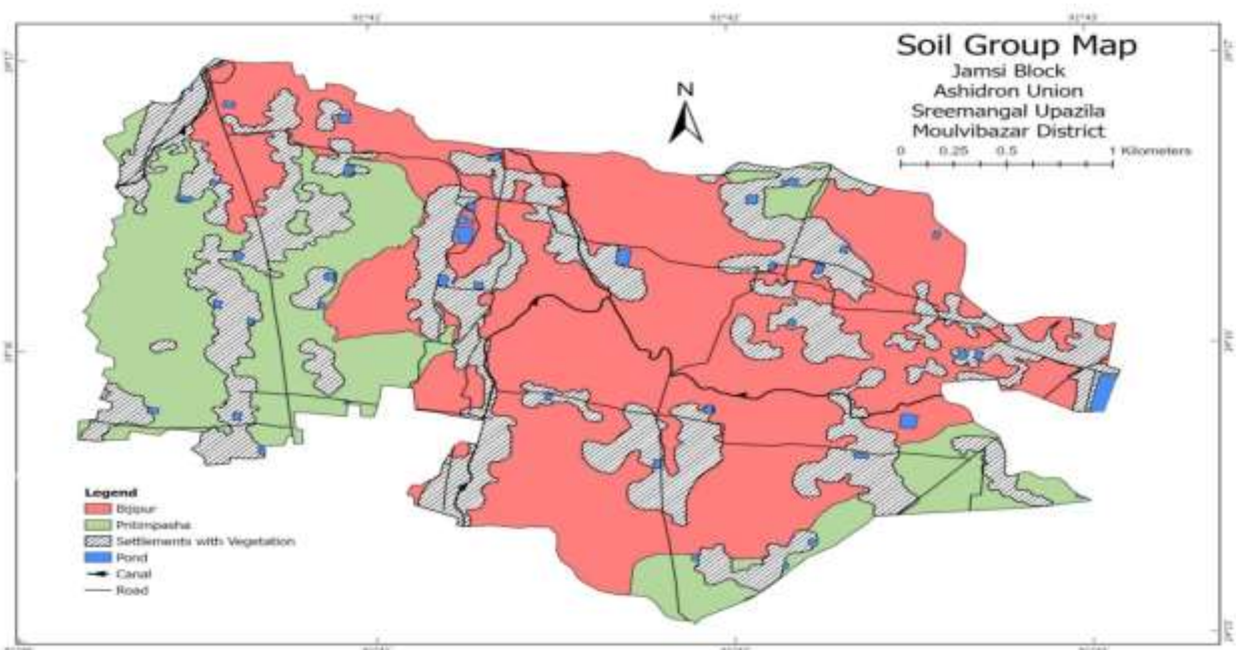
1. 16 blocks were selected within six Divisions, 16 Districts especially intensively cultivated from different agro ecological regions of the country. Blocks were selected keeping in mind their cropping intensity, crop diversification and land use potentials.
2. The detailed soil survey was conducted following soil survey manual.

Block details

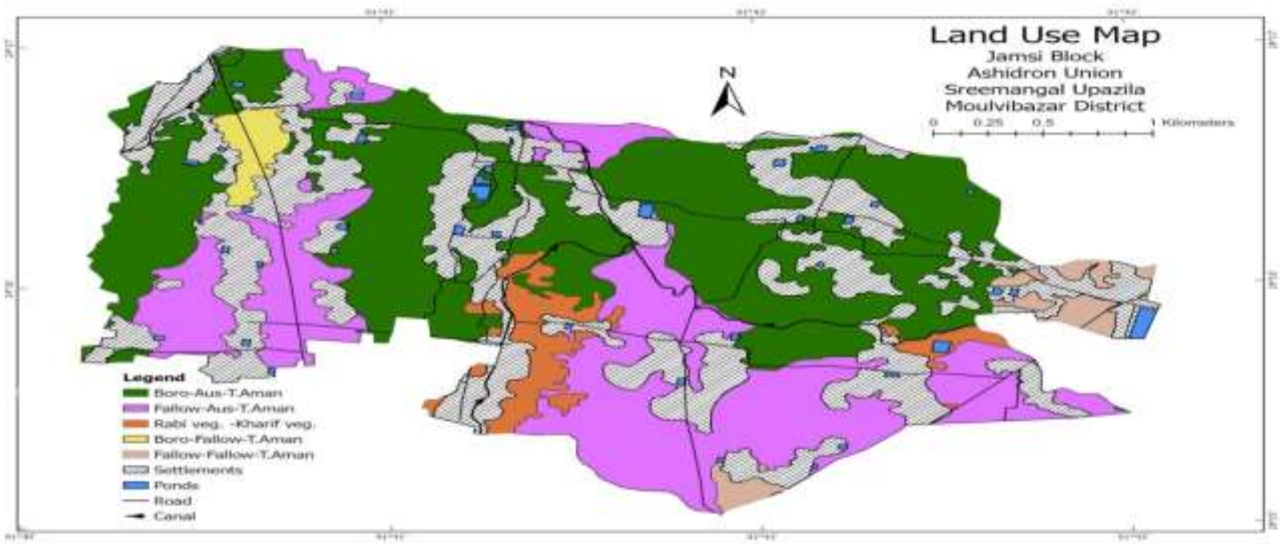
Name of Block :Jamsi
Union-Ashidron
Upazila: Sreemangal
District : Moulvibazar
Mouzas: Six (Jamsi, Paik Para, Parertong, Shaitala, Shankar Sena, Khalilpur (Part)



SL	LAND TYPE	AREA(Ha)
	High Land	564
	Medium High Land	139
	Miscellaneous (Settlements with Vegetation, pond etc.)	295
	Total	**998**



SL	SOIL Series	AREA(Ha)
	Bijipur (sandy loam)	487
	Pritimpasha (clay loam)	216
	Miscellaneous (Settlements with Vegetation, pond etc.)	295
	Total	**998**



SL	LAND USE	AREA (Ha)
	Boro-T.Aus-T.Aman	374
	F-T.Aus-T.Aman	254
	Rabi Veg.-Kharif Veg.	40
	Boro-Fallow-T.Aman	14
	F-F-T.Aman	21
	Miscellaneous (Settlements with Vegetation, pond etc.)	295
	Total	**998**

Block survey activities with the presence of higher officials of MoA, SRDI, DAE

Survey of functional Sugar mills for fertility evaluation for improved soil management

Objectives:

1. To know soil fertility status for STB fertilizer recommendation
2. To find out better land use for farms of sugar mills
3. To evaluate fertilizer wastage and suggesting measures for improving fertilizer use efficiency.
4. To recommend necessary measures for sustainable soil management

Methodology:

1. The farms of functional sugar mills were surveyed. Parameters considered-

-Land type
-Soil series
-Land use or cropping pattern
-Major constraints for crop production

2. Composite soil samples were collected

Progress:

Survey completed four out of nine functional sugar mills

Sl. No.	Name of the sugar mill	Samples collected	Comments
1.	Keru and Company , Dorshana	71	Soil analyzed and FRC & distributed
2.	Joypurhat sugar mill	4	Do
3.	Northbengal sugar mill, Natore	53	Do
4.	Thakurgaon sugar mill	34	Do

Findings of sugar mill survey

1. Excessive chemical fertilizers were used in some of the farms in sugar mills
2. The fertility status of all the farms of sugar mills varied considerably but they used almost same dose of fertilizers
3. Soils of Thakurgaon sugar mill were highly acidic that required liming. But liming was not practiced.
4. Sugarcane grown under conventional soil management. No sustainable soil management practice followed even in light textured soil (sandy loam)
5. There is huge scope for conservation tillage, improved soil management including inter cropping in sugar mill farms
6. Keru and Company has huge scope of using organic fertilizer of their own produce but they don’t use this, and recommendation had been made for using organic fertilizers (Press mud)

7. Press mud had also been collected and analysed in the laboratories to know its quality and results were satisfactory

Survey for conducting soil microbiological study on major soil series of different AEZs of Bangladesh

Objectives:
1.Providing benchmark data on soil specific microbial population and diversity that is required for sustainable soil management.
2.To know the variation in microbial population among soils of different AEZ used under more and less intense cropping.
3.To know microbial constraints in problem soils for improved management.
4. To evaluate soil health conditions of ecologically fragile hot spot areas.

Methodology:
1.The normal/same methodology for collecting soil samples was followed
2. Special care was taken
 -Areas of intensive cropping
 -Problem soils
 -Soils of hot spots (ecologically fragile hot spots)
3. Soils collected for microbial analysis were stored and carried in portable refrigerator

Progress:
1. 63 soil samples were collected from 28 AEZs out of 30.
2. AEZs could not be covered
 a) AEZ 24:St. Martins coral Island &
 b) AEZ 30:Akhaura Terrace
3. Collected samples have been sent to BSMRAU & BARI for microbiological study

Project Proposal Portfolio for Green Climate Fund

Project title	**Climate Smart Sustainable Soil Carbon Management Initiatives for Enhancing Carbon Sequestration, Soil Health and Food Security in Bangladesh.**

<table>
<tr><td rowspan="2">Thematic Sector (GCF)</td><td>Energy</td><td>Transport</td><td>Cities/Industries</td><td colspan="2">Forest/√land use</td></tr>
<tr><td>Health/√Food/Water</td><td>Livelihood</td><td>Built environment</td><td colspan="2">Eco-system services</td></tr>
<tr><td>Risk Area/ Districts</td><td colspan="5">Crop land of entire Bangladesh</td></tr>
<tr><td>AE and IE partner</td><td>AE</td><td>PKSF</td><td>IE</td><td colspan="2">SRDI</td></tr>
<tr><td rowspan="2">Executing Entity/ public/private</td><td>Lead</td><td>SRDI</td><td>support</td><td colspan="2">DAE, DoE</td></tr>
<tr><td>Others</td><td colspan="4">-</td></tr>
<tr><td>Cost of Project 120 (million USD)</td><td>GCF/ √grant</td><td>USD 100 million as GCF grant</td><td>Other/ loan</td><td colspan="2">USD 20 million as co financing</td></tr>
<tr><td>Implementation period</td><td colspan="2">Short / √Medium term</td><td colspan="3">5year (2023-2028)</td></tr>
<tr><td>Present Status</td><td>Pre-feasibility</td><td>√</td><td>Environmental assessment</td><td></td><td>Social Assessment</td></tr>
</table>

Rational and Linkage

1. Indiscriminate use of chemical fertilizer leads to global warming.
2. Excessive use of N- fertilizers in agriculture is contributing to N_2O emissions and NO_3 contamination of ground water.
3. Leftover nitrogen reacts with the soil to produce N_2O and contribute to soil acidification
4. Improper storage and disposal of organic manures causes global warming.
5. National economic loss through subsidy.
6. Affects soil fertility and its resilience for sustainable crop production and threatening food security
7. This intervention is directly linked with SDG, 8th five-year plan, NAP, and GCF trust areas.

Activities

1. Balanced fertilizer application based on prior soil testing through adaptive trial.
2. Strengthening mobile soil testing laboratory (MSTL) with modern sensor-based equipment.
3. Establishing adaptive trials on sustainable soil management and Good Agricultural Practices
4. Enhancing carbon sequestration through organic amendments with the emphasis of application of biochar in degraded light textured soils of Barind tract and piedmont areas
5. Sustainable management of peat soil to minimize emissions in Gopalgonj-Khulna Peat Basin areas
6. Establishment of Barind Soil Management Centre and Peat Soil Management Centre and
7. Human Resource Development and Capacity Building on sustainable soil health, soil organic matter and fertilizer management.

Expected outcome

1. Building up carbon (C) stock
2. Sustainable improvement of soil health
3. Minimize national economic loss and thereby ensuring sustainable environment and food security as well as better livelihood of the marginal and poor farmers and
4. Ensuring potential contribution in reducing carbon emission and global warming.

Miscellaneous Work

1. Active participation in preparing of Project Concept Note entitled CREATE by FAO for GCF
2. Comprehensive Reports prepared on the Agriculture Innovation Mission (AIM) for Climate change and submitted to Ministry of Agriculture.
3. Preparation and Submission of Progress Report on Implementation of Prime Minister's Guidelines
4. Compilation and Submission of Monthly Progress Report
5. Preparation Reports on question answer of Honorable Agriculture Minister for the meeting of National Parliament
6. Activities on "Grievance Redress System (GRS)'
7. Updating Gradation of Cadre Officers

2.1.2 Land Use Planning Section

1. **Responsibilities**
   1. Land Use Planning Section is responsible for planning, supervision and execution of soil survey interpretation activities for various beneficiaries engaged in agricultural development.
   2. Generating basic data on soils, land capability and crop suitability for preparation of short and long term agricultural development plans/projects.
   3. Interpretation of soil database for location specific crop suitability assessment and processing of soil survey data for developing and updating GIS based data bank.

2. **Achievements (2022-23) are shown under following heads**
   - Soil Survey related activities (Conducting Field Survey for Updating Upazila Nirdeshika)

- Annual Performance agreement (APA) related activities
- National Integrity strategy (NIS) related activities
- E-governance and Innovation related activities
- National Social Security Strategy
- Other Technical Activities done in 2022-2023
- Other Activities

3. Soil Survey related activities (Conducting Field Survey for Updating Upazila Nirdeshika):

- Semi-detailed soil survey program was conducted at Laksham upazila, Cumilla, and participated in soil survey program at Paba upazila, Rajshahi
- Areial photographs, topographic maps, existing upazila soil and landform maps as well as DLR map have been used as base materials. During the updating soil survey program, changes of land type, land use, land cover, settlements, water bodies, roads, water recession, drainage class, soil and land degradation and GPS reading of sampling points have been recorded.
- Composite soil samples were collected with GPS reading to compare the changes of nutrient status due to intensive cultivation of modern varieties of different crops with imbalanced application of chemical fertilizers and climate changes.

4. Annual Performance agreement (APA) activities:

Annual Performance Agreement provides a summary of the most important results that a ministry/division expects to achieve during the financial year. This document contains not only the agreed objectives, but also performance indicators and targets to measure progress in implementing them.

Stages of Annual Performance Agreement (APA):

1. Preparation
2. Work plan for action
3. Signing
4. Implementation
5. Monitoring
6. Reporting
7. Evaluation

Basis of Annual Performance Agreement (APA):

1. Allocation of business
2. 8th five year plan
3. SDG
4. Mid-term budgetary framework (MBF)
5. Election manifesto
6. Delta plan

Framework of Annual Performance Agreement (APA):

In order to facilitate the formulation of APA, a policy is formulated and software (APAMS) is prepared in the light of the policy. According to the policy the overall performance, preface, sections and attachments are mentioned below-

Section-1: Ministry/Division’s Vision, Mission, Strategic Objectives and Functions.

Section-2: Final output/impact of different APA activities.
Section-3: Strategic Objectives, Priorities, Activities, Performance Indicators and Targets.
Annex-1: Abbreviation.
Annex-2: Description of Performance Indicators, Implementing Departments/Agencies and Measurement Methodology.
Annex-3: Dependence on other ministry /division's for achievement of APA target.

Major achievement (APA) of SRDI in 2022-23
fiscal year:

1. Field Survey for Updating Upazila Nirdeshika: 50 Upazila.
2. Preparation of union sahayika: 168 unions.
3. Soil sample analysis in static laboratory: 23,603 samples.
4. Fertilizer sample analysis: 5,871 samples.
5. Soil sample analysis through MSTL: 5,600 samples.
6. Soil and water sample analysis for salinity monitoring: 1280 samples.
7. Field trial establishment: 42
8. Online fertilizer recommendation system data updating: 50
9. Training on soil sample collection technique and fertilizer application: 7888
10. Distribution of Fertilizer Recommendation Card: 28,806

Annual Performance Agreement 2022-23 of SRDI was signed between Director General of SRDI and secretary, Ministry of Agriculture. Annual Performance Agreements are placed on the websites of SRDI.

Four (4) quarterly, one (1) half yearly Monitoring Progress report and final draft of Annual Performance Agreements for 2022-23 are submitted to Cabinet Division and Ministry of Agriculture. Appropriate evidence has been submitted against all performance indicators.

Draft APAs are reviewed by the Technical Committee (TC) headed by the Secretary (Coordination and Reforms), Cabinet Division. After the review by the TC. Cabinet Division provides feedback to the Ministries/ Divisions concerned. APAs are finalized by the Ministries/ Divisions incorporating suggestions given by the TC and sent back to the Cabinet Division. APAs are sent for approval of the National Committee on Government Performance (NCGP)

Actual achievements against performance targets are monitored by the Budget Management Committee (BMC) on a quarterly basis. BMC provides necessary guidance to ensure achievement of the targets.

At the end of the year, all Ministries/Divisions review and prepare a Performance Evaluation Report listing the achievements against the agreed results in the prescribed format. This report was finalized by June, 2023.

5. National Integrity Strategy (NIS) Activities:

The government of Bangladesh has taken the challenge of combatting corruption seriously as part of its election pledge implementation. Through a process of wide-ranging stakeholder consultations, the Government approved the National Integrity Strategy (NIS) October 2012. NIS has a in comprehensive set of goals, strategies and action plans aimed at increasing the level of independence, accountability, efficiency, transparency and effectiveness of the state and non state institutions to improve governance and reduce corruption in a holistic manner.

Standard Operational Procedures (SOPs) of Ethics Committee, formulated by Cabinet Division in January 2015 indicates, an implementation cycle of NIS is expected to be established consisting of the steps such as: adequate planning, proper implementation of the plan, regular monitoring of the progress, effective countermeasures to the issues identified by monitoring, and revision of the plan.

Monitoring is conducted to measure progress of activities listed in the NIS work plan. The Integrity Focal Point of SRDI collected necessary information and filled out the monitoring sheet on regular basis. He placed the progress in the Ethics Committee meeting. The Ethics Committee members checked the gap between the plan and actual progress and took necessary decision. As part of effective follow-up, progress of NIS implementation and the monitoring results was discussed in the coordination meeting.
Four (4) Quarterly Monitoring Progress report of NIS 2022-23 submitted to MoA. Supporting documents such as report, letter, statement, photo, video etc. were preserved and submitted together with the monitoring sheet wherever possible.
Attended the meeting & training at MoA regularly as focal point of SRDI NIS Committee.

6. E-governance and Innovation related activities:
Government innovation is a broad term that includes the overall process of initiating new steps, changing existing conditions, and accelerating the development orientation of the government. It can be defined as the effort by a government to find an optimal solution to problems it faces by undergoing a change within itself. Government innovation is a multifaceted process that depends on both internal (organizational culture) and external factors (stakeholder interests).
Monitoring is conducted to measure progress of activities listed in the E-governance and innovation workplan.
Annual Progress report of E-governance and innovation workplan 2022-23 was submitted to MoA. Supporting documents such as report, letter, statement, photo, video etc. were preserved and submitted together with the monitoring sheet wherever possible.

7. National Social Security Strategy:
NSSS was approved in 2015 to tackle triple problems of poverty, vulnerability and marginalization. It is a roadmap for creating a lifecycle based comprehensive social protection system in Bangladesh. The role of Ministry of Agriculture is to Strengthen and consolidate programmes for assisting food availability and nutrition.

#Monthly reports on National Social Security Strategy action plan were submitted by SRDI to MoA. Though we have no National Social Security program in SRDI but SRDI has been playing a role on social security by arranging different farmer’s training which is contributing to the increase in food production in the agricultural sector.

8. Other Technical Activities done in 2022-2023:
Draft map prepared for two Upazilas named Laksham & Paba.

Prepared Land Cover Map (Settlement & River Course Delineation) for Laksham Upazila using ArcGIS.

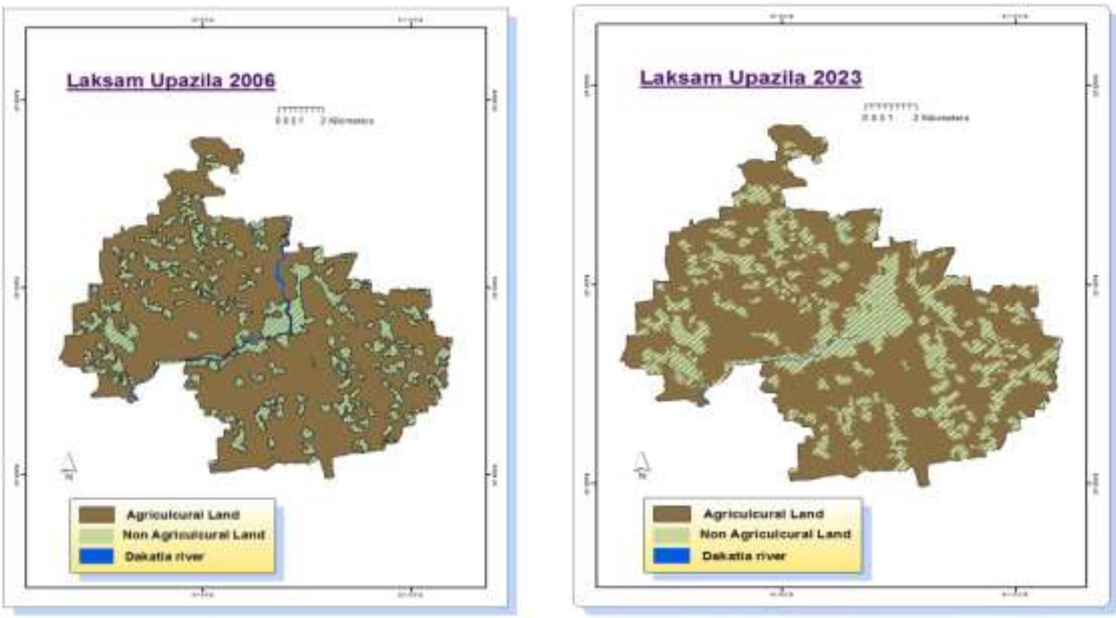


Figure: Total settlement area increased substantially.

Studied land use change pattern in Laksham & Paba Upazila.
Collected Climate Data from Bangladesh Meteorological Department for further studies.
Collected Soil & Water salinity monitoring data from 30 different sites.

9. Other activities:
Work plan prepared for Smart Bangladesh.

Figure: BRRI visit under E-Governance and Innovation workplan.

Figure: Participation in Paba Upazila survey

2.1.3 Land Evaluation and Soil Correlation Section

1. Function of Land Evaluation & Soil Correlation Section

1) Planning, supervision & execution of soil series & other taxonomic units.
2) Maintenance of uniform standard of methodology on soil survey works & keeping records of soil information.
3) Correlation of soil surveys done by other agencies/consultancy.
4) Development & maintenance of the soil museum.

2. Soil Information

1) 15 Physiography
2) 476 Soil Series (453 Soil series and 23 different river alluvium)
3) 50 Soil Monoliths (48 SRDI & 2 BARC)

4) 1178 Correlation Box
5) Recently collected 7 Soil Monoliths

3. Achievements

3.1 Execution of different activities in Soil Museum

- Processing and preservation of soil monoliths.
- Technical description and labeling
- Display collected soil monoliths in Soil Museum
- Processing and preservation of soil correlation boxes.
- Display correlation boxes in the Museum
- Welcome visitors and help them in seeing and learning about the displayed materials in the museum.

3.2 Virtual Soil Museum

- Assistance was given to the Strengthening of Soil Research and Research Facilities Project for building a Virtual Soil Museum.

3.3 Upazila Land and Soil Resource Utilization Guide updating (semi detailed) survey

Sl	Upazila & district	Assigned Officer	Role of section	Date
1.	Trishal, Mymensingh	Premangshu Majumder, SO	Surveyor	Dec, 2022
2.	Belabo, Narsingdi	Ameer Md. Zahid, PSO	Monitoring	Jan, 2023
3.	Sonargaon, Narayanganj	Ameer Md. Zahid, PSO	Monitoring	Dec, 2022

3.4 Purpose-oriented Survey (identification of arsenic pollution)

Sl	Upazila & district	Assigned Officer	Role of section	Date
1.	Singair Manikganj	Ameer Md. Zahid, PSO Md. Mamunur Rahman, PSO	Survey plan, stakeholders' interview, field investigation, collection of soil, water and vegetable crop (sp. carrot) samples, and sending them to laboratory for arsenic analysis	March, 2023

3.5 Project / Program Implementation

Sl	Title	Assigned Officer	Role	Period
1.	Establishing National Land Use and Land Degradation Profile toward Mainstreaming SLM Practices in Sector Policies [ENALULDEP/ SLM] Project	Ameer Md. Zahid, PSO	Focal Person	Since October 2018
2.	Soil Research & Strengthening Research Facilitation Project (SRSRF Project)	Premangshu Majumder, SO	M&E Officer	Since 31-12-2022

3.6 Project / Program Plans Preparation

Sl	Title	Year	Contribution
1.	পাহাড়ী এলাকায় টেকসই মৃত্তিকা ও ভূমি ব্যবস্থাপনার প্রযুক্তি প্রয়োগ এবং মৃত্তিকা গুণাগুণের ভিত্তিতে শস্য উপযোগিতা নিরূপণ। প্রস্তাবিত (2022-2025)	2022-23	Assistance in project building.

3.7 Book/Technical Report/Evaluation Report preparation:

Sl	Title	Year of Publication	Publisher	Contribution
1.	Soil Atlas of Asia	2023	European Commission, JRC and FAO.	Contributing author (Ameer Md. Zahid, PSO)
2.	Land degradation in Bangladesh 2020	December 2022 (extended edition)	SRDI & DoE	Author (Ameer Md. Zahid)
3.	Project Completion Report (PCR) on Land Degradation in Bangladesh 2020	2023 Submitted to DoE/UNEP/GEF.	SRDI	Reporter (Ameer Md. Zahid, PSO)
4.	SRDI's Brochure	2022	SRDI	Author (Both PSO and SO)

3.8 Workshop Presentation/Seminar & Newspaper Article

Sl.	Subject line	Responsibility	Organizer/ Newspaper	Reporter/ Venue	Date
1.	Workshop on Bangladesh Delta Plan 2100	PPT Presentation delivery on Bangladesh Delta Plan 2100	SRDI	Divisional Office, SRDI, Dhaka	08-Feb-2023
2	National workshop on Sustainable Development Goals (SDGs) of SRDI	Delivered PPT presentation SDGs workshop arranged by the authority.	SRDI	SRDI, HQ, Dhaka	13-Jun-2023
2.	উর্বরতা ঘাটতিতে দেশের ৭৫ শতাংশ ভূমি	Interview, information share	বণিক বার্তা	Shahadat Biplob	4-Oct-2022

3.9 Training received

Sl	Title	Organized by	Location	Date
1.	Capacity strengthening on green climate fund (GCF) climate finance proposal development (3-day)	ERD and FAO	Cox's Bazar	7-10 Oct, 2022

3.10 Training imparted

Sl	Title	Organized by	Location	Date
1.	One-day training on balanced fertilizer application and soil sample collection (MSTL)	Divisional Office, SRDI, Dhaka	Dhamrai, Manikganj	03-11-2021
2.	5-day training program for SAAOs on Upazila Nirdeshika Use	Divisional Office, SRDI, Dhaka	ATI, Araihazar	17-11-2022
3.	5-day training program for SAAOs on Upazila Nirdeshika Use	Regional Office, Tangail	Tangail	27-01-2023

3.11 Demonstration Trial

Sl	Title	Organized by	Location	Date
1.	Crop harvest and Field Day in demonstration trail plot	Divisional Office, SRDI, Dhaka	Bhatara, Baliati, Saturia, Manikganj	10-Nov-2022

3.12 Production of videos for mass people awareness

Acted as SRDI focal person for script writing and video preparation for mass people awareness: one on Acidic Soil management in Barind region at Godagari, Rajshahi and the other one on Saline Soil Management in Batiaghata Upazila, Khulna in coordination with FAO-BARC and SRDI regional offices of the respective areas.

3.13 Rendered Services in Different Committees

Sl	Work / Task / Program of action	Responsibility	Date
1.	**SDGs related activities** Arranged meetings, stakeholders' meetings, workshops, delivered lectures in training classes, attended meetings arranged by MoA and other allied departments.	Focal point officer (PSO)	Since 17-Oct-2021
2.	**Citizen's Charter related activities** Played role in implementing for and updating and monitoring of Citizen's Charter of the institute. Arranged quarterly meetings, stakeholders' meetings, learning sessions, monitoring activities, and reporting to the ministry of agriculture and attended meetings arranged by MoA and other allied departments.	Member (SO)	Since 17-Oct-2021 Since 01-Jun-2021

Sl	Work / Task / Program of action	Responsibility	Date
3.	**Activities of Planning Cell:** Played role in preparing of and guidance for projects/programs development, maintaining communication with MoA, Planning Commission, and other stakeholders. Arranged regular meetings of Planning Cell, reporting to the ministry of agriculture and informed the DG of the institute of updates in regular basis.	Convenor (PSO)	Since 30-04-2022
4.	"Climate Smart/Resilient Agriculture" concept note development for GCF	Focal Point (PSO)	Since 10-Apr-2022
5.	Implementation of United Nations Convention to Combat Desertification (UNCCD)	Focal Point (PSO)	20-Jul-2022
6.	Innovation committee	Member (SO)	Since 06-Jul-2021
7.	E-governance committee	Member (SO)	Since 18-Jul-2021
8.	Software management committee	Member (SO)	Since 01-Jun-2021

3.14 Workshop/seminar attended:

- Closing workshop of Meeting the Undernutrition Challenge (MUCH) Project implemented by FAO-GOB-USAID-EU at Pan Pacific Sonargaon (8-May-2023).

- Workshop on soil survey. SRDI, Dhaka, 26-Sep-2022.
- Final workshop on Development of the Soil Atlas of Asia and National Soil Information System arranged by AFACI-BARC-SRDI (August 31, 2023).

- Seminar on NUMAN (Nutrient Management for Diversified Cropping in Bangladesh Project (SRDI component). 12-01-2023

3.15 Meetings attended:

- Attended the meeting on "Establishing National Land Use and Land Degradation Profile toward Mainstreaming SLM Practices in Sector Policies. Honorable Secretary, Dr. Farhina Ahmed, Ministry of Environment, Forestry and Climate Change, presided over the meeting (November 1, 2022)

- Terminal Project Evaluation meeting along with UNEP project consultant and DoE personnel. At DoE, Agargaon on January 15, 2023

- Meeting of Technical Committee of SRDI. Oct 31, 2022.

3.16 Glimpses of the book on land degradation

The project-based research-driven book entitled “Land Degradation in Bangladesh 2020” was written by a team of Ameer Md. Zahid (Lead), Neelima Akter Kohinoor, Altaf Hossain, Dr. Md. Sohrab Ali and Jalal Uddin Md. Shoaib and published by SRDI (Extended edition December 2022), which was showcased in the World Soil Day 2022 Program.

Land degradation (LD) may be assessed by use of periodically determined fertility index data. Deviation from the normal or standard may serve as an assessment of land degradation or improvement. The extent to which LD affects agricultural productivity and poses a threat to food security is fundamentally influenced by economic, environmental, and institutional factors. Major LD processes are soil fertility decline, soil organic matter depletion, acidification, salinization, soil pollution, soil erosion, riverbank erosion, sandy overwash, drought, waterlogging, soil sealing and ecosystem degradation. Nationally LD of moderate to very severe classes has been taken place in 11.24 million ha (76.2%) area in 2020. The results have showed that each year around 27000 ha of land has been gone under degradation since 2000 to 2020. Fertility decline has been found in 75% of the country area. A detailed description of major LD types has been narrated in the book which may be a valuable source of information for taking decisions to make interventions for achieving LD neutrality in 2030. Some indicative solutions to fight against land degradation are also given for each land degradation type in the book.

4. Development need

The main problem of the section is its poor workforce. Practically only one technical person (PSO) is working in the section with four supporting staff. This should be immediately solved.

5. Future program

5.1 Study on parent materials of Barind Tract, Madhupur Tract, Akhaura Terrace and Lalmai Hills to correlate the soils.

Physiography	Soils
Lalmai Hills	Khadimnagar, Lalmai, Salban and Kotbari
Akhaura Terrace	Pattan, Nidarabad, Sibna, Simrail and Rupa
Barind Tract	Kashimpur, Belabo, Tejgaon, Amnura, Nijhuri, Lauta, Gulta
Madhupur Tract	Kashimpur, Belabo, Tejgaon, Noadda, Chandra and Kalma

5.2 Renovation of Soil Museum in the new building.

5.3 Facilitating a Virtual Soil Museum Corner in Soil Museum.

6. Activities in photography

1. Visitors are listening about Soil Museum displays. Oct 25, 2022

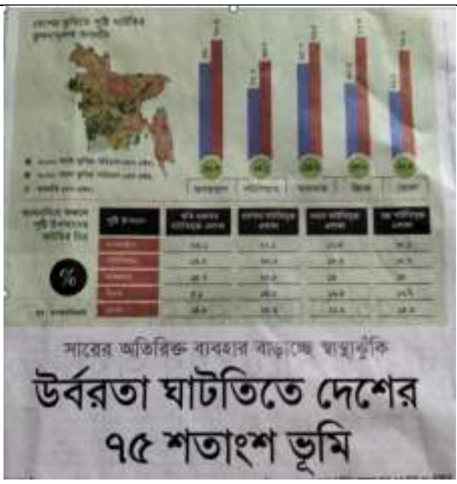
2. Workshop on SDGs. June 13, 2023.

3-4. Monitoring of Belabo Upazila semi-detailed survey. Jan 9, 2023

4. Sonatola soil series.

5. Monitoring of semi-detailed soil survey, Sonargaon Upazila. Dec 16, 2022

6. Arsenic pollution identification in soil, water, and fruits (sp. Carrots). Singair, Manikganj. Mar 10, 2023


সারের অতিরিক্ত ব্যবহার বাড়াচ্ছে স্বাস্থ্যঝুঁকি

উর্বরতা ঘাটতিতে দেশের ৭৫ শতাংশ ভূমি

7. News article in Banik Barta based on SRDI publication. Oct 4, 2022.


8. Meeting of Planning Cell. March 15, 2023.


9. Citizen's Charter Monitoring Team visit at GIS Unit, Sept 7, 2022


10. Stakeholders meeting for Bangladesh Delta Plan 2100. Divisional Office, SRDI, Dhaka. Feb 8, 2023

11. Unwrapping the book entitled “Land Degradation of Bangladesh 2020” on World Soil Day. In presence of honorable Agriculture Minister. Dec 5, 2022

12. Terminal project evaluation meeting at DoE, Jan 15, 2023

13. Field Day in demonstration trail plot. Bhatara, Saturia, Manikganj. Nov 10, 2022

14. Team of semi-detailed soil survey for Upazila Nirdeshika Updating. December 2022. Trishal

2.2 Training & Communication Division

The core function of the Training & Communication Division is the design and coordination of training interventions intended to enhance skill development of SRDI officials and staffs. This division also works on the development, integration, and implementation of a broad range of public affairs activities relative to the strategic direction and positioning of the organization. Training & Communication Division consists of 4 (four) sections viz. Human Resource Development Section, Cartography Section, Publication and Record Section and Data Processing & Statistical and Information & Communication Technologies (DPS & ICT) Section.

2.2.1 Human Resource Management section (HRD)

The functions of Human Resource Development Section are planning and execution of in-service training programme, organizing refresher courses in terms of short training programs for the technical officers and staffs wherever required, organizing training programs on use of soil information obtained through soil surveys for the technical officers and staffs of the beneficiary agencies like Department of Agriculture Extension (DAE), BARRI, BARC, etc. This section works on preparation and collection of training materials in terms of course syllabus such as audio-visual materials, soil monoliths, etc. HRD section also works on the arrangement of theoretical and practical training for the student of different education institutions (e.g., BAU, DU, BSMRAU, SAU, KU, CU etc.) Research Centers & Academies, GO & NGOs on soil survey, soil classification and aerial photo interpretation, GPS, Upazila nirdeshika as per their requirements and request. Arrangement of departmental training of newly recruited officers is another work of this section.

i) In-house Training Achievement-2022-23

Grade	No. of Officers & Staffs	Target		Achieved (up to june'23)	% of Achievement against target (up to june'23)
		Per person	Total		
10-12	8	30	240	240	100
13-17	65	30	1950	1950	100
18-20	63	30	1890	1890	100

ii) Higher Education

SI. No.	Degree	No. of Officers					Remarks
		On-going	**Obtained Scholarship**	**Received permission**	**Requested for permission**	**Completed**	
1	PhD	11*	-	03	04	3	*Joined-5 (But thesis not submitted) On going-6

iii) Workshop and Seminar attended by officers

Sl. No.	Topics	No.	Duration (Days)	Institute
1	Review progress on the implementation of the Sustainable Development Goals (SDGs).	1	1	Bangladesh Atomic Agriculture Research Institute
2	Seminar on Completion of Expanded Cotton Cultivation Scheme of Cotton Development Board	2	1	Cotton Development Board
3	Review progress on the implementation of the Sustainable Development Goals (SDGs).	1	1	Bangladesh Rice Research Institute
4	Transformative Statistics on Environment and Climate Change Statistics/Accounts Links to the International Context	1	1	Bangladesh Bureau of Statistics (BBS)
5	Workshop on what to do to meet the challenges of the 4th Industrial Revolution	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute, Dhaka
6	Workshop on Public Awareness on Right to Information Act and Regulations	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute, Dhaka
7	Workshop on Activities, Progress, Constraints and Prospects of National Agricultural Training Academy (NATA)	2	1	National Agricultural Training Academy (NATA)

	in Implementation of Sustainable Development Goals (SDGs)			
8	Action Plan for Smart Agriculture through 4IR Technology Seminar	2	1	National Agricultural Training Academy (NATA)
9	Establishment of National Spatial Data Infrastructure (NSDI) for Bangladesh	1	5	SoB
10	Workshop aimed at finalizing priority areas of research in different periods in crop sub- sectors	3	1	BARC
11	Geo-Spatial Data Integrating with Socio-Economic, and Environmental Data for Development Data for Developing web Application Seminer	1	1	Bangladesh Bureau of Statistics (BBS)
12	Workshop on Higher Education (PhD) Program under PIU-BARC, NATP-II	4	1	BARC
13	Seminar on Preparation of Large-Scale Topographical Maps of Dhaka City and Surrounding Areas Using Aerial Photography	1	1	Survey of Bangladesh (SoB)
14	Workshop on PIIS and CCM methodology under ACCNLDP-II, project	1	1	Planning Commission, Dhaka
15	Validation Workshop for Digitization of Services of Soil Resource Development Institute on myGov Platform	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute, Dhaka
16	Seminar on Online Fertilizer Recommendation System (OFRS) Update	16	1	Soil Resource Development Institute, Dhaka
17	Bangladesh Delta Plan 2100 Implementation Workshop	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute, Dhaka
18	Workshop on Soil Survey 2022-23	27	1	Soil Resource Development Institute, Dhaka
19	Workshop on Validation of Curriculum and Training Module Seminar	2	1	National Agricultural Training Academy (NATA)
20	Strategic Plan for GIS and Remote Sensing Application in Smart Farming Seminar	2	1	National Agricultural Training Academy (NATA)
21	Audit Management and Monitoring System-2.0 (AMMS-2.0) Seminar	3	1	Audit Complex, Dhaka.
22	Regional workshop on selection of priority areas for agricultural research	6	1	BARC
23	Workshop aimed at finalizing priority areas of research in different periods in crop sub-sectors	3	1	BARC
24	Workshop on Higher Education (PhD)Program under PIU-BARC,	4	1	-

	NATP-II			
25	Regional workshop on selection of priority areas for agricultural research	6	1	-
26	Climate Smart Agriculture Adaption	2	3	-
27	Workshop on Activities, Progress, Constraints and Prospects of National Agricultural Training Academy (NATA) in Implementation of Sustainable Development Goals (SDGs)	2	1	NATA
28	Action Plan for Smart Agriculture through 4IR Technology Seminar	2	1	-
29	Workshop on Validation of Curriculum and Training Module Seminar	2	1	-
30	Strategic Plan for GIS and Remote Sensing Application in Smart Farming Seminar	2	1	-

iv) Attended by officers in local Training programmes

SL	Title/Courses	No.	Duration (Days)	Institute
1	Project Appraisal and Formulation of DPP	1	10	
2	Eco Friendly Plant Protection Techniques	1	10	
3	Integrated Water Resource Management in Agriculture	1	5	
4	Disaster Management Through Climate Smart Agriculture	2	5	NATA
5	Innovation in Public Service	1	5	
6	Public Procurement Procedure	1	10	
7	Rules & Regulations for Organizational Management	1	5	
8	Soil Health Management	1	5	
9	Food Security & Food Safety	1	5	
10	Public Financial Management Training	2	5	
11	Project Appraisal And	1	11	
12	Modern Office Management	2	5	
13	Human Resource Management	2	5	
14	Modern Farm Mechanization	1	5	NATA
15	Industrial Revolution 4.0 in Agriculture	1	10	
16	Advanced ICT	1	15	
17	Public Financial Management	2	5	
18	Commercial Farm Management	1	5	NATA
19	GIS and Remote Sensing for Smart Agriculture	2	10	
20	English Language and Skill Development	1	10	
21	Workshop on Validation of Curriculum and Training Module	2	1	
22	Concept and practices of Integrated Water Resource Management	1	7	CEGIS
23	iBAS++	2	1	Audit Complex, Dhaka
24	Green House Gas inventory and MRV System	2	3	DOE

25	iBAS++ Payment and Expenditure	14	1	Public Finance Bangladesh
26	Half a Century of Rice Research at BRRI Ensuring Food Security in Bangladesh	2	1	
27	FRN Methods Focusing on Cs-137 and pb-210 for ErosionAssessment and Field Work for Designing the FRN Study	3	10	Bangladesh Atomic Energy Commission
28	Skill development training on implementation of use of D-Nothi	2	2	Department of Information and Communication Technology
29	Grievance redressal mechanism and training of officers on GRS software	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute,Dhaka
30	e-GP system Tenders Training for Procuring Entity (PE) Users Training	1	5	MOA
31	Citizen Charter	9th and above grade officers working in SRDI Dhaka	1	Soil Resource Development Institute, Dhaka
32	IoT Based Precision Agriculture for Sustainable production	1	2	
33	Technical Report Writing and Editing	2	3	
34	Training on Forestry and Agroforestry	1	2	
35	Excel Based Data Analysis for Early career Scientist	1	3	
36	Exploratory data analysis in agriculture Research with r Software	1	3	
37	Scientific Report Writing	2	5	
38	Integrated Digital Service Delivery platform	1	2	
39	Forestry and Agroforestry Technologies for Professionals	-	2	
40	Training course on bioinformatics for sustainable development in agriculture	1	4	
41	Climate Smart Agriculture for Adaptation	2	2	
42	Use of Fertilizer Recommendation Guide-2018	4	3	
43	Use of Fertilizer Inspection Manual	1	2	BARC
44	Contemporary Issues and Technologies in Forestry and Agroforestry for Professionals	2	2	
45	Standardization and Interoperability of Agro-Data Ecosystem for Smart Agriculture	1	3	
46	Awareness Building on AI and Policies of Bangladesh Agriculture	1	3	

v) Other Activities done by HRD Section

- Preparing DPP and all corresponding works of the projects submitted to MoA
- Website update and maintenance
- Successful implementation of D-Nothi Program
- APA & SDG Action Plan Activities
- Preparing different Reports, Booklets, Directory etc.
- Innovation activities of SRDI
- Execution of PM's commitment
- Procurement work of SRDI
- Organogram, recruitment rules, different cases etc.

vi) Workplan:2023-24

- Training for capacity building of officers and staff with relation to 4IR.
- GIS related Training for officers.
- Training will be arranged on advanced techniques of Laboratory analysis.
- Workshop/Training will be arranged according to Government policy/demand.
- Fundamental Training on newly appointed officers.
- Training on Nirdeshika writting and Map Preparation.
- Training on Capacity building of all officers.
- Training on Capacity Building of all Staff.

2.2.2 Activities of DPS & ICT Section

- Engaged in-Planning, organizing and execution of GIS related works
- Digitizing, preparation and printing of different types of thematic maps.
- DPSS is responsible for storage, maintenance and security of database on soil and land resources and other information's.

Major type of works done by DPS Section

1. GIS related
2. ICT related
3. Others

1. **GIS related**
   - Preparation of geo-referenced and geo-projected database
   - Map Preparation & Printing

2. **ICT related**
   Server & LAN management
   - Proper monitoring, maintenace and troubleshooting of the server and internet related devices (server, router, bandwidth controller, switch etc.) of SRDI.
   - At present there are 102 internet connections in SRDI head office.

Data Processing & Uploading

- Soil Chemical data are generalized, processed and prepared for uploading
- This uploaded data is used for Online Fertilizer Recommendation System (OFRS) software

3. **Others Technical Support**

a. Updating of Online fertilizer Recommendation Software (OFRS)

- Updating the crop list for OFRS along with fertilizer application methods following Fertilizer Recommendation Guide 2018.

b. Technical assistance for BBS

- Technical assistance and necessary support provided for sharing GIS meta data and developing the website (www.gis.gov.bd) for Bangladesh Geographical Information System Platform (BGISP) organized by BBS.

c. **UpazilaNirdeshika Survey**

- Chandina and shonargoan Upazila Nirdeshika updating survey has been done and draft soil map has been prepared.

d. Hardware maintenance and troubleshooting for different computer of SRDI head office.

e. Compilation of Nutrient data according to AEZ for Updating Fertilizer Recommendation Guide 2023.

f. Technical assistance and necessary support provided to prepared different on demand report for MoA, BARC and others.

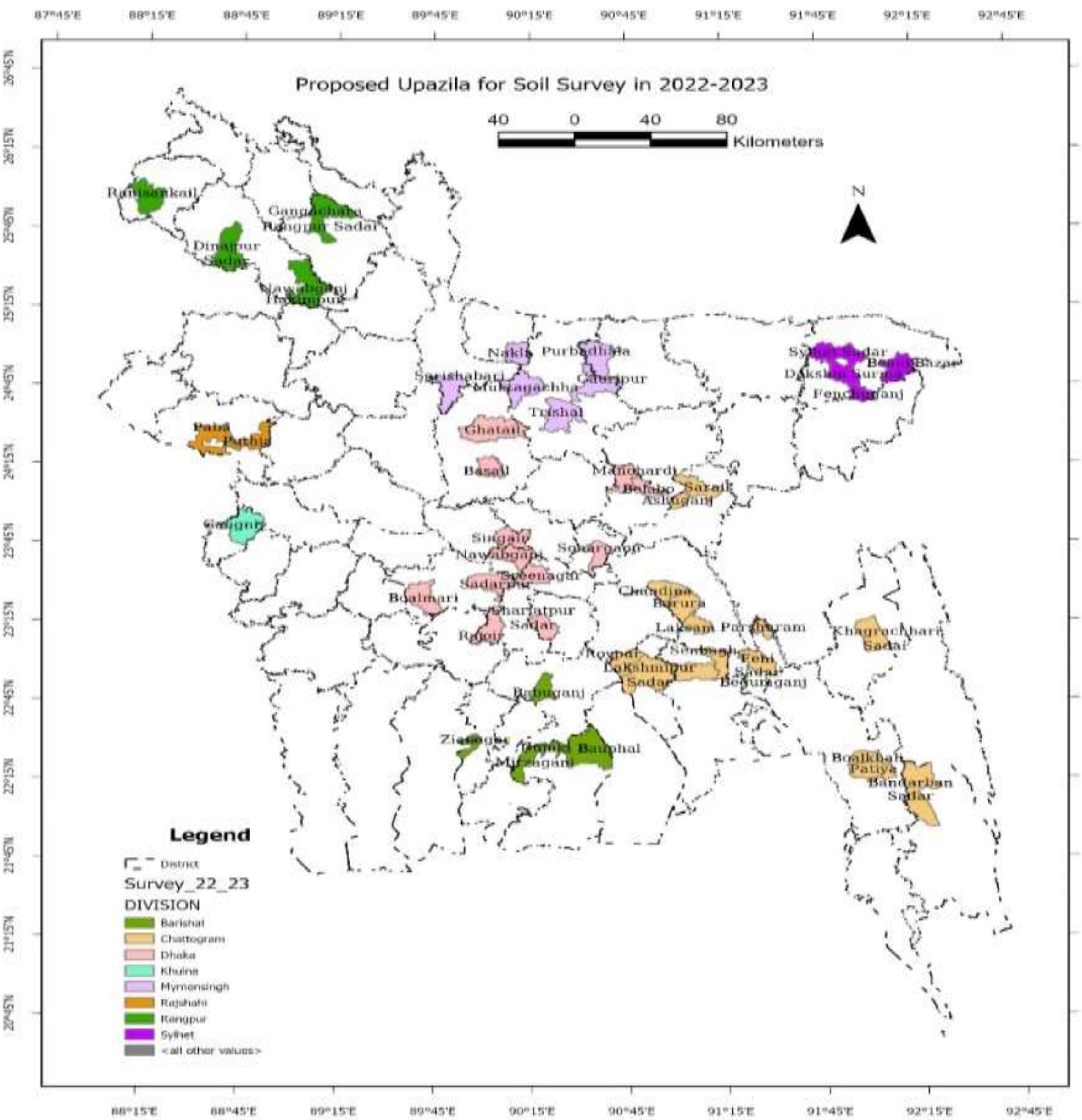
g. Involved in the innovation activities of SRDI.

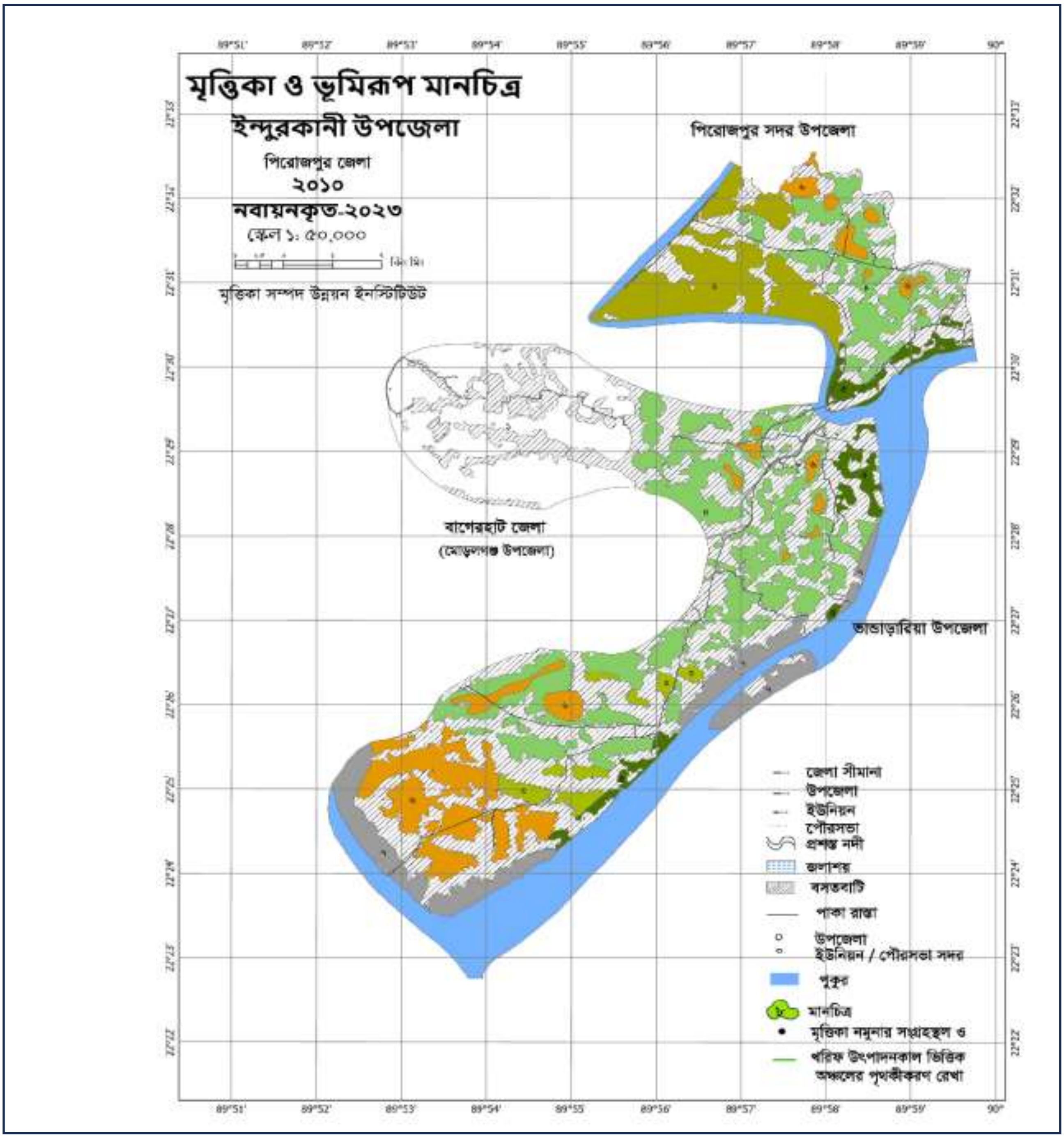
h. Technical assistance provided to the students, scientists other visitors for research purpose.

i. Programme implementation:

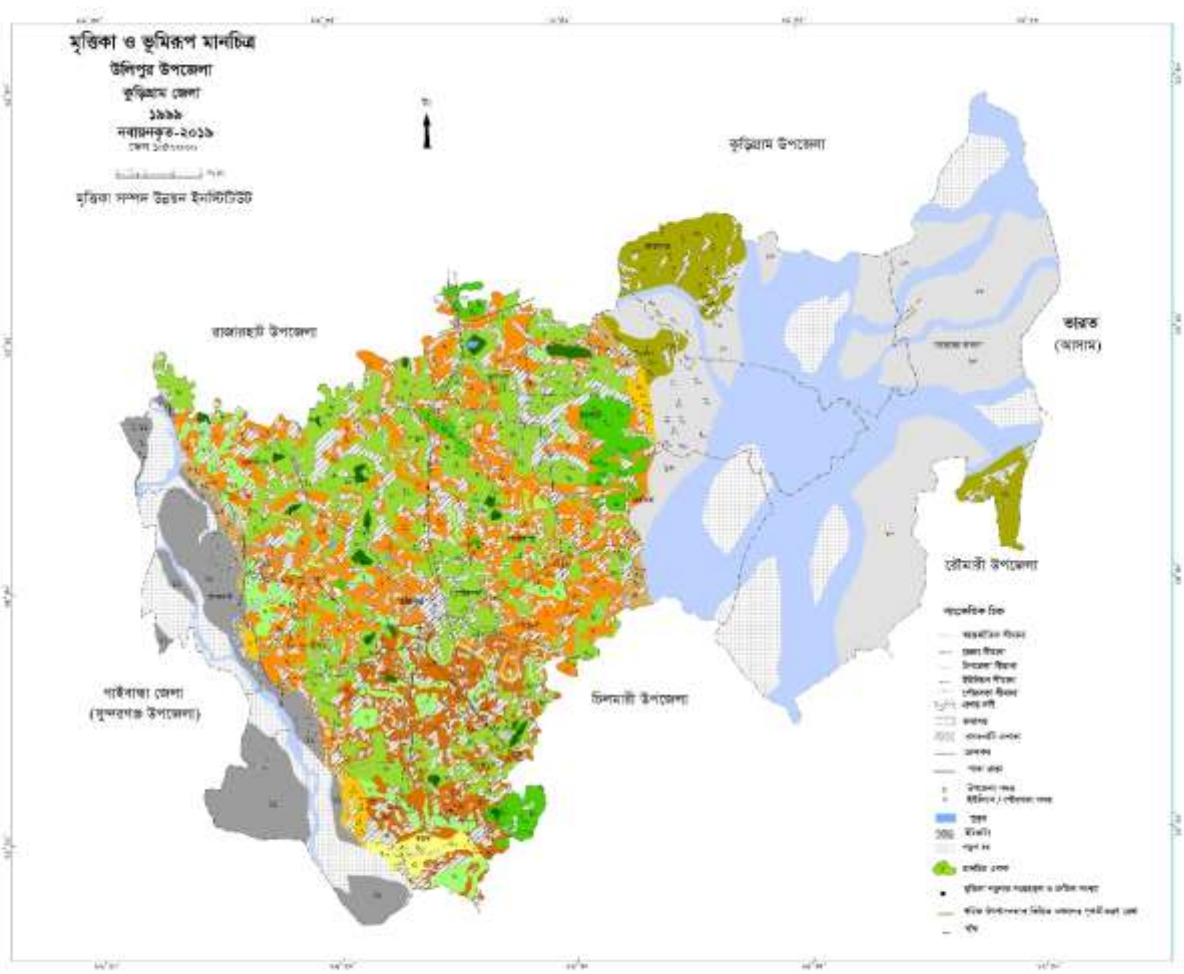
A promramme named “Assessment of Cultivated Land Area for Different Crops Using Remote Sensing and UpazilaNirdeshika”has been implementing with the help of DPS &ICT section.

Map Preparation & Printing





মৃত্তিকা ও ভূমিরূপ মানচিত্র
ইন্দুরকানী উপজেলা
পিরোজপুর জেলা
২০১০
নবায়নকৃত-২০২৩
স্কেল ১: ৫০,০০০
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
পিরোজপুর সদর উপজেলা
বাগেরহাট জেলা
(মোড়লগঞ্জ উপজেলা)
ভান্ডারিয়া উপজেলা
জেলা সীমানা
উপজেলা
ইউনিয়ন
পৌরসভা
প্রশস্ত নদী
জলাশয়
বসতবাটি
পাকা রাস্তা
উপজেলা
ইউনিয়ন / পৌরসভা সদর
পুকুর
মানচিত্র
মৃত্তিকা নমুনার সংগ্রহস্থল ও
খরিফ উৎপাদনকাল ভিত্তিক
অঞ্চলের পৃথকীকরণ রেখা


মৃত্তিকা ও ভূমিরূপ মানচিত্র
উলিপুর উপজেলা
কুড়িগ্রাম জেলা
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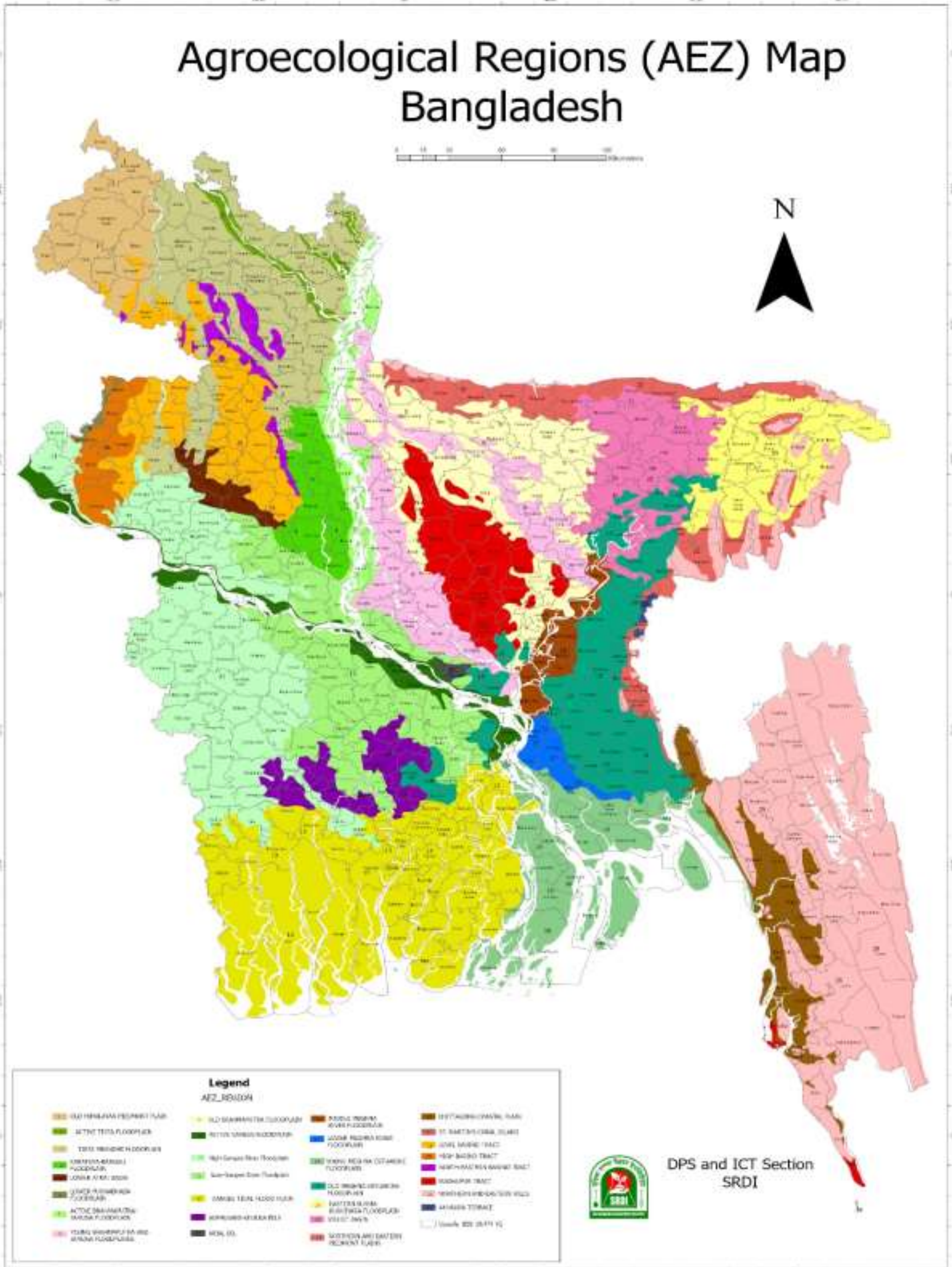
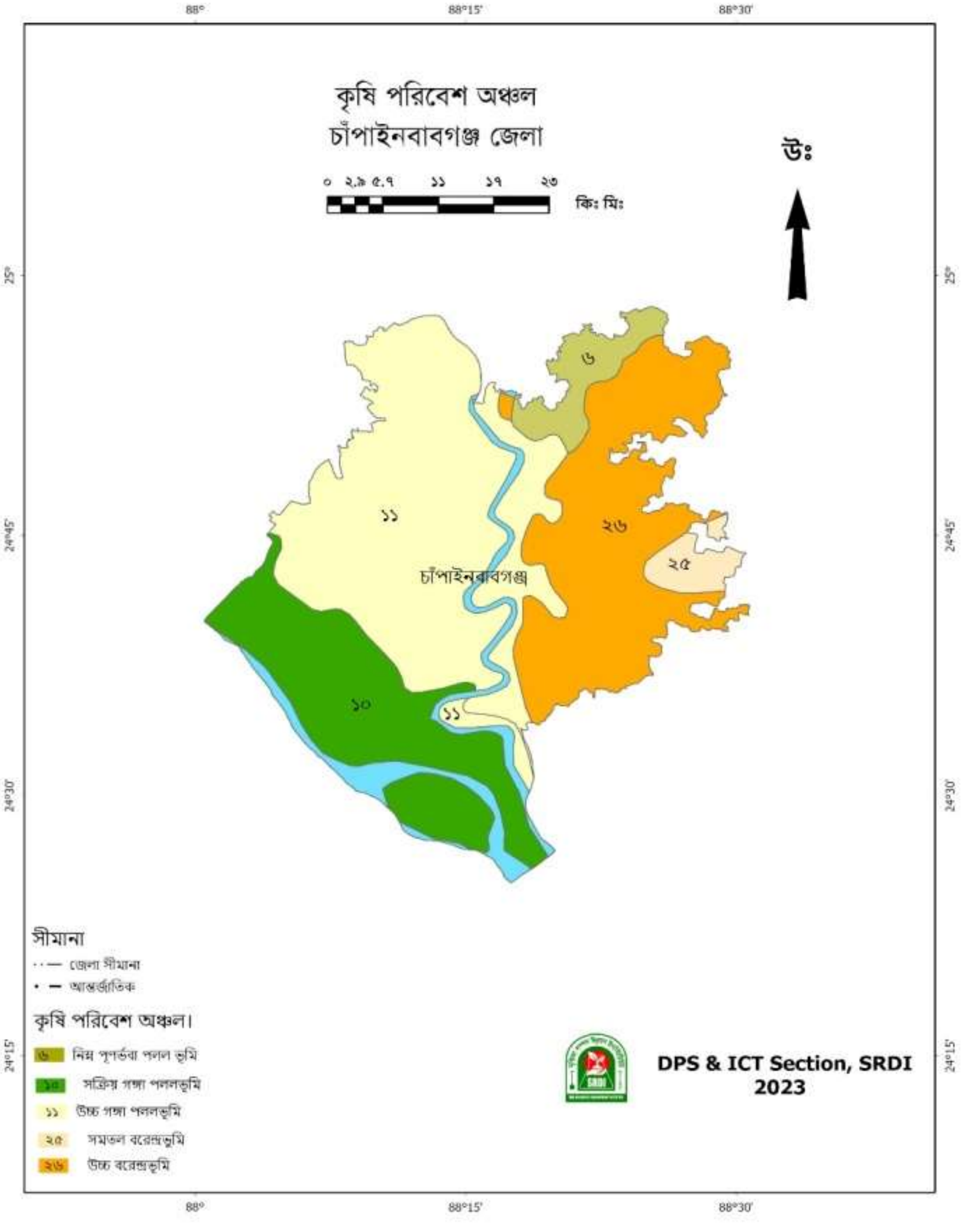
নবায়নকৃত-২০১৯
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
কুড়িগ্রাম উপজেলা
রাজারহাট উপজেলা
ভারত
(আসাম)
রৌমারী উপজেলা
গাইবান্ধা জেলা
(সুন্দরগঞ্জ উপজেলা)
চিলমারী উপজেলা


Agroecological Regions (AEZ) Map
Bangladesh
N
Legend
DPS and ICT Section
SRDI



কৃষি পরিবেশ অঞ্চল
চাঁপাইনবাবগঞ্জ জেলা
০ ২.৯ ৫.৭ ১১ ১৭ ২৩
কিঃ মিঃ
উঃ
88°
88°15'
88°30'
25°
24°45'
24°30'
24°15'
৬
১১
২৬
২৫
চাঁপাইনবাবগঞ্জ
১০
১১
সীমানা
জেলা সীমানা
আন্তর্জাতিক
কৃষি পরিবেশ অঞ্চল।
৬ নিম্ন পুণর্ভবা পলল ভূমি
১০ সক্রিয় গঙ্গা পললভূমি
১১ উচ্চ গঙ্গা পললভূমি
২৫ সমতল বরেন্দ্রভূমি
২৬ উচ্চ বরেন্দ্রভূমি
DPS & ICT Section, SRDI
2023

Data processing & uploading for OFRS. (APA target 50 Updated Upazila/ year).

Updating the crop list for OFRS:

2.2.3 Activities of Cartography Section

1. Map Digitizing:

Name of map	Upazila Name	Map Scale	Nos.
a) Soil and Land type Map	Nandail. Sundarganj, Pirgacha, Saghata, Gosairhat, Lalmai, Chakaria, Gobindaganj, Chouhali, Shibganj, Shibchar, Bajitpur, Shibalaya, Nababganj, Debiganj, Kotalipara, Gopalpur, Chouddagram, Bakerganj, Mirzaganj, Gajaria, Ramu, Moheskhali, Hizla, Rangabali, Rowangchari.	1:50000	26
b) Mouza Wise Upazila Map	Nandail. Sundarganj, Pirgacha, Saghata, Gosairhat, Lalmai, Chakaria, Gobindaganj, Chouhali, Shibganj, Shibchar, Bajitpur, Shibalaya, Nababganj, Debiganj, Kotalipara, Gopalpur, Chouddagram, Gajaria, Ramu, Moheskhali, Hizla, Rangabali, Rowangchari.		26

1. **Map Tracing:**

Name of map	**Upazila Name**	**Map Scale**	**Nos.**
a) Soil and Landtype Map	Paba, Lalmai, Gazipur Sadar, Khaliajuri	1:50000	4
b) Mouza Wise Upazila Map	Paba, Lalmai, Gazipur Sadar, Khaliajuri		4

2. **Map Checking & Correction:**

Name of map	**Upazila/ Union**	**Map Scale**	**Nos.**
Various Map	Various Upazila and Union Map	1:50000	25

3. **Map Printing:**

Name of map	**Upazila/ Union**	**Map Scale**	**Nos.**
Soil and Land form Map	Various Upazila and Union Map	1:50000	30

4. **Map Colouring:**

Name of map	**Upazila/Union**	**Map Scale**	**Nos.**
Upazila and Union	Soil and Landtype Map of Various Upazila & Union.	1:50000	10

5. **Area Calculation:**

Name of map	**Upazila Name**	**Map Scale**	**Nos.**
a) Soil and Landtype Map	Various Upazila and Union Map	1:50000	26

6. **Collection of base materials from SOB**

Name of map	Index no /Area	Photo scale	Nos.
a) Topo Map	Collected from SOB.	1:25000	500
b) Do	Latest Topo Map Collection from SOB under processing.	1:25000	300 (Appx.)
c) Aerial Photo	Latest Aerial Photo Collection from SOB.	1:25000	40

2.2.4 Publication and record section

Publication and Record Section of the Training and Communication Division is responsible for printing, publication and distribution of soil survey and other technical reports and their overall maintenance, to keep liaison with outside agencies for the above-mentioned purpose and to assist the authority in technical & administrative support on different aspect.

Achievements:

a) Sale of publications (2022-2023):

Title	Name of the organization		Qty (Copy)	Purpose
Upazila Nirdeshika	Autonomous	BRAC University	08	Academic
		East West University	08	Academic
		Rajshahi University	01	Academic
	Govt.	DAE, Rangabali, Patuakhali	03	Official Use
		PD, Nine Upazila Development Project	01	Official Use
		Department of Urban Development	08	Official Use
	Non-Govt.	PIMS	02	Research
		ACI Crop Care	01	,,

Total = 32 copies

Collections:

- Book/Journal/Report 25 copies

a) Prepare Proposal of Nomination for
- Bangabandhu National Agriculture Award
- Bangamata Begum Fazilatun Nesa Mujib Award
- Bangabandhu Public Administration Award
- Independent Award
- Ekushe Award
- UN Public Service Award
- Begum Rokeya Award etc.

b) Prepare Proposal of Nomination for Betar Kothika

c) Distribution:
- Poster 20 copies

d) Reader Services-Provided library services for 180 readers.

Work plan: 2023-24

- Procurements of Books, Journal, Magazines etc.
- Publish Poster , Booklet and Leaflet.
- Publish Annual Report
- Publish Mrittika Katha
- Publish Leaflet,Calendar, Note Book, Diary etc.
- SRDI's publication selling.
- Book/ Annual Report /Journal Collection
- Printing of Upazila Nirdeshika, Union Shohayeka & RSS Report.
- Distribution of Upazila Nirdeshika, Union Shohayeka, Poster, Booklet , Leaflet etc.
- Library automation & digitization.
- Provided technical & administrative support on different aspect.

2.3 Upazila Nirdeshika Cell

Three hundred and forty-five reports of Upazila Nirdeshika have been updated till June 2023 with a series of coordinated efforts such as semi-detailed soil survey for updating of relevant maps, collection of land quality and soil characteristics data, soil sample collection for laboratory analysis followed by report writing with the processing of relevant updated data generated during field survey and laboratory analysis. SRDI scientists engaged in district offices usually conduct the soil survey and prepare draft report for respective surveyed Upazila. Editing of the report is done initially by divisional head (Chief Scientific Officer) who supervise survey-based soil mapping and finally by the editorial board acting particularly as the approval authority of Upazila Niredeshika publication. The activities involved in the Upazila Nirdeshika updating system can be expressed as a flow-chart (Figure 1).

The entire activity is coordinated by Upazila Nirdeshika Cell of SRDI Head Office, thirty-five updated Nirdeshika has been published during the period of 2022-2023 under revenue budget of SRDI (Table 1).

Table. List of updated Land and Soil Utilization Guide (Nirdeshika) Published During the financial year 2022-2023

SL. No.	Name of Upazila of Updated Nirdeshika	Name of Respective District
1	Jajeera	Shariatpur
2	Keshobpur	Jashore
3	Kotchandpur	Jhenaidah
4	Kustia Sadar	Kustia
5	Atwari	Panchagarh
6	Dumuria	Khulna
7	Dighalia	Khulna
8	Mehediganj	Barishal
9	Agailjhara	Barishal
10	Mithapukur	Rangpur
11	Pirgacha	Rangpur
12	Dirai	Sunamganj
13	Panchagarh Sadar	Panchagarh
14	Koshba	Brahmanbaria

15	Chouddagram	Comilla
16	Faridganj	Chandpur
17	Baniachong	Habigang
18	Gazipur Sadar	Gazipur
19	Khaliajuri	Netrokona
20	Nandail	Mymensingh
21	Meherpur Sadar	Meherpur
22	Damurhuda	Chuadanga
23	Kalia	Narail
24	Jamalpur Sadar	Jamalpur
25	Shahzadpur	Sirajganj
26	Bagha	Rajshahi
27	Bagatipara	Natore
28	Saghata	Gaibandha
29	Birol	Dinajpur
30	Bakerganj	Barisal
31	Kalmakanda	Netrokana
32	Nasirnagar	Brahmanbaria
33	Ulipur	Kurigram
34	Borhanuddin	Bhola
35	Bholahat	Chapainababganj

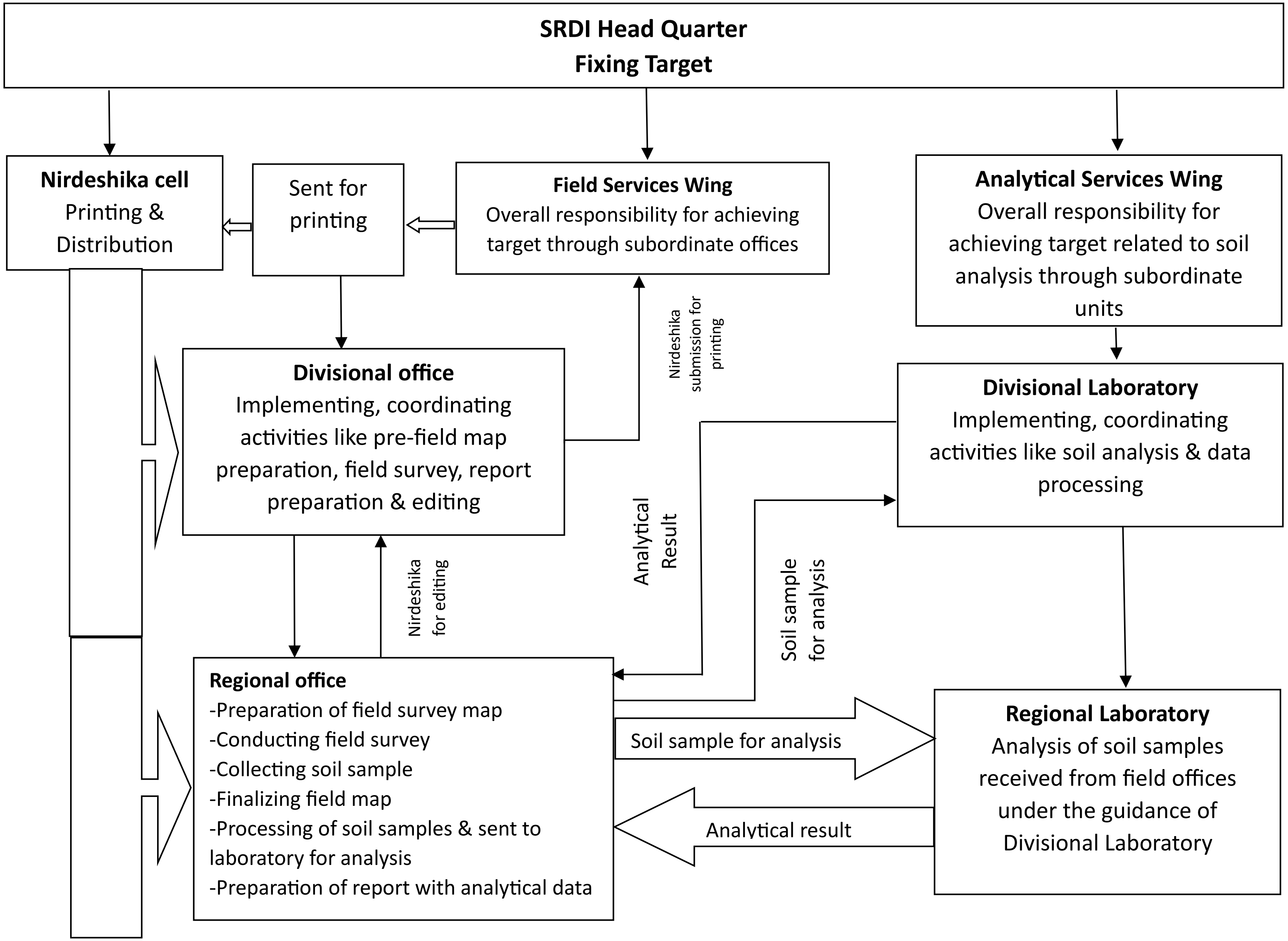


Figure 1: Flow chart of Nirdeshika Preparation

Chapter 3: Activities of Field Offices

3.1 Updating Upazilas Land and Soil Resource Utilization Guide (Upazilas Nirdeshika) through Semi-detailed Soil Survey

Introduction

Upazila Land and soil Resource Utilization Guide (Upazila Nirdeshika) developed through semi detailed soil survey is one of the basic tools used for local agricultural planning. Commencing from 1986, first round publication of all the 459 Upazila Nirdeshika was completed by June 2002. Following that updating programme of Upazila Nirdeshika has been taken and continued. The guide broadly comprises land and soil characteristics, land use, hydrological and agro climatic, soil fertility, agricultural limitations and potentialities of a Upazila. As our agricultural lands are changing due to urbanization, industrialization and construction of new settlement, the need for planning and execution updating Nirdeshika programme has arisen. As a result, SRDI carrying out programme to update previous data for developing realistic agricultural planning. Other than resource-based planning tool the Nirdeshika also guide the user to make fertilizer recommendation for crops. To mitigate upcoming challenge in agriculture rational use of soil and land resources is of prime importance. Therefore, the programme has been launched with the following objectives.

Objectives

- To update the land, soil and land use database for local level agricultural development planning.
- To update the soil fertility database.
- To accommodate the changes due to infrastructure developments (roads, homestead, embankments etc.).

Methodology

Base Materials: Existing Upazila Soil and Landform Map (1:50,000), aerial photographs of approximate scale of 1:25,000 of 1:30,000, topographic maps (1:50,000), DLR maps (1: 63,360) was used as field base maps.

Methods: Based on recent aerial photo interpretation a photo interpretative Soil and Landform Map was prepared with help of existing one. The map consists of legend depicting soil mapping unit(s), land type, Mrittika Dal (Soil group), drainage class etc.

Ground truthing was done through validating mapping unit, land, soil information following regular traverse and grid as required by semi-detailed survey.
Soils were examined as often as necessary along traverse lines. For each 200 hectares of land, one composite soil sample was collected. The sampling intensity was increased as and when necessary, according to the complexity of mapping unit.

Composite soil samples are collected from adjacent to or possibly nearer point of previous sampling sites with GPS reading so as to compare the changes of nutrient status due to intensive cultivation.

Mini pits were opened and described as and when necessary. Soil samples were also taken in correlation boxes (if necessary) from identified Mrittika Dal for using as reference for soil correlation. During soil sample collection, information on inundation depth, cropping pattern, constraints for agricultural development etc. were collected through conversation with farmers.

Collected composite soil samples were analyzed in the laboratory and updated Upazila Nirdeshika was prepared through assembling field information and laboratory data.

Table. Progress of Upazila Nirdeshika Updating

District	Field Survey		Map finalization		Draft Report Preparation		Final Report Preparation	
	Target	Achievement	Target	Achievement	Target	Achievement	Target	Achievement
Divisional Office, Dhaka								
DO, Dhaka	Singair	Completed	Singair	In process	-	-	-	-
	Sonargaon	Completed	Sonargaon	In process	-	-	-	-
RO, Tangail	Ghatail	Completed	Mirzapur	Completed	Mirzapur	In process	Delduar	Completed
	Basail	Completed	Delduar	Completed	Kendua	In process	Islampur	Completed
RO, Faridpur	Boalmari	Completed	Boalmari	In process	Faridpur Sadar	In Process	Zajira	Completed
	-	-	Madaripur Sadar	Completed	Nagarkanda	In Process	Kalkini	Completed
RO, Kishorgonj	Austagram	Completed	Austagram	Completed	Austagram	In process	Austagram	In process
	Bhairab	Completed	Bhairab	In Process	Bhairab	In Process	Bhairab	In process
	Itna	Completed	Itna	In Process	Itna	In Process	Itna	In process
	Kukiarchar	Completed	Kukiarchar	Completed	Kukiarchar	In Process	Kukiarchar	In process
	Mithamain	Completed	Mithamain	Completed	Mithamain	Completed	Mithamain	Submitted
	Nikli	Completed	Nikli	In Process	Nikli	In Process	Nikli	In process
RO, Mymensingh	Muktagacha	Completed	Mymensingh Sadar	Completed	Mohongonj	In Process	Nandail	Submitted
	Gouripur	Completed	Goforgaon	Completed	Netrokona sadar	In Process	kalmakanda	Submitted
RO, Narshingdi	Belabo	Completed	Belabo	Completed	Savar	Completed	Savar	Submitted
RO, Madaripur	Shariatpur Sadar	Completed	-	-	-	-	-	-
	Sadarpur	Sadarpur						
Netrokona	Purbadhala	Completed	Purbadhala	Going on	Durgapur	In Process	Khaliajuri	submitted
Jamalpur	Nakla	Completed	Nakla	Completed	Vedargonj	In Process	Jamalpur Sadar	submitted
	Sarishabari	Completed						
Divisional Office, Chattogram								
Chattogram	Patiya	Completed	Patiya	In Process	-	-	-	-
	Boalkhali	Completed	Durgapur	Completed	-	-	-	-
Cox's Bazar			Teknaf	Teknaf	Teknaf	Teknaf		
Cumilla	Begumgonj	Completed	Chaddugram	Completed	Sonaimuri	In Process	Chaddugram	submitted
	Porshuram, Feni	Completed	-	-	-	-	-	-
Rangamati	Khagrachhari sadar	Completed	Panchhari	Completed	Mohalchhari	In Process	Panchhari	Submitted
	Bandarban Sadar	Completed	Mirsarai	Completed	Faridganj	Completed	Mirsrai	Completed
Brahmanbaria	Ashuganj	Completed	Nasirnagar	Completed	Nasirnagar	Completed	Nasirnagar	In Process
	Sarail	Completed	Derai	Completed	Derai	Completed	Derai	In Process
Noakhali	Senbag	Completed	Senbag	In procss	-	-	-	-
	Lakshmipur	Completed						
	Feni	Completed						
Divisional Office, Rajshahi								
Rajshahi	Paba,Rajshahi	Completed	Paba	Completed	-	-	-	-
Chapainawabganj	Puthia, Rajshahi	Completed	Bholahat	Completed	Bholahat	Completed	Gurudaspur, Mohadebpur, Mohonpur	Completed
	-	-	Nachole	Going on	Nachole	In Process		
Pabna	Faridpur	Completed	Faridpur	Completed	-	-	Vangura	Completed
Bogura	-	-	Fulsori	Completed	Fulsori	In Process	Kasba	
Naogaon	-	-	-	-	Bagaha	Completed	Bagaha	Completed
	-	-	-	-	Bagatipara	Completed	Bagatipara	Completed
	-	-	-	-	Manda	In Process	-	-
Sirajganj	-	-	Matlab, Chandpur	Completed	Baraigram, Natore	In Process	Shahjadpur, Sirajganj	Completed
Divisional Office, Rangpur								
Rangpur	Sadar	Completed	Sadar	Completed	Mithapukur	Completed	Sunderganj	Completed
	Gangachora	Completed			Pirgacha	In Process	-	-
Dinajpur	Dinajpur sadar	Dinajpur sadar	Birol	Birol	Birol	-	Birol	-
	Hakimpur	Completed	Hakimpur	Completed	-	-	-	-
Lalmonirhat			Gabindaganj	Completed	Bhurungamari	Completed	Gabindaganj	Completed
Panchagarh	-	-	-	-	-	-	Panchagarh Sadar	Panchagarh Sadar
Gaibandha	-	-	Saghata	Completed	Saghata	Completed	Saghata	Completed
Divisional Office, Khulna								
Khulna	-	-	-	-	-	-	Dumuria	Completed
Jashore	-	-	Keshobpur,	Completed	Avoynagar	Completed	Chougacha,	Completed
	-	-	Avoynagar	Completed	-	-	Keshobpur	Completed
	kalia	Completed	kalia	Completed	kalia	Completed	kalia	Completed
	Bagharpara	Completed	Bagharpara	Completed	Bagharpara	Completed	Bagharpara	Completed
Kushtia	Gangni	Gangni	Kushtia Sadar	Kushtia Sadar	Gangni		Kushtia Sadar	Kushtia Sadar

District	Field Survey		Map finalization		Draft Report Preparation		Final Report Preparation	
	Target	Achievement	Target	Achievement	Target	Achievement	Target	Achievement
			Meherpur Sadar	Meherpur Sadar			Meherpur Sadar	Continued
Satkhira	Babugonj	Babugonj	Potuakhali Sadar	Potuakhali Sadar	Babugonj		Digholia	Digholia
							Potuakhali Sadar	Continued
Jhenaidah								
			Gosairhat	Completed			Gosairhat	Completed
			Kotchandpur	Completed			Kotchandpur	Completed
			Mirpur	Completed			Mirpur	Completed
Divisional Office, Barishal								
Barishal	-	-	Bakerganj	Completed	-	-	Bakerganj	Completed
	-	-	Banaripara	Completed	-	-	Banaripara	Completed
	-	-	-	-	Nesarabad	Completed	-	-
Bhola			Daulatkhan	Daulatkhan	Daulatkhan	Daulatkhan	Borhaunuddin	Borhaunuddin
			Borhaunuddin	Borhaunuddin				
Perojpur	Indurkani	Indurkani						
Patuakhali	Bauphol	Bauphol						
Patuakhali	Mirzaganj	Mirzaganj						
	Dumki	Dumki						
Barishal			Agailjhara	Agailjhara			Agailjhara	Agailjhara
Pirozpur			Mathbaria	Mathbaria	Mathbaria	Mathbaria		
Divisional Office, Sylhet								
Sylhet	Beanibazar	Completed	Golapganj	Completed	Sullla	Completed	Biswambharpur	Completed
	Fenchuganj	Completed						
Moulvibazar	Sylhet Sadar	Completed	Ajmiriganj	Completed	Baniachong	Completed	Baniachong	Completed
	Dakshin Surma	Completed						
Sunamganj			Dharmapasha	Completed	Derai	Completed	Derai	Completed
			Tahirpur	Completed				

Findings of Selective Upazilas under Field Services Wing

Major findings of Muktagacha Upazila, Mymensigh

i) Total area-31,290
ii) Total sample collected-155
iii) Physiography & AEZ code- Old Brahmaputra Floodplain (9), Madhupur Tract (28)
iv) Major land type- HL, MHL, MLL & LL
v) Major soil group- Tejgaon, Belabo, Noadda, Sayek, Chandra, Kolma, Khilgaon, Sonatala, Silmandi, Lokdeo. Ghatail.

Changes in Land Type

Land type	Previous (2009)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	9,936	31.76	9,323	29.80	-1.97	1. Increasing Trend Was found at sector of urbanization, settlement and highways overtime. 2.Increase of commercial fishing area.
Medium Highland	14,569	46.56	14,043	44.88	-1.67	
Medium Lowland	1,106	3.53	840	2.68	-0.85	
Lowland	137	0.44	68	0.22	-0.22	
Miscellaneous	5,542	17.71	7,016	22.42	+4.71	
Total	31,290	100	31,290	100	-	

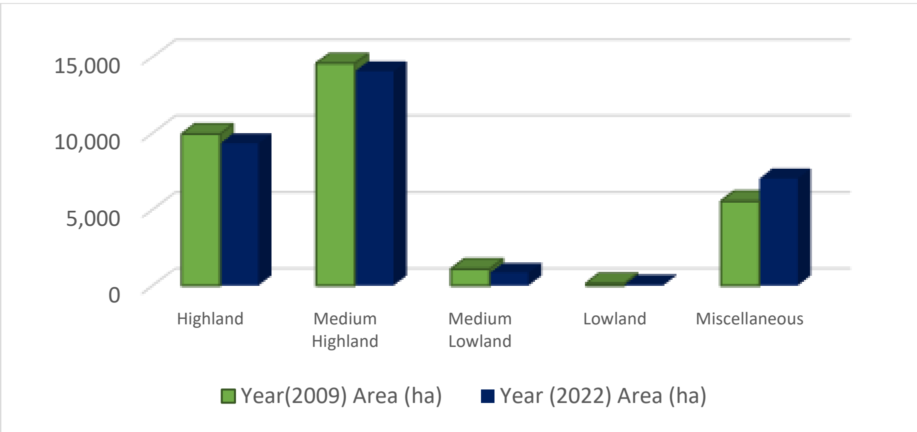


Fig. Comparison of Land type between 2009 and 2022 of Muktagacha upazila

Changes in Land Use:

Land Use	Previous (2009)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Wood Plant (Sal/teak)	470	1.50	235	0.75	-0.75	Farmers are Interested in rice cultivation for ensuring food security.
Annual Crop (Banana/Papaya/Sugarcane)	1,865	5.90	1,095	3.5	-2.40	
R.veg- K.veg	655	2.10	1,565	5	+2.9	
Rabi crop- Boro-F-T.Aman	3,233	10.04	1,878	6	-4.04	
Boro-F-T.Aman	15,433	49.37	17,207	55	+5.34	
Boro-F-F	1,243	4	939	3	-1.00	
Others	2,849	9.10	1,355	4.3	- 4.77	
Miscellaneous	5,542	17.72	7,016	22.45	+4.72	
Total	31,290	100	31,290	100	0.00	

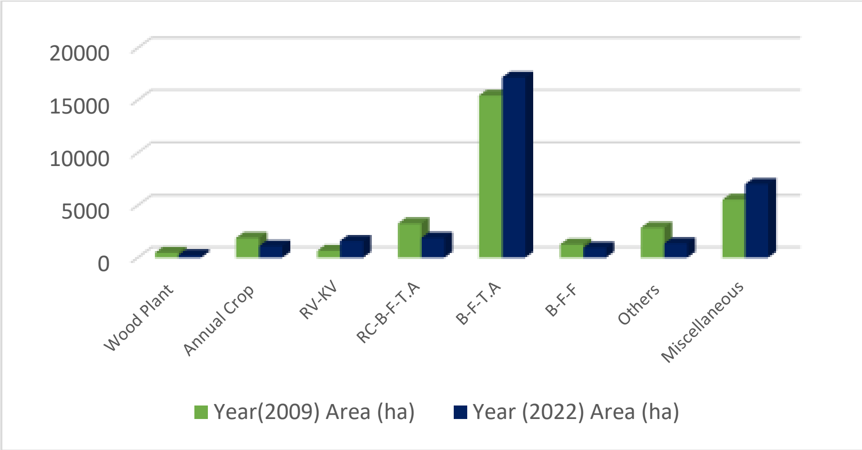


Fig. Comparison of Land use between 2009 and 2022 of Muktagacha upazila

Major findings of Gouripur Upazilla, Mymensingh:

i) Total area-27,676
ii) Total sample colleted-138
iii) Physiography & AEZ code- Brahmaputra Floodplain (8,9)
iv) Major land type- HL, MHL, MLL, LL & VLL
v) Major soil group- Nokla, Sherpur, Sonatala, Melandoho, Silmandi, Lokdeo, Ghatail, Gouripur, Dhamrai, Shyamgong, Ghorargaon, Balina, Silty alluvium, Sandy alluvium.

Changes in Land Type

Land type	Previous (2010)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	9,979	36.00	9,911	35.81	-0.19	1. Increasing Trend Was found at sector of urbanization, settlement and highways overtime. 2.Increase of commercial fishing area.
Medium Highland	8,882	32.1	8,745	31.55	-0.55	
Medium Lowland	3,289	11.9	3,240	11.7	-0.2	
Lowland	986	3.6	986	3.6	00	
Very Lowland	235	0.9	187	0.69	-0.21	
Miscellaneous	4,305	15.5	4,607	16.65	+1.15	
Total	27,676	100	27,676	100	00	

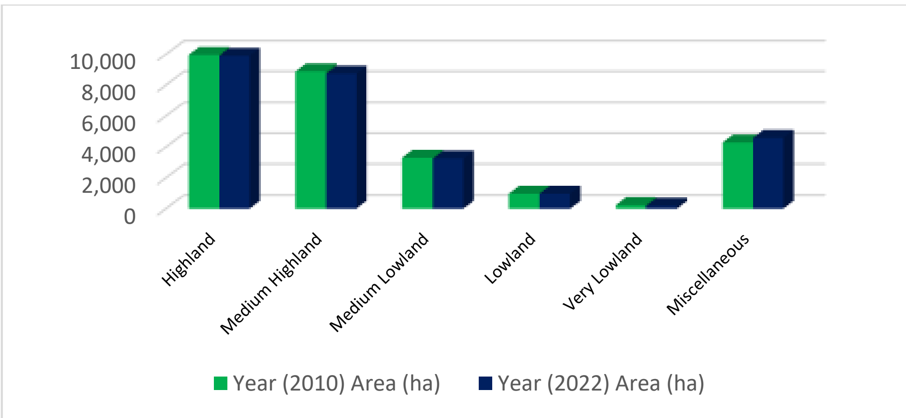


Fig. Comparison of Land type between 20010 and 2022 of Gouripur upazila

Changes in Land Use:

Land Use	Previous (2010)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Banana/Sugarcane	222	0.8	0.0	00	-0.8	Farmers are Interested in rice cultivation for ensuring food security.
Rabi Veg- Kharif Veg	130	0.5	581	2.1	+1.6	
Rabi Crop- F- T.Aman	1,115	4.0	1,384	5	+1	
Rabi Crop-Jute/T.Aus- T.Aman	401	1.4	00	00	-1.4	
Boro-Jute/T.Aus-T.Aman	714	2.6	415	1.5	-1.1	
F-Jute- T.Aman	276	1	00	00	-1	
Boro-T.Aus-T.Aman	401	1.4	1,217	4.4	+3	
Boro-F- T.Aman	14,597	52.8	15,111	54.60	+1.8	
Boro-F-F	4,120	14.9	3,183	11.5	-3.4	
F-F-T.Aman	313	1.1	00	00	-1.1	
Others	1,082	4	1,178	4.25	+0.25	
Miscellaneous	4,305	15.5	4607	16.65	+1.15	
Total	**27.676**	**100**	**27.676**	**100**	**0.00**	

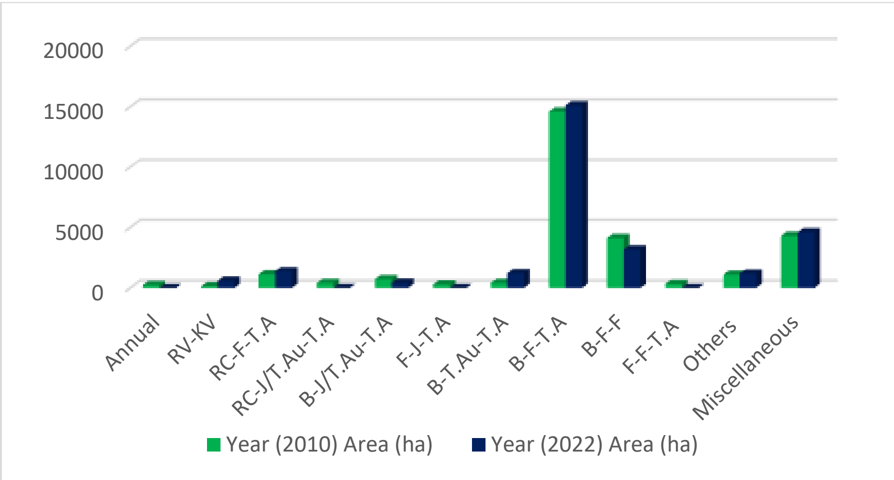


Fig. Comparison of Land use between 2010and 2022 of Gouripur upazila

Major findings of Ghatail Upazila, Tangail

i) Total area: 45,171 ha

ii) Total sample collected: 232

iii) Physiography and AEZ code: Madhupur Tract (28), Old Brahmaputra floodplain (9)

iv) Major land type: High land, Medium High Land, Medium Low Land and Low Land

v) Major soil group: Tejgao, Belabo, Kalma,Gerua, Noadda, Chandra, Sonatala,Silmondi, Ghatail, Lokdeo, Savar Bazar.

Change in Land Type

Land type	Previous (2009)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	14492	32.1	13551	30	-2.1	For settlement
Medium Highland	12101	26.8	12874	28.8	+1.7	Decreasing flood
Medium Lowland	9860	21.8	9079	20.1	-1.7	Transformation to medium high land
Lowland	4711	10.4	4246	9.4	-1	Transformation to medium low land
Miscellaneous	4007	8.9	5421	12		
Total	45,171	100	45,171	100		

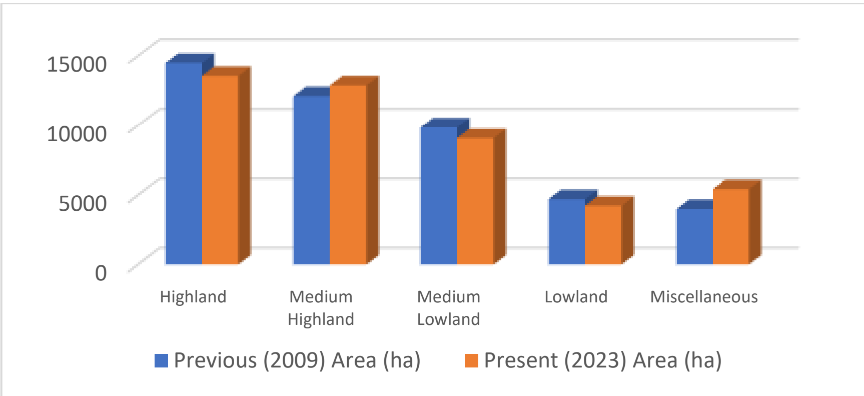


Fig. Comparison of Land type between 2009 and 2023 of Ghatail upazila

Changes in land use

Cropping Pattern	2009		2023		% increase/ decrease	Possible reason
	Area (ha)	%	Area (ha)	%		
Forest (Gazari/shal/Acacia/Menjium/ Ucalyptus	2709	6.0	1807	4	-2	Deforestation
Bush	735	1.6	452	1	-0.6	Cleaning of bush
Orchard (Jackfruit/Mango/Guava/Jujube	1543	3.4	2259	5	+1.6	Orchard establishment
Banana	1450	3.2	2259	5	+1.8	
Pineapple	2032	4.5	2484	5.5	+1.0	
Sugarcane	612	1.3	677	1.5	+0.2	Profitable crops
Ginger/Turmeric	807	1.8	903	2.0	+0.2	
Rabi vegetables- Kharif vegetables	1542	3.5	1806	4.0	+0.5	
Rabi crops-B. Aus/Jute-T. Aman	1790	4.0	2259	5.0	+1.0	
Rabi crops-B. Aus/Jute-Fallow	2127	4.7	1580	3.5	-0.5	
Fallow-Fallow- B. Aman	614	1.4	452	1.0	-0.4	
Fallow-Fallow- T. Aman	644	1.4	452	1.0	-0.4	
Mustard-Boro- T. Aman	2410	5.3	3162	7.0	+1.7	
Mustard-Boro- DWA	2631	5.8	2259	5.0	-0.8	
Boro- Fallow-T. Aman	6247	13.8	5195	11.5	-2.3	
Boro- Fallow- DWA	4239	9.4	3387	7.5	-1.9	
Boro-B. Aus/Jute-T. Aman	1672	3.7	2259	5.0	+1.3	

Boro-Fallow-Fallow	6624	14.7	5421	12.0	-2.7	
Others	736	1.6	677	1.50	-0.1	
Miscellaneous (Homestead/Water bodies etc.)	4007	8.9	5420	12	3.1	
Total:	**45171**	**100**	**45171**	**100**		

Major findings of Bashail Upazila, Tangail

i) Total area: 15,626 ha
ii) Total sample collected: 93
iii) Physiography and AEZ code:) Brahmaputra flood plain (7.8.9)
iv) Major land type: High land, Medium High Land, Medium Low Land and Low Land
v) Major soil group: Sonatala,Melandaha,Silmondi, Ghatail, Dhamrai Savar Bazar,Brahmaputra alluvium

Change in Land Type

Land type	Previous (2009)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	190	1.2	156	1	-0.2	For settlement
Medium Highland	3480	22.2	3750	54	+1.8	Decreasing flood
Medium Lowland	2545	16.1	2234	14.3	-1.8	Transformation to medium high land
Lowland	5721	36.8	5310	34.5	-2.3	
Very lowland	1355	8.7	1563	34.5	+1.3	
Miscellaneous	2335	15	2532	16.2	+1.2	
Total	15626	100	15626	100		

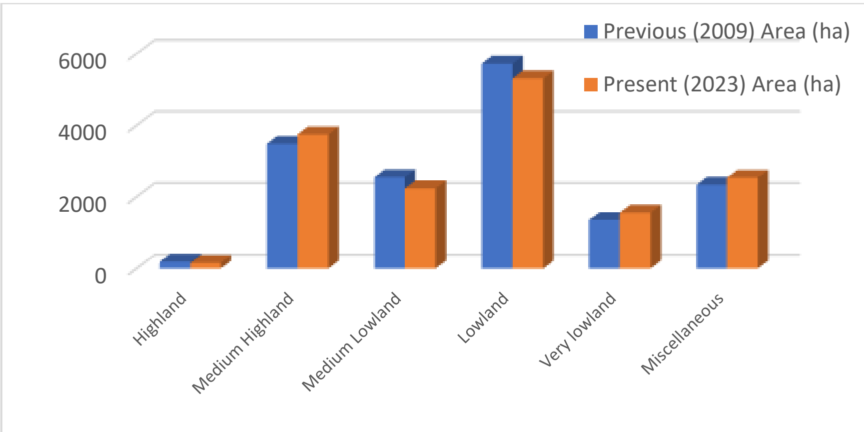


Fig. Comparison of Land type between 2009 and 2023 of Bashail upazila

Changes in land use

Cropping Pattern	2009		2022		% increase/ decrease	Possible reason
	Area (ha)	%	Area (ha)	%		
Sugarcane	89	0.57	69	0.40	-0.17	
Rabi crops (Groundnuts/Caown/Mustard/ Job/ Vegetables/pulses-Fallow	51	0.32	71	0.50	+0.10	
Rabi crops –T. Aus – T. Aman	217	1.39	197	1.26	+0.13	
Rabi crops –Aus/Jute – Fallow	925	5.92	825	5.28	-0.64	
Rabi crops –Aus/Jute – T. Aman	194	1.24	214	1.37	+0.13	
Mustard –Boro – T. Aman	142	0.90	1142	7.31	+6.41	
Mustard –Boro – DWA	825	5.28	1825	11.68	+6.40	
Rabi crops – Mixed B. Aus+Aman	629	4.02	0	0	0	
Boro – Fallow - T. Aman	1862	11.91	862	5.51	-6.4	
Boro – Fallow - T. Aman	947	6.06	2947	18.86	-12.80	
Boro – Fallow – B. Aman	3459	22.13	1679	10.81	-11.32	
Fallow – Fallow – B. Aman	269	1.72	0	0	0	
Boro (Local) – Fallow - Fallow	3492	22.34	2983	19.09	-3.25	
Others	190	1.20	270	1.72	0.52	
Miscellaneous	2335	15.00	2532	16.20	1.20	
Total:	**15626**	**100**	**15626**	**100**		

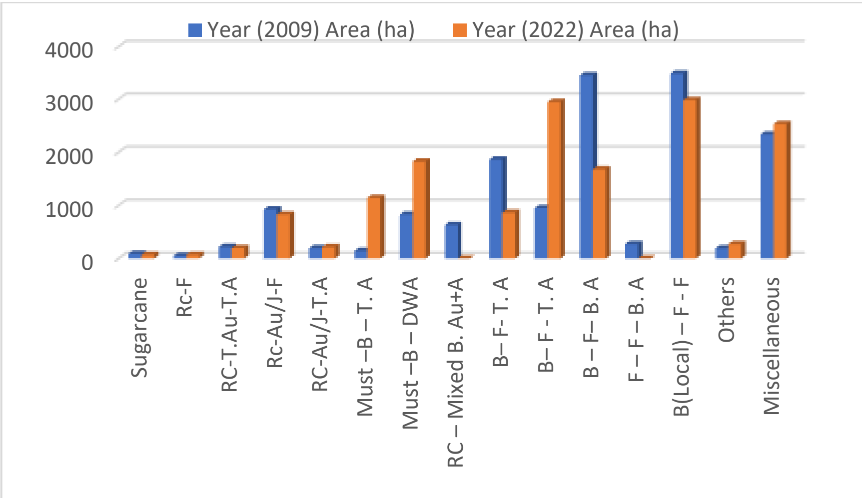


Fig. Comparison of Land use between 2009 and 2022 of Bashail upazila

Major findings of Sadarpur Upazila, Faridpur

i) Total area-28579 ha

ii)Total sample colleted- 101

iii)Physiography& AEZ code- Active Ganges Floodplain (10), Low Ganges River Floodplain (12)

iv)Major land type-Highland, Medium Highland, Medium Lowland, Lowland

v)Major soil group- Sara, Gopalpur, Ishwardi, Ghior, Ganger Poli, Ganger Bele

Changes in Land Type

Land type	Previous (2005)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	955	3.3	1276	4.5	+ 1.2	
Medium Highland	10675	37.4	5959	20.9	- 16.5	
Medium Lowland	7098	24.8	7805	27.3	+ 2.5	
Lowland	2369	8.3	1928	6.7	- 1.6	
Miscellaneous	7482	26.2	11611	40.6	+ 14.4	
Total	**28579**	**100**	**28579**	**100**		

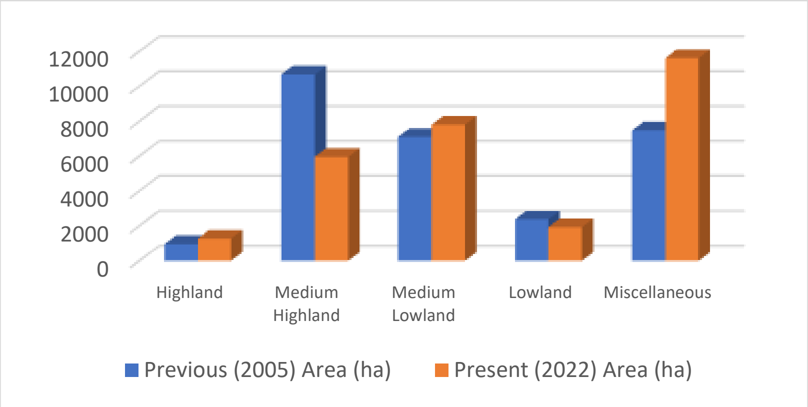


Fig. Comparison of Land type between 2005and 2022 of Sadarpur upazila

Changes in Land Use

Land Use	Land type	2005		2022		% increase/ decrease	Possible reasons
		Area (ha)	%	Area (ha)	%		
1. Sugarcane		2136	7.5	800	2.8	-4.7	
2. Rc – Jute		2505	8.8	2840	9.9	+1.1	
3.Rc- Mixed B. Aus and B.Aman		3525	12.3	3050	10.7	-1.6	
4. Rc- B Aus- Fallow		2008	7.0	1328	4.7	-2.3	
5.Rc – Fallow- T. Aman		1237	4.3	1530	5.5	+1.2	
6. Rc-B. Aman		1004	3.5	750	2.6	-0.9	
7. Groundnut_ Fallow- T. Aman		2008	7	1550	5.5	-1.5	
8. Boro- Fallow- T Aman		1977	6.9	1630	5.7	-1.2	
9. Boro- Fallow		3390	11.8	1900	6.6	-5.2	
10. Others		1307	4.7	1590	5.4	+0.7	
11.Misc(crops)		7482	26.2	11611	40.6	+14.4	
12. Total		**28,579**	**100.0**	**28,579**	**100.0**		

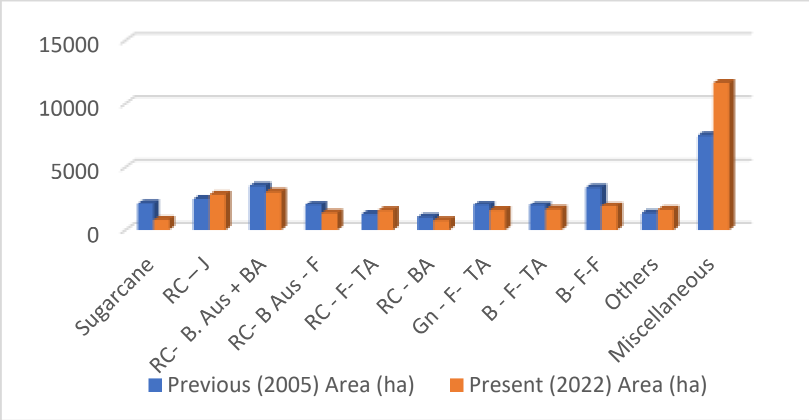


Fig. Comparison of Land use between 2005 and 2022 of Sadarpur upazila

Major findings of Rajoir upazila, Madaripur

i) Total area-22928ha

ii)Total sample colleted-128

iii)Physiography& AEZ code - Ganges Floodplain (12,10)

- Meghna Estuarine Floodplain (19)

- Gopalganj Khulna bils (14)

iv)Major land type-High Land, Medium High Land, Medium Low Land, Low Land and Very Low Land

v)Major soil group – Sara, Gopalpur, Ishwardi, Ghior, Ganges Bele Mati, Ganges Poly Mati, Magra, Pirojpur, Kotalipara, Rajoir, Harta and Satla.

Changes in Land Type

Land type	2010 (Year)		2023(Year)		% increase (+)/ decrease (-)	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	1309	5.71	1073	4.7	1.01(-)	1) Soil erosion & sedimentation due to flood, results very lowland changes to lowland 2) Increasing settlement area due to over population growth, results decrease highland & medium highland
Medium Highland	4550	19.84	4335	18.9	0.94(-)	
Medium Lowland	7817	34.09	8734	38.0	3.91(+)	
Lowland	6052	26.40	4927	21.5	4.9(+)	
Very lowland	345	1.51	336	1.5	1.01(-)	
Miscellaneous	2855	12.45	3523	15.4	2.95(+)	
Total	22928	100	22928	100		

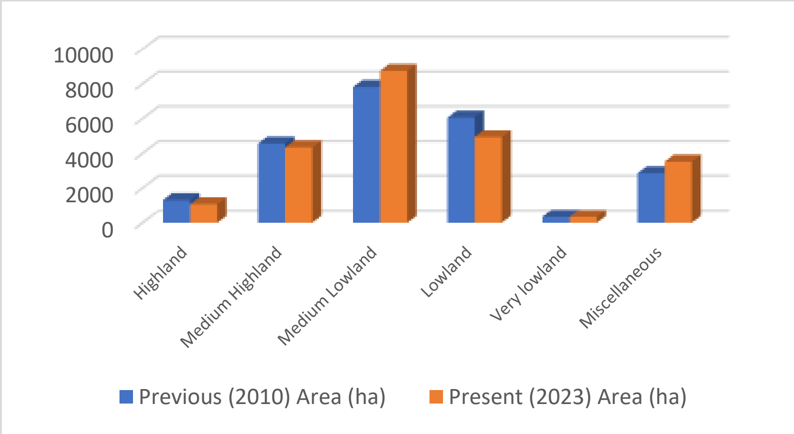


Fig. Comparison of Land type between 2010 and 2023 of Rajoir upazila

Changes in Land Use

Land Use	2010 (year)		2023(year)		% increase(+)/ decrease(-)	Possible Reasons
	Area (ha)	%	Area (ha)	%		
Rc - F/B Aus -F	292	1.27	190	0.8	0.47(-)	1)Cultivation of HVY rice 2) Increases Boro rice cultivation due to high yield 3) Increases high value crops like pulse & oil
Rc –J-TA	1893	8.26	1975	8.6	0.34(+)	
Rc –J-F	2767	12.07	2810	12.3	0.23(+)	
Rc-Mixed B Aus & Aman	1871	8.16	1005	4.4	3.76(-)	
Boro(HYV)-F-TA	1605	7.00	2547	11.1	4.1(+)	
Boro(HYV)-F-B Aman	1980	8.64	1180	5.1	3.54(-)	
Boro(HYV)-F-F	8175	35.65	9037	39.4	3.75(+)	
Boro(Local)-F-F	837	3.65	106	0.5	3.15(+)	
Others Cropping Pattern	653	2.85	555	2.4	0.45(-)	
Miscellaneous	2855	12.45	3523	15.4	2.95(+)	
Total	**22928**	**100**	**22928**	**100**		

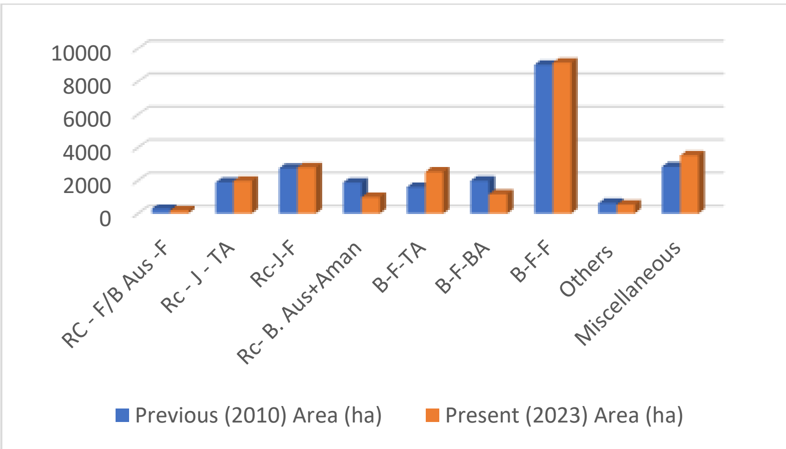


Fig. Comparison of Land type between 2010 and 2023 of Rajoir upazila

Major findings of Nakla Upazila, Sherpur

i) Total area- 17,351 ha.
ii) Total sample collected- 97.
iii) Physiography & AEZ code- Piedmont Plane (22), Old Brahmaputra Flood plain (9), Young Brahmaputra Flood plain (8), Active Brahmaputra Flood plain (7).
iv) Major land type- High Land, Medium High Land, Medium Low Land, Low Land.
vi) Major soil group- Ramnagar, Pritimpasha, Nalitabari, Nakla, Sherpur, Sonatola, Silmondi, Ghatail, Balina,Melandaha, Dhamrai, Brahmaputra Silty alluvium, Brahmaputra Sandy alluvium.

Changes in Land Type:

Land type	2001 (Year)		2022 (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	5,576	32.13	4,868	28.10	-4.03	New Settlement, Infrastructure etc. occupied the high Land.
Medium Highland	5,007	28.86	5,144	29.60	+0.74	Change of inundation depth
Medium Lowland	4,110	23.69	3,904	22.50	-1.19	
Lowland	815	4.70	785	4.50	-0.20	
Miscellaneous	1,843	10.62	2,650	15.30	+468	Increase of Settlement
Total	**17,351**	**100.00**	**17,351**	**100.00**		

Changes in Land Use:

Sl. No	Land Use	2001 (year)		Land Use	2022 (year)	
		Area(ha)	%		Area (ha)	%
01.	R. Vegetable- Aus- F	30	0.17	Annual (Zinger/ Termaric/ Sugercane/ Banana)	330	1.90
02.	F-Aus- B. Aman	89	0.51	Boro- F- F	625	3.60
03.	F- F- DWTA	60	0.30	Boro- F- T. Aman	4,125	23.77
04.	Boro- F- F	1649	9.50	Sweet Potato- Jute- F	85	0.49
05.	Sugarcane	373	2.15	Black gram-Boro-F	20	0.12
06.	RC- Aus/Jute-F	1,640	9.60	Mustard- Boro- T. Aman	4,895	28.21
07.	F- Aus/Jute- T. Aman	2,256	13	Potato- Maize - T. Aman	515	2.97
08.	RC- Aus/Jute- T. Aman	2,163	12.47	Maize -Jute- T. Aman	115	0.66
09.	Boro- F- T. Aman	3876	22.34	Maize -F- T. Aman	1,436	8.28
10.	Boro- F- DWTA	2,547	14.67	Wheat-Jute- T. Aman	120	0.69
11.	Mustard- Boro- F	34	0.20	Spice (Onion,Garlic, Chilli) - Jute- T. Aman	33	0.19
12.	F- F- B.Aman	67	0.39	Spice (Onion, Garlic, Chilli)- Aus- T. Aman	10	0.06
13.	RC- Jute-F	67	0.39	Wheat-Aus- T. Aman	70	0.40
14.	Groundnut- F- F	159	0.92	Boro- Aus- T. Aman	300	1.73
15.	RC- F- B. Aman	152	0.88	Boro- Jute- T. Aman	175	1.01
16.	R. Vegetable -K. Vegetable	77	0.44	Potato- Boro- T. Aman	1,070	6.17

17.	Others/Fallow	269	1.55	Pulse- F- F	7	0.04
18.	Miscellaneous	1,843	10.62	Blackgram-Boro- T. Aman	20	0.11
19.				Vegetable-Boro-F	660	3.80
20.				R. Vegetable -K. Vegetable	60	0.35
21.				Onion- Maize-K. Vegetable	10	0.06
22.				Mustard- Boro- K. Vegetable	5	0.03
23.				Potato- Maize -K. Vegetable	15	0.09
24.				Miscellaneous	2,650	15.27
	Total	**17,351**	**100.00**		**17,351**	**100.00**

Major findings of Sariatpur Sadar Upazila, Shariatpur

i) Total area-17,282 (ha)
ii)Total sample colleted- 76
iii)Physiography & AEZ code- Active Ganges Floodplain (10), Low Ganges River Floodplain (12), Old Meghna Estuarine Floodplain (19)
iv)Major land type- Highland, Medium Highland, Medium Lowland, Lowland
v)Major soil group- Sara, Gopalpur, Ishwardi, Ghior, Paisha, Dedidar, Burichong, Ganger Poli, Ganger Bele

Changes in Land Type

Land type	Previous Survey (2007)		Present Survey (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	470	2.7	529	3.1	+0.34	
Medium Highland	2672	15.5	2619	15.2	-0.31	
Medium Lowland	6543	37.8	6227	36.0	- 1.83	
Lowland	2642	15.3	2388	13.8	- 1.47	
Miscellaneous	4955	28.7	5519	31.9	+3.27	
Total	17,282	100	17,282	100		

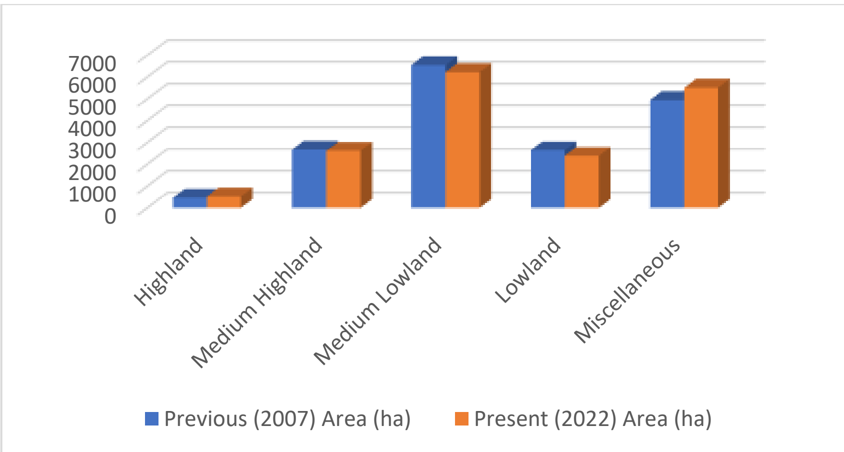


Fig. Comparison of Land type between 2007 and 2022 of Shariatpur sadar upazila

Changes in Land Use

Land Use	Previous Survey (2007)		Present Survey (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Rabi Veg. – Kharif Veg.	470	2.7	530	3.1	+0.4	
Rc – Jute - T.Aman	596	3.5	615	3.6	+0.1	
Rc- Jute – Fallow	2077	12.0	2005	11.6	-0.4	
Rc – Mixed B Aus, B Aman	1935	11.2	2080	12.0	+0.8	
Boro- Fallow	5347	30.9	4658	27.0	-3.9	
Boro - B. Aman	764	4.4	850	4.9	+0.5	
Boro - Fallow- T Aman	406	2.3	620	3.6	+1.3	
Boro – Fallow - Fallow	344	2.0	-	-	-	
Others	388	2.3	405	2.3	0	
Miscellaneous	4955	28.7	5519	31.9	+3.2	
	17,282	**100.0**	**17,282**	**100.0**		

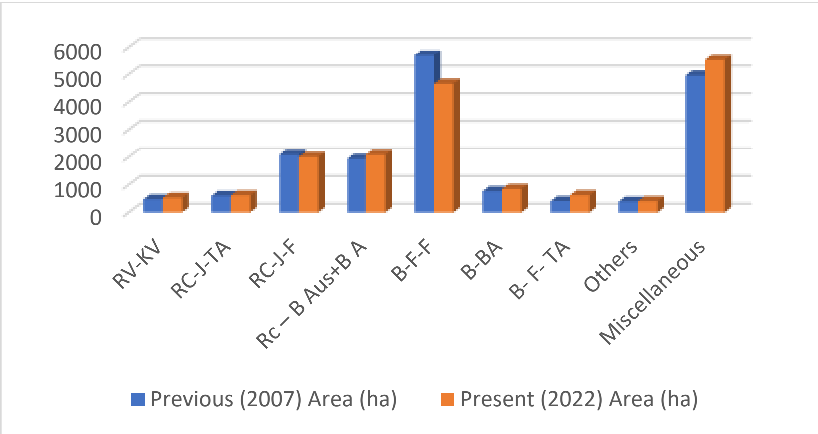


Fig. Comparison of Land use between 2007 and 2022 of Shariatpur Sadar upazila

Major findings of Sreenagar upazila, Munsiganj

i) Total area- 19239 hectare
ii) Total sample colleted- 65
iii) Physiography & AEZ code- Ganges Floodplain (10, 12), Arial Bil (15), Meghna Estuarine Floodplain (19)
iv) Major land type- Medium high land, medium low land, low land, very low land
vi) Major soil group- Sara, Gopalpur, Darshana, Ishwardi, Amjhupi, Ghior, Naraibag, Jalkundi, Arial, Maheshpur, Rampal etc

Changes in Land Type

Land type	2007 (Year)		2022 (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
High land	159	0.8	109	0.6	-0.2	Area of low land has been decreased due to accumulation of silt
Medium high land	456	2.4	406	2.1	-0.3	
Medium low land	4397	22.8	5207	27.0	4.2	
Low land	4580	23.9	3800	19.8	-4.1	
Very low land	5602	29.1	5422	28.2	-0.9	
Miscellaneous	4045	21.0	4295	22.3	2.3	
Total	19239		19239			

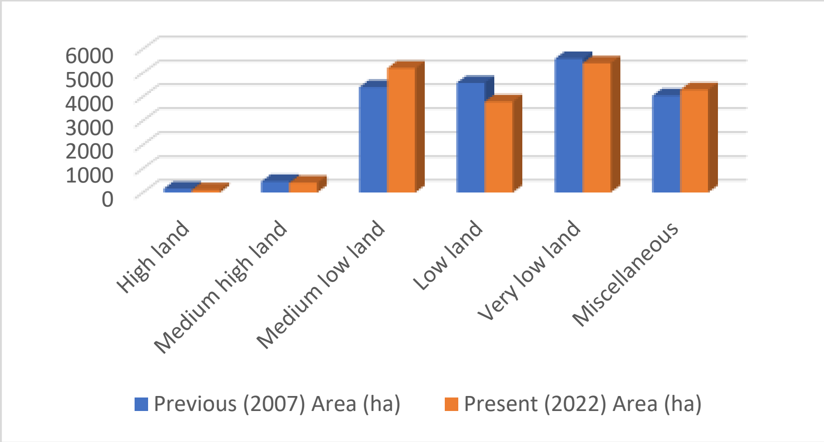


Fig. Comparison of Land type between 2007 and 2022 of Sreenagar upazila

Changes in Land Use:

Land Use	2007 (year)		2022(year)		% increase/ decrease	Possible Reasons
	Area (ha)	%	Area (ha)	%		
Boro- Fallow- Fallow	11556	60.07	11920	61.96	1.89	Land use pattern has been changed due to change of socio-economic condition of the people
Boro- Fallow- T. Aman	151	0.78	210	1.10	0.32	
Rabi crops- T. Aus- T. Aman	654	3.40				
Mustard- Boro- Fallow	433	2.25	378	1.96	-0.29	
Grasspea- B. Aman	478	2.48				
Rabi crops- B. Aus	300	1.56				
Rabi crops- Mixed B. Aus & Aman	224	1.16				
Rabi crops- Aus/ Jute/ Sesame	261	1.36				
Potato- Jute/ Sesame	262	1.37				
Grasspea- Boro (Modern)	131	0.68				
Rabi crops/ Rabi vegetables- Fallow- T. Aman	139	0.72				
Potato- Fallow- B. Aman			720	3.74		
Potato- Maize- Fallow			645	3.35		
Maize- Fallow- B. Aman			378	1.96		
Mustard- Fallow- Fallow			375	1.95		
Rabi vegetables- Kharif vegetables			95	0.50		
Others	605	3.14	223	1.16	-1.98	
Miscellaneous	4045	21.03	4295	22.32	1.29	
Total	19239	100	19239	100		

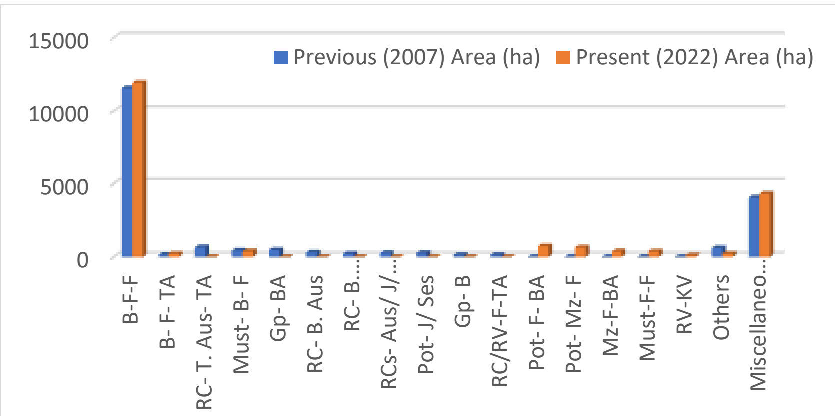


Fig. Comparison of Land use between 2007 and 2022 of Sreenagar upazila

Major findings Purbadhala, Netrokona

i) Total area- 31,442 ha
ii) Total sample collected- 147
iii) Physiography & AEZ code- Old Brahmaputra Floodplain (AEZ 9)
Northern and Eastern Piedmont Plain (AEZ-22)
iv) Major land type- High land, Medium High land, Medium Low land, Low land & Very Low land.
v) Major soil group- Sunatola, Silmondi, Lookdew, Ghatail, Shemgonj, Balina, Mohanganj, Kangsha, Susang, Chinakuri.

Changes in Land Type

Land type	Previous (Year 2009)		Present (Year 2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	11218	35.7	11002	35.0	-0.7	Land type Calculation using digital mapping
Medium Highland	8292	26.4	8268	26.3	-0.1	
Medium Lowland	4479	14.2	4599	14.6	+0.4	
Lowland	1257	4.0	1289	4.1	+0.1	
Very lowland	413	1.3	408	1.3	-	
Miscellaneous	5783	18.4	5876	18.7	+0.3	
Total	31442	100	31442	100	0	

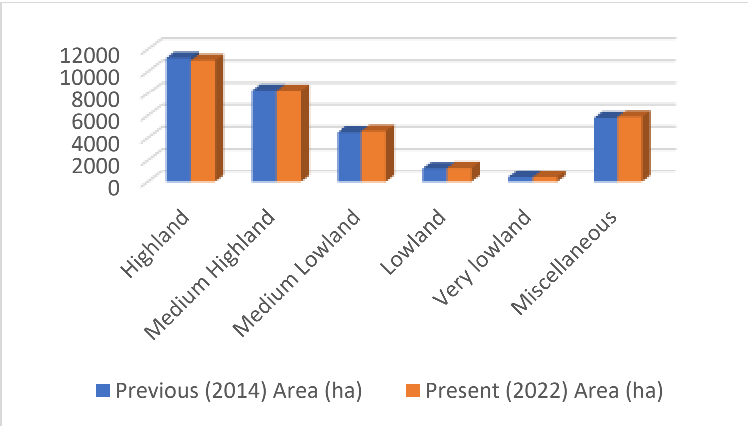


Fig. Comparison of Land type between 2009 and 2022 of Purbadhala upazila

Changes in Land Use

Land Use	Previous (Year 2009)		Present (Year 2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1. Musterd-Boro-Taman	757	2.40	786	2.5	+ 0.1	This overall change in crop arrangement has been observed based on the changes in socio-economic status of the farmers & their needs.
2. Potato-Boro-Taman	639	2.03	630	2.0	- 0.03	
3. Wheat-Fellow-Taman	639	2.03	315	1.0	- 1.03	
4. Boro-Fellow-Taman	14589	46.40	15375	48.9	+ 2.5	
5. Boro-Fellow-Fellow	6149	19.56	6195	19.7	+ 0.14	
6. Musterd-Fellow-Taman	639	2.03	1415	4.5	+ 2.47	

7. Robi-Fellow -T aman	1277	4.06	314	1.0	- 3.06	
8. Fellow-TAus-Taman	970	3.09	536	1.7	- 1.39	
Miscellaneous	5783	18.40	5876	18.7	+ 0.3	
Total	**31442**	**100**	**31442**	**100**	**0**	

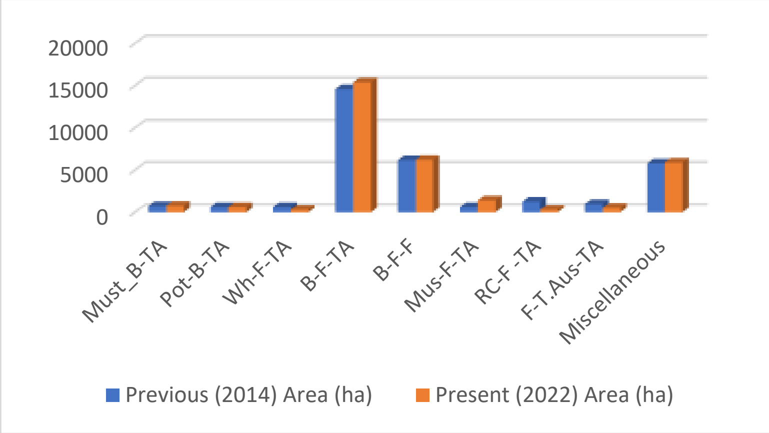


Fig. Comparison of Land use between 2009 and 2022 of Purbadhala upazila

Major findings of Belabo upazila, Narsingdi

i)Total area- 11768Ha

ii)Total sample collected - 186

iii) Physiography & AEZ code- (a) Madhupur tract (28)

(b) Old Brahmmaputra Flood Plains (9)

iv) Major land type- Hill, High land, Medium High Land, Medium Low land

v) Major soil group- Tejgaon, Belabo, Noadda, Kalma, Khilgaon, Sonatala, Tengarchar, silmondi,Nraibagh, Khalerchar, Ghorargaon

Change in Land Type

Slope class/Land type	Previous (2014)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	3430	29.15	3352	28.48	0.67	
Medium Highland	4140	35.18	4015	34.12	1.06	Settlement due to industrialization and urbanization
Medium Lowland	1756	14.92	1614	13.72	1.2	
Lowland	171	1.45	150	1.27	0.18	
Miscellaneous	2271	19.3	2637	22.41	-3.11	
Total	11768	100	11768	100		

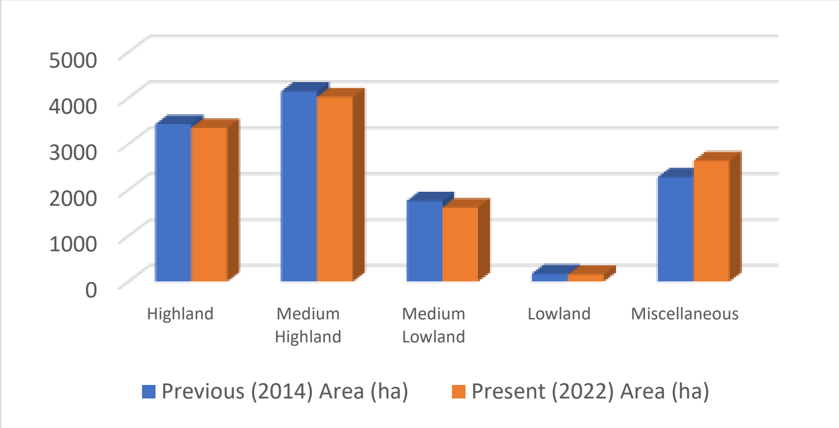


Fig. Comparison of Land type between 2014 and 2022 of Belabo upazila

Change in Land Use

Sl. No	Land Use	Previous (2014)		Present (2023)		% increase/ decrease	Possible reasons
		Area (ha)	%	Area (ha)	%		
1.	Ginger/Turmeric/S.cane /Pineapple	756	6.42	552	4.69	1.73	
2.	Fruit orchards (lotkon, banana, guava, Jackfruit, lemon) and forest trees	426	3.62	560	4.76	-1.14	
3.	Rabi vegetables (bean, potato/cabbage/cauliflower/eggplant) - Kharif vegetables (bitter gourd etc.)	1770	15.04	1800	15.3	-0.26	
4.	Robi Vege - F - T Aman	142	1.21	140	1.19	0.02	
5.	Boro - F - T Aman	3632	30.86	3589	30.5	0.36	
6.	Jute -F _ T.Amon	380	3.23	230	1.95	1.28	
7.	B - F – F	1927	16.37	1900	16.15	0.22	
8.	Robi crops (Mustard, Wheat) – T Amon	136	1.16	150	1.27	-0.11	
9.	Miscellaneous cropping pattern	328	2.79	210	1.78	1.01	
10.	Miscellaneous	2271	19.3	2637	22.41	-3.11	
11.	Total	11768	100	11768	100	0	

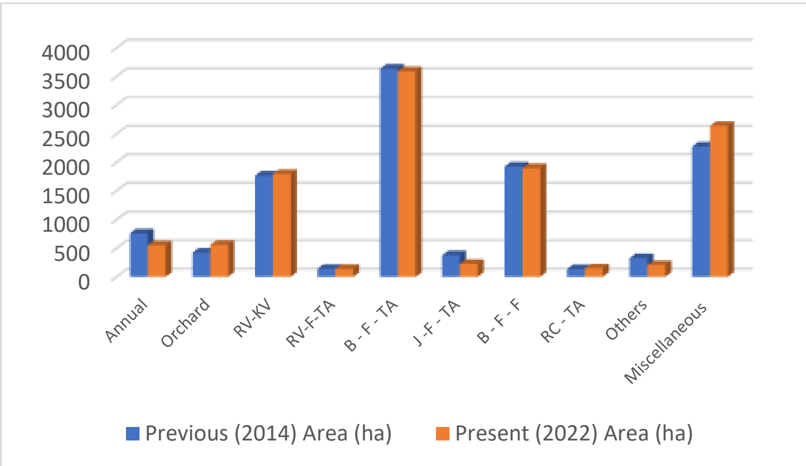


Fig. Comparison of Land use between 2014 and 2022 of Belabo upazila

Major findings of Dumki upazila, Patuakhali

i) Total area- 9513 ha
ii)Total sample colleted- 63
iii)Physiography& AEZ code-Gangage tidal Floodplain (13)
iv)Major land type-Highland&
Medium Highland
v)Major soil group-Ramgoti
Jhalokati
Barishal&
Ganges Katal Polimati

Changes in Land Type

Land type	Previous (2007)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	112	1.2	240	2.5	(+) 1.3	Raised land as cultivable land converted into homestead garden, orchard and settlement
Medium Highland	6,460	68	5,442	57.2	(-) 10.8	
Miscellaneous	2,941	30.8	3,831	40.3	(+) 9.5	Gain of area due to homestead garden, orchard and settlement
Total	9,513	100	9,513	100		

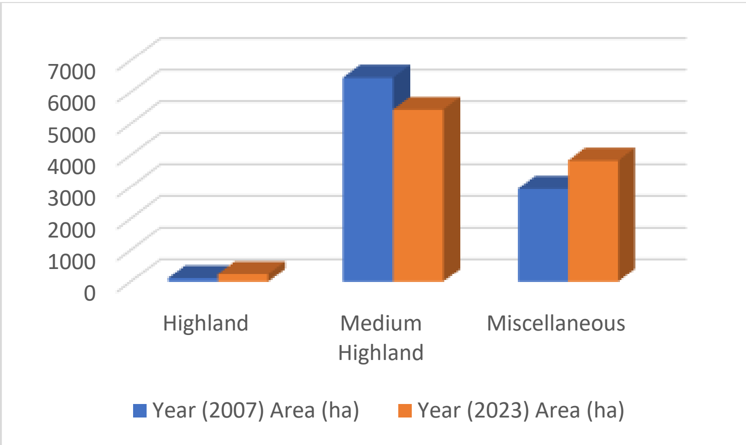


Fig. Comparison of Land type between 2007 and 2023 of Dumki upazila

Changes in Land Use

Land Use	Previous (year)		Present (year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
RC (Mung/ Khesari/Chili) – T.Aus - T.A	1072	11.3	1155	12.1	(+)0.8	
RC (Mung/Felon/Sunflower/Watermelon) – F -T.Aman	1799	18.9	2936	30.9	(+) 12.0	
Winter veg.- Summer veg.-T.Aman	200	2.1	414	4.3	(+) 2.2	Higher return from vegetables
F- F- T. Aman	845	8.9	400	4.2	(-) 4.7	
F- T. Aus- T.Aman	2235	23.5	577	6.1	(-) 17.4	Lack of irrigation

Others	421	4.4	200	2.1	(-) 2.3	
Miscellaneous	2941	30.9	3,831	40.3	(+)9.4	
Total	9513	100	9513	100		

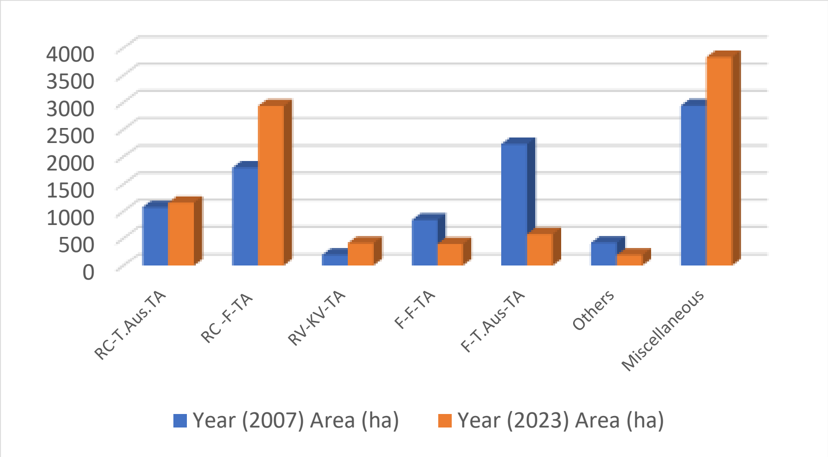


Fig. Comparison of Land use between 2007 and 2023 of Muktagacha upazila

Major findings of Mirzagonj upazila, Potuakhali

i) Total area- 17552 hectare

ii) Total sample collected- 81

iii) Physiography & AEZ code- Ganges Tidal Floodplain (13)

iv) Major land type- Medium High Land

vii) Major soil group- Ramgati, Jhalakati, Barishal & Ganges Polymati

Changes in Land Type

Land type	2009 (Year)		2023(Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	403	2.3	363	2.1	-0.2	-Increased homestead area -Urbanization -River erosion Conversion of Ag. Land to non-Ag. Land.
Medium Highland	11377	64.8	10869	61.9	-2.9.	
Miscellaneous	5772	32.9	6320	36	3.1	
Total	17552	100	17552	100		

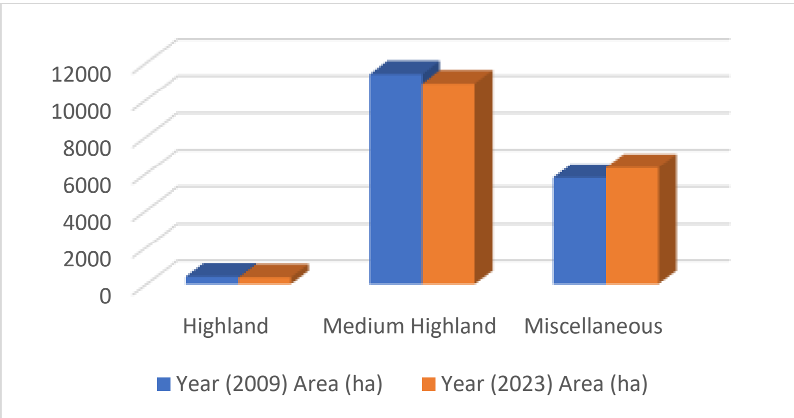


Fig. Comparison of Land type between 2009 and 2023 of Mirzaganj upazila

Changes in Land Use

Land Use	2009		2023		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Rabi & Kharif Vegetables	-	-	59	0.3	0.3	-Socio economic transformation -Govt. imitative & incentives - Availability of short duration variety and seeds of T Aus rice
RC – TAU - TA	1297	7.4	1948	11.1	3.7	
F – TAU -TA	2509	14.3	4197	23.9	9.6	
RC – F - TA	4840	27.6	2224	12.7	-14.9	
F – F - TA	2731	15.6	2441	13.9	-1.7	
Homestead Soil	403	2.3	363	2.1	0.2	
Miscellaneous	5772	32.9	6320	36.0	3.1	
Total	17552	100.0	17552	100.0		

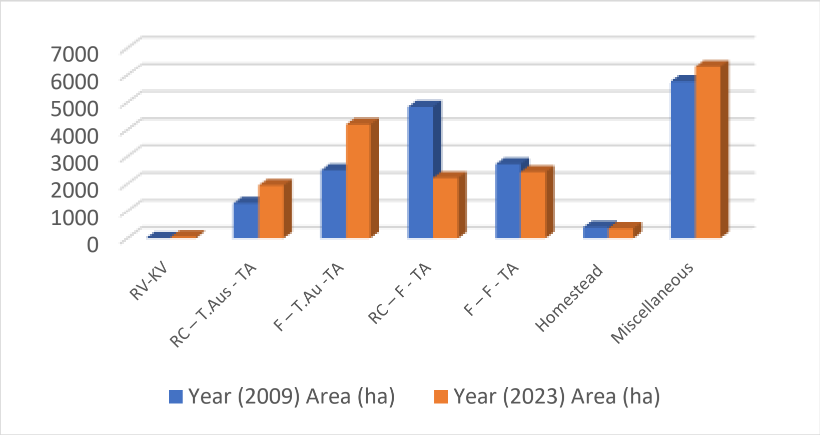


Fig. Comparison of Land type between 2009 and 2023 of Mirzaganj upazila

Major findings of Indurkani upazila, Pirojpur

i) Total area- 10,358 ha
ii)Total sample colleted- 60
iii)Physiography & AEZ code- Ganges Floodplain (12) and Ganges Tidal Floodplain (13)
iv)Major land type- Medium Highland
v)Major soil group- Sara, Muladi, Mehendigonj, Ramgati, Jhalakati, Barisal, Polimati
Changes in Land Type

Land type	Previous (2010)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	350	3.4	312	3.0	-0.4	Cultivable land converted into homestead garden, orchard and settlement
Medium Highland	6,271	60.5	5307	51.2	-9.3	
Miscellaneous	3,737	36.1	4739	45.8	+9.7	Gain of area due to homestead garden, orchard and settlement
Total	10,358	100.0	10,358	100.0	-	

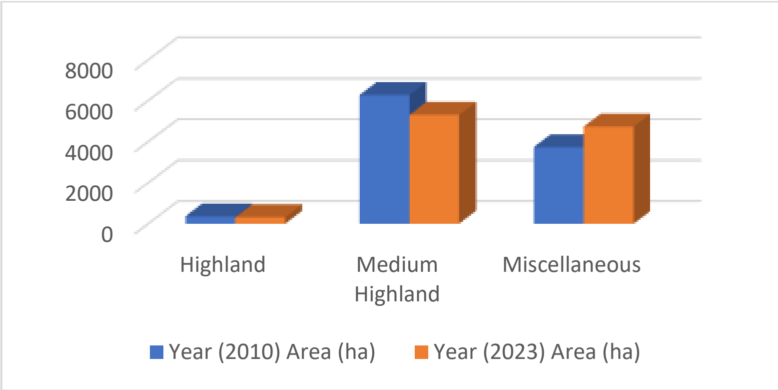


Fig. Comparison of Land type between 2010 and 2023 of Indurkani upazila

Changes in Land Use

Land Use	Previous (2010)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1. RV-KV	235	2.3	310	3.0	+0.7	
2. B-F-TA	903	8.7	1115	10.8	+2.1	Increased irrigation facility
3. RC- T.Aus- TA	735	7.1	1087	10.5	+3.4	
4. F-T.Aus- TA	3684	35.6	1921	18.5	-17.1	
5. RC-F- TA	312	3.0	507	4.9	+1.9	
6. F-F-TA	527	5.0	325	3.1	-1.9	
8. Others	225	2.2	354	3.4	+1.2	
***Miscellaneous	3,737	36.1	4739	45.8	+9.7	
Total	10,358	100.0	10,358	100.0	-	

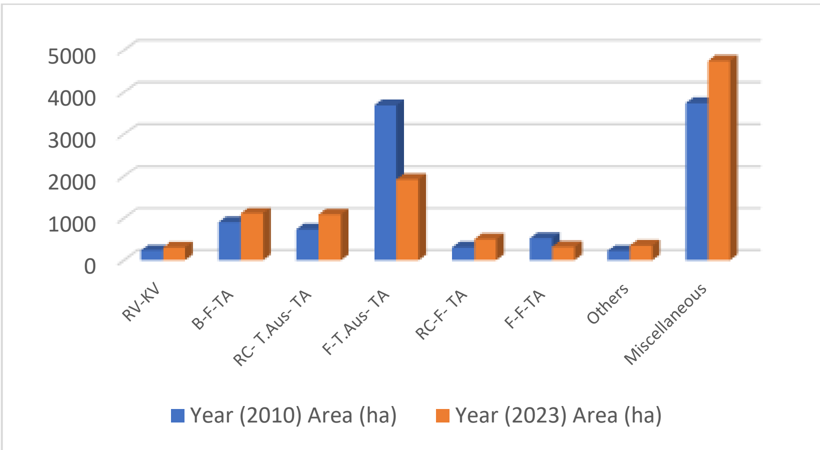


Fig. Comparison of Land use between 2010 and 2023 of Indurkani upazila

Major findings of Babugonj upazila, Barishal

i) Total area-15, 247 hectares
ii) Total sample colleted-111
iii) Physiography & AEZ code- Ganges floodplain (12) and Ganges tidal floodplain (13)
iv) Major land type- High land, Medium High land, Medium Low land and Very low land

v) Major soil group-Sara, gopalpur, hijla. Joyonti, muladi, mehendigonj, baliyakandi, ramgoti, jhalokati, barisal.

Change in Land Type

Land type	Previous (1999)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
High land	1,733	11.4	1,451	9.5	-16.27	Settlement area increased
Medium High land	8,904	58.4	5,483	36.0	-38.42	
Medium Low land	475	3.1	525	3.4	+10.5	
Very low land	-	-	-	-	-	
Miscellaneous	4,135	27.1	7,788	51.1	+88.3	
Total	15,247	100.0	15,247	100.0		

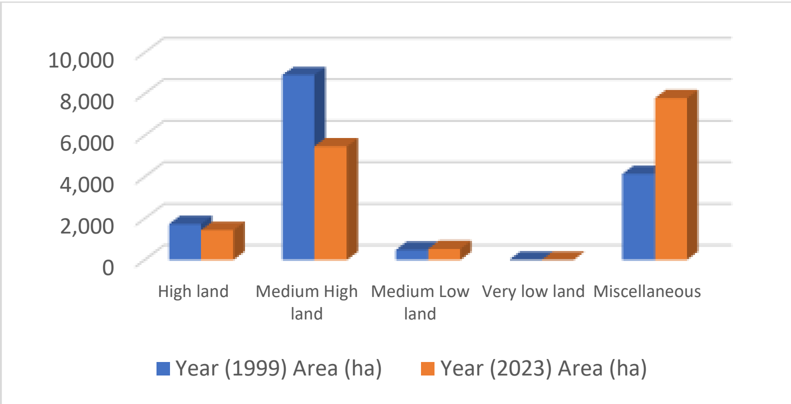


Fig. Comparison of Land type between 1999 and 2023 of Babuganj upazila

Change in Land Use

Land Use	Previous (1999)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Annual	217	1.4	301	1.97	+38.70	
2.Perinnial	-	-	36	0.23	+100	
3.RV-KV	-	-	186	1.20	+100	
4. RC-Jute-TA			2,928	19.21	+100	
5. RC-F-TA	1,654	10.84	722	4.73	-56	
6.B- F-TA	1,643	10.77	1,984	13.01	+20.75	
7.F-F- TA	2,134	13.99	-	-	-100	
8. B- F-F	227	1.5	109	0.71	- 51.98	
9.RC-BA-TA	755	4.96	-	-	-100	
Miscellaneous	4,135	27.1	7,788	51.1	+88.3	
Total	15,247	100.0	15,247	100.0		

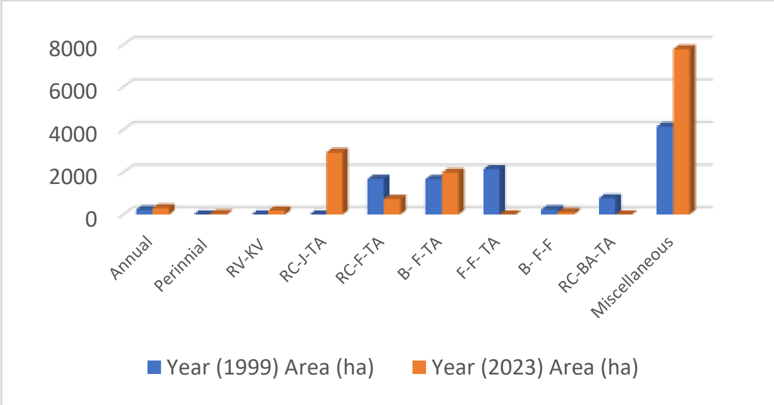


Fig. Comparison of Land use between 1999 and 2023 of Babuganj upazila

Major findings of Ashuganj upazila, Brahmanbaria

i) Total area-6,759 ha
ii) Total sample collected-62
iii) Physiography & AEZ code - a) Old Meghna Estuarine Floodplain (AEZ-19)
b) Middle Meghna River Floodplain (AEZ-16)
iv) Major land type - Medium High land, Medium Low land Low land
v) Major soil group - Chandina, Debidwar, Burichong, Meghna sand silt,Meghna loam silt

Change in Land Type

Land type	Previous (2009)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
High land	253	3.74	203	3.00	(-) 0.74	Due to new roads, homesteads and decrease of annual rainfall
Medium High land	1,463	21.64	1,552	22.96	(+) 1.32	
Medium Low land	3,368	49.82	3,257	48.18	(-) 1.64	
Low land	459	6.80	456	6.75	(-) .05	
Miscellaneous	1,216	18.00	1,291	19.11	(+) 1.11	
Total	6,759	100.0	6,759	100.0	0.00	

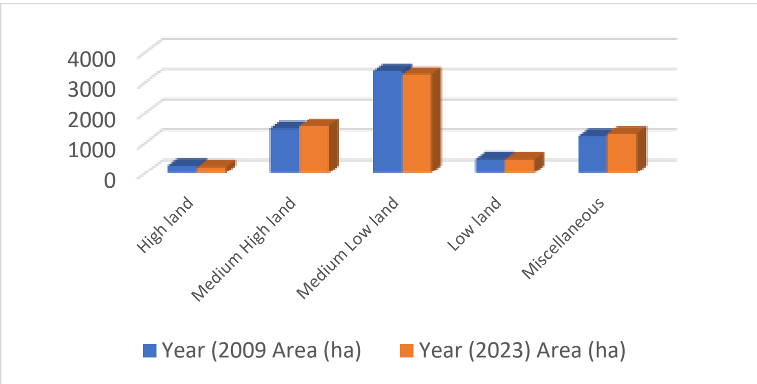


Fig. Comparison of Land type between 2009 and 2023 of Ashuganj upazila

Change in Land Use

Land Use	Previous (2009)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Homestead Vegetables	253	3.74	203	3.00	(-) 0.74	Due to changes of land type
2. Rabi Vegetables-Boro-T. Aman	635	9.40	641	9.48	(+) 0.08	
3 Boro-T. Aus-T. Aman	193	2.86	270	3.99	(+) 0.13	
4. Boro (Modern)-F-T.Aman	635	9.39	641	9.48	(+) 0.09	
5. Boro-F-T.Aman	253	3.74	270	3.99	(+) 0.25	
6. Rabi Vegetables-F-T Aman	253	3.74	270	3.99	(+) 0.25	
7. Rabi Vegetables-F-B. Aman	382	5.65	371	5.49	(-) 0.16	
8. Boro (HYV) -F-F	1716	25.39	1604	23.73	(-) 1.66	
9.Boro (HYV) -F- B. Aman	764	11.30	742	10.98	(-) 0.32	
10.Rabi Vegetables-F-F	138	2.04	137	2.03	(-) 0.01	
11.Boro (Local)-F-F	321	4.75	319	4.73	(-) 0.02	
Miscellaneous	1216	18.00	1,291	19.11	(+) 1.11	
6,759	100.0	6,759	100.0	0.00		

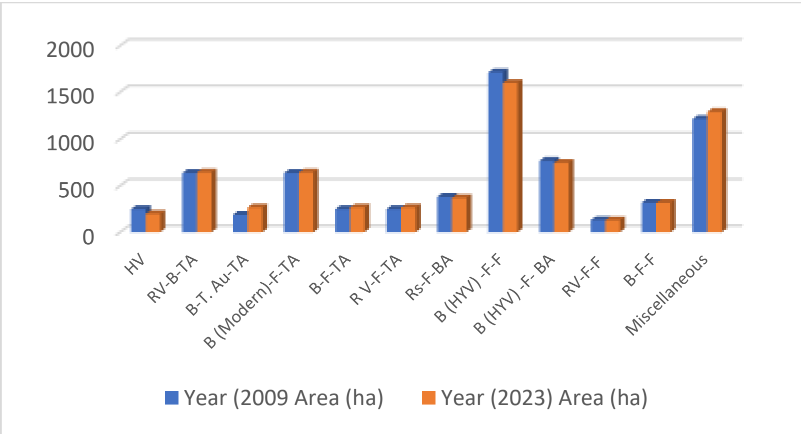


Fig. Comparison of Land use between 2009 and 2023 of Ashuganj upazila

Major findings of Sarail upazila, Brahmanbaria

i) Total area-21,530 ha

ii) Total sample collected-120

iii) Physiography & AEZ code - a) Old Meghna Estuarine Floodplain (AEZ-19)
b) Middle Meghna River Floodplain (AEZ-16)
c) Sylhet Basin (AEZ-21)

iv) Major land type - High Land, Medium High land, Medium Low land, Low land, Very Low land.

v) Major soil group - Chandina, Debidwar, Burichong, Tangerchar, Fuldi, Borda,Balaganj, Titas, Fagu, Nasirnagar, Nabinagar.

Change in Land Type

Land type	Previous (2009)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
High land	127	0.59	137	0.64	(+) 0.05	Due to new roads, homesteads and decrease of annual rainfall
Medium High land	3,873	17.99	3,993	18.55	(+) 0.56	
Medium Low land	5,789	26.89	5,820	27.03	(+) 0.14	
Low land	3,617	16.80	3,616	16.79	(-) 0.01	
Very low land	4,082	18.96	3,887	18.05	(-) 0.91	
Miscellaneous	4,042	18.77	4,077	18.94	(+) 0.17	
Total	21,530	100.0	21,530	100.0	0.00	

Change in Land Use

Land Use	Previous (2009)		Present (2023)		% increase/ Decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Homestead Vegetables	267	1.24	270	1.25	(+) 0.01	Due to changes of land type
2. Rabi and kharif Vegetables	127	0.59	137	0.64	(+) 0.05	
3. Boro-T. Aus-T. Aman	506	2.35	547	2.54	(+) 0.19	
4.Mustard - Boro -T.Aman	253	1.17	273	1.27	(+) 0.10	
5. Boro-F-T.Aman	2042	9.48	2039	9.47	(-) 0.01	
6. Boro-F-B.Aman	96	0.44	96	0.44	0	
7. Rabi Vegetables-F-T Aman	721	3.35	673	3.13	(-) 0.22	
8. Rabi Vegetables-F-B. Aman	290	1.35	269	1.25	(-) 0.20	
9. Rabi Vegetables-Jute/Dhaincha-F	98	0.46	96	0.44	(-) 0.02	
10. Rabi Vegetables-F-T Aman	321	1.50	273	1.27	(-) 0.33	
11.Boro -F- T. Aman	2239	10.40	2920	13.56	(+) 3.16	
12.Mustard - Boro -F	1252	5.82	1154	5.36	(-) 0.46	
13. Boro -F-F	819	3.80	591	2.75	(-) 1.05	
14. Boro-F-B.Aman	386	1.79	375	1.74	(-) 0.05	
15. Rabi Vegetables-F-B. Aman	386	1.79	507	2.36	(+) 0.57	
16.Boro -F-F	2518	11.69	2011	9.34	(-) 2.35	
17.Mustard - Boro -F	430	2.00	591	2.75	(+) 0.75	
18.Boro-F-B. Aman	547	2.54	559	2.60	(+) 0.06	
19.Rabi Vegetables-F-F	335	1.56	455	2.11	(+) 0.55	
20.Boro -F-F	3640	16.91	3430	15.93	(-) 0.98	
21.Boro (Local) -F-F	482	2.24	457	2.12	(-) 0.12	
Miscellaneous	3775	17.53	3807	17.68	(+) 0.15	
Total	21,530	100.0	21,530	100		

Major findings of Begumgonj, Noakhali

i) Total area - 23,766 ha
ii) Total sample collected - 125
iii) Physiography & AEZ code - a) Old Meghna Estuarine Floodplain (AEZ 19)
iv) Major land type - Medium Highland, Medium Lowland, Lowland.
v) Major soil group - Chandina, Chandrogonj, Ciloniya, Debidwar, Burichang,

Change in Land Type:

Land type	Previous (2004)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	497	2.09	554	2.33	+0.24	Due to new roads, homesteads and decrease of annual rainfall
Medium Highland	4883	20.55	4100	17.25	-3.30	
Medium Lowland	11731	49.36	11911	50.12	+0.76	
Lowland	1086	4.57	951	4.00	-0.57	
Miscellaneous	5569	23.43	6250	26.30	+2.87	
Total	23766	100.00	23766	100.00		

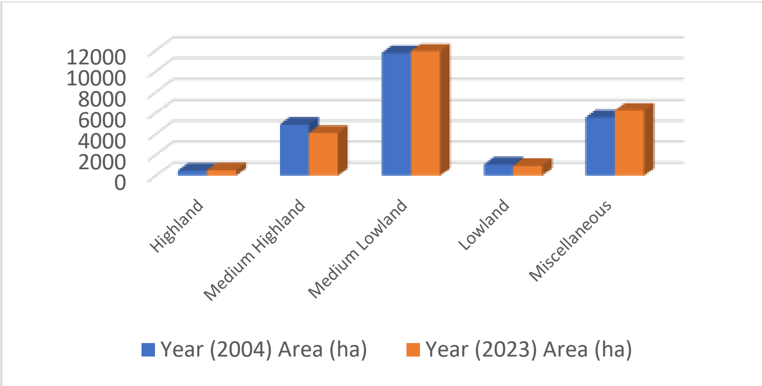


Fig. Comparison of Land type between 2004 and 2023 of Begumganj upazila

Change in Land Use:

Land Use	Previous (2004)		Present (2023)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Rabi Vegetables-Kharif Vegetables	497	2.09	554	2.33	+0.24	Due to changes of land type.
2. Rabi Crops –T.Aus-T. Aman	642	2.71	539	2.27	-0.44	
3. Rabi Crops –F - T. Aman	490	2.06	411	1.73	-0.33	
4.Boro – F – T. Aman	1077	4.53	905	3.81	-0.72	
5. Boro – F – F	2674	11.25	2245	9.44	-1.81	
1. Boro – F – F	11731	49.36	11911	50.12	+0.76	
1. Boro – F – F	1086	4.57	951	4.00	-0.57	
Miscellaneous	5569	23.43	6250	26.30	+2.87	
Total	23766	100.00	23766	100.00		

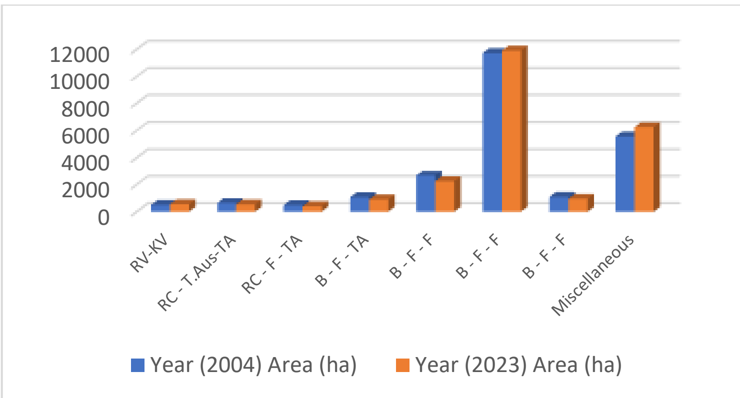


Fig. Comparison of Land use between 2004 and 2023 of Muktagacha upazila

Major findings Porshuram Upazila, Feni

i) Total area - 9830 ha
ii)Total sample collected - 59
iii) Physiography & AEZ code - Northen Eatern Hills and Northern Eastern Piedmont Plain
iv)Major land type - High Land
v)Major soil group – Shalbon, Rangamati, Bajipur, Pahartoli, Pritimpasha

Changes in Land Use

Land Use	Previous (2008 Year)		Present (2023 Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Annual Crops(Jackfruits/Litchi/Mango/ Eukalyptus/gamari/shishu/chapalish/shegun and other fruits orchard	418	2.1	491	5.0	2.9	Due to increased crop intensity
Rabi Vegetables-Kharif Vegetables	2073	10.3	1966	20.0	9.7	
Rabi crops-Seedbed-T. aman	653	3.3	491	5	1.7	
Boro-Fellow-T. Aman	12429	61.9	4915	50	-11.9	
Fellow – Fellow-T.Aman	1037	5.2	197	2	3.2	
Other Croping Pattern	568	2.8	295	3	0.2	
Miscellaneous (Homestead/Water bodies /Garden etc)	2888	14.4	1475	15	0.6	
Total	20,066	100	9830	100		

N.B. As Fulgazi Upazila is separated from Porshuram Upazila, the size of Porshuram Upazila has decreased.

Major findings of Khagrachari Sadar upazila, Khagrachari

i) Total area-29,587 ha
ii)Total sample colleted-203
iii)Physiography & AEZ code - Norther and eastern hill (29)
iv)Major land type - Highland, Medium Highland
v)Major soil group - Tamabil, Dhum, Sitakunda, Barkal, Suvolong, Kuholong, Ghaghra, Khadimnagar, Shalban, Lama, Nalua, Rangamati, Kassalong, Karnofuli, Ruma, Mirsarai, Maghachhari
Changes in Land Type:

Land type	2010 (Year)		2022(Year)		% increase(+)/ decrease(-)	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	24,606	83.2	24506	82.8		
Medium Highland	1,367	4.6	1,367	4.6		
Miscellaneous	3614	12.2	3714	12.6		
Total	29,587	100	29,587	100		

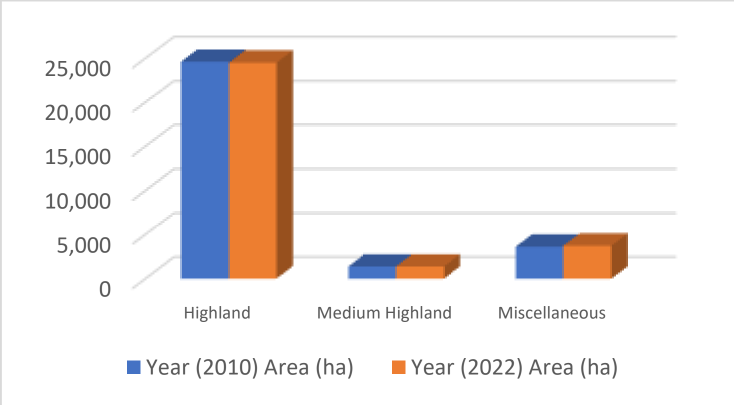


Fig. Comparison of Land type between 2010 and 2022 of Khagrachari sadar upazila

Changes in Land Use

Land use	2010		2022		% increase (+)/ Decrease (-)	Possible Reasons
	Area (Ha)	%	Area (Ha)	%		
Forest	10202	34.5	7841	26.5	8% (-)	Converted to orchard
Orchard	2387	8.1	6952	23.5	15% (+)	Orchard increases due to economic benefit
Jum and annual crop	1917	6.5	1479	5	1.5% (-)	Jum plot reduced converted to orchard
Fallow	7579	25.6	4723	15.9	9.3% (-)	Converted to orchard
Annual crop	1063	3.6	1479	5	1.4 % (+)	increase due to economic benefit
Rc- F - TA	851	2.9	1479	5	2.1 (+)	Increases Boro rice cultivation due to high yield
Rc-Kharif Veg-TA	607	2.1	592	2		
Rc- TAus-TA	304	1	296	1		
Boro (HYV)-F-TA	607	2.1	592	2		
F – TAus- TA	456	1.5	440	1.5		
Miscellaneous	3614	12.2	3714	12.6		
Total	29587	100	29587	100		

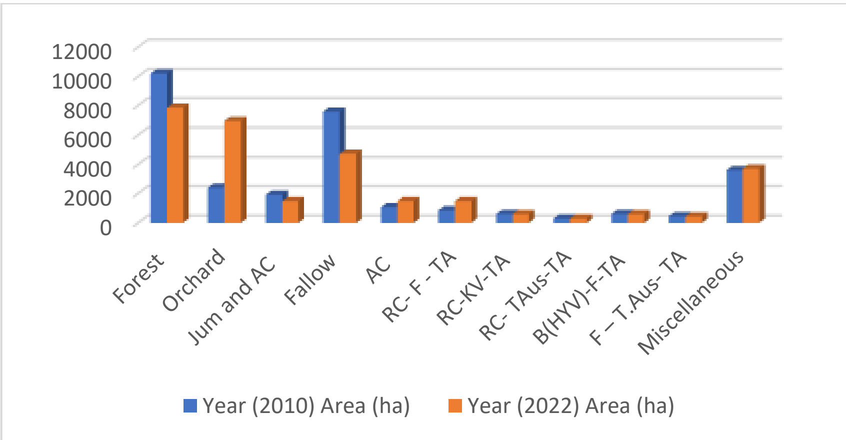


Fig. Comparison of Land type between 2010 and 2022 of Khagrachari sadar upazila

Major findings of Gangni upazila, Meherpur

i) Total area- 33,932 ha
ii) Total sample collected- 120
iii) Physiography & AEZ code- Ganges Floodplain and AEZ 11
iv) Major land type- Highland, Medium Highland, Medium Lowland, Lowland
v) Major soil group- Sara, Gopalpur, Ishurdi, Ghior, Ramdia
Changes in Land Type

Land type	Previous (2002)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	15,225	44.9	13,857	40.84	-9.04	
Medium Highland	11,829	34.9	11,768	34.68	-0.63	
Medium Lowland	2,112	6.2	1,633	4.81	-22.42	
Lowland	34	0.1	34	0.1	-	
Very lowland	-	-	-	-	-	
Miscellaneous	4,732	13.9	6,640	19.57	+40.79	
Total	**33,932**	**100.0**	**33,932**	**100.0**		

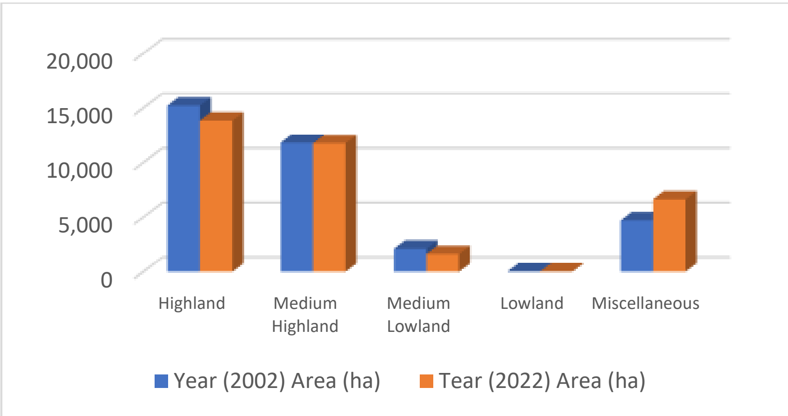


Fig. Comparison of Land type between 2002and 2022 of Gangni upazila

Changes in Land Use

Land Use	Previous (2002)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Annual	1,380	4.1	1,775	5.2	+26.83	
Perennial	-	-	1,330	3.9	-	
Miscellaneous	4,732	13.9	6,640	19.60	+41	
Rabi vegetables-Kharif vegetables	912	2.7	1,780	5.3	+96.30	
Rabi crops-Fallow-T. Aman	6,662	19.6	1,115	3.3	-83.16	
Rabi crops/Boro-Jute-T. Aman	5,226	15.4	5,100	15	-2.60	

Rabi crops/Boro-Jute-Fallow	1,825	5.3	440	1.3	-75.47	
Boro-Fallow-T. Aman	8,433	24.9	3,325	9.8	-60.64	
Tobacco-Fallow-T. Aman	1,928	5.7	890	2.6	-54.39	
Khesari/Pea/Boro-Fallow-B. Aman	1,682	5	-	-	-	
Boro (Local/HYV)-Fallow-Fallow	987	2.9	440	1.3	-55.17	
Maize-Cotton	-	-	665	2	-	
Wheat-Jute-Rice/T. Aman	-	-	9,980	29.4	-	
Others	165	0.5	452	1.3	+160	
Total	**33,932**	**100.0**	**33,932**	**100.0**		

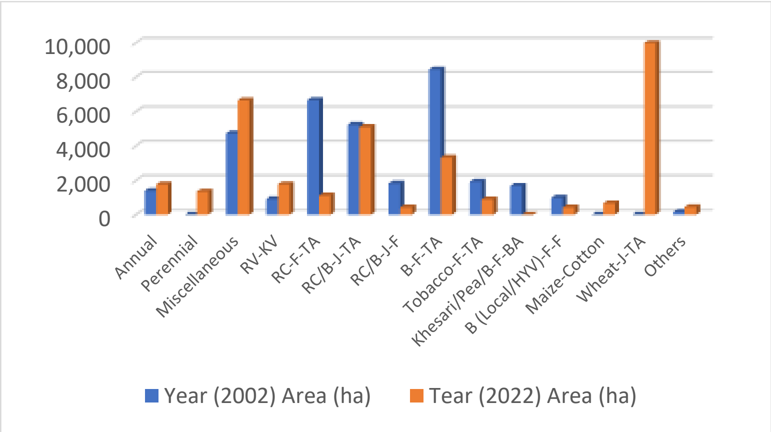


Fig. Comparison of Land type between 2002 and 2022 of Gangni upazila

Major findings of Puthia Upazila, Rajshahi

i) Total area - 19,264 ha,
ii)Total sample collected - 91
iii)Physiography & AEZ code - High Ganges flood plain (11)
iv)Major land type - High Land
v)Major soil group - Sara

Changes in Land Type

Land type	Previous (2009 Year)		Present (2023 Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	9071	47.10	8729	45.3	-3.8	Due to settlement and other manmade activities.
Medium High land	5356	27.8	5696	29.6	6.3	
Medium Low land	1857	9.6	1487	7.7	-19.9	
Low land	224	1.2	264	1.4	17.9	
Miscellaneous	2756	14.30	3088	16.0	12.0	
Total	16,264	100.00	16,264	100		

Changes in Land Use

Land Use	Previous (2009 Year)		Present (2023 Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Mango and other fruits orchard+ Onion/Garlic/Mustard/Lentil	974	5.1	15411	8.0	2.9	Due to increased crop intensity
Sugarcane+ Onion/ Garlic/Mustard/Lentil	5612	29.1	3853	20.0	-9.1	
RV-KV	258	1.3	578	3.0	1.7	
Onion/Tomato/Mustard/Potato-Boro-T. Aman	2019	10.5	2119	11.0	0.5	
Onion/Wheat/Lentil-Maize/Mungbean-T.Aman	128	0.7	193	1.0	0.3	
Potato/Mustard/Wheat/Maize/Onion-T.Aus/Mungbean/Jute-T.Aman	1555	8.1	2023	10.5	2.4	
Boro/Lentil/Potato/Wheat/Onion-Fallow-T.Aman	769	4.0	963	5.0	1.0	
Boro- Fallow-T.Aman	1967	10.2	1156	6.0	-4.2	
Boro/Wheat/Onion-T.Aman/Jute-Fallow	886	4.6	963	5.0	0.4	
Garlic/Onion/Masturd-Boro-Fallow	560	2.9	482	2.5	-0.4	
Boro-Broadcast Aman	720	3.7	674	3.5	-0.2	
Garlic/Onion/ Boro-Fallow-Fallow	996	5.2	963	5.0	-0.2	
Other cropping patterns	64	0.3	668	3.47	3.1	
Miscellaneous						
Settlement	2501	13.0	2626	13.6	0.65	Due to manmade activities (road, culvert, bridges fisheries etc)
Homestead (Vitimati)	278	1.4	292	1.5	0.07	
River	64	0.3	58	0.3	-0.03	
Pond	30	0.2	192	1.0	0.84	
Water bodies	97	0.5	85	0.4	-0.06	
Others	64	0.3	127	0.7	+0.03	
Miscellaneous (Total)	3034	15.75	3380	17.77	+2.02	
Total	19,264	100	19,264	100		

Major findings of Paba Upazila, Rajshahi

i) Total area- 28,616 ha,
ii)Total sample collected- 114
iii)Physiography & AEZ code - Barind Tract (27), High Ganges flood plain (11,10)
iv)Major land type- High Land
v)Major soil group - Amnura, Ekdala, Ryana, Sara, Gopalpur, Ishurdi, Ghior.

Changes in Land Type

Land type	Previous (Year 2008)		Present (Year 2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	12,989	43.6	13,154	45.9	+ 2.3	Some medium low lands are converted to settlement and Some medium low and low land area has been included in the fisheries culture.
Medium High land	6,157	20.7	5,725	20.	-0.7	
Medium Low land	3,551	11.9	194	01	+10.9	
Low land	958	3.2	-	-	-3.2	
Miscellaneous	4,496	15.1	8,195	28.6	+13.5	
Total	29,783	100%	28,616	100%		

Change in Land Use

Cropping pattern (2008)	Cropping pattern (2022)	Year 2008		Year 2022		% increase/ decrease	Possible reasons
		Area (ha)	%	Area (ha)	%		
Boro- Fallow-T.Aman	Boro- Fallow- T.Aman	5,933	20.0	892	3.1	-16.9	Climate change, technological development, socio-economic condition of the farmers.
Boro- Fallow- Fallow	-	3,433	11.5	-	-	-	
Potato- Maize/Jute- T.Aman	Rabi crops (Mustard/ Potato /Wheat/ Maize [rabi]/ Rabi vegetables- Maize/Jute- T.Aman	2,912	9.8	2231	7.8	-2.0	
Potato- Fallow-T.Aman	Potato /Mustard- Fallow-T.Aman	2,324	7.8	1041	3.6	-4.2	
Sugarcane-Onion- Fallow	Sugarcane + relay crop (Onion/ Lentil etc.)	1,643	5.5	892	3.1	-2.4	
Rabi vegetables (Brinjal/Tomato)- Kharif vegetables (Bottle gourd/Bitter gourd/Pointed gourd)	Rabi vegetables (Cabbage/Cauliflower/Radish/Brinjal /Tomato/Bean/Chilli)- Kharif vegetables (Lady's finger/ Bottle gourd/Bitter gourd/Pointed gourd/Basil etc.)	1,641	5.5	3,123	10.9	+5.4	
Rabi crops (Wheat/Onion/Potato)- Fallow/Sesame- T.Aman	Rabi crops (Mustard/Potato)- Boro-T.Aman	1,376	4.6	4,313	15.1	+10.5	
Mango/Jackfruit/Lichi/ Ber/Bettel leaf vine	Fruit Orchard (Mango/Jackfruit/ Lichi/Ber/Banana/ Papaya etc.	364	1.2	1,633	5.8	+6.0 [(5.8+ 2.6) -(1.2+ 1.2)]	
Banana/Papaya		364	1.2				
-	Bettel leaf vine			744	2.6		
Other cropping patterns		5,229	17.8	5,550	19.4	+1.6	
Miscellaneous							
Settlement	1762	5.9	5143	18.0	+12.1		
Homestead (Vitimati)	313	1.1	2.0	2.0	+0.9		

River	2146	7.2	1932	6.7	-0.5		
Pond	-		355	1.2	+1.2		
Waterbodies	275	0.9	193	0.7	-0.2		
Miscelleneous (Total)	4,496	15.1	8,195	28.6	+13.5		
Total	29,783	100%	28,616	100%			

Major findings Faridpur Upazila, Pabna

i) Total area- 14553
ii)Total sample colleted- 72
iii)Physiography & AEZ code- 12, 4
iv)Major land type- MLL, LL
v)Major soil group- Ghior, batra

Changes in Land Type

Land type	Previous (Year)		Present (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	525	3.61	582.12	4		
Medium Highland	1496	10.28	1746.36	12		
Medium Lowland	2416	16.60	4511.43	31		
Lowland	6808	46.78	4511.43	31		
Very lowland	1301	8.99	1746.36	12		
Miscellaneous	2007	13.79	1455.3	10		
Total	14553					

Changes in Land Use

Land Use	Previous (year)		Present (year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Arable	525	3.61	582.12	4		
	1496	10.28	1746.36	12		
	2416	16.60	4511.43	31		
	6808	46.78	4511.43	31		
	1301	8.99	1746.36	12		
	2007	13.79	1455.3	10		
Total	14553					

Major findings Hakimpur Upazila, Naogaon

i) Total area - 9,993 ha
ii)Total sample collected - 67
iii) Physiography & AEZ code - Barind Tract (25)
iv)Major land type - High Land
v)Major soil group - Amnura

Changes in Land Type

Land type	Previous (2009Year)		Present (2022 Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	5,722	57.26	4,956	49.59	-8	Due to land use change
Medium Highland	2,649	26.51	3,053	30.55	4	
Miscellaneous	1,622	16.23	1,984	19.85	4	
Total	9,993	100.00	9,993	100.00	0	

Changes in Land use

Land Use	**Year 2022**		**Cropping Pattern**	**Year 2009**		**% Change (increase/ decrease)**	**Probable cause**
	Area (ha)	**%**		**Area (ha)**	**%**		
1. Boro – fallow-T-Amon	6020	60.24	Wheat, Mustard-Boro-Aman	1236	12.37		tremendous improvement in irrigation system and transportation.
2. Potato + Boro-fallow T.Amon	650	6.50	Vegetables-Rabi-Fallow-Aman	1616	16.17		
3. Mustard, boro-fallow-T Amon	450	4.50	Boro-Fallow - Aman	3751	37.54		
4. Potato-Wheat, Maize-Fallow-Aush	321	3.21	others	1962	19.63		
5. Garlic, watermelon-jute-T. Aman	56	0.56					
6. Vegetables-Vegetables-T. Aman	175	1.75					
7. Lentils, jute-fallow-T.Aman	11	0.11					
8. Vegetable-Mastured-T.Aman	10	0.10					
9. Wheat, Aush-Moog- T.Aman	50	0.50					
10.Turmaric-Turmaric-Turmaric	10	0.10					
11. Betel leaf- Betel leaf- Betel leaf	26	0.26					
12. Wheat-Aush-T.Aman	20	0.20					
13. others	950	9.51					
Miscellaneous							
Settlement	1029	10.30		1142	11.43	1.131	increase of population (house, road)
Homestead (vitimati)	130	1.30		201	2.01	0.710	

Pond	75	0.75		75	0.75		
Water body	10	0.10		10	0.10		
Total	9993	100.00		9993	100.00		

Major findings of Rangpur Sadar, Rangpur

i) Total area- 35964
ii)Total sample colleted-163
iii)Physiography& AEZ code-
iv)Major land type- Highland, Medium Highland, Medium Low Land
v)Major soil group- Pirgacha, Gangachara, Palashbari, Kaunia, Laskara

Change in Land Type

Land type	Previous (Year)		Present (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	13,104	41.07	12,211	33.95	-7.12	Settlement, Expansion of Markets, Industries etc
Medium Highland	13,118	41.11	13,927	38.73	-2.38	
Medium Lowland	613	1.92	810	2.25	+0.33	
Lowland	-	-	-	-	-	
Very lowland	-	-	-	-	-	
Miscellaneous	5075	15.90	9016	25.07	+9.17	
Total	31910	100	35964	100		

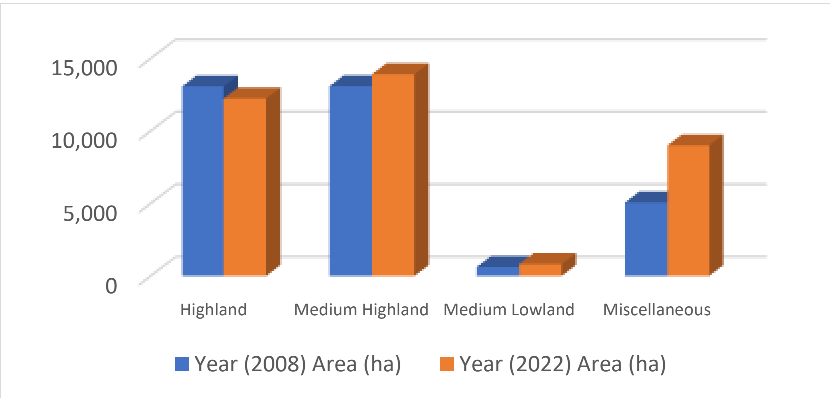


Fig. Comparison of Land type between 2008 and 2022 of Rangpur sadar upazila

Change in Land Use

Land Use	Previous (year)		Present (year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Mango/Litchi/Banana/Jackfruit/Sugarcane	391	1.2	470	1.3	+0.1	Invention of High Yielding Variety, Inclination of farmers to produce profitable crops, Expansion of irrigation facilities, Implementation of modern method of agriculture, Increase of awareness etc.
2. Rabi vegetables- Kharif vegetables	496	1.5	650	1.8	+0.3	
3. Rabi crops (Potato, Tobacco, Wheat, Muatard, Onion, Garlic)- Fallow-T.aman	5838	18.3	4760	13.24	-5.06	
4.Potato-boro-Fallow-T.aman	7220	22.6	5522	15.35	-7.25	
5. Boro-Fallow-T.aman	6293	19.7	8253	22.95	+3.25	
6. Potato-Tobacco-Fallow-T.aman	2815	8.8	4655	12.95	+4.15	
7.Tobacco- Fallow-T.aman	319	1.0	1019	2.84	+1.84	
8.Boro- Fallow-Fallow	613	2.0	810	2.25	+0.25	
9.Others	2850	8.9	809	2.25	-6.65	
Miscellaneous	5075	16.0	9016	25.07	+9.07	
Total	31,910	100	35,964	100		

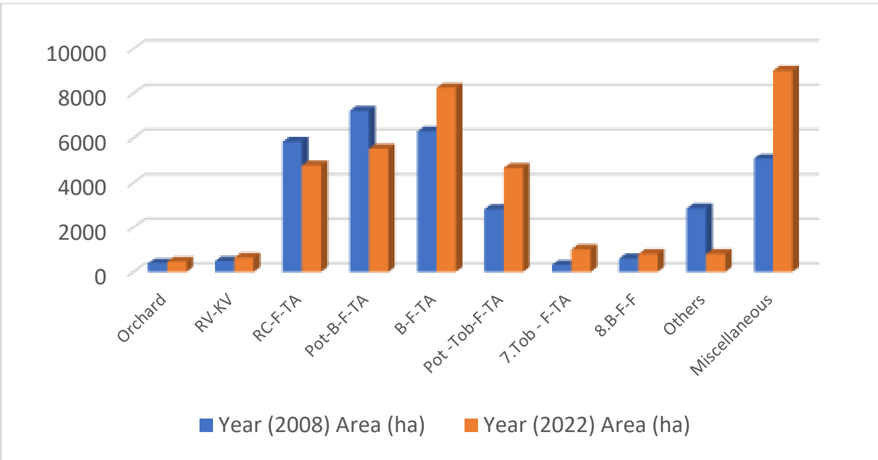


Fig. Comparison of Land use between 2008 and 2022 of Rangpur Sadar upazila

Major findings Gangachara Upazila, Rangpur

i) Total area- 24,565 ha,
ii)Total sample collected- 91
iii)Physiography & AEZ code - Active Tista flood plain (2) & Tista flood plain (3)
iv)Major land type - High Land
v)Major soil group - Gangachara, Polashbari, Kaunia,Tista Sands,Tista Silts

Changes in Land Type

Land type	Previous (2010Year)		Present (2023 Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	8,007	29.7	6,942	28.26	-1.44	Khalea union has been deducted
Medium Highland	11,700	43.4	10,724	43.65	-0.25	
Medium Lowland	1,813	6.7	1,803	7.34	+0.64	
Lowland						
Miscellaneous	5,457	20.2	5,096	20.7	+0.54	
Total	26,977	100	24,565	100		

Changes in Land Use

Land Use	Previous (2010 year)		Present (2023 year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Tobacco-Boro-T.Aman	4,749	17.6	6,141	25	+7.4	Introduction of new variety and cultivation in charland
2. Boro-Fallow-T.Aman	4,535	16.8	1,227	5	-11.8	
3. Rabi crops -Fallow - T.Aman	2,637	9.8	1,227	5	-4.8	
4. Tobacco-Jute/Fallow-T.Aman	2,407	8.9	2,456	10	+1.1	
5. Potato-Boro/Tobacco-T.Aman	1,600	5.9	3,685	15	+9.1	
6.Boro seedbed/Wheat/ Tobacco-Fallow-TAman	841	3.1	1,227	5	+1.9	
7.Other cropping pattern	3,629	13.5	3,510	14.3	+0.8	
Miscellaneous	5,457	20.2	5,096	20.7	+0.54	
Total	26,977	100	24,565	100		

Major findings of Dinajpur Sadar, Dinajpur

i) Total area- 35, 447 ha.
ii)Total sample colleted- 150
iii)Physiography & AEZ code- Old Himalayan Peidmont Plain (1), Barind Tract (25 & 27)
iv)Major land type- High Land, Medium High Land & Medium Low Land.
v)Major soil group- Belabo, Noadda, Amnura, Ekdala, Ranisankail, Pirgachha, Palasbari, Amgaon, Jamun, Gangachara, Srirampur, Kaunia.

Changes in Land Type

Land type	Previous (Year-2010)		Present (Year-2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	14,155	39.9	13,774	38.9	–1.00	Infrastructural Development, Top Soil Removal for Brick kiln, Riverbank Erosion etc.
Medium Highland	13,471	37.9	11,455	32.3	–5.6	
Medium Lowland	286	0.8	294	0.8	0.00	
Miscellaneous	7,589	21.4	9,924	28.0	+6.6	
Total	35,447	200.0	35,447	100.0		

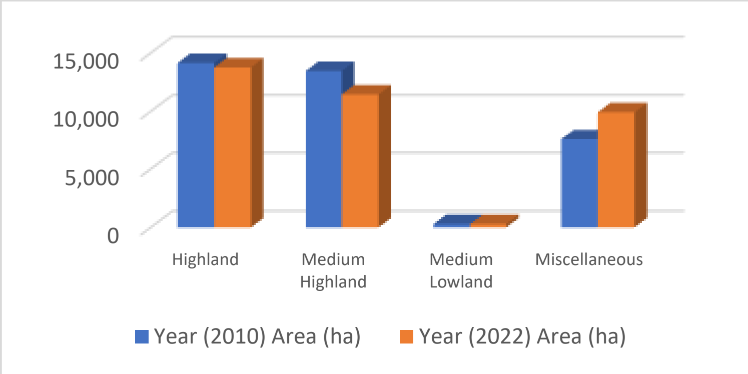


Fig. Comparison of Land type between 2010 and 2022 of Dinajpur sadar upazila

Changes in Land Use

Land Use	Previous (year-2010)		Present (year-2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Mango/Litchi/Banana/Jackfruit/Sugarcane	1,008	2.8	1135	3.2	+0.4	Invention of High Yielding Variety, Modern Agricultural Technology, More Irrigation Facility, Increase of Awareness etc.
Rabi Crops (Mustard/Potato/Wheat/Maize/Vegetables)-Boro-T. Aman	1,783	5.0	3616	10.2	+5.2	
Rabi Crops (Mustard/Potato/Wheat/Maize/Aush/Jute)-T. Aman	-	-	2977	8.4	+8.4	
Rabi Vegetables (Potato/Cauliflower/Cabbage/Onion/Brinjal/Bean/Tomato)-Kharip Vegetables (Bitter Gourd/Snake Gourd/Sponge Gourd/Parball/Pumpkin/Ladies Finger/Basil etc)	1,112	3.1	2837	8.0	+4.9	
Rabi Crops (Mastard/Potato/Wheat/Maize/Vegetables)-F-T. Aman	9,520	26.9	6026	17.0	-9.9	
Boro (Modern)-Fallow-T. Aman (Modern)	14,099	39.8	8045	22.7	-17.8	
Other Patterns	336	1.0	887	2.5	+1.5	
Others (Settlement/Water body/Orchard etc,)	7589	21.4	9924	28.0	+6.6	
Total	35,447	100.0	35,447	100.0		

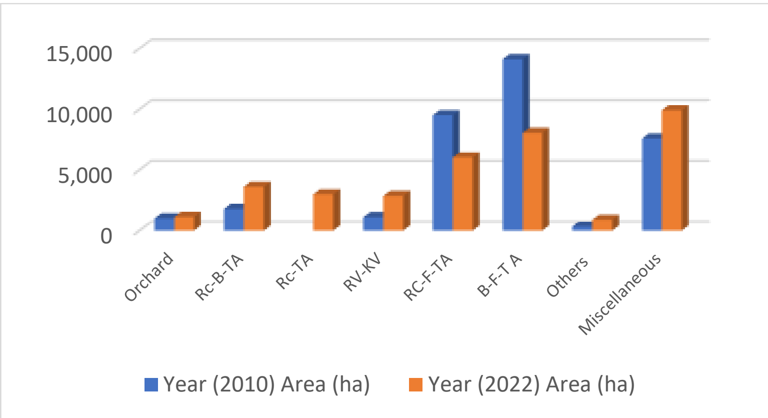


Fig. Comparison of Land type between 2010 and 2022 of Dinajpur sadar upazila

Major findings of Ranishankail upazila, Thakurgaon

i) Total area-28,760
ii) Total sample colleted-161
iii) Physiography & AEZ code-Old Himalayan Piedmont plain (1), Tista Meander Floodplain (3)
iv) Major land type- High land, Medium high land, Medium low land
v) Major soil group- Ranishankail, Pirgacha, Palashbari, Jamun, Gangachara, Baliadangi, Atowari, Srirampur, Menanagar, Kaunia, Laskara

Changes in Land Type

Land type	Previous (2008)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	14,681	51.05	12,862	44.72	-6.33	Increase of settlement, expansion of markets, removal of top soil, riverbank erosion etc.
Medium Highland	9,890	34.39	10,738	37.34	2.95	
Medium Lowland	846	2.94	1,034	3.60	0.64	
Lowland	-	-	-	-	-	
Miscellaneous	3,343	11.62	4,126	14.35	2.73	
Total	28,760	100	28760	100	-	

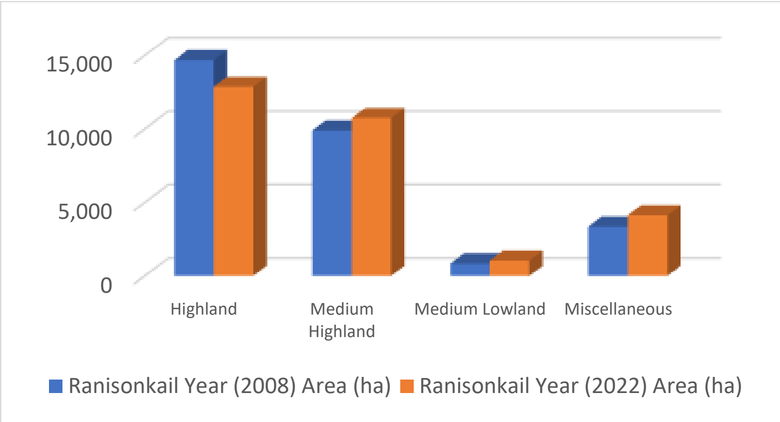


Fig. Comparison of Land type between 2008 and 2022 of Ranishankail upazila

Changes in Land Use

Land Use	Previous (year)		Present (year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Mango/Litchi/Banana/Bamboo	1,120	3.89	1,168	4.06	0.17	Invention of high yielding variety, inclination of farmers to produce rofitable crops expansion
Sugarcane/Banana1/Papaya/ + Potato/Pulse/Red Amaranths	247	0.86	172	0.60	-0.26	
Rabi Crops (Wheat/Mustard/Potato)- Boro- T. Aman	1,424	4.95	1,293	4.50	-0.45	

Rabi Crops (Wheat/Mustard/Potato)- Jute- T. Aman	169	0.59	121	0.42	-0.17	of irrigation facilities, implementation of modern method of agriculture, increase of awareness etc.
Potato-Maize-T. Aman	560	1.95	632	2.20	0.25	
Rabi Vegetables (Potato/Cabage/Cauliflower/Onion/ Brinjal/Bean/Tomato)-Kharif Vegetable (Bitter Gourd/Snake Gourd/Pumpkin/Ladies Finger etc.)	3,469	12.06	3,493	12.15	0.08	
Mustard/Potato/Wheat/Maize/Rabi Vegetables- F.-T.Aman	10,312	35.86	10,149	35.29	-0.57	
Boro (Ufshi)-F-T.Aman (Ufshi)	7,071	24.58	6,425	22.34	-2.24	
Boro (Ufshi)-F-F	846	2.94	1,034	3.59	0.65	
Others	199	0.69	147	0.51	-0.18	
Miscellaneous (Settlement, Water Body, Orchard etc.)	3,343	11.62	4,126	14.35	2.73	
Total	28,760	100	28,760	100	0.00	-

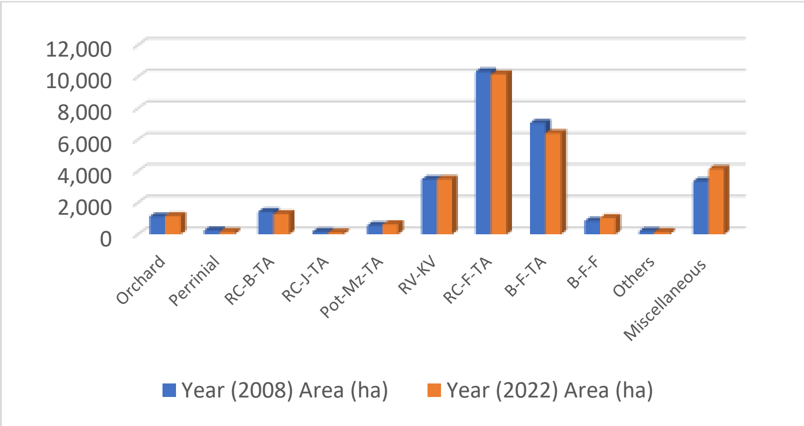


Fig. Comparison of Land use between 2008 and 2022 of Ramishankail upazila

Major Findings of Sylhet Sadar, Sylhet

Change in Land Type

Slope class/Land type	Previous (2008)		Present (2022)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	8219	26.1	7145	22.7	-3.4	
Medium Highland	5465	17.3	4862	15.4	-1.9	
Medium Lowland	6022	19.1	5957	18.9	-0.2	
Lowland	4059	12.9	4098	13	0.1	
Very lowland	1403	4.5	1416	4.5	0.0	
Miscellaneous	6347	20.1	8037	25.5	5.4	
Total	31525	100	31525	100	0.0	

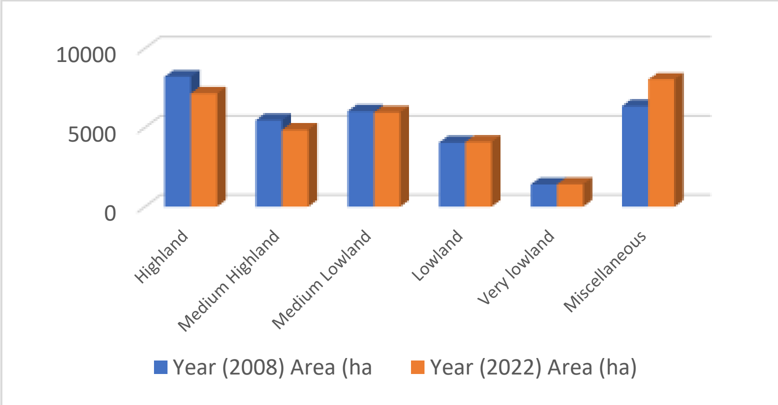


Fig. Comparison of Land type between 2008 and 2022 of Sylhet sadar upazila

Change in Land Use

Land Use	Previous (Year)		Present (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
1.Tea Garden	5598	17.80	5345	17.00	-0.80	
2. Forest	735	2.30	685	2.20	-0.10	
3. Bamboo and Bushy Areas	266	0.90	240	0.80	-0.10	
4.Rabi Veg-Fallow-T.Aman	72	0.20	710	2.30	2.10	
5.Rabi Veg.-B.Aus-T.Aman	72	0.20	765	2.40	2.20	
6.Rabi Veg.-Kharif Veg	351	1.10	1320	4.20	3.10	
7. Fallow-T.Aus-T.Aman	1430	4.50	4120	13.10	8.60	
8. Fallow-B.Aus-T.Aman	2048	6.50	220	0.70	-5.80	
9. Boro-Fallow-T.Aman	116	0.40	2775	8.80	8.40	
10. Boro-Fallow-B.Aman	116	0.40	60	0.20	-0.20	
11.Rabi Veg. -Fallow	73	0.30	70	0.20	-0.10	
12. Fallow-Fallow-T.Aman	2923	9.30	2843	9.00	-0.30	
13. Fallow-Fallow-B.Aman	4016	12.70	1200	3.70	-9.00	
14. Boro-Fallow-Fallow	5387	17.10	2475	7.80	-9.30	
15. Fallow	1965	6.20	650	2.10	-4.10	
16. Miscellaneous	6347	20.10	8037	25.50	5.40	
Total	31515	100	31515	100	0	

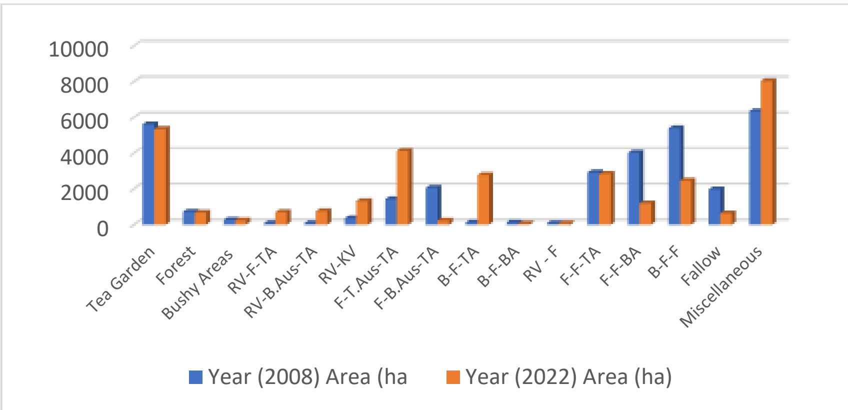


Fig. Comparison of Land use between 2008 and 2022 of Sylhet sadar upazila

Major Findings of Dakhsin Surma, Sylhet

Change in Land Type

Slope class/Land type	Previous (Year)		Present (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Highland	777	4.00	730	3.70	-0.30	
Medium Highland	5857	29.80	5324	27.10	-2.70	
Medium Lowland	5247	26.70	5130	26.10	-0.60	
Lowland	3013	15.30	3116	15.90	0.60	
Very lowland	866	4.40	909	4.60	0.20	
Miscellaneous	3884	19.80	4435	22.60	2.80	
Total	19644	100.00	19644	100.00	0.00	

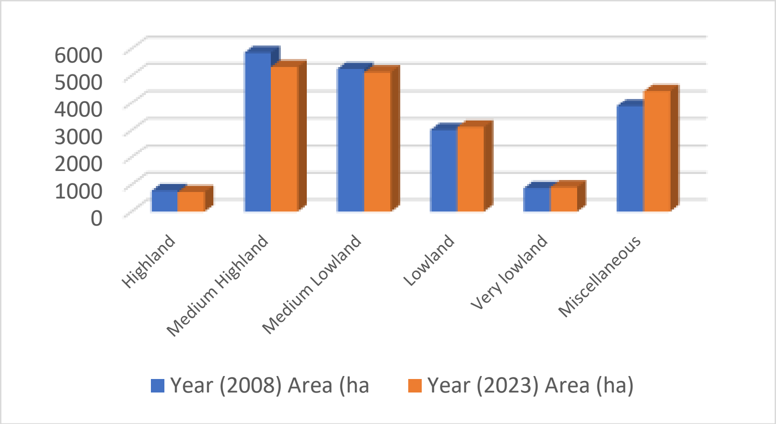


Fig. Comparison of Land type between 2008 and 2023 of Dakhsin surma upazila

Changes in Land use

Land Use	Previous (Year)		Present (Year)		% increase/ decrease	Possible reasons
	Area (ha)	%	Area (ha)	%		
Bamboo and Bushy Areas	46	0.20	35	0.20	0.00	
Rabi Veg-Fallow-T.Aman	132	0.70	120	0.60	-0.10	
Rabi Veg.-B.Aus-T.Aman	131	0.70	80	0.40	-0.30	
Rabi Veg.-Kharif Veg	179	0.90	450	2.30	1.40	
Fallow-T.Aus-T.Aman	2236	11.40	3300	16.80	5.40	
Fallow-B.Aus-T.Aman	2348	11.90	350	1.80	-10.10	
Boro-Fallow-T.Aman	162	0.80	3800	19.30	18.50	
Boro-Fallow-B.Aman	325	1.70	150	0.80	-0.90	
Rabi Veg. -Fallow	131	0.70	80	0.40	-0.30	
Fallow-Fallow-T.Aman	1250	6.40	3350	17.10	10.70	
Fallow-Fallow-B.Aman	3790	19.30	350	1.80	-17.50	
Boro-Fallow-Fallow	4425	22.50	2800	14.30	-8.20	
Fallow	605	3.00	344	1.80	-1.20	
Miscellaneous	3884	19.80	4435	22.60	2.80	
Total	19644	100.00	19644	100.00	0.00	

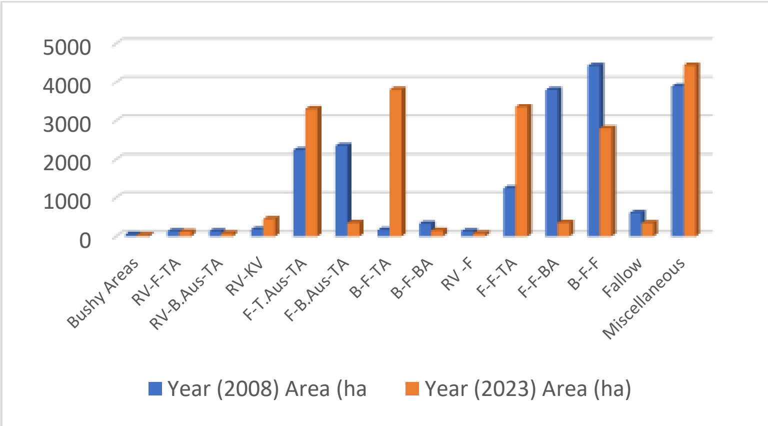


Fig. Comparison of Land type between 2008and 2023 of Dakhsin surma upazila

3.2 Union Land, Soil and Fertilizer Recommendation Guide (Union Sahayika) Preparation

Union based Land, Soil and Fertilizer Recommendation Guide (Union Sahayika) is being used as a tool for agricultural development activities/planning at grassroots level. It provides soil and land associated information more precisely at Union level. The guide facilitates the farmers to acquire land and soil related information for their area. In addition, it acts as a tool for location-based fertilizer recommendations for any crops. In 2022-2023, total number of Union Sahayika prepared by field offices was 234.

Table. Union Sahayika prepared by respective Divisional & Regional office (2022-23)

Name of Divisional/ Regional Office	District	Upazila	No. of Union Sahayika prepared
Regional Office, Faridpur	Faridpur	Baliakandi	7
Regional office, Gopalganj	Sathkira	Assasuni	11
Regional office, Jamalpur	Jamalpur	Jamalpur Sadar	3
	Sherpur	Nakla	2
Regional office, Munshiganj	Munshiganj	Sirajdikhan	4
Regional office, Mymensingh	Mymensingh	Bhaluka	6
Regional office, Netrokona	Netrokona	Barhatta	5
Regional office, Narsingdi	Narsingdi	sadar	3
Regional office, Tangail	Tangail	Kalihati	6
Regional Office, Chapainawabganj	Chapainawabganj	Chapainawabganj sadar	5
Regional Office, Naogaon	Naogaon	Badalgachi & Naogaon Sadar	6
Regional Office,Bogura	Bogura	Adamdighi	5
Regional Office, Sirajganj	Sirajganj	Raiganj	6
Regional Office,Pabna	Pabna	Iswardi	5
Regional Office, Dinajpur	Dinajpur	Chiribandar	7
Regional Office, Gaibandha	Gaibandha	Sadullapur	6
	Joypurhat	Kalai	6
Regional Office, Lalmonirhat	Lalmonirhat	Kaliganj	6
Regional Office, Thakurgaon	Thakurgaon	Thakurgaon Sadar	23
		Pirganj	1
		Haripur	6
		Baliadangi	5
Regional Office, Jashore	Narail	Lohagara	8
Regional Office, Kushtia	Chuadanga	Alamdanga	10
Regional Office, Jhenaidah	Magura	Sreepur	8
	Jhenaidah	Harinakundu	2
Regional Office, Satkhira	Khulna	Koyra	7
Regional Office, Patuakhali	Barishal	Hizla	3
		Mehendiganj	2
Regional Office, Bhola	Bhola	Charfassion	5
	Perojpur	Indurkani	3

Name of Divisional/ Regional Office	District	Upazila	No. of Union Sahayika prepared
	Jhalakat	Rajapur	2
Regional Office, Brahmanbaria	Brahmanbaria	Bancharampur	12
Regional Office, Cumilla	Cumilla	Homna	6
Regional Office, SRDI, Rangamati	Brahmabaria	Akhaura	6
Divisional Office, Sylhet	Sylhet	Balaganj	5
Regional Office, Moulvibazar	Moulvibazar	Juri	6
Regional Office, Sunamganj	Sunamganj	Sunamganj Sadar	10
		Chatok	5
		Total	**234**

Union Sahayika is an effective tool for local level agricultural planning and for location specific fertilizer recommendation. Field officers (SAAOs) of Department of Agricultural Extension (DAE) could be more equipped by this guide in respect of providing advisory services to farmers as a part of their professional demand.

3.3 Monitoring & Evaluation of Farmers' Service through Mobile Soil Testing Laboratories (MSTL)

(a) Introduction: Soil Test Based (STB) fertilizer use is considered one of the best practices to minimize the yield gap. The farmers of the country are not yet fully aware of the benefit of the STB fertilizer application for crop production. For this reason, SRDI operates farmers' service through MSTL to provide soil testing service at grass root level with a view to motivating farmers regarding balanced use of fertilizers. Actually, it is a programme for developing awareness among farmers about soil test-based fertilizer use so that farmers become more interested to get services from static laboratory. SRDI propelled this programme through two MSTL since 1996. At present, SRDI runs 10 MSTL for serving the farmers with soil testing facilities in Rabi and Kharif season every year.

(b) Objectives

- To enhance awareness among the farmers on the benefit of balanced fertilizer application according to STB and crop requirements.
- To assess the effect of soil test-based fertilizer application on crop production.

In 2022-2023, soil analytical service through MSTL provided to 80 Upazila of the country and provided 5,081 farmers with Fertilizer Recommendation Cards.

Table. Name of the Upazila and number of soil samples analyzed through MSTL under Farmer's Service Programme during Rabi 2022 season

Sl. No	Name of Divisional/ Regional Office	District	Upazila	No. of Soil Samples Analyzed
1	SRDI, Regional Office, Faridpur	Faridpur	Bhanga	50
2		Rajbari	Pangsha	53
4	Jamalpur	Jamalpur	Jamalpur Sadar	50
5			Madargonj	50
6		Sherpur	Nokla	60
7			Sreebordi	52
8	Kishoreganj	Kishoreganj	Austogram	50
9	Regional Office, Madaripur	Madaripur	Madaripur Sadar	50
10		Shariatpur	Shariatpur Sadar	50
11	SRDI, RO, Munshiganj	Munshiganj	Lauhajang	36
12	SRDI, RO, Mymensingh	Mymensingh	Muktagacha	50
13	SRDI, RO, Netrokona	Netrokona	Kalmakanda	50
14	Regional office, Narsingdi	Narsingdi	Monohordi	52
15	Regional office, Tangail	Tangail	Tangail sadar	52
16			Bhuapur	52
17	DO, Baridhal	Jhalokathi	Jhalokathi Sadar	50
18	Regional Office, Patuakhali	Barguna	Barguna Sadar	50
19		Patuakhali	Patuakhali Sadar	50
20	Regional Office, Bhola RO	Bhola	Daulatkhan	50
21	Divisional Office, Khulna	Bagerhat	Bagerhat sadar	50
22		Khulna	Dumuria	50
23	Regional Office, Jashore	Jashore	Keshobpur	49
24		Narail	Kalia	51
25	Regional Office, Kustia	Chuadanga	Chuadanga Sadar	50
26		Kushtia	Kushtia Sadar	50
27	Regional Office, Jhenaidah	Jhenaidah	JhenaidahSadar	50
28	Regional Office, Satkhira	Satkhira	Tala	50
29	Divisional Office, Rajshahi	Rajshahi	Durgapur	50
30		Natore	Lalpur	50
31	Regional Office, Naogaon	Naogaon	Manda	50
32	Regional Office, Chapainawabganj	Chapainawabganj	Shibganj	75
33	Regional Office Sirajganj	Sirajganj	Tarash	50
34	Regional Office, Pabna	Pabna	Atgharia	50
35	Regional Office, Bogura	Bogura	Shibgonj	50
36	Divisional Office, Rangpur	Nilphamari	Nilphamari Sadar	50
37	Regional Office, Dinajpur	Dinajpur	Birganj	55
38	Regional Office, Gaibandha	Gaibandha	Gobindoganj	50
39	Regional Office, Lalmonirhat	Lalmonirhat	Chilmari	50
40	Regional Office, Thakurgaon	Thakurgaon	Thakurgaon Sadar	62
41	Divisional Office, Chattogram	Chattogram	Sitakondo	50
42			Bashkhali	50
43			Patiya	50
44	Regional Office, Brahmanbaria	Brahmanbaria	Sarail	50
45	Regional Office, Coxsbazar	coxsbazar	Coxsbazar sadar	100

Sl. No	Name of Divisional/ Regional Office	District	Upazila	No. of Soil Samples Analyzed
46	Regional Office, Cumilla	Cumilla	Cumilla Sadar South	50
47			Chandina	50
48	Regional Office, Chandpur	Chandpur	Faridgonj	50
49	Regional Office, Noakhali	Feni	Dagonbhuiya	50
50		Noakhali	Kobirhat	50
51	Regional Office, Rangamai	Rangamati	Naniarchar	50
52			Kaukhali	50
53	Divisional Office, Sylhet	Sylhet	Fenchuganj	45
54	Regional Office, Moulvibazar	Moulvibazar	Moulvibazar Sadar	54
55		Habiganj	Azmiriganj	49
56	Regional Office, Sunamganj	Sunamganj	Bishwamvarpur	50
		Total		**2,847**

Table. Name of the Upazila and number of soil samples analyzed through MSTL under Farmer's Service Programme during Kharip 2023 season

Sl. No		District	Upazila	No. of Soil Samples Analyzed
1	Regional Office, Faridpur	Faridpur	Nagarkanda	50
2	Regional Office, Gopalganj	Gopalganj	Kasiani	50
3	Regional Office, Mymensingh	Mymensingh	Mymensingh Sadar	50
4	Regional office, Narsingdi	Narsingdi	Belabo	204
5	Regional office, Tangail	Tangail	Sakhipur	52
6			Ghatail	52
7	Divisional Office, Barishal	Barishal	Bakerganj	50
8		Barishal	Babuganj	50
9	Divisional Office, Khulna	Khulna	Dighalia	50
10	Regional Office, Jashore	Jashore	Jhikargacha	50
11	Regional Office, Kustia	Chuadanga	Damurhuda	50
12	Regional Office, Jhenaidah	Jhenaidah	Jhenaidah Sadar	50
13	Regional Office, Chapainawabganj	Chapainawabganj	Nachole	55
14	Regional Office, Bogura	Joypurhat	Kalai	50
15	Rangpur	Rangpur	Mithapukur	50
16	Regional Office, Dinajpur	Dinajpur	Kaharol	63
17	Regional Office, Gaibandha	Gaibandha	Palashbari	50
18	Regional Office, Thakurgaon	Thakurgaon	Thakurgaon Sadar	379
19			Baliadangi	157
20			Ranishankail	185
21			Pirganj	210
22			Haripur	100
23	Regional Office, Cumilla	Cumilla	Barura	55
24	Regional Office, Moulvibazar	Moulvibazar	Sremangal	122
			Total	**2234**

3.4 Soil and Water Salinity Monitoring

Introduction

The total area of Bangladesh is 147, 570 km^2. The coastal area covers about 20% of the country and over thirty percent of the net cultivable area. It extends inside up to 150 km from the coast. Out of 2.85 million hectares of the coastal and offshore areas about 0.83 million hectares are arable lands, which cover over 30% of the total cultivable lands of Bangladesh. A part of the coastal area, the Sundarbans, is a reserve natural mangrove forest covering about 4,500 km^2. The remaining part of the coastal area is used in agriculture. The cultivable areas in coastal districts are affected with varying degrees of soil salinity. The coastal and offshore area of Bangladesh includes tidal, estuaries and river floodplains in the south along the Bay of Bengal. Agricultural land use in these areas is very poor, which is roughly 50% of the country's average (Petersen & Shireen, 2001). Tidal and estuarine floodplains cover almost 98% of the coastal area. Small areas (2%) with river floodplains and peat basins are found in the northern part of the coastal area. Tidal floodplains occur in Satkhira, Khulna, Bagerhat, Pirozpur, Jhalukhati, Barisal, Patuakhali, Chittagong and Cox's Bazar district. They cover a total of 18,65,000 ha or about 65% of the coastal area. Estuarine floodplains occur in Noakhali, Bhola and Patuakhali districts and in the north-western part of Chittagong district. They cover about 9,37,000 ha or about 33% of the coastal area. Saline soil contains an excess of soluble salts, especially sodium chloride. In other words, soils that develops under the influence of the electrolyte of sodium salts, with a nearly neutral reaction. Dominant salts are sodium sulphate and sodium chloride, but seldom sodium nitrate, magnesium sulphate, or magnesium chloride. They are non-sodic soils containing soluble salts in such quantities that they interfere with the growth of most crop plants. The pH of the saturated saline soil is usually less than 8.3. These soils are geographically associated with arid, semi-arid, sub-humid and humid areas as well. The estimates indicate that Bangladesh has about 2.8 million ha (Chanratchakool, 2007) of land affected by salinity and poor quality water. The total area includes deltaic floodplains and offshore islands. This comes to about one-fifth of the total areas of Bangladesh and lies around the northern apex of the Bay of Bengal. The saline soils are mainly found in Khulna, Barisal, Patuakhali, Noakhali and Chittagong districts of the coastal and offshore lands (Figure 1). Due to a number of environmental factors the coastal soils are slightly moderately saline on the surface, and highly saline in sub-surface layers and substrata.

According to SRDI (2012) out of 2.86 million hectares of coastal and off-shore lands about 1.056 million hectares of arable lands are affected by varying degrees of salinity. Crop production in salt affected areas in the coastal regions differs considerably from non saline areas. Crops yields, cropping intensity, production levels and people's livelihood quality are much lower than that of other parts of the country (BBS, 2001). Many of the projected climate change impacts will reinforce the baseline environmental, socio-economic and demographic stresses already faced by Bangladesh. Therefore, it is imperative to regularly monitor the soil and water salinity.

Objectives

- To determine the soil and water salinity round the year and to delineate area under different degrees of salinity.

- To determine the particular time frame in a year when surface water is suitable for irrigation.
- To record present land use and crop response to soil salinity.
- To provide necessary data base for developing appropriate technology to deal with the changed situation.

Methodology

Field data is being collected from strategically representative sites of the coastal area. Soil samples at variable depths (0-10cm, 10-30cm and 30-60cm), water samples from surface (river, canals, ponds and water bodies), underground water (Hand Tube Well, Shallow Tube Well and Deep Tube Well) are collected twice in every month. Salinity of soils and water is determined by EC meter.

Findings

Khulna Division

28 soil salinity sites and 26 surface water salinity sites were selected in Khulna division (greater Khulna and Jashore district and Satkhira district). In greater Khulna, monitoring sites are located in Batiaghata, Dumuria, Fultala, Koyra, Dakop of Khulna district, Mongla, Morelganj, Sharankhola of Bagerhat district and Shyamnagar of Satkhira district. In greater Jashore the monitoring sites are located in Jashore Sadar and Kesobpur of Jashore district and Kalia, Lohagara and Narail Sadar of Narail district. In Satkhira monitoring sites are located in Satkhira sadar, kolaroa, Ashashuni, Tala of satkhira district. Surface water (river, canals) samples were collected twice in month during dry season and once in a month during rainy season. Salinity of water was determined by EC meter.

Table 6. Site specification of the soil sample collection sites of Khulna Division

Sl no.	Name of site	Location	Soil series	Land type	Land Use	Physiography
			Khulna			
1	Krishnanagar,	Krishnanagar, Batiaghata, Khulna	Bajoa	MHL	F-TA	GTF
2	Krishnanagar	Krishnanagar, Batiaghata, Khulna	Dumuria	MHL	F-TA	GTF
3	Ghutudia	Ghutudia, Dumuria, Khulna	Bajoa	MHL	F-TA	GTF
4	Ghutudia	Ghutudia, Dumuria, Khulna	Dumuria	MHL	F-TA	GTF
5	Kismat	Kismat, Fultala, Batiaghata	Bajoa	MHL	F-TA	GTF
6	Kismat	Kismat, Fultala, Batiaghata	Dumuria	MHL	F-TA	GTF
7	Fultala,	Fultala, Batiaghata, Khulna	Bajoa	MHL	F-TA	GTF
8	Fultala,	Fultala, Batiaghata, Khulna	Dumuria	MHL	F-TA	GTF
9	Digraj	Digraj ,Biddarbaon, Mongla	Barisal	MHL	F-TA	GTF

10	Digraj	Digraj, Biddarbaon, Mongla	Barisal	MHL	F-TA	GTF
11	Shibbari	Shibbari, Paikgacha	Barisal	MHL	F-TA	GTF
12	Boloibunia	Boloibunia, Morellganj	Barisal	MHL	F-TA	GTF
Jashore						
13	Narail Ferry ghat	Narail Sadar, Narail	Gopalpur	HL	RV-KV	GRF
14	Baraipara	Kalia, Narail	Gopalpur	MHL	RV-KV	GRF
15	Kalna ghat	Lohagara, Narail	Sara	HL	RC-F-TA	GRF
16	Sagardari	Kesabpur, Jahore	Amjhupi	MHL	B-F-TA	GRF
17	Noapar	Jashore Sadar, jashore	Gopalpur	HL	Banana Orchard	GRF
18	Tularampur	Narail Sadar, Narail	Sara	HL	Banana Orchard	GRF
19	Gobra Bazar	Narail Sadar, Narail	Gopalpur	MHL	RC-F-TA	GRF
20	Baradia	Kalia, Narail	Gopalpur	HL	RC-J-F	GRF
21	Sheikhati	Narail Sadar, Narail	Gopalpur	HL	RV-KV	GRF
Satkhira						
22	Shrifalkathi	Ishwaripur, Shyamnagar	Barishal	MHL	B-F-TA	GTF
23	Varashimla	Varashimla, kaligonj	Barisal	MHL	B-F-TA	GTF
24	Capra	Capra, Budhhata, Ashashuni.	Barisal	MHL	B-Fish	GTF
25	Shokhipur	Shokhipur, Debhata	Ishwardi	MHL	B-F-TA	GRF
26	Shreepatipur	Shreepatipur, Kolaroa.	Ishwardi	MHL	B-F-TA	GRF
27	Binerpota	Binerpota, Satkhira	Ishwardi	MHL	B-F-TA	GRF
28	kumira	kumira, Tala.	Ishwardi	MHL	B-F-TA	GRF

Graphical presentation of some selected soil monitoring site of Khulna division:

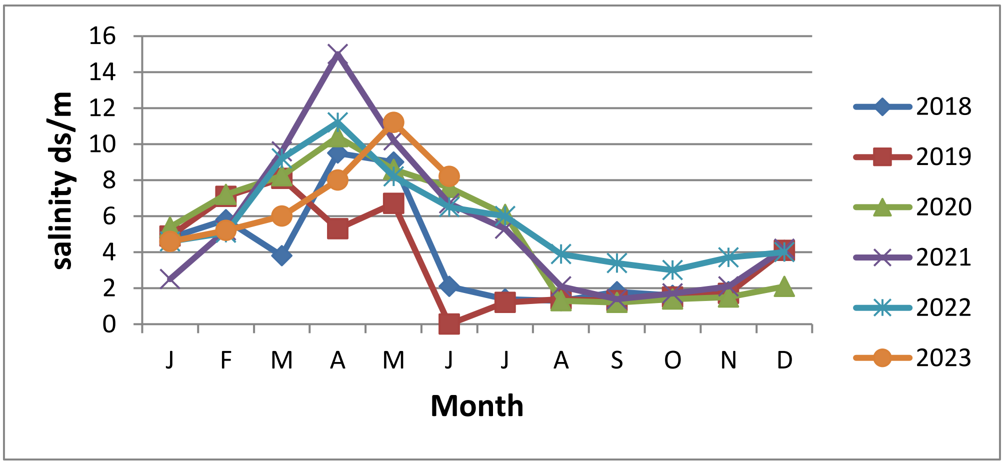


Fig. Salinity level of Soil series: Bajoa, MHL, Location: Krishnanagar, Batiaghata.

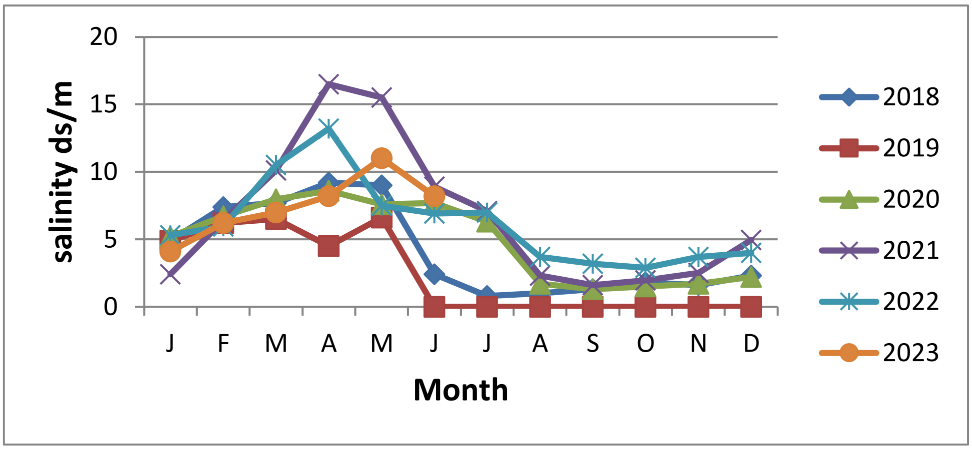


Fig. Salinity level of Soil series: Bajoa, MHL, Location: Kismat Fultala, Batiaghata.

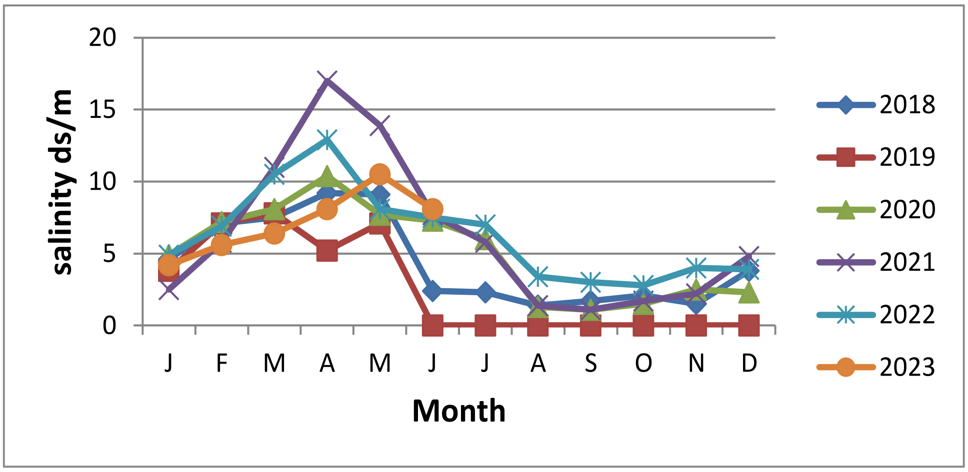


Fig. Salinity level of Soil series: Bajoa, MHL, Location: Fultala, Batiaghata.

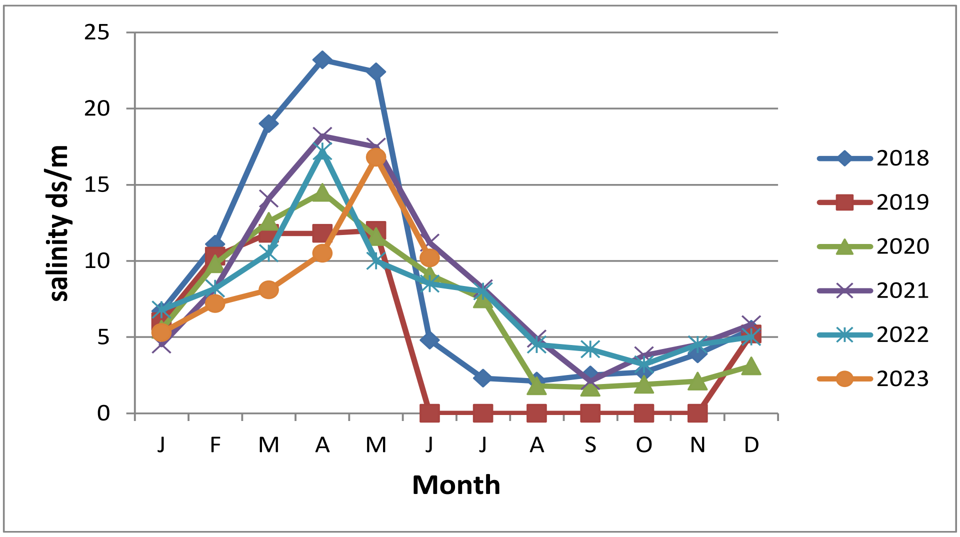


Fig. Salinity level of Soil series: Barisal, MHL, Location: Digraj Biddarbaon, Mongla.

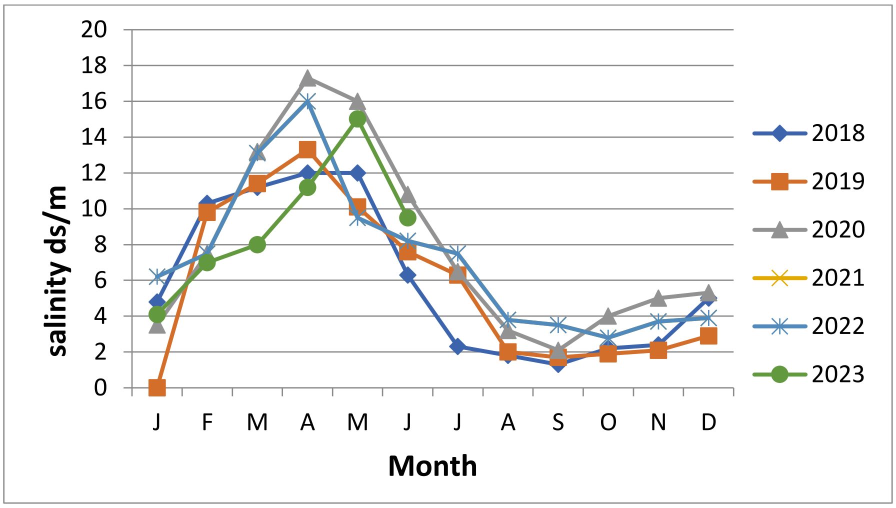


Fig. Salinity level of Soil series: Barisal, MHL, Location: Shibbari, Paikgacha.

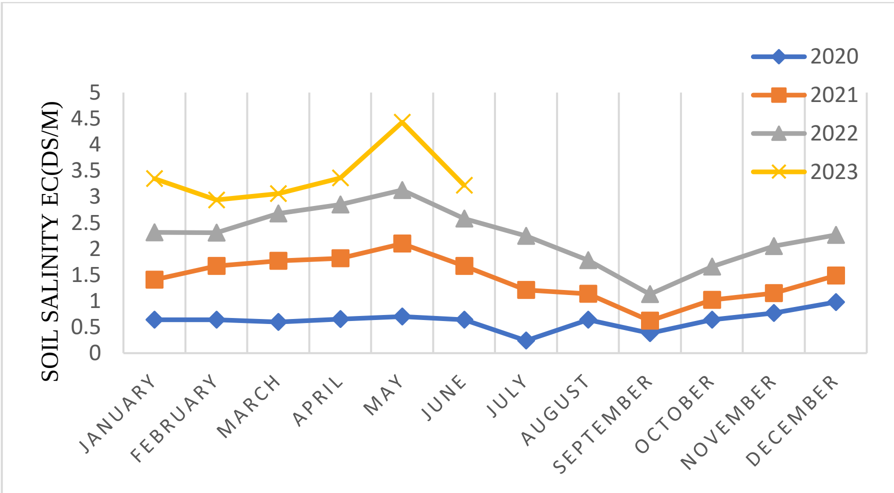


Fig. Salinity level of Soil series: Gopalpur, HL, Narail Ferry Ghat, Narial Sadar

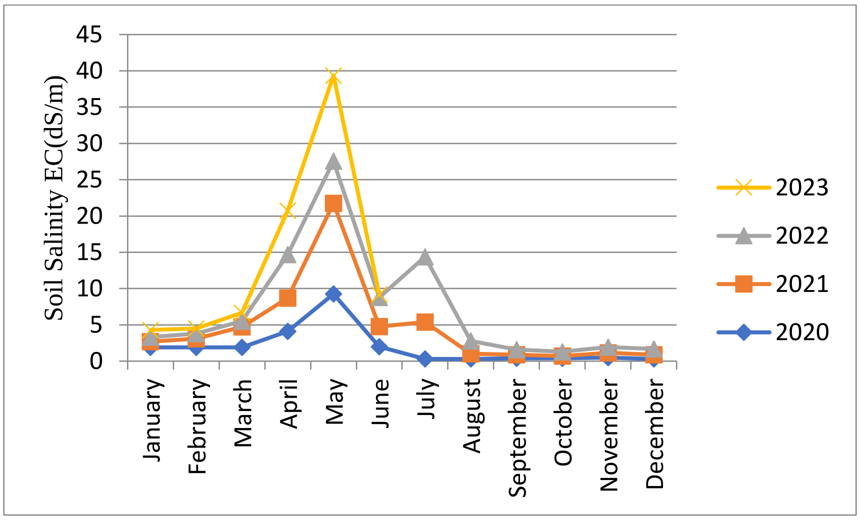


Fig. Salinity level of Soil series: Sar, HL, Kalnaghat, Lohagara, Narail

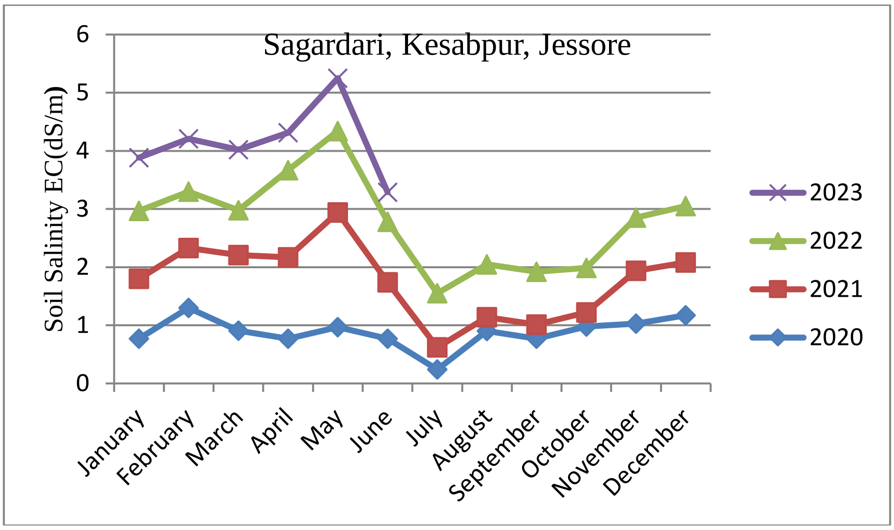


Fig. Salinity level of Soil series: Amjhupi, MHL, Sagardari, Kesabpur, Jessore

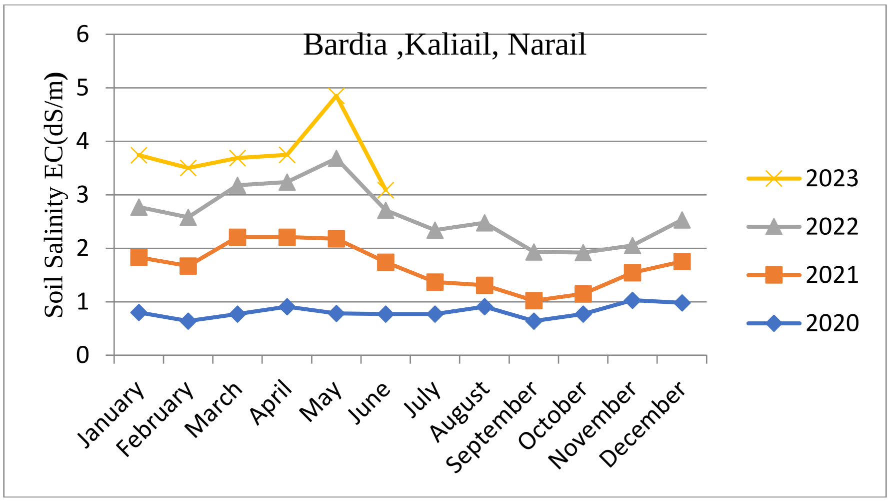


Fig. Salinity level of Soil series: Gopalpur, HL, Bardia, Kaliail.

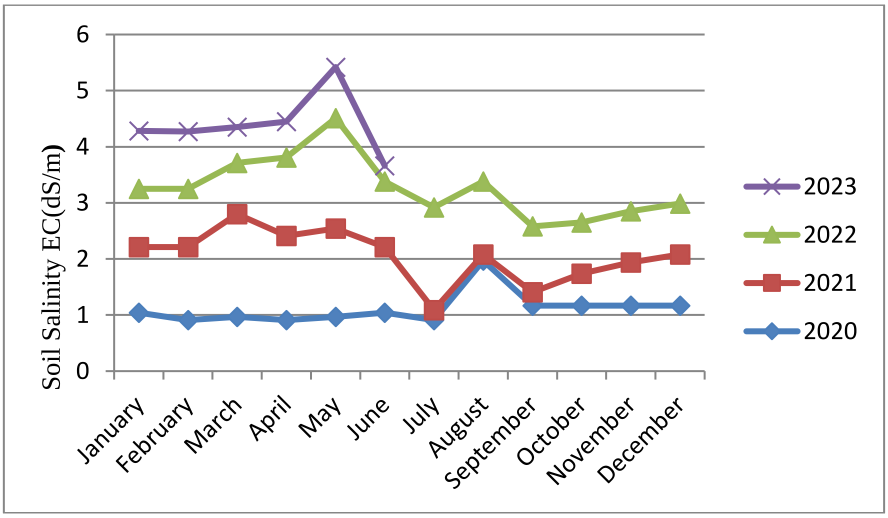


Fig. Salinity level of Soil series: Gopalpur, HL, Sheikhati, Narail Sadar

Table 7. Site specification of the water collection sites of Khulna Division

Sl. No	Name of river	Location
Khulna		
1	Madhumati River	Mollahat, Bagerhat
2	Rupsa River	Rupsa Ferryghat, Khulna.
3	Shailmari River	Koiya Bazar, Batiaghata, Khulna.
4	Vadra River	Khornia.Dumuria, Khulna
5	Shibsha River	Paikgacha HQ, Khulna.
6	Kazibachha River	Batiaghata, Khulna
7	Pasur River	Mongla port, Mongla, Bagerhat.
8	Daratana River	Bagerhat ferryghat, Bagerhat.
9	Panguchi River	Morelgonj HQ, Bagerhat.
10	Ghoshiakhali River	Rampal, Bagerhat
Jashore		
11	Chittra River	Narail Ferry ghat.Narail Sadar
12	Kapotaxma River	Sagardari, Kesabpur, Jessore.
13	Bhairab River	Noapara, Jessore.
14	Afra River	Tularampur, Narail Sadar
15	Chittra River	Gobra, Narail sadar, Narail (New site).
16	Naboganga River	Baraypara, Kalia.
17	Modhumoti River	Bardia, Lohagara.
18	Modhumoti River	Kalna ghat, Lohagara
19	Afra River	Shaikhati, Narail.
Satkhira		
20	Kapotaksha River	Patkelghata, Tala, Satkhira.
21	Betna River	Benerpota, Satkhira sadar, Satkhira.
22	Kakshiali River	Kaligonj HQ, Satkhira.
23	Morichap River	Ashashuni, Satkhira.
24	Betna River	kolaroa bazar, kolaroa, Satkhira
25	Sapmara khal	parulia, Debhata, Satkhira
26	kholpatua River	Noyabeki, Shyamnagar, Satkhira

Graphical presentation of some selected water monitoring site of Khulna division:

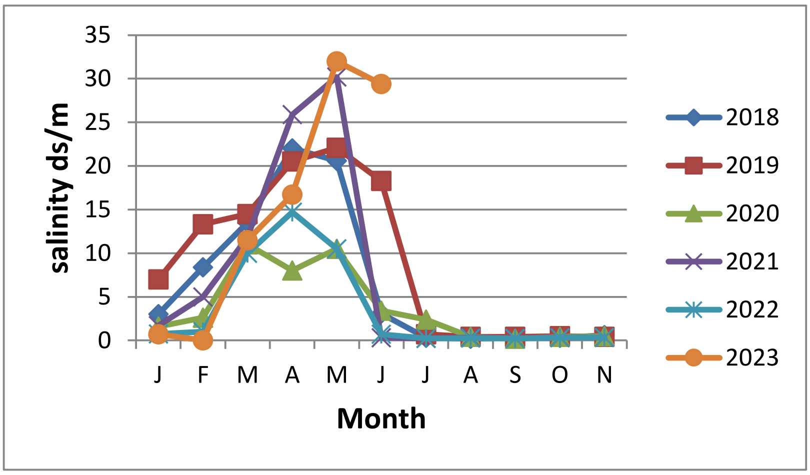


Fig. Salinity level of Rupsa River, Rupsa Ferryghat, Khulna.

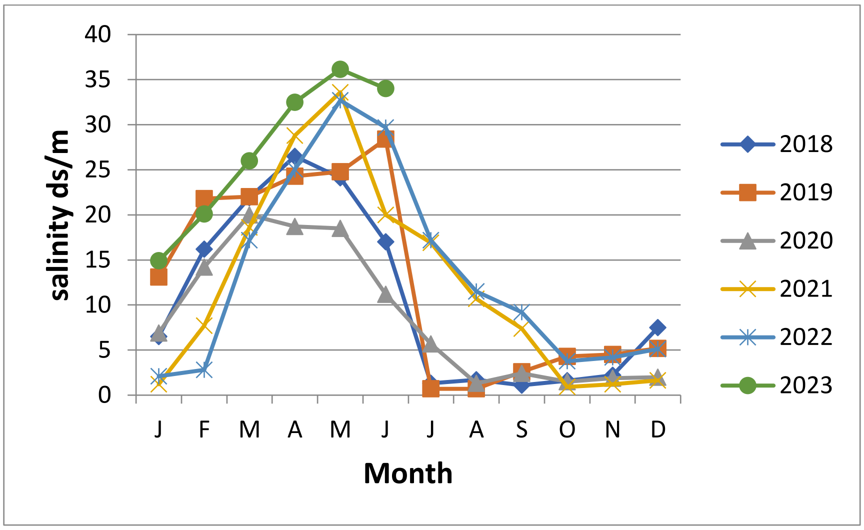


Fig. Salinity level of Shibsha River, Paikgacha Hq, Khulna.

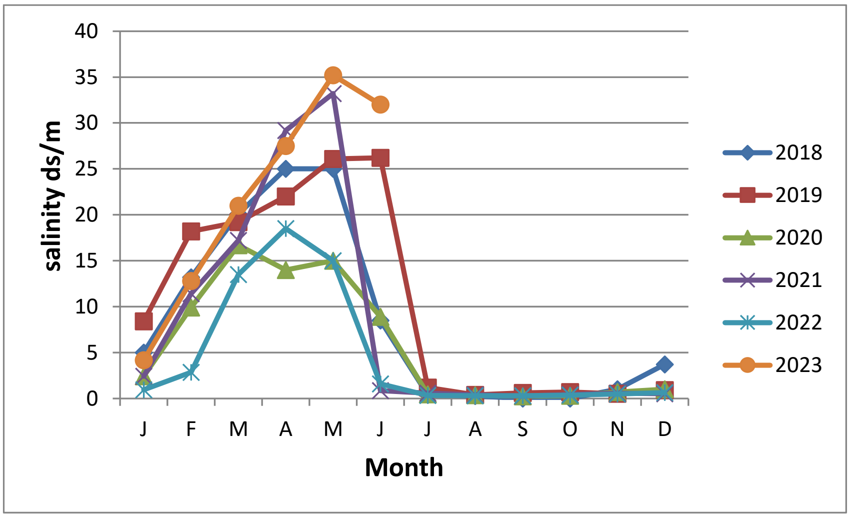


Fig. Salinity level of Kazibachha River, Batiaghata, Khulna

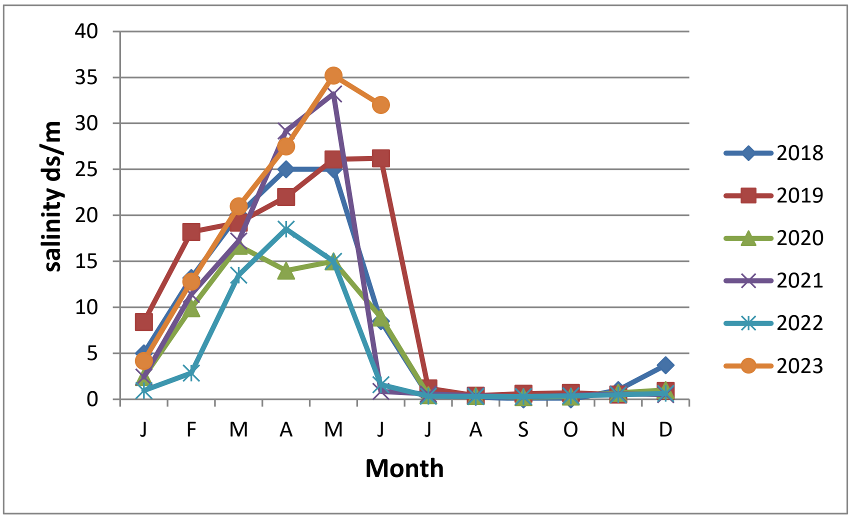


Fig. Salinity level of Pasur River, Mongla Port, Mongla, Bagerhat.

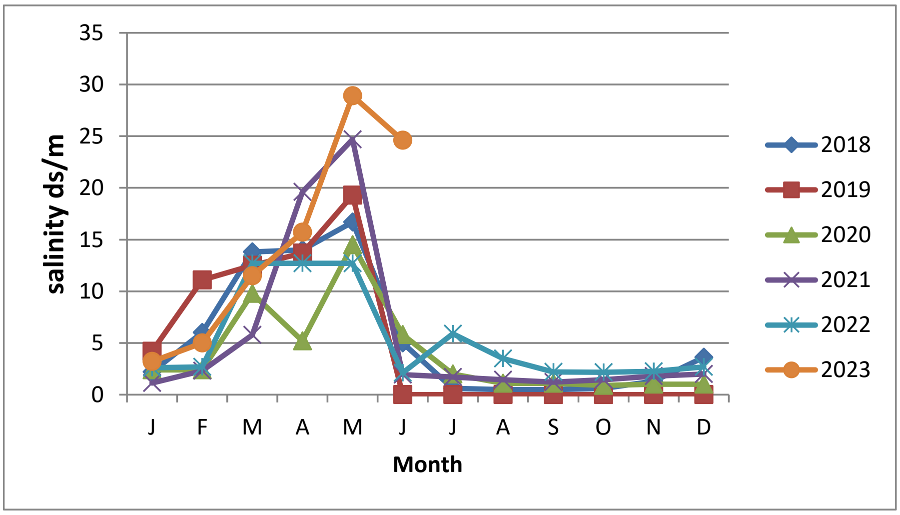


Fig. Salinity level of Daratana river, Bagerhat ferryghat, Bagerhat.

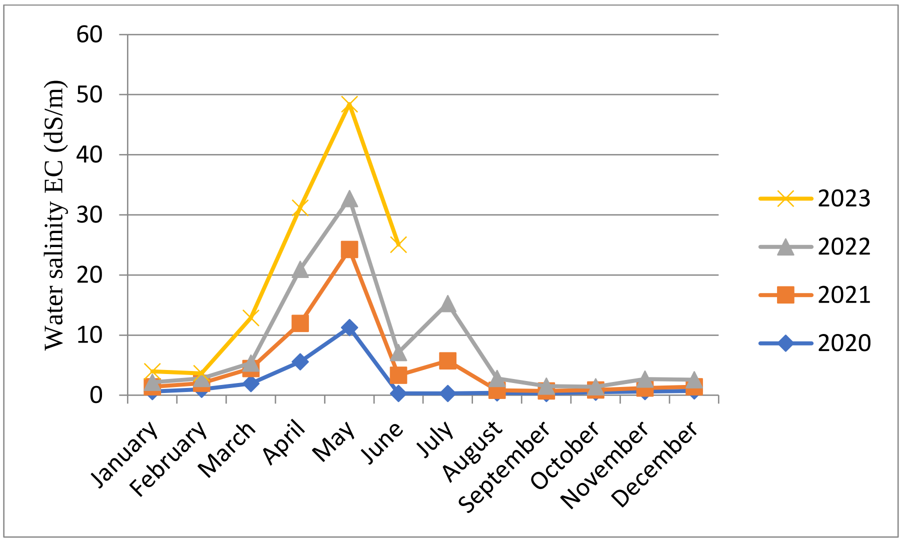


Fig. Salinity level of Kapotaxma River, Sagardari, Kesabpur, Jashore

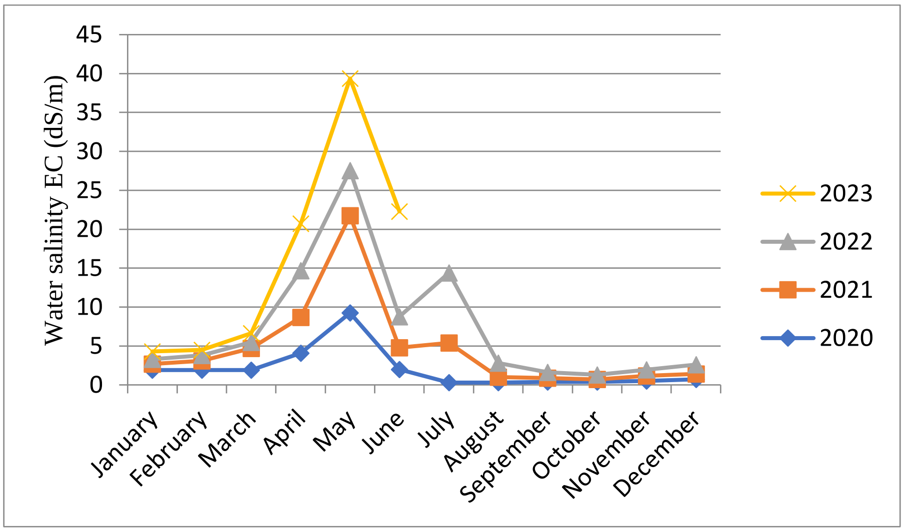


Fig. Salinity level of Bhairab River, Naapara, Jashore

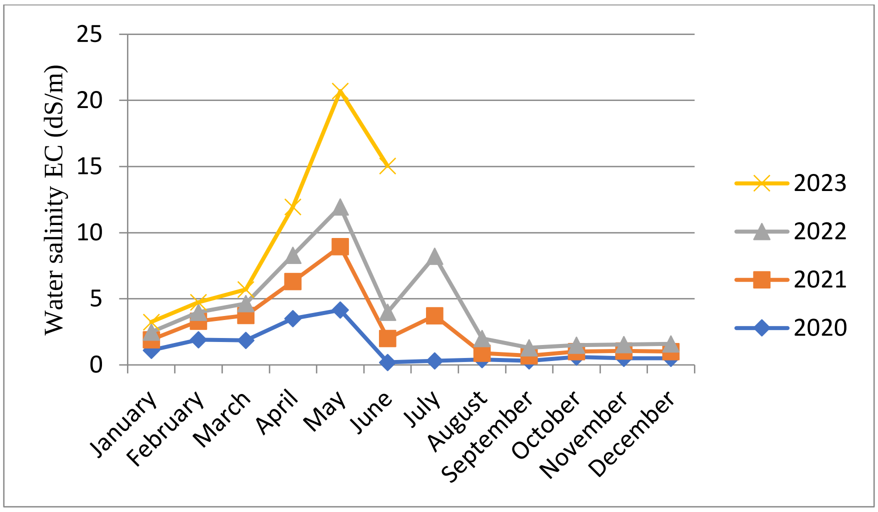


Fig. Salinity level of Afra River, Tularampur, Narail Sadar.

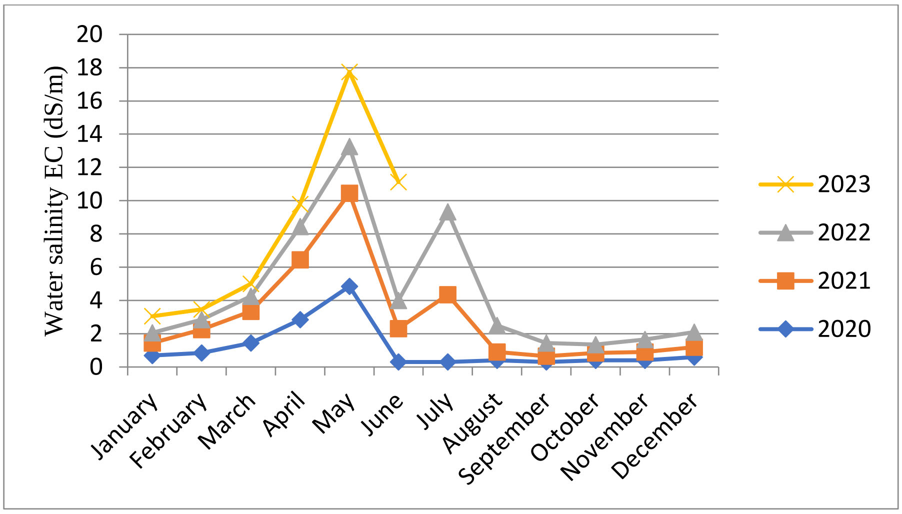


Fig. Salinity level of Chittra River, Gobra, Narail Sadar.

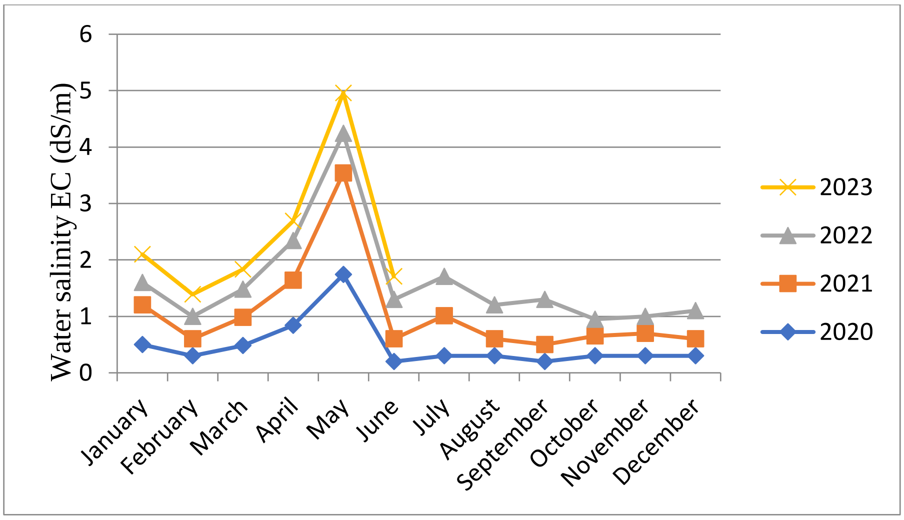


Fig. Salinity level of Modhumoti River, Kalnaghat, Lohagara, Narail.

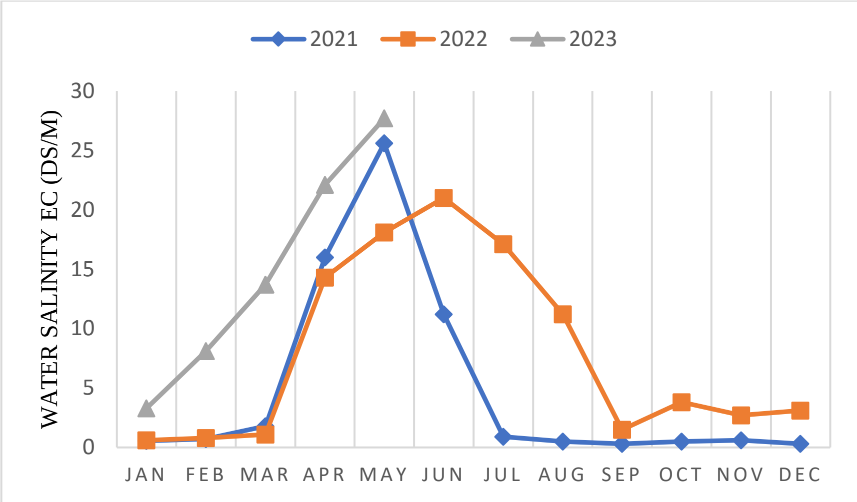


Fig. Salinity level of Kapotaksha river, Patkelghata, Tala, Satkhira.

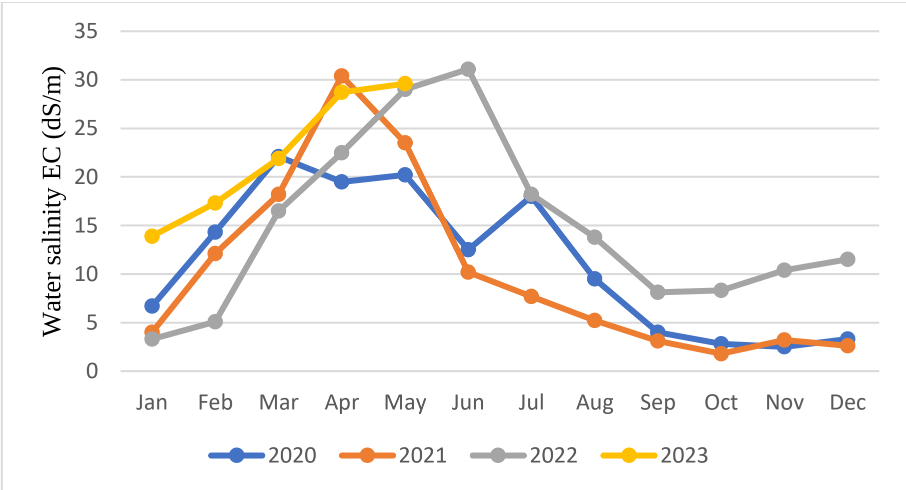


Fig. Salinity level of Morichap river, Ashashuni, Satkhira.

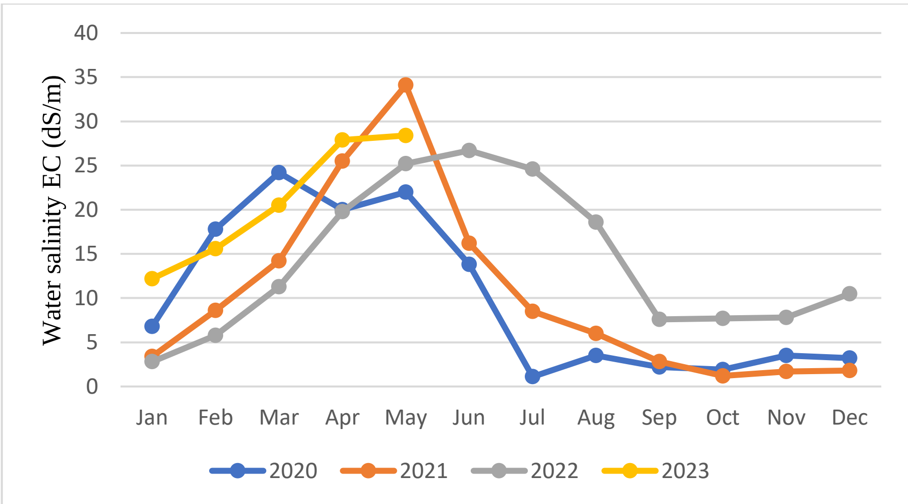


Fig. Salinity level of Kakshiali river, Kaligonj HQ, Satkhira

Barishal Division

24 surface water salinity sites and 3 soil salinity sites were selected in greater Barisal and Patuakhali District. In Barisal monitoring sites are located in Nazirpur, Mathbaria, Pirojpur Sadar and Indurkani of Pirojpur District and Charfashion, Manpura, Bhola Sadar, Tazumuddin, Borhanuddin and Lalmohan of Bhola District. In Patuakhali the monitoring sites are located in Amtali, Taltali, Barguna Sadar, Patharghata, Bamna and Betagi of Barguna District and Kalapara, Galachipa, Patuakhali Sadar, Bauphal, Dashmina and Mirzaganj of Patuakhali District. Surface water (river) samples were collected twice in month during dry season and once in a month during rainy season. Salinity of water was determined by EC meter.

Table 8. Site specification of the soil collection sites of Barishal Division

Sl no.	Name of site	Location	Soil series	Land type	Land Use	Physiography
Patuakhali						
1	Sikandarkhali	Sikandarkhali, Amtali, Barguna	Jhalakathi	MHL	RC- T.Aus -TA	GTF
2	Taltali	Taltali, Sadar, Barguna	Jhalakathi	MHL	RC- T.Aus-TA	GTF
3	Kalapara	Kalapara Sadar, Patuakhali	Barishal	MHL	RC- F- TA	GTF

Table 8. Site specification of the water collection sites of Barishal Division

Sl. No	Name of river/DTW	Location
Barishal		
1	Baleshwar river	Nazirpur Upazila Sadar
2	Panguchi river	Indurkani Upazila Sadar
3	Kacha river	Bekutia Ferry Ghat
Patuakhali		
4	Tentulia	Panpatti Launchghat, Galachipa
5	Payra	Taltali Sadar, Taltali, Borguna
6	Payra	Amtali ferryghat, Amtali, Borguna
7	Payra	Payrakunja, Patuakhali Sadar
8	Bishkhali	Patharghata Launchghat, Patharghata, Borguna
9	Bishkhali	Baraitala ferryghat, Borguna Sadar
10	Bishkhali	Bamna launchghat, Bamna, Borguna
11	Bishkhali	Betagi launchghat, Betagi, Borguna
12	Baleshwar	Bara Machua Ferryghat, Mathbaria, Pirojpur
13	Baleswar	Padma Sluice gate, Patharghata, Barguna
14	Andharmanik	Kalapara Ferryghat, Kalapara, Patuakhali
15	Galachipa	Galachipa Ferryghat, Galachipa, Patuakhali
Bhola		
16	Meghna	Ilisha Launchghat, BholaSadar
17	Meghna	Doulatkhan Launchghat, Doulatkhan, Bhola
18	Meghna	Hakimuddin Launchghat, Borhanuddin, Bhola
19	Meghna	Tojumuddin Launchghat, Tojumuuddin, Bhola
20	Meghna	Mongolsikder Launchghat, Lalmohon, Bhola
21	Meghna	Betua Launchghat, Charfassion, Bhola
22	Tetulia	Gongapur Launchghat, Borhanuddin, Bhola
23	Tetulia	BholaKheyaghat, Bhola Sadar, Bhola
24	Tetulia	Veduria launchghat, Bhola Sadar, Bhola

Graphical presentation of soil monitoring site of Barishal division:

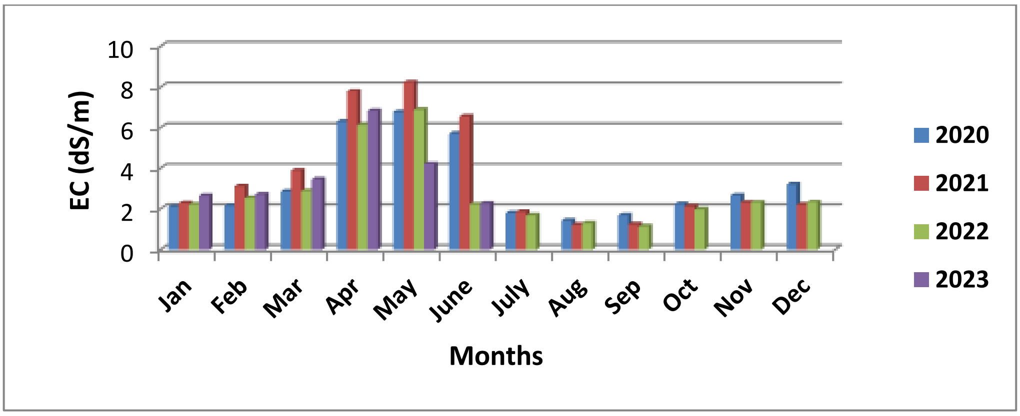


Fig. Salinity level of soil series Jhalakathi, MHL, observed at Amtali, Barguna

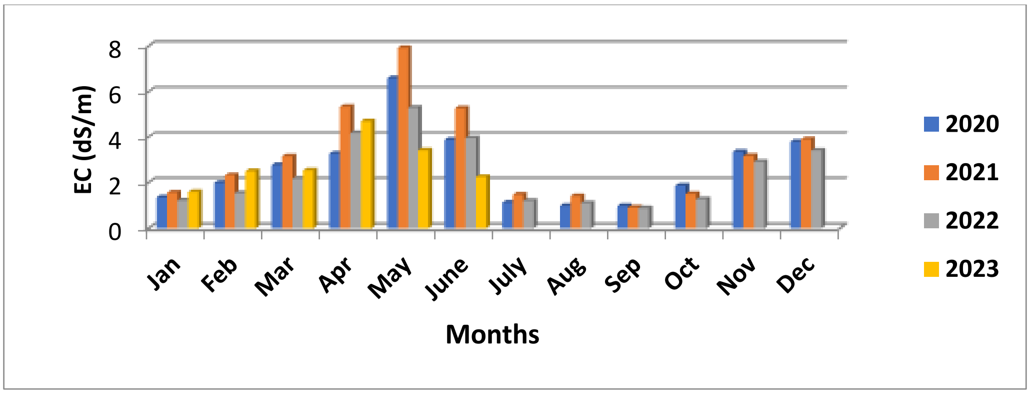


Fig. Salinity level of soil series Jhalakathi, MHL, observed at Taltali, Barguna

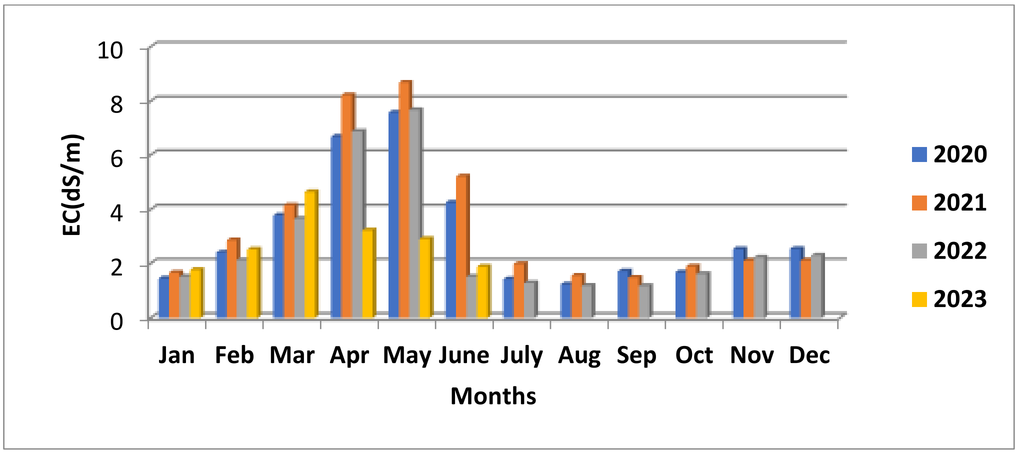


Fig. Salinity level of soil series Jhalakathi, MHL, Kolapara, Potuakhali

Graphical presentation of some selected water monitoring site of Barishal division:

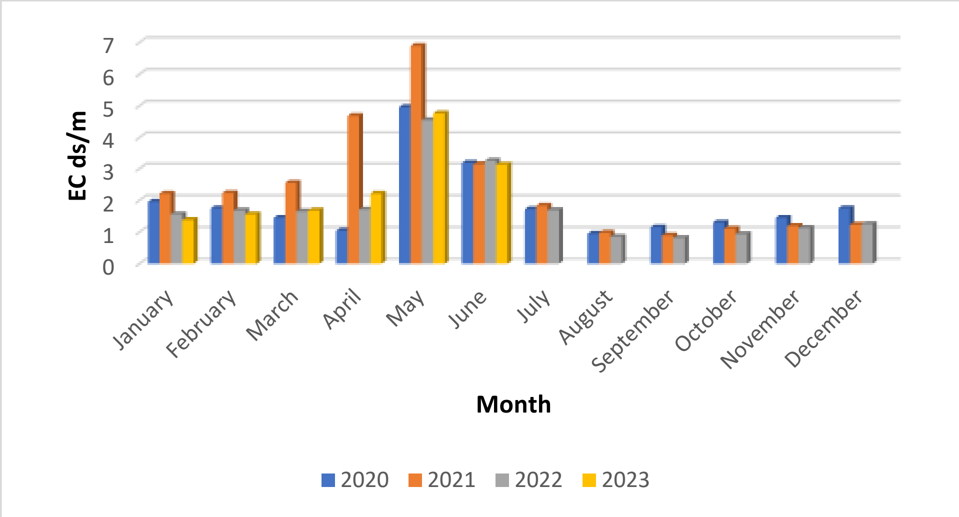


Fig. Salinity level of Baleshwar river, Nazirpur Upazila Sadar, Pirojpur

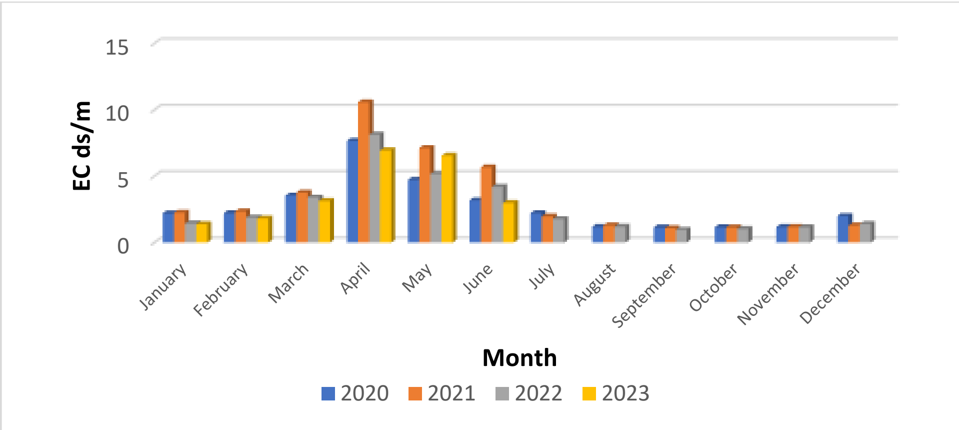


Fig. Salinity level of Payra river, Indurkani Upazila Sadar, Pirojpur,

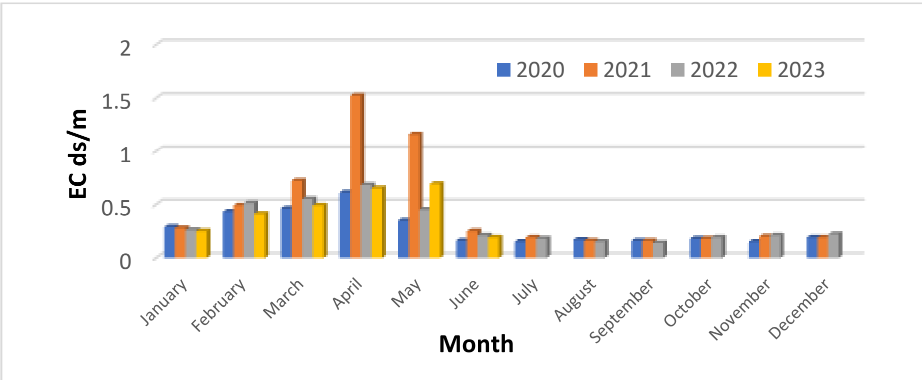


Fig. Salinity level of Kacha river, Bekutia Ferry Ghat, Pirojpur

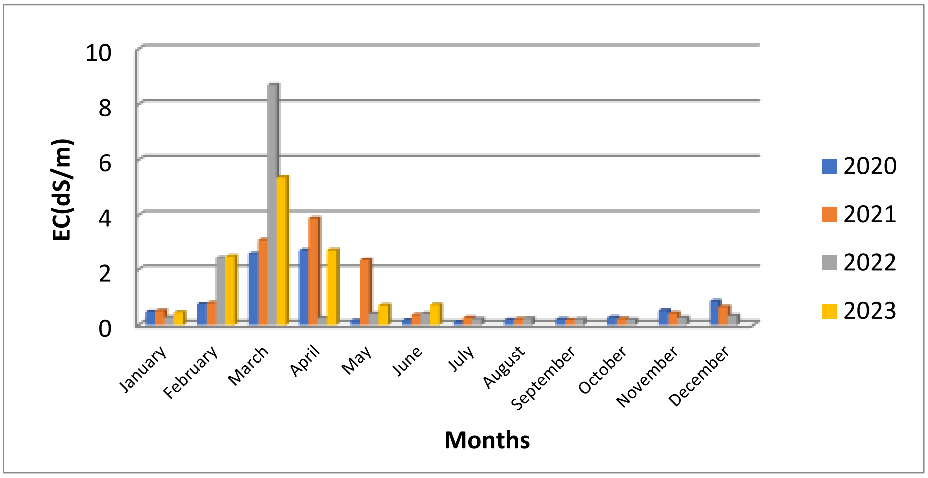


Fig. Salinity level of Meghna River, Doulatkhan Launchghat, Doulatkhan, Bhola

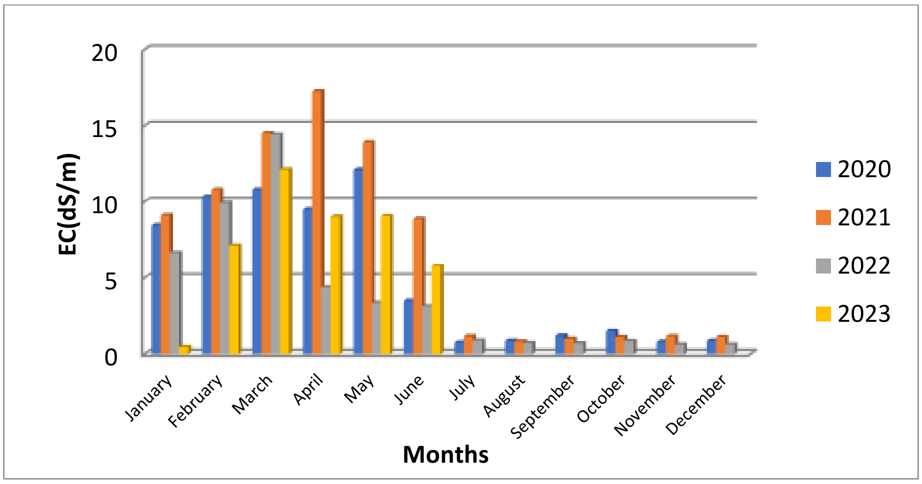


Fig. Salinity level of Meghna River, Tojumuddin Launchghat, Tojumuuddin, Bhola

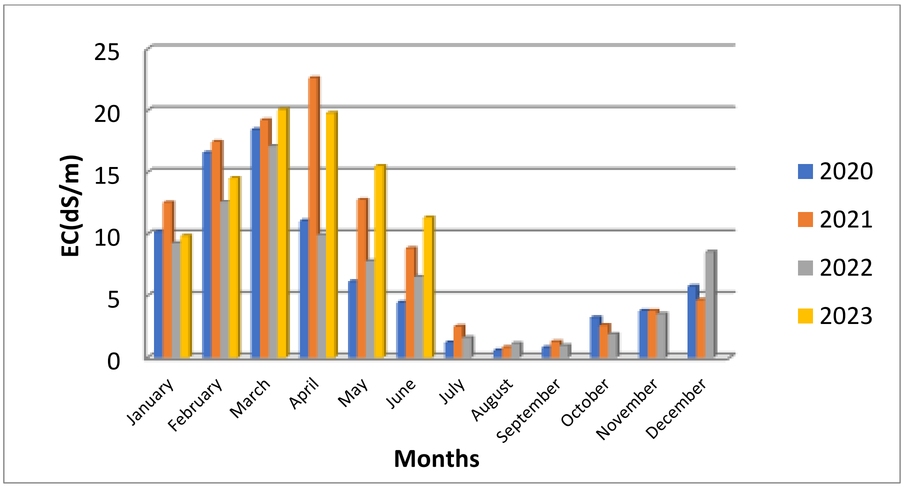


Fig. Salinity level of Meghna River, Betua Launchghat, Charfassion, Bhola

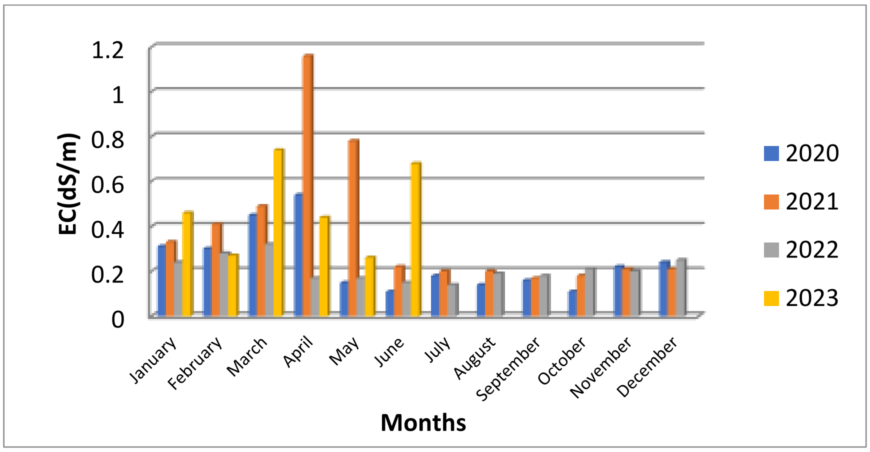


Fig. Salinity level of Tetulia River, Veduria launchghat Bhola Sadar

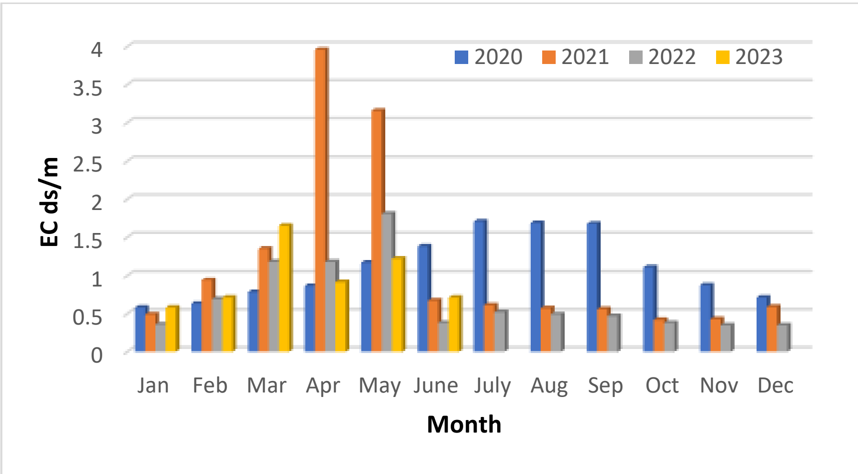


Fig. Salinity level of Bishkhali River, Patharghata launchghat, Patharghata, Barguna

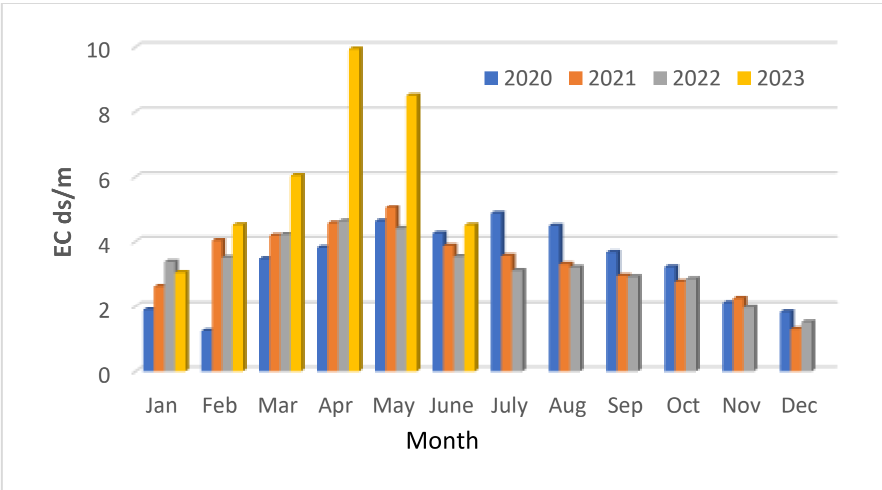


Fig. Salinity level of Baleswar river, Padma Sluice gate, Patharghata, Barguna

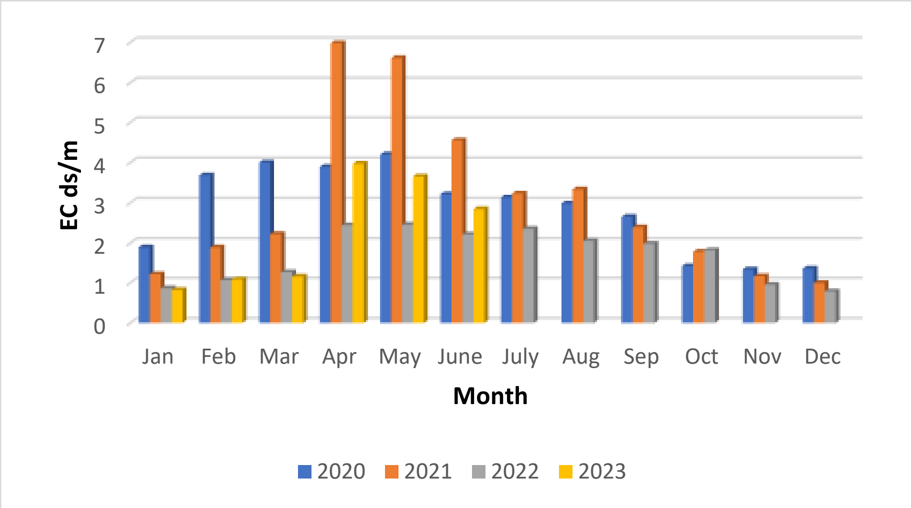


Fig. Salinity level of Baleswar River, Bara Machua Steamerghat, Mathbaria, Pirozpur

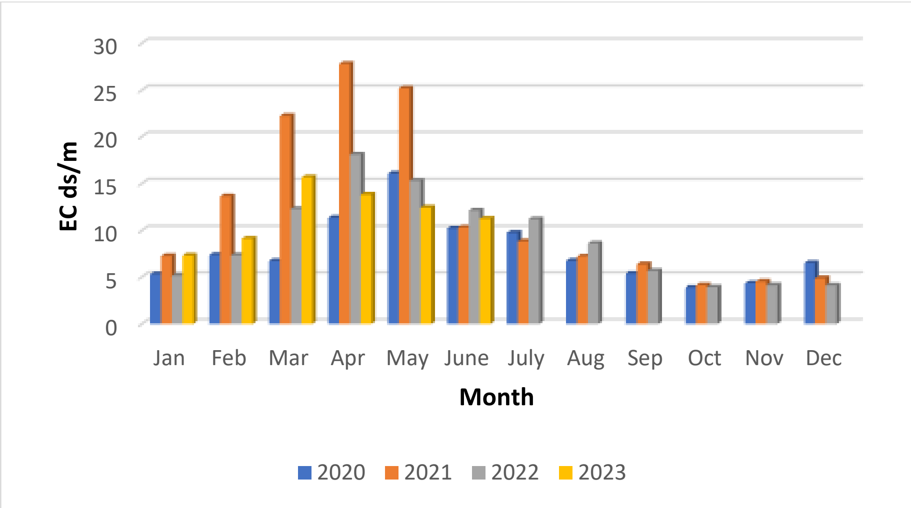


Fig. Salinity level of Andharmanik River, Kalapara Ferryghat, Kalapara, Patuakhali

Gopalganj

Soil and water salinity observed for the first time in Gopalganj district in this year. 7 surface water salinity sites and 7 soil salinity sites were selected in Gopalganj district. The monitoring sites are located in Different area of Gopalganj District. Surface water (river, STW) samples were collected twice in month during dry season and once in a month during rainy season. Salinity of water was determined by EC meter.

Soil Salinity Data

Year 2023	Monthwise EC Value											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dumuria	6.08	2.50	2.50	2.50	5.58							
Patgati	5.45	5.58	7.98	4.18	3.80							
Khalek Bazar	9.12	17.70	16.60	14.20	9.25							
Horidaspur	9.38	8.38	11.79	7.98	6.21							
Vatiapara	0.38	4.69	4.82	1.17	1.30							
Satpar	4.44	4.44	5.58	5.07	1.83							
South Gangarampur	0.64	0.91	1.04	0.91	1.30							

Water Salinity Data

Year 2023		Monthwise EC Value											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dumuria	river	0.54	0.48	0.59	1.70	3.34							
	STW	5.77	5.95	6.12	5.25	5.84							
Patgati	river	0.58	0.46	0.59	1.97	3.69							
	STW	1.10	1.12	1.12	1.15	1.10							
Khalek Bazar	river	0.56	0.47	0.53	2.13	4.16							
	STW	5.75	5.85	5.91	5.95	5.93							
Horidashpur	river	0.51	0.49	0.46	0.37	0.45							
	STW	0.74	0.73	0.73	0.80	0.76							
Vatiapara	river	0.51	0.42	0.47	0.49	0.64							
	STW	1.27	1.16	1.19	1.21	1.18							
Satpar	river	0.51	0.44	0.39	0.35	0.35							
	STW	5.36	1.20	1.27	1.18	1.16							
South Gangarampur	river	0.55	0.45	0.38	0.34	0.32							
	STW	1.11	5.45	4.55	4.64	4.56							

3.5 Technology Transfer through Adaptive Trials

Introduction

Technology Transfer through Adaptive Trial programme has been initiated to popularize Upazila Nirdeshika based fertilizer recommendation system among the farmers as well as to demonstrate the benefits of balanced fertilizers to conserve soil health with sustainable crop production. Using balanced fertilizers not only averts misuse of valuable fertilizers but also declines environmental pollution. Use of balanced fertilizers contributes ensuring the sustainability of increased trend of crop yields. To popularize balanced fertilizer application among farmers with a view to reducing crop production cost and environmental pollution, adaptive trials are established on the basis of Upazila Nirdeshika.

Objectives

- To exhibit the benefit of using balanced fertilizer in crops according to Upazila Nirdeshika soil test results.
- To promote the use of Upazila Nirdeshika among farmers.
- To stimulate the farmers to conserve soil health through rationale use of chemical fertilizers.

Materials and Methods

Two different plots of farmer's are selected for setting up of adaptive trial at Upazila level. Land type and soil group of the plot is identified using Soil and Landform Map attached with Upazila Nirdeshika. Then fertility status is determined from data given Table Kha of the respective mapping unit (Chapter 2). Fertilizer dose is determined according to fertility status.

All inputs are supplied by SRDI for both of the farmers for 30 decimal lands. Recommended agronomic practices are followed in the trial plot. But the control plot is managed by the farmers according to their normal practice. Time to time visit and monitoring is ensured by the SRDI and DAE experts to provide timely suggestion. When crops are ready to harvest, a field day is arranged for crop cutting inviting farmers, GO/ NGO officials and public representatives.

Results and Discussion

After crop cutting from the trial plots in every District and Upazila it was observed that trial plot yield was higher than that of control plot. Farmer's knowledge gap, resource constraint and lack of communication with resource persons are responsible for the yield.

Table. Comparative crop yield between FRC based fertilizer and farmer's practice in (FY 2022-2023)

Sl. No.	Name of Upazila	District	Crop & Variety	Average yield (t/ha)		
				Farmer's field	Demonstration plot	Yield increase%
1	Trishal	Mymensingh	BRRI dhan-49	5	6.40	+28
2	Mymensingh Sadar	Mymensingh	BRRI dhan-52	4.8	6.0	+25
3	Jamalpur Sadar	Jamalpur	BRRI dhan-75	5.74	7.12	1.38
4	Nalitabari	Sherpur	BRRI dhan-87	4.14	5.23	1.09
5	Tangail sadar	Tangail	BRRI dhan-73	5.4	6.6	22
6	Tangail sadar	Tangail	BRRI dhan-73	5.5	6.7	22
7	Boalmari	Faridpur	BINA dhan-17	4.8	6.0	25%
8	Madhukhali	Faridpur	BRRI dhan-87	4.0	4.9	22%
9	Madaripur Sadar	Madaripur	BARI Sarisha-14	1.2	1.5	25%
10	Tala	Satkhira	BRRI dhan87	5.2	5.7	+9.61
11	Dumuria	Khulna	BRRI dhan87	5.4	6.3	+16.7
12	Chitolmari	Bagerhat	BARI Tomato-15	68.02	76.07	+11.83
13			Mustard (local variety)	1.0	1.1	+10.00
14			BARI Tomato-3	41.56	47.34	+13.90
15			BARI Lau -4	33.26	37.45	+12.59
16	Fakirhat	Bagerhat	BRRI dhan49	4.60	5.50	+19.56
17			BRRI dhan62	3.92	4.50	+14.79
18	Jashore sadar	Jashore	BRRI dhan87	5.5	6.2	+12.72
19	Monirampur	Jashore	BRRI dhan87	5.7	6.68	+17.19
20	Doulatpur	Kushtia	BRRI dhan87	4.4	5.2	+18.18
21	Alamdanga	Chuadanga	BRRI dhan87	5.4	5.7	+5.55
22	Satkhira Sadar	Satkhira	Cauliflower (Hybrid)	46.56	51.61	+10.84
23			Cabbage (Hybrid)	85.87	93.56	+ 8.95
24			BRRI dhan75	4.2	5.1	+21.43
25			BINAdhan-17	5.2	6.1	+17.31
26	Debhata	Satkhira	Brinjal (Hybrid)	59.78	65.47	+9.51
27			Pointed Gourd (Hybrid)	29.39	33.27	+13.20
28	Wazirpur	Barishal	T Aman Rice	5.01	6.32	24

Sl. No.	Name of Upazila	District	Crop & Variety	Average yield (t/ha)		
				Farmer's field	Demonstration plot	Yield increase%
			BRRI dhan 52			
29	Babuganj		T Aman Rice BR-23	4.19	5.08	21
30	Betagi	Barguna	Boro, BRRI dhan-87	5.13	6.14	20
31	Amtali		Boro, BRRI dhan-87	5.14	5.78	12
32	Raozan	Chattogram	Amon Brri Dhan-87	4.0	4.5	12
33	Fatikchari		Amon Brri Dhan-87	6	6.5	8
34	Ashuganj	Brahmanbaria	Bari Sharisha-14	1.05	1.21	15
35	Cumilla Sadar South	Cumilla	BRRI Dhan-87	5.5	6.1	+11.0
36	Cumilla Adarsha Sadar	Cumilla	BRRI Dhan-87	5.7	6.4	+12.3
37	Sadar	Noakhali	BRRI dhan-87	4.2	4.7	12
38	Kobirhat	Noakhali	BRRI dhan-93	4.4	5.2	18
39	Naniarchar	Rangamati	Aman-22 (BRRI Dhan 80)	4.31	5.03	14.3
40	Naniarchar	Rangamati	Aman-22 (BRRI Dhan 75)	4.42	5.3	16.6
41	Godagari	Rajshahi	Aman (BRRI dhan -51)	4.3	5.2	21.0
42	Tanore	Rajshahi	Aman (BRRI dhan -51)	4.5	5.5	22.5
43	Chapainawabganj sadar	Chapainawabganj	Boro (BRRI Dhan-29)	7.78	8.68	11.57
44	Sirajganj Sadr	Sirajganj	Wheat (BARI Gam-33)	3.75	4.6	22.67
45	Naogaon, Sadar	Naogaon	Wheat (BARI Gam-33)	2.99	3.59	20.07%
46	Shajahanpur	Bogura	Boro (BRRI Dhan-71)	4.15	5.2	25.30
47	Bogura Sadar	Bogura	Boro (BRRI Dhan-71)	4.2	5.15	22.62
48	Chatmohor	Pabna	Aman BRRI dhan-87	5.1	6.3	23.52
49	Atgharia	Pabna	Aman BINA dhan-7	4.4	5.4	22.72
50	Rangpur sadar	Rangpur	Aman (BRRI 87)	5.5	5.86	6.54
51	Mithapukur	Rangpur	Amon (BR 11)	5.28	5.67	7.38
52	Kaunia	Rangpur	Mustard (BARI 14)	1.17	1.35	15.38
52	Kaharol	Dinajpur	Aman (BRRI-51)	3.85	4.32	12
54	Chirir Bandar		Aman (BRRI-34)	2.81	3.23	15
55	Birol		Mustard (BARI-14)	1.38	1.55	12.3
56	Sadar	Gaibandha	Mustard Bari Sarisha-14	1.3	1.6	23%

Sl. No.	Name of Upazila	District	Crop & Variety	Average yield (t/ha)		
				Farmer's field	Demonstration plot	Yield increase%
57	Lalmonirhat Sadar	Lalmonirhat	BARI Sarisa-14	1.10	1.30	18.20
58	Thakurgaon Sadar	Thakurgaon	Potato (BARI Alu-7)	24.8	28.4	14.51
59	Dakshin Surma	Sylhet	BRRI dhan75	3.55	4.5	26.76%
60	Sylhet Sadar	Sylhet	BRRI dhan87	5.10	6.4	25.49%
61	Moulvibazar Sadar	Moulvibazar	BRRI Dhan87	5.8	6.30	8.62%
62	Sreemangal	Mouvibazar	BRRI Dhan87	4.96	5.84	17.74%

Conclusion

Farmers obtained higher yield by using balanced dose of fertilizer on the basis of Upazila Nirdeshika. It is a low/no cost technology which contributes farmers higher yield through sustainable soil management. The results revealed that farmers got 1.09%-28% higher yield in different crops and varieties in comparison to farmers' practices in different locations.

3.6 Distribution of Fertilizer Recommendation Cards

Intoduction

Increasing crop production through sustainable soil management is now a global concern. It is also relevant to our Sustainable Development Goals SDGs. It is a harsh reality that our government has to ensure food security with limited land resources. So, food security is indissolubly linked with soil health management. We must feed our swelling population, but it should not be for the cost of nutrient mining. Keeping it in view SRDI launched the programme in order to popularize and disseminate practice of balanced fertilizer use among farmers throughout the country. In 2022-2023, total number of fertilizer recommendation cards distributed was 16574, of which 6843 numbers were on the basis of Upazila Nirdeshika, 9024 on the basis of OFRS and rest 707 were soil test basis.

Table. Fertilizer Recommendation Cards Distribution:

Name of Office	District	Upazila	Type of service		
			Nirdeshika based	Online based	Soil test based
Regional Office, Mymensingh	Mymensingh	Mymensingh Sadar, Trishal, Tarakanda.	250	340	-
Regional Office, Narsingdi	Narsingdi	Monordi, Shibpur, Belabo	100	530	-
Regional Office, Munshiganj	Munshiganj	Sreenagar, Tongibari, Sirajdikhan, Gazaria	25	400	-
Regional Office, Netrokona	Netrokona	Kalmakanda, Netrokona Sadar	100	400	-
Regional Office, Jamalpur	Jamalpur	Jamalpur Sadar, Islampur, Melandaha Sorishabari,	330	487	-

Name of Office	District	Upazila	Type of service		
			Nirdeshika based	Online based	Soil test based
	Sherpur	Sherpur Sadar, Nokla, Sreebordi, Nalitabari Jhinaigati			
Regional Office, Jashore	Jeshore	Monirampur, Jashore sadar	120	600	-
Regional Office, Jhenaidah	Jhenaidah	JhenaidahSadar	100	305	-
Regional Office, Kushtia	Kushtia	Kumarkhali, Khoksa, Doulatpur, Mirpur	132	316	-
	Chuadanga	Alamdanga, Damurhuda	70		-
	Meherpur	Gangni, Baradi	-	130	-
Regional Office, Satkhira	Satkhira	Satkhira sadar, Kaligonj, koraroa Debhata	120	600	-
Divisional office, Barishal	Pirozpur	Mathbaria	150	-	-
Regional Office, Patuakhali	Barguna	Betagi, Barguna Sadar	250	75	-
	Patuakhali	Bauphal, Dumki	710	80	-
Regional Office, Bhola	Bhola	Bhola sadar, Daulatkhan, Borhanuddin, Charfassion	310	201	-
Regional Office, Brahmanbaria	Brahmanbaria	Sarail, Nabinagar, Ashugonj	200	150	-
Regional Office, Cumilla	Cumilla	Debidwar, Cumilla Adarsha Sadar, Lalmai, Chandina, Cumilla Sadar, South Burichang	282	442	-
Regional Office, Rangamati	Rangamati	Rangamati Sadar, Kaukhali, Naniarchar, Kaptai	163	150	-
	Khagrachhari	Mohalcchari	-	100	-
Regional Office, Chapainawabganj	Chapainawabganj	All Upazilla	382	220	-
Regional Office, Naogaon	Naogaon	Naogaon Sadar	100	190	-
Regional Office, Bogura	Bogura,	Bogura Sadar,	200	340	-
	Joypurhat	Shahjahanpur, Kalai			
Regional Office, Pabna	Pabna	Pabna sadar, Sujanagar, Atgharia	200	340	-
Regional Office, Sirajganj	Sirajganj	All Upazilla	150	140	-
Divisional Office, Rangpur	Rangpur	Mithapukur, Pirgacha Rangpur Sadar, Taraganj	430	360	-
	Nilphamari	Kishoreganj, Dimla, Domar, Joldhaka.			

Name of Office	District	Upazila	Type of service		
			Nirdeshika based	Online based	Soil test based
Regional Office, Dinajpur	Dinajpur	Dinajpur Sadar, Kaharol, Chirir Bandar, Birol	528	150	52
Regional Office, gaibandha	Gaibandha	Sadar, Palashbari, Sadullapur, Gobindagang	300	200	50
Regional Office, Lalmonirhat	Lalmonirhat	Sadar	270	330	39
	Lalmonirhat	Aditmari			
Regional Office, Thakurgaon	Thakurgaon	Thakurgaon Sadar, Baliadangi, Ranishankail, Pirganj, Haripur	220	700	566
Divisional office, Sylhet	Sylhet	Beanibazar, Balaganj Osmaninagar, Golapganj	300	200	-
Regional Office, Moulvibazar	Moulvibazar	Moulvibazar Sadar, Srimangal	351	352	-
Regional Office, Sunamganj	Sunamganj	Sunamganj Sadar, Duarabazar		196	-
Total			**6843**	**9024**	**707**

3.7 Advisory Services to Beneficiaries

Name of Office	District	Upazila	Agency	Service Provided
Regional Office, Mymensingh	Mymensingh	Mymensingh Sadar	Bangladesh Agricultural University (BAU)	Soil series identification, profile description, sample collection of MS & PhD student.
Regional Office, Narsingdi	Narsingdi	Naringin Sadar	DD, DAE	Distribution of Updated Nirdeshika 1. sadar-5 2. shibpur-5
Regional Office, Jamalpur	Jamalpur Sherpur	Jamalpur Sadar Melandaha Nakla	Kendua Mrittika Krishi Club Chorpolisha Mrittika Krishi Club Nakla Mrittika Krishi Club	In 2022-23, A total of 3 'Mrittika Krishi Club' established with 50-100 advanced farmers under SRDI Innovation programme.
Regional Office, Tangail	Tangail	Tangai sadar Ghatail Basail Dhanbari Gopalpur Madhupur	DAE, BADC Farmers Students Scientists	Poster, leflet, booklet, festoon distribution, FRC, Soil fertility data, Soil management
Divisional Office, Barishal	Barishal	Barishal Divisional Office	Barishal University	Soil profile description and soil texture and soil series identification
			Dept. of Soil Sc. Patuakhali Science & Technology University	Provided data and information on soil nutrient

			FAO	status and soil and water salinity.
Regional Office, Patuakhali	Patuakhali	Sadar Kalapara Bauphal Dumki	DAE	Providing information on soil fertility & productivity and soil & water salinity
	Barguna	Sadar Patharghata Taltali Betagi		
Regional Office, Bhola	Bhola	All Upazilla	DAE	Provided information on soil and water salinity of Bhola District.
	Bhola	Daulatkhan	Farmers group	Identify Soil Salinity related problems give suggestion for salinity management.
	Bhola	Bhola Sadar and Daulatkhan	BARI, Bhola	Provided Upazilla Land and soil related information.
	Bhola	Bhola Sadar Upazilla	Govt Bhola College	Soil profile description and soil texture and soil series identification
	Jhalakathi	Nalcity, Jhalakathi Sadar, Rajapur	DAE	Provided Land use and soil series related information.
Divisional Office, Chattogram	Chattogram	Sadar	War Cemetery	10 Soil Samples were tested and reported.
Regional Office, Brahmanbaria	Brahmanbaria	Sadar	Titas gas field	Advise for scientific and proper way of soil sample collection and Soil test for determination of Heavy metal (Pb,Cr)
Regional Office, Cumilla	Cumilla	Cumilla Sadar South	UAO, DAE Cumilla Sadar South	Updated Nirdeshila 30
Reginal Office, Rangamati	Rangamati	Rangamati Sadar	Karnaphuli paper mill	Fertility data
			CEGIS	Soil conservation methods
Divisional Office, Khulna	Khulna	-	Khulan University	Provide upazila nirdeshika & union sahayika, aerial photo interpretation technique, Soil survey technique, Salinity information
	Khulna, Satkhira		Solidaridad	FRC, Salinity management technologies, Salinity information
	Satkhira, Jashore		Jagorani Chakra Foundation	
Regional Office, Chapainawabganj	Chapainawabganj	All Upazilas, RU, Exim Bank Agricultural University	#DAE, Different Agencies, RU, Exim Bank Agricultural University, Students & Farmers. <u>#No of benefishieries</u> (Farmers = 1400 MS students =10, PhD students =2 Organization & others= 501)	# Soil sample collection, soil and fertilizer recommendation provided to farmers, students and researchers. #To grow awareness about soil health management. #MS students, PhD students (collecting soil samples from different soil series). # Information supplied to Ph.D. & MS student

				regarding Soil series & Land type.
Regional Office, Naogaon	Naogaon	All Upazila	DAE, Farmers & Students	Soil sample collection and fertilizer recommendation provided
Regional Office, Bogura	Bogura, Joypurhat	All Upazila	DAE, Farmers & Students	Soil sample collection, fertilizer recommendation card and information provided
Regional Office, Bogura	Bogura, Joypurhat	All Upazila	DAE, Farmers & Students	Soil sample collection, fertilizer recommendation card and information provided
Regional Office, Pabna	Pabna	All Upazila	DAE, Farmers & Students	Soil sample collection and fertilizer recommendation provided
Regional Office, Sirajganj	Sirajganj	Sadar	BADC, BSRI	provide help to collect Soil samples
Regional Office, Sirajganj	Rajshahi University	Rajshahi	Ms students of Soil science Dept.	provide help to collect Soil samples and other help in Research activities
Regional Office, Gaibandha	Gaibandha	Palashbari	A.R Malik seed Comp. Ltd.	Soil Sample collection technique training
			UAO, DAE	Discussion on benefit of Upazilanirdeshika& Union soyahika uses
		Sadullapur, Sadar	UAO, DAE	Discussion on how to use Upazilanirdeshika& Union soyahika.
Regional Office, Dinajpur	Dinajpur	Dinajpur Sadar	Hajee Mohammad Danesh Science and Technology University (HSTU)	Soil Profile Presentation in Field Trip
			Department of Agriculture Extension, HSTU	Technical Assistance
Regional Office, Gaibandha	Gaibandha	Palashbari	A.R Malik seed Comp. Ltd.	Soil Sample collection technique training
			UAO, DAE	Discussion on benefit of Upazila nirdeshika & Union soyahika uses
		Sadullapur, Sadar	UAO, DAE	Discussion on how to use Upazila nirdeshika & Union soyahika.
Regional Office, Lalmonirhat	Lalmonirhat	Aditmari	I Farmer Pvt. Ltd.	Technical Support Provided
			MS students of Hajee Danesh Science & Technology University, Dinajpur	Technical Support Provided
		Sadar	LGED	30 Farmers training imparted
Regional Office, Thakurgaon	Thakurgaon	Thakurgaon Sadar	Thakurgaon Sugar Mill	Soil Survey of the farms under Sugar Mill of Thakurgaon
	Dinajpur	Dinajpur Sadar	Department of Agricultural Extension, HSTU	Technical Assistance in their project work

3.8 Other Activities

3.8.1 Training Imparted

Name of Office	Title of the programme	Duration	Host organization	Participant	
				Type	Number
Regional Office, Mymensingh	Training on Soil Sample Collection	1 Day	SRDI, RO Mymensingh	Farmers	50
	Training on Soil Sample Collection	1 Day	SRDI, RO Mymensingh	Farmers	50
	Training on use of Upazilla Nirdeshika	5 Day	SRDI, RO Mymensingh	SAAO	50
	Training on Data Entry In Software using Survey 123 Apps	1 Day	SRDI, RO Mymensingh	SAAO	30
Regional Office, Narsingdi	Farmer training on Soil Sample Collection technique for Soil testing at MSTL	1 day	SRDI, RO Narsingdi	Farmers	100
Regional Office, Munshiganj	Training on soil sample collection methodology and application of balanced fertilizer (for MSTL Jamuna)	2 days	SRDI, RO Munshiganj	Farmers	50
Regional Office, Netrokona	MSTL Farmers Training	1 Day	SRDI, RO, Netrokona	Farmers	50
Regional Office, Jamalpur	Soil sample collection technique.	1 Day	SRDI, RO, Jamalpur	Farmers	200
	Determination of crop cultivation area using Remote Sensing and Upazila Nirdeshika	1 Day	SRDI, RO, Jamalpur	SAAO	30
Regional Office, Tangail	Method of soil sample collection and use of balance fertilizer	1 Day	SRDI, RO Tangail	Farmers	150
	Use of upazila soil and land utilization guide	5 Days	SRDI, RO Tangail	SAAO	50
Regional Office, Kishoreganj	Method of soil sample collection and use of balance fertilizer	1 Day	SRDI, RO Kishoreganj	Farmers	50
Regional Office, Gopalganj	Method of soil sample collection and use of balance fertilizer	1 Day	SRDI, RO Kishoreganj	Farmers	290
Regional Office, Faridpur	Method of soil sample collection and use of balance fertilizer	1 Day	SRDI, RO Faridpur	Farmers	150
Regional Office, Madaripur	Method of soil sample collection and use of balance fertilizer	1 Day	SRDI, RO Madaripur	Farmers	130
Chattogram	Training on soil sampling methods and application of balanced fertilizers	1 day	SRDI. Chattogram	Farmer	150
Brahmanbaria	MSTL Training : Soil Sample Collection	1day	SRDI	Farmer	50

	Procedure, Use of Balance Fertilizer and Identification of Adulterated Fertilizer etc.				
Regional Office, Cumilla	Soil Sample Collection Procedure, Use of Balance Fertilizer and Identification of Adult red Fertilizer	1day	SRDI	Farmer	150
Regional Office, Chandpur	Soil Sample Collection Procedure	1day	SRDI	Farmer	50
Regional Office, Rangamati	Soil sample collection technique, identification of adulterate fertilizers, Soil & Fertilizer management	1(one day)	SRDI, Rangamati	farmer	100
Divisional Office, Barishal	Method of soil sample collection & use of balanced fertilizer	1 day	SRDI	Farmers	50
Regional Office, Patuakhali	Farmers Training on Importance of Soil Test, Sample Collection Technique & Balanced Fertilizer Application	1 day	SRDI, Patuakhali	Farmers	100
Regional Office, Bhola	Soil sample collection technique, identification of adulterate fertilizers, methods & time of fertilizer application, deficiency symptoms of nutrient element and use of balanced fertilizer. Salinity management	1 day	SRDI, Bhola	Farmer	50
	Crop Signature Collection Using Remote Sensing Technology	1 day	SRDI, Bhola	SAAO	30
Divisional Office, Khulna	Problematic soil management	2 days	Funded by: GKBSP project Implemented by: SRDI, DO, Khulna	Officers	1
	Soil sample collection technique, identification of adulterate fertilizers, methods & time of fertilizer application, deficiency symptoms of nutrient element and use of balanced fertilizer. Salinity management	1 day	SRDI, DO, Khulna		510

	Use of Upazila Nirdeshika and Union Sahayika	5 days	SRDI, DO, Khulna	SAAO	45
Regional Office, Jashore	Collection of soil sample collection and balanced fertilizer application	01 day	SRDI	Formers	150
	Use of soil and land use guide	05 day	SRDI	SAAO	50
	Modern cotton cultivation and technologies transfer	01	CDB	CDB personnel	50
Regional Office, Jhenaidah	Training on soil sampling, use of balanced fertilizers and methods of detection of adulterated fertilizers	01 day	SRDI, RO, Jhenaidah	Farmers	100
Regional Office, Kushtia	Training of SAAO on Use of "Upazila Land and Soil Resource Use Guidelines"	5 days	Funded by: SRSRF project Implemented by: SRDI, RO, Kushtia	SAAO	50
	Training of farmers on soil sample collection technique, identification of adulterate fertilizers, methods & time of fertilizer application, deficiency symptoms of nutrient element and use of balanced fertilizer	1 day	SRDI, Kushtia	Farmer	150
Regional Office, Satkhira	Soil sample collection technique, identification of adulterate fertilizers, methods & time of fertilizer application, deficiency symptoms of nutrient element and use of balanced fertilizer. Salinity management	1 day	SRDI, Satklhira	Farmer	410
Divisional Office, Rajshahi	Training on Upazila Land and Soil Resource utilization guide	05 days	Divisional Office, Rajshahi	SAAO,s	50
	Training on soil sample collection and soil management (MSTL)	02 days	Divisional Office, Rajshahi	Farmers	100
Regional Office, Naogaon	Training on soil sample collection and soil management (MSTL)	01 day	Regional Office, Naogaon	Farmers	50
Regional Office, Chapainawabganj	Acid Soil Management and	02 days	Regional Office, Chapainawabganj	SAAO, s	20

	Sustainable crop production.				
Regional Office, Chapainawabganj	Training on balanced fertilizer utilization, soil sample collection and Identification of Adulterated fertilizers.	01day	Regional Office, Chapainawabganj	Farmers	150
Regional Office, Sirajganj	Training on soil sample collection and soil management (MSTL)	1 days	Regional Office, Sirajganj	Farmers	50
Regional Office, Bogura	Training on soil sample collection and soil management (MSTL)	1 days	Regional Office, Bogura	Farmers	100
Divisional Office, Rangpur	Methods of Soil Sample Collection, Use of Balanced Fertilizer & Fertilizer Management	01 Day	SRDI, Divisional Office, Rangpur	Farmers	100
	Training on Upazila Nirdeshika	5 days		SAAO	50
	Method of Soil Sample Collection, Use of Balance Fertilizer & Fertilizer Management	01 Day	SRDI, Regional Office, Dinajpur	Farmers	150
	Training on Use of Upazila Nirdeshika	05 Days		SAAO	50
Regional Office, Gaibandha	Soil Sample collection technique	1 days	SRDI	Farmer	100
Regional Office, Lalmonirhat	MSTL Farmers Training at Chilmari upazila During Rabi season.	1 Day	SRDI, Lalmonirhat	Farmers	50
Regional Office, Thakurgaon	Method of Soil Sample Collection, Use of Balance Fertilizer & Fertilizer Management	01 Day	SRDI, Regional Office, Thakurgaon	Farmers	150
	Training on Use of Upazila Nirdeshika	05 Days		SAAO	50
Divisional Office, Sylhet	Soil Sample Collection Training (MSTL)	1 day	SRDI	Farmers	50
	Training on Soil Management, OFRS And Balanced Fertilizer Use (Funded by SRSRF project)	1 day	SRDI	Farmers, UDC Entrepreneurs And Other Beneficiaries	90
	Training on use of Upozila Nirdeshika (Funded by SRSRF project)	5 days	SRDI	SAAO	50

Regional Office, Moulvibazar	Soil Sample Collection Training (MSTL)	1 day	SRDI	Farmers	100
Regional Office, Sunamganj	Soil Sample Collection Training (MSTL)	1 day	SRDI	Farmers	50

3.8.2 Distribution of saplings and/seedlings

Name of Office	District	Upazila	Number		Total	Remarks
			Fruits	Vegetables		
Regional Office, Mymensingh	Mymensingh	Mymensingh Sadar	80	-	80	Saplings were distributed Among Farmer`s
Regional Office, Jamalpur	Jamalpur	All upazilas	100	150	250	
Regional Office, Munshiganj	Munshiganj	Munshiganj Sadar	50	200	250	
Regional Office, Netrokona	Netrokona	Kalmakanda	250	250	500	
Regional Office, Narsingdi	Narsingdi	Monohordi	100	0	100	
Regional Office, Tangail	Tangail	Tangail sadar	300	-	300	
Divisional Office, Barishal	Barishal	Uzirpur	-	1200	1200	
Regional Office, Patuakhali	Patuakhali	Patuakhali Sadar	250	-	250	
		Mirzaganj	52	468	520	
Regional Office, Bhola	Bhola	Daulatkhan	100	250	350	
Regional Office, Brahmanbaria	Brahmanbaria	Sarail	50	50		
		Nasirnagar	50	50		
Regional Office, Cumilla	Cumilla	Cumilla Sadar South	100	-	200	
		Chandina	100	-		
Regional Office, Chandpur	Chandpur	Faridgonj	100	-	100	
Regional Office, Rangamati	Rangamati	Naniarchhar	-	500	500	
Regional Office, Jhenaidah	Jhenaidah	Jhenaidah Sadar	-	600	600	
Regional Office, Kushtia	Kushtia	Kushtia Sadar	150	666	816	
	Meherpur	Gangni	25	75	100	
	Chuadanga	Alamdanga	-	102	102	
Regional Office, Naogaon	Naogaon	All Upazila	200	-	200	
Regional Office, Bogura	Bogura	Bogura Sadar and Gabtoli	250	-	250	
Regional Office, Pabna	Pabna	All Upazila	250	-	250	
Regional Office, Sirajganj	Sirajganj	All Upazila	250	-	250	
Regional Office, Dinajpur	Dinajpur	Dinajpur Sadar	100	-	100	
Regional Office, Moulvibazar	Moulvibazar	Moulvibazar Sadar,	86	129	215	
		Sreemangal	80	120	200	
		Kamalganj	-	12	12	


Pursuing field survey activities by SRDI field survey team


Supervising Field survey activities by monitoring team of MoA


Adaptive trial plot photo

Organizing field day of adaptive trial


Conducting Farmer’s training


Distribution of plant Seedling/sapling among farmers

Speech by Director General, SRDI in a farmer’s training programme


Fertilizer recommendation card distribution

Chapter 4: Activities of Analytical services Wing

4.1 Achievement of Central Laboratory

Introduction

Central Laboratory is operated under the Headquarter of Soil Resource Development Institute. This Laboratory usually conducted chemical and physical analyses of soil supplied by different stake holders like Government organizations, Private entrepreneurs, farmers, research fellow, NARS institutions, universities, and NGOs. But after the revisit of the organogram Central Laboratory conducted some research activities in collaboration with national and international organizations. In 2022 Central Laboratory conducted a study "Micronutrient Fertilizer quality Audit in Bangladesh" with an international collaborative Project named Nutrient Management for Diversified Cropping in Bangladesh (NUMAN) jointly funded by Krishi Gobeshona Foundation (KGF) and Australian Center for International Agricultural Research (ACIAR). Another study was conducted "Detail Soil Survey of Project Hub" under the same Project support.

Goal

Ensure judicious and profitable use of scarce land and soil resources of the country and keep environmental pollution related to agrochemicals at zero level.

Functions of Central Laboratory

- Research activities on different soil and environmental related issues;
- To maintain the quality of analytical work of different Laboratories of SRDI;
- To maintain the quality of imported fertilizers, new fertilizer registration, renewal fertilizer registration;
- To analyze water and plant samples received from different organizations;
- To analyze fertilizer samples in order to assist the agricultural system to control adulteration of fertilizers.

Program of Central Laboratory:

- Quality control of the chemical analysis of different Laboratories for updating Upazila Nirdeshika
- Research Program
- Publications
- Training
- Quality control of fertilizers

Research Program Conducted by Central Laboratory

Experiment 1: Micronutrient Fertilizer Quality in Bangladesh

Introduction

Fertilizer adulteration might one of the causes for yield loss and lack of farmer confidence in fertilizer recommendations. The fertilizer recommendations from NARS and FRG were based on pure and appropriate concentration of N, P, K, S, Zn and B; however, adulterated fertilizers might not provide expected results to the farmers, thus the farmers would deprive of the satisfactory yield of a crop and farmers had to buy and apply more fertilizers to their field for yield maximization. Moreover, continuous application of adulterated fertilizers might have played adverse effect on soil nutrient balance which affected soil health. Quality of fertilizers played an important role to ensure desirable crop yield as well as crop quality. It is imperative to collect various fertilizers from the local level during establishment of crops in the selected cropping patterns in project hub areas and analyze the samples to verify the nutrient concentrations in fertilizer. It would help on policy guidelines to ensure quality fertilizer at field level. To assess the quality of fertilizer marketed by different fertilizer company an investigation needed to carry out under the fertilizer quality audit activities of Nutrient Management for Diversified Cropping in Bangladesh (NUMAN) Project. As a part of NUMAN Project, Soil Resource Development Institute (SRDI) collected and determined the nutrient content of different fertilizers that were applied by the farmers. As per the decision of the 2nd year Annual Review meeting that only micro nutrient fertilizers quality would be determined in the 3rd year and on ward due to the adulteration rate was found higher in micronutrient fertilizer samples. The study findings of 2018 and 2019 revealed that the Government subsidised macronutrient fertilizers like Urea, TSP, DAP and MoP quality was found good enough. So, no need to make further quality audit for Urea, TSP, DAP, MoP. In addition, the quality of calcium and magnesium containing low-cost fertilizers like gypsum and magnesium sulphate was found standard that was found in the study area.To assess the quality of micronutrient fertilizer marketed by different fertilizer company an investigation was carried out under the fertilizer quality audit activities of Nutrient Management for Diversified Cropping in Bangladesh (NUMAN) Project from 2020 to 2022. Therefore, considering the above perspectives, under the quality audit activities of fertilizer, SRDI collected and determined the nutrient content in both macronutrient and micro nutrient fertilizer during 2018-2019 and after that 2020-2022 SRDI intensify the micronutrient fertilizer sampling to identify the real feature of the nutrient content of different company's micronutrient fertilizers marketed at field level.

Methods and materials

Soil Resource Development Institute (SRDI) conducted the study of fertilizer quality audit of different Government specified fertilizers used in the farmer's field of the study areas. In 2018 and 2019 SRDI collected and determined the quality of both macronutrient fertilizers at six hub area. In the 1st and 2nd year it was observed that Government subsidized macronutrient fertilizer quality was good enough at farm level. Therefore, as per the decision of the 2nd year Annual Review meeting that only micro nutrient fertilizers quality would be determined in the 3rd, 4thand 5thyear due to the adulteration rate was found higher in micronutrient fertilizer samples. In the 5th year two more hub i.e. Damuddya, Shoriatpur and Saidpur, Nilphamari were included as NUMAN Project study area. SRDI also conducted fertilizer quality audit in these two-study area as per the suggestion of Project steering committee. Therefore, under the quality audit activities of fertilizer, SRDI collected and determined the nutrient content only in micronutrient fertilizers like Zinc sulphate mono hydrate, Zinc sulphate heptahydrate, Chelated Zinc, Solubor Boron and Boric acid samples marketed by different fertilizers companies from the neighbouring hub areas those were applied by the farmers. The fertilizers samples were collected from Mymensingh, Thakurgaon, Gudagari and Durgapur hub areasbefore Rabi season in January. On the other hand, from Dacope, Khulna and Amtali, Barguna hubs fertilizer samples were collected before Kharif season in July-August. Fertilizer samples were collected following the protocol of Fertilizer Inspection Manual, 2003. On the basis of availability of the micronutrient fertilizer in the local market, neighbouring the hub areas the above-mentioned fertilizer samples were collected along with trade names, pack size, unit price and address of the marketing companies. A total of 918 fertilizer samples (Urea-24; TSP-24; DAP-24; MoP-24; Gypsupsum-24; Zinc sulphate monohydrate-244; Zinc sulphate heptahydrate-72; Chelated zinc- 196; Solubor- 170 and Boric acid-116) were collected (Table 1 and Table 2). Collected micronutrient fertilizer samples were analysed following the standard procedure 'Manual for Fertilizer Analysis, 2003' approved by the Government of the People's Republic of Bangladesh.

Table 1 Different macronutrient fertilizer samples collected from six hub areas of NUMAN project during 2018-2019

Hub	Urea	TSP	DAP	MoP	Gypsum
Mymensingh	**4**	**4**	**4**	**4**	**4**
Thakurgaon	**4**	**4**	**4**	**4**	**4**
Durgapur	**4**	**4**	**4**	**4**	**4**
Godgari	**4**	**4**	**4**	**4**	**4**
Dacope	**4**	**4**	**4**	**4**	**4**
Amtali	**4**	**4**	**4**	**4**	**4**
Total	**24**	**24**	**24**	**24**	**24**

Table 2 Different micronutrient fertilizer samples collected from eight hub areas of NUMAN project during 2018-2022

Hub	Zinc (mono)	Zinc- hepta	Chelated - Zn	Solubor	Boric acid
Mymensingh	48	09	36	33	22
Thakurgaon	41	16	42	49	24
Durgapur	49	10	35	24	17
Godgari	40	14	35	29	17
Dacope	26	05	21	13	13
Amtali	21	04	15	08	11
Damuddya	11	07	03	04	03
Saidpur	08	07	09	10	09
Total	**244**	**72**	**196**	**170**	**116**

Result and Discussions

Macronutrient Quality

It was found that 100% Urea, TSP, DAP, MoP, Chelated zinc and Boron fertilizer samples were standard fertilizers as per Government approved specification. It was also observed that 96% samples of Gypsum were standard while 4% Gypsum was adulterated. One thing is notable that Bangladesh government given huge incentives in both Urea and non-Urea fertilizers. Major non-Urea fertilizers are TSP, DAP, MoP. Production, import and maintaining quality of these fertilizers are regulated by different Government organizations. Therefore, the adulteration of macronutrient fertilizer in both urea and non-urea is almost absent. It found that quality of Gypsum almost standard but sometimes Dolomite, Calcites are sold as Gypsum by miss branding or miss bagging that might cause little quantity of Gypsum adulteration (Table 3).

Table 3 Macronutrient fertilizer quality in the six-hub area during 2018-2019

Fertilizer	Total	Standard	Adulterated	Standard (%)	
				Quality	Adulterated
Urea	24	24	0	100	0
TSP	24	24	0	100	0
DAP	24	24	0	100	0
MOP	24	24	0	100	0
Gypsum	24	23	1	96	4
Total	120	119	1	-	-

Micronutrient fertilizer quality

Zinc sulfate monohydrate

It was observed that during 2018-2022 SRDI collected 244 zinc sulfate monohydrate fertilizer samples of different marketing company from the hub area. Out of 244 zinc sulfate monohydrate fertilizer samples of different companies it was found that 35% sample contained only 0-5% Zn while 33% zinc sulfate monohydrate fertilizer samples contained 30-35% Zn. Only 3% samples maintained the Government minimum requirements (Table 4).It is mentionable that the minimum Zn and S content in Zinc sulfate monohydrate fertilizer was 36% and 17.5% respectively, as per Government specification. There was no consistency found in the Zn and S content in zinc sulfate monohydrate fertilizer samples. Zinc sulfate monohydrate fertilizers were non-complained not only the shortage of desirable Zn and S but also excessive presence of undesirable toxic heavy metal like lead, cadmium, nickel and Chromium. It might be concluded that 97% zinc sulfate monohydrate fertilizers were adulterated at different degrees of adulteration.

Table 4 Overall quality of Zinc sulfate mono hydrate fertilizer in the hub area during 2018-2022

Zinc content (%)	No. of fertilizer	Percent of fertilizer (%)
<1.0	31	13
0.0-5.0	50	20
5.1-10.0	7	3
10.1-15.0	8	3
15.1-20.0	14	6
20.1-25.0	23	10
25.1-30.0	39	16
30.1-35.0	64	26
>35.0	8	3
Total	**244**	**100**

Table 5 Over all zinc sulfate heptahydrate fertilizer quality in the study area during 2018-2022

Zinc content (%)	Fertilizer (No.)	Percent of fertilizer (%)
<1.0	12	15
0.0-5.0	13	18
5.1-10.0	1	1
10.1-15.0	11	15
15.1-19.99	14	20
>20.0	22	31
Total	72	100

Zinc sulfate heptahydrate

It was observed that among the zinc sulfate heptahydrate fertilizer samples it was found that 31% were complained that contained more than 20 % Zn while 33% zinc sulfate heptahydrate samples that contained only 0-5% Zn (Table 5). It was mentionable that as per Government specification the minimum Zn and S content in a zinc sulphate heptahydrate fertilizer were 21% and 10.5% respectively. Zinc sulfate heptahydrate fertilizers, adulteration was found due to absence of desirable amount of zinc and sulfur content as well as the presence of undesirable toxic heavy metal like cadmium (Cd), lead (Pb), nickel (Ni) and chromium (Cr) that exceed the allowable limit. It might be concluded that 31% zinc sulfate heptahydrate fertilizer samples were complained while the 69 % were non-complained and the degree adulteration might be variable(Table 5).

Table 6 Overall quality of Chelated zinc fertilizers in different hub areaduring 2018-2022

Hub	Complaint	Non-complaint	Total	Complaint (%)	Non complaint (%)
Mymensingh	19	17	36	53	47
Thakurgaon	20	22	42	48	52
Durgapur	19	16	35	54	46
Godagari	17	18	35	46	54

Dacope	14	07	21	67	23
Amtali	10	05	15	67	23
Damuddya	03	0	03	100	0
Saidpur	05	04	09	56	44
Total	**107**	**89**	**196**	**53**	**47**

Chelated zinc

A total of 196 chelated zinc samples were collected from six hub areas during 2018- 2022. The highest number chelated zinc samples were collected from Thakurgaon (42) while the lowest chelated zinc fertilizer samples were collected from Damuddya (3). The highest percent of complaint chelated zinc fertilizer were found at at Damuddya (100%) while the lowest percent were identified at Godagari (46%).At Mymensingh hub percent of complaint chelated Zn was 53% while the non-complaint Chelated Zn was 47%. At Thakurgaon hub percent of complaint chelated Zn was 48% while the non-complaint Chelated Zn was 52%. At Durgapur hub percent of complaint chelated Zn was 54% while the non-complaint Chelated Zn was 46%. Apparently, there were found some chelated zinc fertilizer samples that contained more than 10% Zn which was above the minimum requirement of the Government specification but the presence of undesirable S in the sample made them adulterated. Chelated zinc fertilizers were also adulterated by the presence of unwanted heavy metal like Cd, Pb, Ni and Cr that exceeded the maximum alloable limit. Finally, it might be concluded that 53% chelated zinc fertilizers were found complaint and rest 47% were non- complaint marked in the six-hub area (Table 6).

Table 7 Overall solubor boron fertilizer quality in different hub area during 2018-2022

Hub area	**Complaint sample**	**Non-complaint sample**	**Total Sample**	**Complaint (%)**	**Non-complaint (%)**
Mymensingh	29	04	33	88	12
Thakurgaon	36	13	49	73	27
Durgapur	18	06	24	75	25
Gudagari	25	04	29	86	14
Dacope	10	03	13	77	23
Amtali	06	02	08	75	25
Damuddya	04	0	4	100	0
Saidpur	10	0	10	100	0
Total	**138**	**32**	**170**	**81**	**19**

Solubor boron

A total of 170 solubor boron fertilizer samples were collected from six hub areas during 2018-2022. The highest number of solubor boron fertilizer samples were collected from Thakurgaon (49) while the lowest solubor boron fertilizer samples were collected from Damuddya (4). The highest percent of complainant Solubor B was found at Damuddya and Saidpur (100%) while the lowest percent was observed at Thakurgaon (73%). At Mymensingh hub, there found 88% solubor boron fertilizers were complaint while 12% samples were found non-complaint. At

Thakurgaon hub, there found 73% solubor boron fertilizers were complaint while 27% samples were found non-complaint. At Durgapur and Amtali hub, there found 75% solubor boron fertilizers were complaint while 25% samples were found non-complaint. At Godagari hub, there found 86% solubor boron fertilizers were complaint while 14% samples were found non-complaint. At Dacope hub, there found 77% solubor boron fertilizers were found complaint while 23% samples were found non-complaint. It might be concluded that 81% solubor boron fertilizers were found complaint while 19% were non-complaint (Table 7).

Table 8 Over all Boric acid fertilizer quality in the study area during 2018-2022

Hub	Complaint	Non-complaint	Total	Complaint (%)	Non complaint (%)
Mymensingh	12	10	22	55	45
Thakurgaon	16	08	24	67	33
Durgapur	07	10	17	41	59
Godagari	07	10	17	41	59
Dacope	05	08	13	38	62
Amtali	09	02	11	82	18
Damuddya	02	1	3	67	33
Saidpur	09	0	9	100	0
Total	67	49	116	58	42

Boric acid

A total of 116 boric acid fertilizer samples were collected from six hub areas during 2018-2022. The highest number of boric acid fertilizer samples were collected from Thakurgaon (24) while the lowest boric acid fertilizer samples were collected from Damuddya (3). The highest percent of complainant boric acid was found at Saidpur (100%) while the lowest percent was observed at Dacope (38%). At Mymensing hub, there found 55% boric acid fertilizers were complaint while 45% samples were found non-complaint. Thakurgaon and Damuddya hub, there found 67% boric acid fertilizers were found complaint while 33% samples were found non-complaint. At Durgapur and Godagari it was observed that 41% boric acid fertilizer samples were found complaint while the non-complaint boric acid fertilizers were 59%. At Amtali hub, there found 82% boric acid fertilizers were complaint while 18% samples were found non-complaint. It might be concluded that 58% boric acid fertilizers were found complaint while 42% were non-complaint (Table 8).

Conclusions

Macronutrient fertilizers were found compliant with standards. Zinc sulfate mono hydrate fertilizers (n=236) are non-compliant with the standard, with 13 % containing <1% Zn, 33% containing 0-5% Zn, 26 % are close to the standard i. e. > 30 % Zn and only 3% Zinc sulfate mono hydrate fertilizers (n=8) fulfill the Govt. minimum requirements. Zinc sulfate hepta-hydrate fertilizers (n=50) are non-compliant with the standard, with 15 % containing <1% Zn, 33% containing 0-5% Zn and 31% Zinc sulfate hepta-hydrate fertilizers (n=22) fulfill the Govt. minimum requirements. Zinc chelate fertilizers 53% are compliant (n=104) while 47% fertilizers are not complaint (n=92). Zinc chelate highly variable in different hub. Solubor fertilizers are 81% are compliant (n=138) while 19% fertilizers are not complaint (n=32). Solubor boron fertilizers were found highly variable in different hub. Boric acid fertilizers are 58% are compliant (n=67) while 42% fertilizers are not complaint (n=49). Boric acid fertilizers were found highly variable in different hub.

Expt-2: River, Canal and Soil water salinity of some selected sites of Amtali and Dacope (KGF funding) (SRDI)

Soil salinity monitoring at Amtali

Materials and Methods

River, canal and soil salinity were measured at different location of Amtali and Dacope since 2018-2022 in every month. For water salinity was measured in every month in the day of new moon, during high tide using EC meter. Soil salinity was also measured at that time using EC meter where soil water ratio was 1:5.

Results and discussions

River, Canal and Soil water salinity of Amtali

Barishal Division covers about 1/5th coastal area of Bangladesh. It occupies 2/5th of the coastal area comprising 18 Districts. It is considered the most potential part of coastal area with respect to availability of abundant source of surface water and comparatively lower degree of soil salinity. Unlike, most part of this Division has still scope for horizontal expansion of cropping area. It has comparatively fertile lands having opportunity of natural siltation every year. This means that crop production here is possible with limited intervention. As compared to south western part of the coastal area the country Barishal Division had been experiencing less intrusion of sea water farther inland from Bay of Bengal. Because, unlike north western part (Khulna Division) Barishal division has number of mighty rivers with profuse upstream flow. The rivers are namely Baleswar, Bishkhali, Payra, Andermanik, Tetulia and Meghna. As huge volume of water flows from upper catchment area in the rainy season, the rivers become full to the brim. Consequently, sea water has no or limited access in the inland area. But in dry season, due to cessation of rain in upper riparian area rivers gradually get less flow during dry months (January-May). This causes less water pressure from upstream side. As a result, sea water moves towards inland area through different rivers depending on their flow or load of discharge. Contrary to Barishal Division Rivers of Khulna Division have been silted and are not able to receive upstream flow even in rainy season.

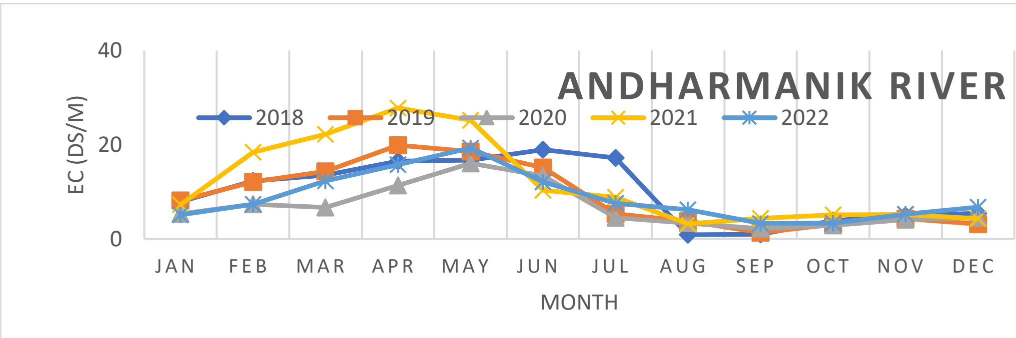


Fig.1 River water salinity of Andharmanik River, Kalapara Ferryghat, Upazila Sadar (21.985N, 90.218E).

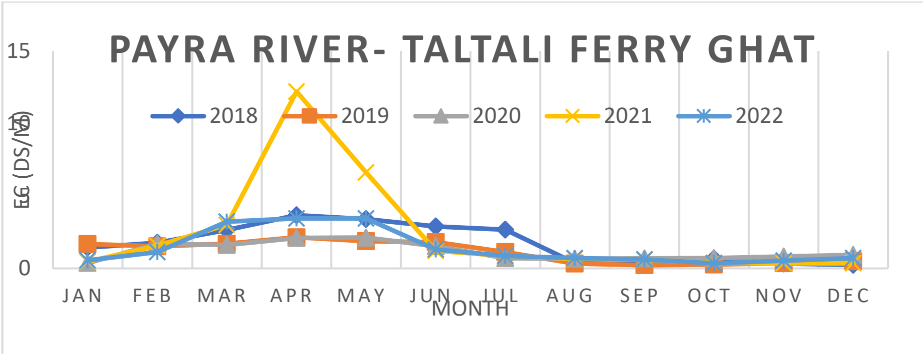


Fig. 2 River water salinity of Payra River, Taltali ferry ghat Upazila Sadar (21.996N, 90.073E).

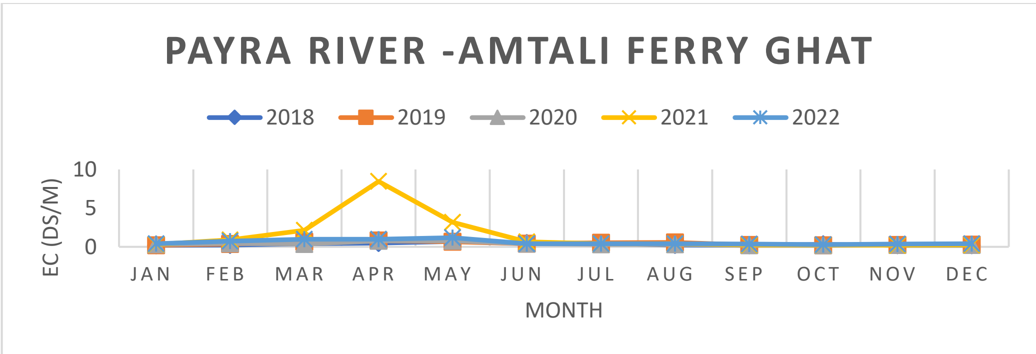


Fig.3 River water salinity of Piyra river at Amtali ferry ghat during 2018-2022.

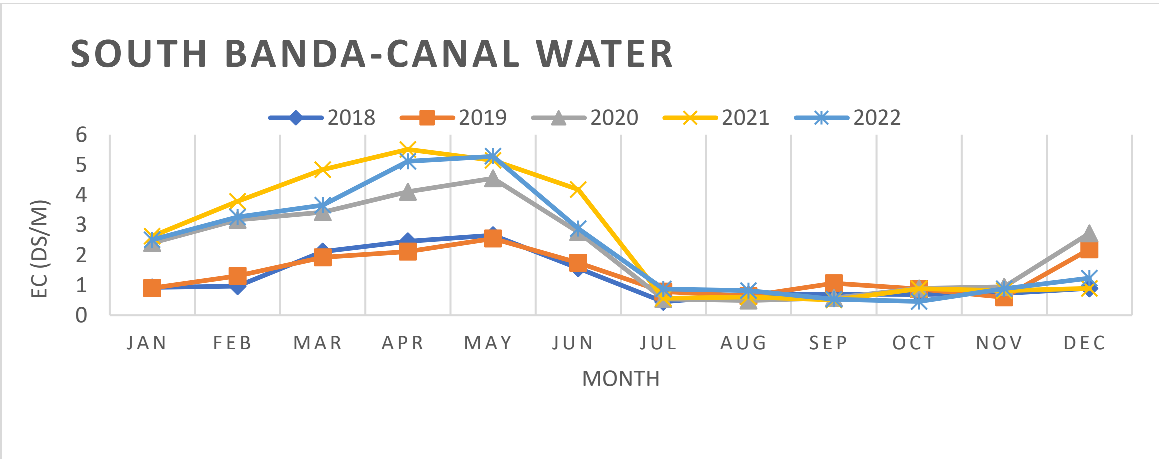


Fig. 4 Canal water salinity of Sluice gate at South to Bandra, Amtali (22.028N, 90.245E).

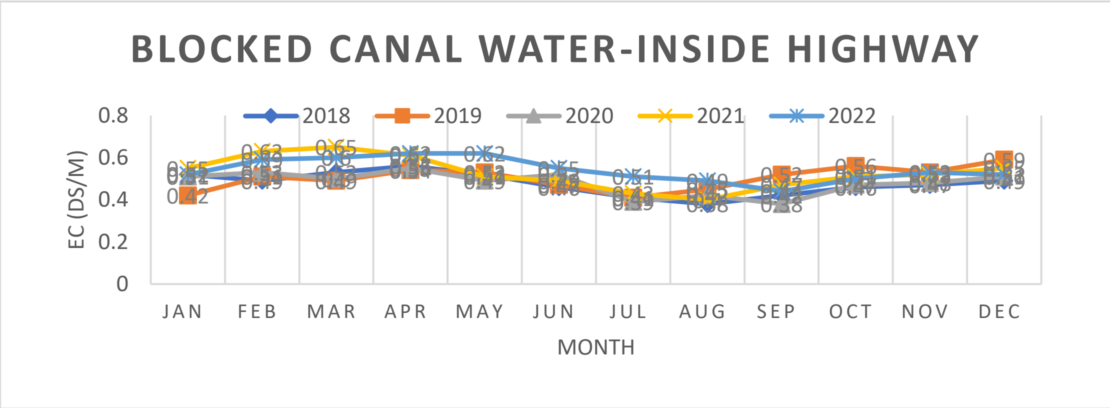


Fig. 5 Canal water salinity of Amtali upazila Boundary (Blocked canal inside to highway) Amtali, (22.022N, 90.241E).

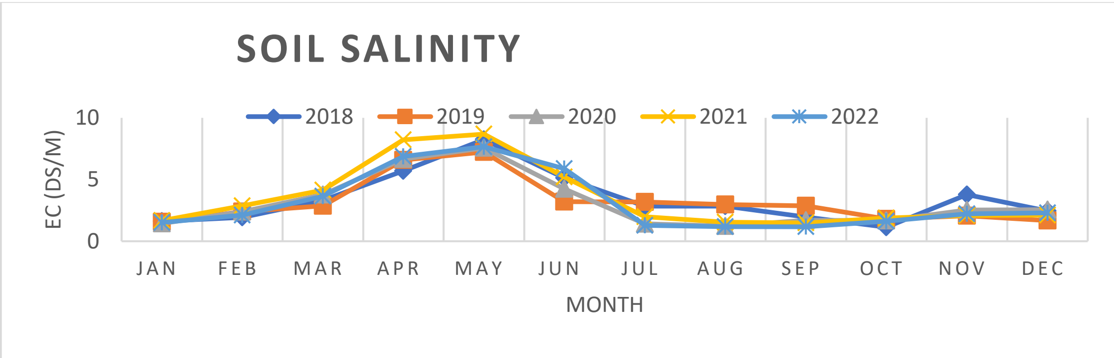


Fig 6 Soil salinity observed at Kalapara (21^{0}59′54.4″N, 90013′53.6″E).

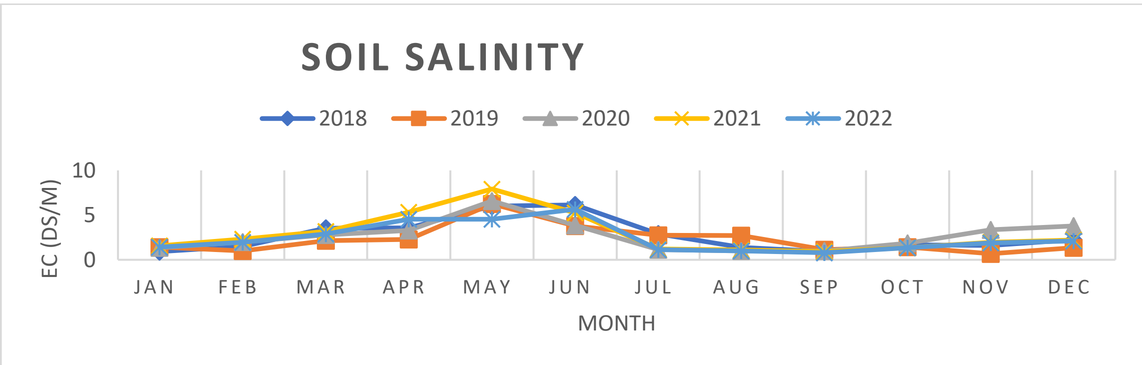


Fig. 7 Soil salinity observed at Taltali (21^{0}59′53.8″N, 90004′47.8″E).

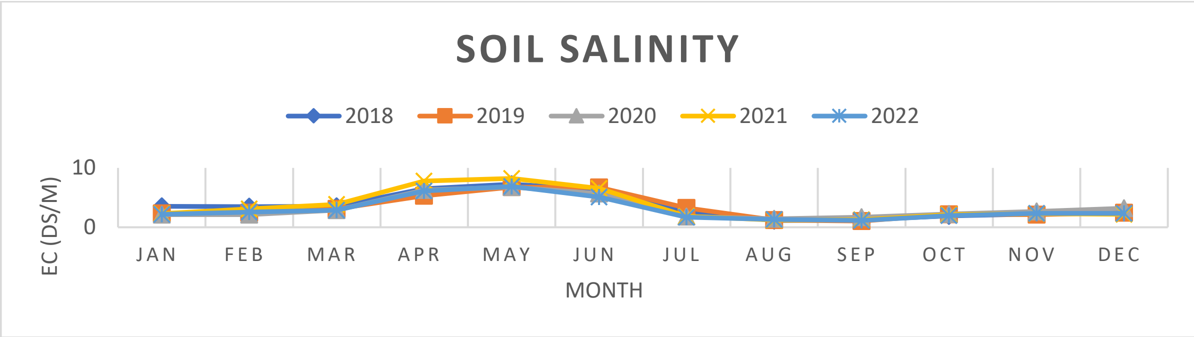


Fig. 8 Soil salinity observed at Sikanderkhali (South), Amtali, (22^{0}01′27.0″N, 90^{0}14′38.4″E).

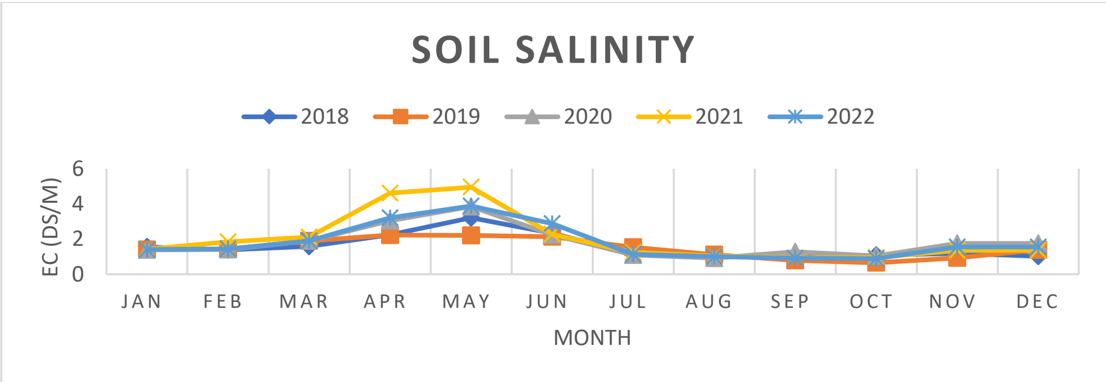


Fig. 9 Soil salinity observed at Sikanderkhali (North), Amtali, (22^{0}02′18.9″N, 90^{0}14′34.7″E).

Based on the longterm data of SRDI salinity monitoring program it was found that in every river in Barishal Division there was a point of saline and sweet water interface (the highest position of sea water intrusion) which showed no significant change for several decades. But in 2021, especially during March-April, an unusual rise of river water salinity noticed that was unprecedentedly highest in remembrance. Although the abnormally rising situation did not continue further in May (Fig. 1- 9). It might be an awakening signal for sustainability of longterm harmony of sea water intrusion pattern in this area. Not only Patuakhali, Barguna and Bhola Districts faced the crisis, the inland District like Jhalakathi and Barishal Districts were also the victim**.** It may be mentioned that the river Kirtankhola beside the Barishal Divisional town is a known source of sweet water. Normally sea water intrusion occurs in the river up to Barguna point (in the name of Bishkhali). But in April, 2021 this point was found to be shifted inward through Jhalakathi up to Barishal city. Kirtankhola River was more than 0.75 dS/m. Not only Kirtankhola or Bishkhali River but also other rivers were badly influenced by sea water at the time. Detailed data on total river system could not be generated due to pandemic situation.

Possible reason of the problem

It was revealed that more than 90 percent of the flow in Bangladesh's three major rivers, the Ganges, Brahmaputra and Meghna, originates outside the country (Brammer, 2012). It was also explained that the Brahmaputra and the Meghna rivers begin to rise in March-April as a result of heavy pre-monsoon rainfall in the north-east of India and the north-east of Bangladesh. The other major river the Ganges starts to rise later in May, because pre-monsoon rains start later in the Ganges catchment area. The lowest flows generally occur in February-March in Brahmaputra and Meghna. Whereas the lowest flow in the Ganges occur in April or early May.

In Barishal Division all major rivers except Baleswar are connected and flowing from the Meghna. For this reason, this area mainly receives accumulated flow of three major rivers through the Meghna. Bangladesh Water Development Board (BWDB) could not provide any data on river discharge for the time of abnormal salt water intrusion. However, it may be assumed that the bumping of river water salinity might be due to the reduced flow of the Brahmaputra and Meghna especially in April, 2021. It might be because of withdrawal of water or erratic rainfall pattern. Although during January-April, 2021, there was no rain (Table 1), but it might not be the vital reason for the catastrophe.

Table 1 Comparative data on rainfall (mm) during 2016 to 2021

Year/Month	January	February	March	April
2016	2.4	50.0	0	8.6
2017	0	0	68.2	384.4
2018	0	0	22.0	88.9
2019	0	65.9	38.0	78.3
2020	58.2	0	5	167
2021	0	0	0	0

Possible impact

About 33 percent of Barishal Division is affected by soil salinity at different degrees of intensity (Table 2). In other words, salinity affects 54 percent of cultivated area of which 19 percent is severely affected (soil salinity, EC value>8 dS/m). If this unusual salinity intrusion persists in upcoming years there would be more area under salinity hazard and soils of non-saline area would be victim of salinization. Moreover, surface water source of irrigation would be squeezed due to scanty source of sweet water. Intrusion of sea water might also affect the sweet water aquifer of the non-saline area creating crisis of drinking water which is a major public health issue.

Table 2Distribution saline affected area in Barishal Division

District	Total cultivated area (ha)	Total saline affected area (ha)	Percent (%) of saline affected area
Barishal	1,37912	12,360	9
Jhalakathi	55,859	4,620	8
Pirojpur	85,282	35,830	42
Bhola	1,48,109	94,570	64
Patuakhali	1,94,548	1,55,180	80
Barguna	1,10,137	95,620	87

Source: Saline Soils of Bangladesh, SRDI, 2012

It is appeared from table that Jhalakathi and Barishal are two Districts least affected by soil salinity. But in April, 2021 almost all the rivers and canals of the districts carried brackish and saline water due to sea water intrusion. If this trend continues in the following year, it will be a catastrophe for this area in the foreseeable future.

Possible measures

a) Strengthening salinity monitoring activities with increased number of sites covering strategic points of different rivers.
b) BWDB & Bangladesh River Research Institute should generate data on river discharges during entire dry season.
c) Data coordination among concerned departments under different ministries.
d) Meteorological and hydrological data transfer from upper riparian countries.
e) Monthly fluctuation of river flow should be monitored through remote sensing technique.
f) Policy intervention, if needed.

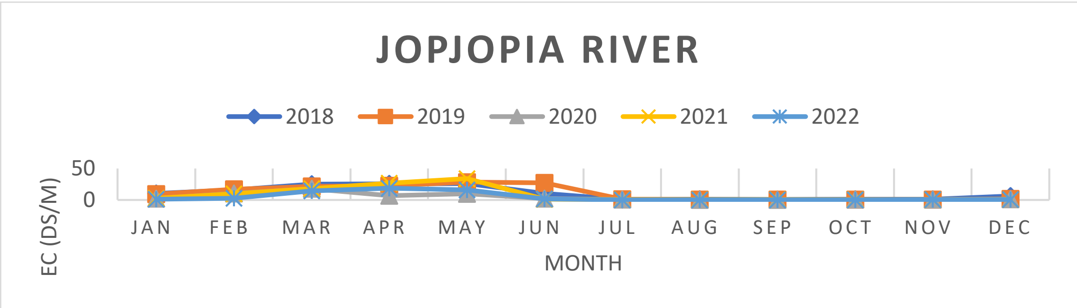


Fig. 10 River water salinity of the river, Jopjopia, Pankhali, Dacope, Khulna.

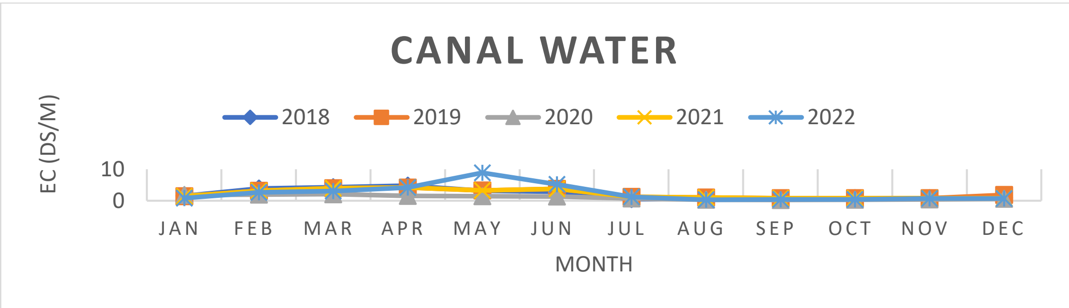


Fig. 11 Canal water salinity at canal, Pankhali Mouza, Pankhali Union of Dacope, Khulna.

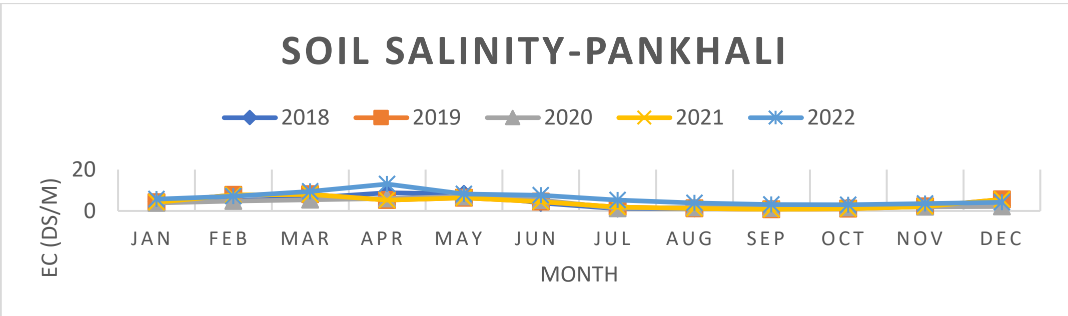


Fig.12 Soil salinity at Pankhali Mouza, Pankhali Union of Dacope, Khulna.

River, Canal and Soil water salinity of Dacope

Khatail is a mouza situated at Pankhali union in Dacope upazila of Khulna district. Its area is 365 ha ad was surveyed in March, 2019. The physiography of the survey area was Ganges Tidal Floodplain. Landform was nearly level. Soil series found namely Bajoa, Jhalokati, Dumuria and Barisal. Land type was medium high land. Land use was mostly F-F-T. aman and in some cases it was Bo/rabicrops-F-T. aman where sweet water is available. As the area is saline, the land use of the area is restricted. Salinity of the river and canal water starts increasing from mid-February and goes to peak in May/June. Growing crops in this period is very hard. In rainy season salinity of both soil and water reduces and T. aman cultivation is possible without hazards. After T. aman harvest, water recedes from the surface of the land is very late, so rabicrops cannot be cultivated due to late recession of surface water. The most of the soil series are heavy clay in nature and the water holding capacity is low. It is also a problem for rabicrops cultivation in this area. The salinity condition of nearby river/canal water and soil EC & pH are given (Fig 10, 11, 12).

Conclusions

Drainage and surface water management should be strengthened through proper polder management. Canal network should be revived for mass population in the southern part of Bangladesh. Payra River water might be a potential source of surface water irrigation source.

Conduct Detail Soil Survey of Farm Soils of NUMAN Project Hubs at Botlagari, Saidpur, Nilphamari; Charmalagaon, Damuddya, Shariatpur and Daraishkathi, Damuddya, Shariatpur

Materials and Methods

The methods of the survey were based on high intensity survey i.e., detailed soil survey. The detailed soil survey was carried out on the basis of detailed field observations of soils, topography and other environmental characteristics and also collection of representative soil samples for chemical analysis. The detailed soil survey was carried out by survey team in April 2022 at Botlagari, Saidpur, Nilphamari; Charmalagaon, Damuddya, Shariatpur and Daraishkathi, Damuddya, Shariatpur. During field survey mouza map (1 inch =1 mile), soil association maps (1:125,000) of reconnaissance soil survey, Land and soil Resource Utilization Guides (Upazila Nirdeshika), toposheet (1:50,000), aerial photographs (1:30,000), soil and land form map (1:50,000) were used as base materials. Grid method was followed for field observations. After every 30 meters along and apart the traverse line soils were checked with auger and spade by digging mini-pits. The soil series represents a group of soil derived from similar parent materials under similar condition of development and resembling each other closely in their physical and chemical properties. Profile descriptions were performed according to FAO guide lines. Detailed land use patterns were recorded. On the basis of the survey information Soil map, land type and land use map (1: 8000) were prepared. Finally, area and extent of different soil series were calculated cartographically.

All chemical analysis of soil was accomplished following standard methods. Soil pH by Glass Electrode pH meter method with soil water ratio 1:2.5 (McLean, 1982), Soil ECe was determined by using EC meter, organic matter by Walkley-Black method (Nelson and Sommers, 1982), total N by Kjeldhal system (Bremner and Mulvaney, 1982), available P by

Bray and Kurtz Method (1945), K and Na by ammonium acetate extraction method using Flame Photometer while Ca and Mg using AAS (Barker and Surh, 1982), available S is determined by Turbidimetric method (Page *et al.,* 1989), available Zn, Cu, Fe and Mn is determined by DTPA Extraction method using AAS (Page *et al.,* 1989) and B is determined by calcium chloride extraction method (Wolf, 1974). Exchangeable acidity is determined by KCl extracting method (Bloom, 1979).

Soil sample information from different study area

Across the catena traverse routes were selected along north-south direction. At Botlagari across the catena traverse routes were selected along north-south direction. At Botlagari horizon wise 8 soil samples were collected from 2 representative soil pedons and 31 composite soil samples were collected from different identified soil series. At Char Mala Malagaon 13 horizon wise soil samples were collected from 2 representative soil pedons and 25 composite soil samples were collected from different identified soil series. On the other hand, at Daraishkathi 12 horizon wise soil samples from 2 representative soil pedons and 22 composite soil samples were collected from different identified soil series.

1.2 Results and Discussions

1.2.1.1 Location, geology, hydrology and climatic features of Botlagari mouza

The Botlagari mouza of NUMAN site was about 2.5 km North of Saidpur Upazila head quarter at an elevation of about 12 meters above the mean sea level, lying between 25^{0} 48″0˜ to 25^{0} 48″50˜ North latitude and 88^{0} 52″30˜ to 88^{0} 53″0˜ East longitudes. The entire survey area covered by Tista Meander Floodplain (AEZ 3). Soils occupying nearly level to very gently undulating topography. The entire area occupied by Highland and Medium Highland with olive grey, silt loam & silty clay loam, acidic, low to moderate CEC soils. The land area is characterized by both beyond monsoon flooding to seasonally shallowly flooded soil, the latter being inundated 45cm, but occasionally up to 90 cm. Soil of upper catena was found to be coarse textured and soil of lower catena was moderate textured. Silt loam soil of upper catena are suitable for diversified upland crops. Whereas soil belonging lower position being silty clay loam texture is suitable both for rice and non-rice crops. Based on meteorological data of Rangpur Meteorological Station it was revealed that like other places of Bangladesh the Botlagari belongs to tropical monsoon climate. Although Bangladesh is endowed with six seasons in year, it is distinctly characterized by three main seasons. The winter or dry season (Rabi) prevailing from November to February is dry and cool. It has the lowest temperature and humidity of the year with a very little rainfall which occurs mostly as occasional drizzles due to depressions. The pre-monsoon or hot season (pre-kharif or early summer) prevails from March to May. It has the highest temperature and evaporation rate of the year. Occasional thunder showers sometimes accompanied by hails take place during pre-monsoon. This is popularly termed as “Kal-baishakhi” (north-western). The monsoon or rainy season (Kharif or late summer) starts in June and continues to October. It was appeared that June-October is the rainy season and November-May is the dry season. More than 90% of the rain falls during the rainy season. The average annual rainfall is below 1725mm. Highest average rainfall (408 mm) was recorded in July and lowest (07 mm) in January. The highest extreme hot temperature (43.9^{0} C) occurs in May and lowest (3.9^{0} C) in February. The relative humidity remains high throughout the year. It ranges from 60%-88%, highest in the rainy season and lowest in the dry season.

1.2.1.2 Agro-climate of Botlagari mouza

Based on rainfall and temperature regimes Bangladesh have been divided into a number of agro-climate regions, each of which is characterized by a code. The parameters used for identification of the agro-climatic zones are:

a) Average length of the pre-kharif period when rain fed soil moisture supply is intermittent and uncertain.
b) Average length of the rain fed kharif and rabi growing period (days).
c) Average number of days in a year with minimum temperatures bellows 15^0C.
d) Average number of days in a year with maximum summer temperature above 40^0 C.

It was observed that this mouza is under agro- climate code K_5 p_3T_5 e_2, indicating the kharif growing season is 210-220 days. The pre-kharif transition period occurs covering the range 30-40 days. Duration of Rabi season 120-140 days. The number of days with minimum temperature below 15^o C varies from 90-110 and maximum temperature above 40 ^{o} C varies from only 0.5 to 5 day per year.

1.2.1.3 General nature of the soils

Soils occupy nearly level to very gently undulating, ridge soil being unflooded and basin soil goes under shallow flooding during monsoon, soils are imperfectly to poorly drained. Their topsoil and subsoil colour usually ranged from light olive grey to grey and texture was silt loam to silty clay loam (Table 1). Substratum soil belongs to olive grey to light olive grey having loam and sandy textured soil. Subsoil structure varied from angular blocky to prismatic. The whole profile was non-calcareous.

Table 1 Different soil series and their distribution

Topography	Soil series	Position of the catena
Nearly level to very gently undulating low ridges	Gangachara	Upper part of catena
Nearly level, low ridges	Kaunia	Lower part of catena

1.2.1.4 Soil mapping units

In the mouza, two soil series have been recognized which have been mapped into two soil mapping units (Table 2). The soil mapping units are based on soil series. The soil mapping units have been described in terms of areas and extent, morphological properties, soil salinity, nutrient status, cropping patterns and major constraints.

Table 2 Soil mapping unit, area and percentage

Mapping unit	Physiography	Soil series	Land Type	Area (ha)	Percent (%)
1	Tista Meander Floodplain	Gangachara	HL	8.44	10.54
			MHL	3.56	4.44
2		Kaunia	MHL	38.94	48.62
Settlement				8.58	10.71
Truncated				9.84	12.29

Brick field	4.22	5.27
Pond	0.78	0.97
Road	5.29	6.61
Pond scare	0.44	0.55
Total	29.15	100.0

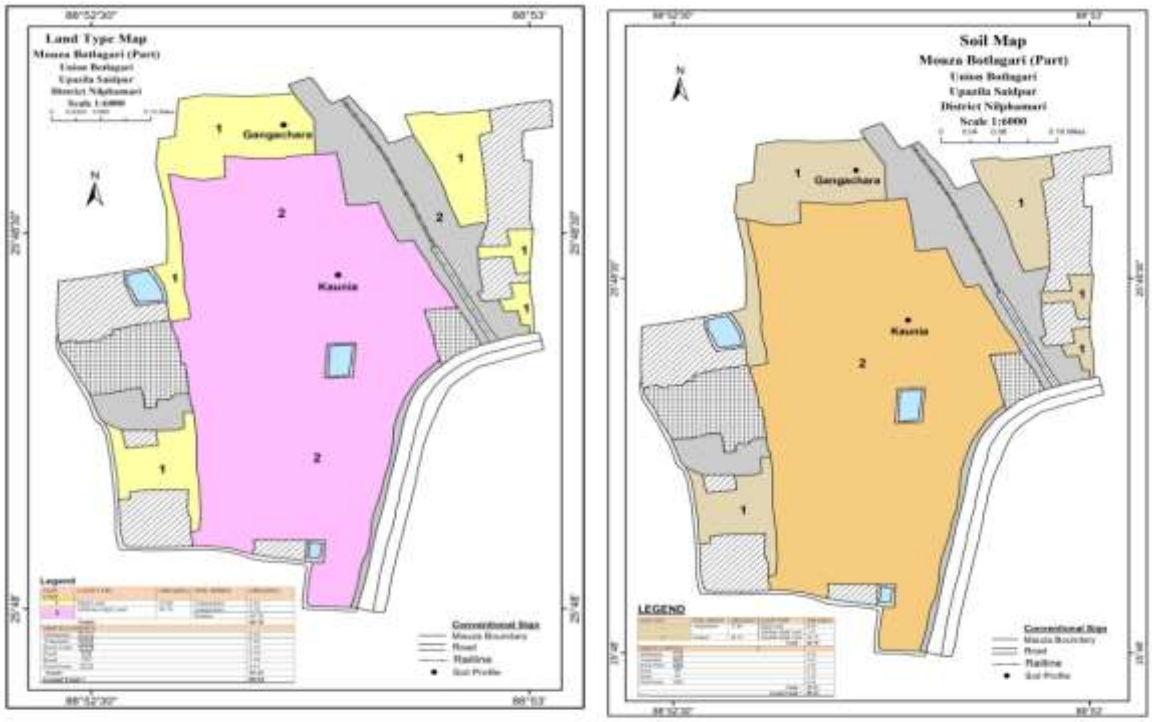


Fig. 1 Land type & Soil map of Botlagari mouza.

1.2.1.5 Present agricultural opportunities and constraints

Critical for growing Aus or Jute due to shorter Kharif-1 growing season. Congenial for growing T. aman due to longer Kharif- growing season. Congenial for growing Rabi crops due to longer & cooler Rabi growing season. More suitable for wheat, potato & winter vegetable cultivation. High temperature may affect Boro crop during flowering stage (Table 3). Soil degradation is evident due to anthropogenic causes like top soil removal for brick kiln and road construction without adequate drainage facilities caused drainage concession.

Table 3 Soil and Land Type wise cropping pattern at Botlagari

Soil series and Land Type	Present Land Use
Gangachara, High Land	Potato- Maize- T aman
	Potato- Boro- T aman
	Potato- Aroid- T aman
Gangachara, Medium High Land	Boro- Fallow- T aman
Kaunia, Medium High Land	Boro- Fallow- T aman

1.2.1.6 Soil Profile description

Gangachara Series

Gangachara series includes imperfectly and poorly drained, intermittently and seasonally flooded soils developed in medium textured Tista alluvium. These soils have a grey, iron-stained, loam to silt loam top soil overlying on olive-grey finely mottled yellow and brown, loam to silt loam subsoil with weak blocky structure in B horizon.

Ap	0-15 cm	grey (5Y 5/1) moist with iron stains along root channels; loam; massive; non-sticky and slightly plastic wet; friable moist; many very fine and fine tubular pores; common very fine and fine roots; abrupt smooth boundary; pH 5.3
B2	15-45 cm	grey (5Y 5/1) moist with common fine distinct dark yellowish-brown mottles; loam; weak coarse angular blocky structure; non-sticky; slightly plastic wet, friable moist, slightly hard dry; thin grey cutans along root channels; many fine tubular pores; abrupt smooth boundary; pH 6.3
C1	45-75 cm	Olive-grey (5Y 5/2) moist with common fine distinct dark brown mottles; loam; massive; non-sticky; slightly plastic wet, friable moist; abrupt smooth boundary; pH 6.4
C2	75-135 cm	olive-grey (5Y 5/2) moist; fine sand; single grain; loose moist, non-sticky and non-plastic wet; pH 6.6

Kaunia Series

Kaunia series includes poorly drained, seasonally flooded soils developed in moderately fine textured Tista alluvium. They are olive grey, yellowish brown mottled with prismatic structure in B horizon.

Ap	0-15 cm	Grey (5Y 5/1) moist with iron stains along root channels; silt loam; massive breaking into coarse angular clods; friable moist, slightly sticky and slightly plastic wet; friable moist; common fine and very fine tubular pores; common very fine and fine roots; abrupt smooth boundary; pH 5.9
B2	15-40 cm	olive-grey (5Y 5/2) moist with common fine distinct dark yellowish-brown mottles; silty clay loam; strong coarse prismatic structure with continuous thin grey cutans on vertical ped faces; sticky and plastic wet, firm moist; common fine tubular pores; few fine roots; clear smooth boundary; pH 6.2

C1	40-85 cm	olive-grey (5Y 5/2) moist with common medium distinct yellowish-brown mottles; silt loam; massive; slightly sticky and slightly plastic wet, friable moist; common very fine and fine tubular pores; clear smooth boundary; pH 6.7
C2	85-140 cm	olive-grey (5Y 5/2) moist with common fine distinct yellowish-brown mottles; silt loam; massive, stratified; slightly sticky and non-plastic wet, friable moist; pH 6.7

1.2.1.7 Soil Chemical properties

Low pH (Strongly acidic), deficiency of N, K, Ca, Mg, S, Zn, B with lower CEC value, whereas the P build up in soils has been noticed. To increase the fertilizer use efficiency in the soils liming should be highly emphasized.

1.2.2.1 Location, geology, hydrology and climatic feature of Char Malagaon Mouza

The Char Malagaon mouza of NUMAN site was about 8 km West of Damuddya Upazila head quarter at an elevation of about 5 meters above the mean sea level, lying between 23^0 07'20" to23^0 09'0" north latitude and 90^0 21'50" to 90^0 23'30" east longitudes. Located on the North-western part of Dhanakati Union, South- western part of Damuddya Upazila of Sariatpur District, the entire survey area covered by Low Ganges River Floodplain (AEZ 12). Lands having nearly level to very gently undulating topography. The entire area occupied by Medium Highland with olive or olive brown, silty clay loam, calcareous, moderate CEC. Soil of upper catena was found to moderate textured and soil of lower catena was finer in texture. Silty clay loam soil occupied by nearer to upper catena is suitable for mainly upland crops. Whereas soil of middle position of the catena being silty clay texture is suitable for wetland crops. Based on meteorological data of Faridpur Meteorological Station it was revealed that like other places of Bangladesh the Char Malagaon belongs to tropical monsoon climate. Although Bangladesh is endowed with six seasons in year, it is distinctly characterized by three main seasons. The winter or dry season (Rabi) prevailing from November to February is dry and cool. It has the lowest temperature and humidity of the year with a very little rainfall which occurs mostly as occasional drizzles due to depressions. The pre-monsoon or hot season (pre-kharif or early summer) prevails from March to May. It has the highest temperature and evaporation rate of the year. Occasional thunder showers sometimes accompanied by hails take place during pre-monsoon. This is popularly termed as “Kal-baishakhi” (north-western). The monsoon or rainy season (Kharif or late summer) starts in June and continues to October. It was appeared that June-October is the rainy season and November-May is the dry season. More than 90% of the rain falls during the rainy season. The average annual rainfall is below 1885 mm. Highest average rainfall (363 mm) was recorded in June and lowest (04 mm) in January. The highest extreme hot temperature (36.1^0 C) occurs in April and lowest (9.5^0 C) in January. The relative humidity remains high throughout the year. It ranges from 60%-88%, highest in the rainy season and lowest in the dry season.

1.2.2.2 Agro-climate of Char Malagaon

It was observed that this mouza is under agro- climate code K6p4, T3e1, indicating the kharif growing season is 220-230 days. The pre-kharif transition period occurs covering the range 40-50 days. Duration of Kharif season 120-145 days. Duration of Rabi season is120-145 days. The number of days with minimum temperature below 15º C varies from 50-70 and maximum temperature above 40 º C varies from only 0 to 1 day in each two years (Table 4).

Table 4 Seasonal characteristics of Char Malagaon mouza

Growing season	Duration	No. of days	No. of days < 15^0	No. of days > 40^0
Rabi	21 October-2 March	120-145	50-70 days per year (6 December-4 February)	0.0-0.5 day per year
Kharif-1	24 March-8 May	40-50		
Kharif-2	3 May-14 December	220-230		

1.2.2.3 General nature of the soils

Soils occupy nearly level to very gently undulating, soil goes under shallow flooding during monsoon, soils are imperfectly to poorly drained (Table 5). Their topsoil and subsoil colour usually ranged from olive to olive brown and texture was silty clay loam to silty clay. Substratum soil belongs to olive to olive brown having silt loam to silty clay loam soil. Subsoil structure varied from angular blocky to prismatic. The whole profile was calcareous.

Table 5 Different soil series and their distribution

Topography	**Soil series**	**Position of the catena**
Upper slope of nearly level ridge	Gopalpur	Upper part of catena
Upper slope of very gently undulating ridge	Ishwardi	Middle part of catena

1.2.2.4 Soil mapping units

In the mouza, two soil series have been recognized which have been mapped into two soil mapping units (Table 6). The soil mapping units are based on soil series. The soil mapping units have been described in terms of areas and extent, morphological properties, soil salinity, nutrient status, cropping patterns and major constraints.

Table 6 Soil mapping unit, area and percentage

Mapping unit	**AEZ**	**Soil series**	**Land Type**	**Area (ha)**	**Percent (%)**
1		Gopalpur	MHL	81.94	47.84
2		Ishwardi	MHL	36.90	21.54
Settlement				23.65	13.81
Pond scare				17.79	10.39
Road				7.54	4.40
Pond				3.46	2.02
Total				171.28	100

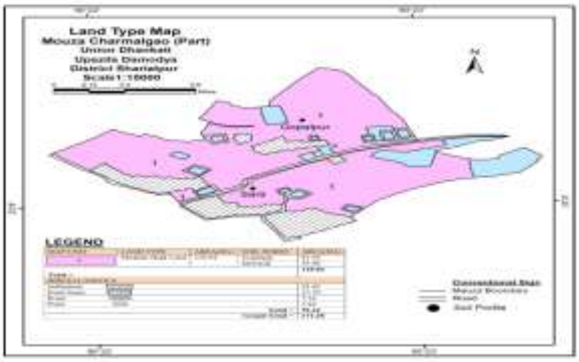



Fig.2 Land type & Soil map of Char Malagaon mouza.

1.2.2.5 Present agricultural opportunities and constraints Char Malagaon

Congenial for growing T aman due to longer Kharif-2 growing season. Congenial for growing Rabi crops due to longer & cooler Rabi growing season. Least chance of high temperature effect on Boro crop. Late water recession, not before December. Lack of drainage infrastructure. Transformation of crop land into pisiculture. Ponding of land creates acute drainage problem for crop growing lands. Late water recession restricts cultivation of non-rice Rabi crops. Unfavorable condition created by fish culture forced farmers to shift from crop production. Fish farming is more profitable than crop farming (Table 6)

Table 6 Soil and Land Type wise cropping pattern at Char Malagaon

Soil series and Land Type	Present Land Use
Gopalpur, Medium High Land	Boro- Fallow- Fallow
	Mustard- Kenaf- T aman
	Mustard- Kenaf- Fallow
	Potato-Jute- Fallow
	Mustard/Wheat/Potato- Jute- T aman
Ishwardi, Medium High Land	Boro- Fallow- Fallow

1.2.2.6 Soil Profile description

Gopalpur series

Gopalpur series formed from Gangetic parent material that are seasonally shallowly to moderately deeply flooded, poorly drained, olive brown, calcareous, silty clay loam with prismatic and subangular blocky structure in the B horizons.

Ap_1	0-15 cm	Olive (5Y 5/4) moist and light olive grey (5Y 3/2) dry with many fine distinct dark brown mottles; Silty clay loam; cloddy; slightly sticky, slightly plastic wet; friable moist; many fine roots; abrupt smooth boundary; pH 7.3
Ap2	15-25	Olive brown (2.5Y 4/4) moist with few fine distinct dark brown mottles; Silty clay loam; massive; slightly sticky, slightly plastic wet; friable moist;

	cm	many fine and very fine tubular pores; calcareous; many fine and very fine roots; abrupt smooth boundary; pH 7.6
B21	25-45 cm	Olive (5Y 5/4) moist with few fine faint olive mottles; Silty clay loam; weak prismatic breaking into weak and moderate coarse and medium subangular blocky; slightly sticky, slightly plastic wet friable moist; nearly continuous and patchy thin olive grey cutans along ped faces; many very fine and tubular pores; calcareous; abrupt smooth boundary; pH 8.0
B22	45-60 cm	Olive brown (2.5Y 4/4) moist with few fine distinct brown mottles; Silty clay loam; moderate coarse prismastic breaking into moderate coarse and medium subangular blocky; slightly sticky, slightly plastic wet; friable moist; many very fine and common fine tubular pores; calcareous; abrupt smooth boundary; pH 8.2
B23	60-80 cm	Olive brown (2.5Y 4/4) moist; Silty clay loam; modrate coarse prismatic breaking into moderate coarse subangular blocky; slighty Sticky, slightly plastic wet; friable moist; nearly continuous moderately thick olive grey cutans along ped faces; calcareous; pH 8.2
C1	80-155+ cm	Olive brown (2.5Y 4/4) moist; silty clay loam; slightly Sticky, slightly plastic wet; friable moist; strongly calcareous; pH 8.1

Ishwardi series

Ishwardi series formed from Gangetic parent material that are intermittently and seasonally shallowly to moderately deeply flooded, poorly drained, olive to olive brown, calcareous, silty clays with moderate prismatic and subangular blocky structure in the B horizon.

Ap1	0-15 cm	Grey (5Y 5/1) moist with common fine distinct yellowish-brown mottle; silty clay; sticky, plastic wet; common fine and medium tubular pores; common fine roots; abrupt wavy boundary; pH 7.7
Ap2	15-25 cm	Grey (5Y 5/1) moist with few fine distinct yellowish brown mottle; silty clay; strong coarse and medium prismatic breaking into moderate coarse and medium subangular blocky; sticky, plastic wet; extremely firm moist; common fine tubular pores; few fine roots; abrupt wavy boundary; pH 7.9
B21	25-45 cm	Light olive brown (2.5Y 5/4) moist with few fine distinct yellowish mottles; silty clay; strong coarsr prismatic breaking into medium subangular blocky; sticky, plastic wet; very firm moist; common fine tubular pores; few fine roots; slightly calcareous; abrupt wavy boundary; pH 8.0
B22	45-60 cm	Olive (5Y 5/3) moist with few fine distinct yellowish brown mottles; Silty clay; strong coarse prismastic breaking into moderate coarse angular blocky; sticky, plastic wet; extremely firm moist; few fine roots; strongly calcareous; abrupt smooth boundary; pH 8.1
B23	60-80 cm	Olive (5Y 5/3) moist with few fine distinct yellowish brown mottles; Silty clay; moderate coarse prismatic breaking into moderate coarse subangular

		blocky; Sticky and plastic wet; very firm moist; few fine roots; strongly calcareous; abrupt smooth boundary; pH 8.1
C1	80-155 cm	Olive (5Y 5/3) moist with common fine faint yellowish brown and yellowish brown mottles; silt loam; moderate very coarse prismatic dark grey mottles; slighty Sticky, slightly plastic wet; friable moist; common fine tubular pores; strongly calcareous; abrupt smooth boundary; pH 8.1
C2	155+ cm	Olive (5Y 5/3) moist with common fine distinct olive brown mottles; silty clay loam; moderate coarse prismatic; slightly sticky, slightly plastic wet; friable moist; strongly calcareous; abrupt smooth boundary; pH 8.2

1.2.2.7 Soil Chemical properties of Char Malagaon

Neutral soil pH, medium organic matter, optimum to high P and S, very high Ca and Mg, high to very high Zn indicates the fertile soils of the area. Rich Ca and Mg influences the CEC. Only K and B is the limiting nutrients in the study area. Drainage facility paused due to unplanned road construction which is very important to increase cropping intensity of the area.

1.2.3.1 Location, geology, hydrology and climatic feature Daraishkati Mouza

The Daraishkati mouza of NUMAN site was about 10 km West of Damuddya Upazila head quarter at an elevation of about 5 meters above the mean sea level, lying between 23^0 09'20" to23^0 10'10" north latitude and 90^0 22'40" to 90^0 23'20" east longitudes. Located on the Southern part of Islampur Union, North-western part of Damuddya Upazila of Sariatpur District. The entire survey area covered by Low Ganges River Floodplain (AEZ 12). Lands having nearly level topography. The entire area occupied by Medium Highland with olive or olive brown, silt loam to silty clay loam, calcareous, moderate CEC. Soil of upper catena was found to be coarse textured and soil of lower catena was moderate texture. Silt loam soil of upper catena is suitable for upland crops. Whereas lower position soil having silty clay loam texture is suitable both for upland and wet land crops. Based on meteorological data of Faridpur Meteorological Station it was revealed that like other places of Bangladesh the Daraishkati belongs to tropical monsoon climate. Although Bangladesh is endowed with six seasons in year, it is distinctly characterized by three main seasons. The winter or dry season (Rabi) prevailing from November to February is dry and cool. It has the lowest temperature and humidity of the year with a very little rainfall which occurs mostly as occasional drizzles due to depressions. The pre-monsoon or hot season (pre-kharif or early summer) prevails from March to May. It has the highest temperature and evaporation rate of the year. Occasional thunder showers sometimes accompanied by hails take place during pre-monsoon. This is popularly termed as "Kal-baishakhi" (north-western). The monsoon or rainy season (Kharif or late summer) starts in June and continues to October. It was appeared that June-October is the rainy season and November-May is the dry season. More than 90% of the rain falls during the rainy season. The average annual rainfall is below 1885 mm. Highest average rainfall (363 mm) was recorded in June and lowest (04 mm) in January. The highest extreme hot temperature (36.1^0 C) occurs in April and lowest (9.5^0 C) in January. The relative humidity remains high throughout the year. It ranges from 60%-88%, highest in the rainy season and lowest in the dry season.

1.2.3.2 Agro-climate of Daraishkathi

It was observed that this mouza is under agro- climate code K6P4,T3e1, indicating the kharif growing season is 220-230 days. The pre-kharif transition period occurs covering the range 40-

50 days. Duration of Kharif season 120-145 days. The number of days with minimum temperature below 15° C varies from 50-70 and maximum temperature above 40 ° C varies from only 0 to 1 day in each two years (Table 7).

Table 7 Seasonal characteristics of Draiskathi mouza

Growing season	Duration	No. of days	No. of days < 15^0	No. of days > 40^0
Rabi	21 October-2 March	120-145	50-70 days per year (6 December-4 February)	0.0-0.5 day per year
Kharif-1	24 March-8 May	40-50		
Kharif-2	3 May-14 December	220-230		

1.2.3.3 General nature of the soils

Soils occupy nearly level, upper position soils remain beyond flooding and lower part of ridge soils go under shallow flooding during monsoon, soils are imperfectly to poorly drained. Their topsoil and subsoil colour usually ranged from dark greyish brown to olive brown and texture was silt loam to silty clay loam. Substratum soil belongs to light olive brown to brown colour having silt loam to silty clay textured soil. Subsoil structure varied from angular blocky to prismatic. The whole profile was calcareous (Table 8).

Table 8 Different soil series and their distribution

Topography	**Soil series**	**Position in the catena**
Upper slope of nearly level ridge	Sara	Upper part of ridges
Nearly level upper part of ridge	Gopalpur	Nearer to upper part of ridges

1.2.3.4 Soil mapping units

In the mouza, two soil series have been recognized which have been mapped into two soil mapping units (Table 9). The soil mapping units are based on soil series. The soil mapping units have been described in terms of areas and extent, morphological properties, soil salinity, nutrient status, cropping patterns and major constraints.

Table 9 Soil mapping unit, area and percentage

Mapping unit	**AEZ**	**Soil series**	**Land Type**	**Area (ha)**	**Percent (%)**
1		Gopalpur	MHL	81.94	47.84
2		Ishwardi	MHL	36.90	21.54
Settlement				23.65	13.81
Pond scare				17.79	10.39
Road				7.54	4.40
Pond				3.46	2.02

Total	171.28	100

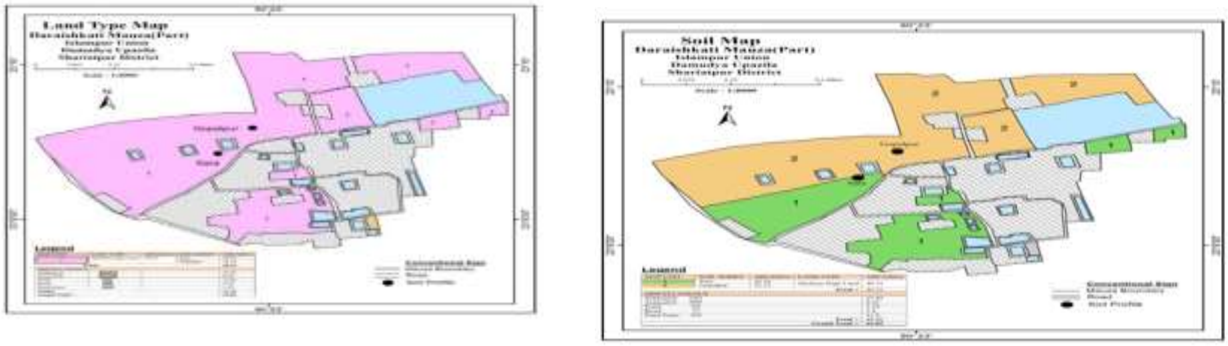


Fig. 3 Land type & Soil map of Daraishkathi mouza.

1.2.3.5 Present agricultural opportunities and constraints of Darishkathi

Congenial for growing aman due to longer Kharif-2 growing season. Congenial for growing Rabi crops due to longer & cooler Rabi growing season. Least chance of high temperature effect on Boro crop. Late water recession, not before December. Lack of irrigation infrastructure. Transformation of crop land into pisiculture. Ponding of land creates acute drainage problem for crop growing lands. Late water recession restricts cultivation of non-rice Rabi crops. Unfavorable condition created by fish culture forced farmers to shift from crop production. Fish farming is more profitable than crop farming. Present land use for agriculture is very confined due to drainage congession (Table 10).

Table 10 Soil and Land Type wise cropping pattern at Daraiskathi

Soil series and Land Type	Present Land Use
Sara, Medium High Land	Mustard/Wheat/Kenaf- Fallow- Chilli, Lentil/Black gram
Gopalpur, Medium High Land	Boro- Fallow- Fallow

1.2.3.6 Soil Profile description

Sara series

Sara series formed from Gangetic parent material that are intermittently flooded, imperfectly drained, calcareous olive to olive brown, calcareous silt loam with prismatic and subangular blocky structure in the B horizon.

Ap1	0-15 cm	Dark greyish brown (2.5Y 4/2) moist; silty clay loam; massive; slightly sticky, slightly plastic wet; friable moist; many fine tubular pores; many fine roots; strongly calcareous; abrupt smooth boundary; pH 7.2
B21	15-40 cm	Light olive brown (2.5Y 5/6) Moist; silt loam; weak coarse prismatic breaking into weak coarse and medium subangular blocky; slightly sticky,

		slightly plastic wet; friable moist; common fine tubular pores; strongly calcareous; abrupt smooth boundary pH 7.8
B22	40-75 cm	Olive (5Y 5/4) moist with few fine distinct dark brown mottles; silt loam; moderate coarse prismatic breaking into moderate coarse subangular blocky slightly sticky, slightly plastic wet; friable moist; continuous thin olive grey cutans along vertical ped faces; strongly calcareous; pH 7.9
C1	75-125+ cm	Light olive brown (2.5Y 5/4) moist with common fine distinct yellowish-brown mottles; silt loam; stratified; slightly sticky, slightly plastic wet; friable moist; strongly calcareous; pH 8.1

1.2.3.7 Soil Chemical properties

Slightly alkaline soil pH, medium organic matter, low N, low to medium K, optimum S, very high Ca and Mg, low Zn and B the fertile soils of the area. There are many limiting nutrients have been observed in the study area. Drainage facility paused due to unplanned road construction which is very important to increase cropping intensity of the area.

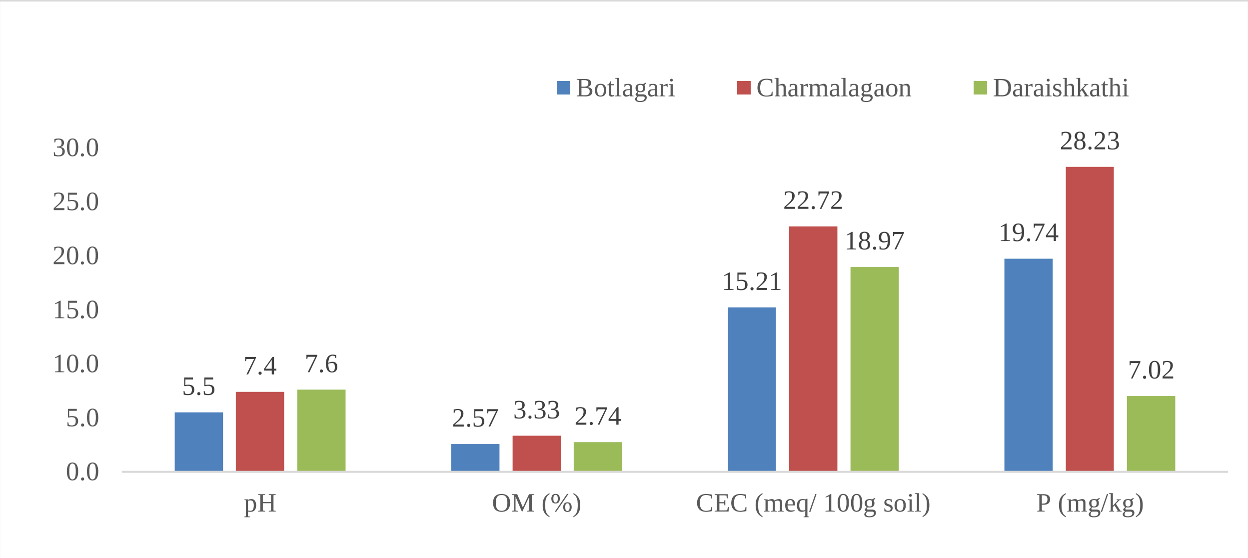


Fig. 4 Comparative soil fertility among three mouza.

4.2 Achievement of Divisional and Regional Laboratory

4.2.1 Analytical Works

Abstract

Quality fertilizers recommendations for sustainable crop production soil teste, plant analysis and quality determination of fertilizer are useful tools. Soil teste gives a measure of the availability of nutrients to crops, plant analysis indicates the actual removal of the nutrients from the soil and quality determination of fertilizer helps to determine the actual need of fertilizers. Therefore, 24 static laboratories and 10 mobile soil testing laboratories (MSTL) under Analytical Services Wing (ASW) of Soil Resource Development Institute (SRDI) providing analytical work of soil, plant, water and fertilizer to prepare fertilizer recommendation card, standardize fertilizer and fertilizer related materials, qualify irrigation water and to quantify removal of the nutrients from the soil. In 2022-2023, total 32,583 samples and 2,72,287 ingredients were analyzed in 23 static laboratories and 10 mobile soil testing laboratories of

which 25,051 soil samples with 2,41,780 ingredients, 365 plant samples with 1,887 ingredients, 423 water samples with 1,844 ingredients and 6,744 fertilizer samples. The sources of soil, plant and water samples were mainly farmers, upazila land and soil resource use nirdeshikha update program of SRDI, NARS (National Agricultural Research System) institutes, universities, and different government organizations (GOs) and non-government organizations (NGOs). In case of fertilizer the sources of samples were mainly Department of Agricultural Extension (DAE), port, and different GOs and NGO. The revenue earning from the analytical work Tk. 65,97,538.00 Besides the analysis soil, plant, water and fertilizer samples laboratories under ASW performing training on soil sample collection and adulterate fertilizers identification at field level.

Introduction

Soil is the backbone of our food security. Without healthy soils, farmers wouldn't be able to provide us with feed, fiber, food, and fuel. Soil is the original source of the nutrients that we use to grow crops. The nutrients move from the soil into plants that we eat. Soils naturally contain many nutrients like N, P, K, S, Ca, Mg. B, Zn, Cu, Fe, Mn, Mo and Cl. These nutrients allow plants to grow. When soil nutrients are missing or in short supply, plants suffer from nutrient deficiency and stop growing. When the nutrient level is too low, the plant cannot function properly and produce the food necessary to feed the worlds' population. Once crops are harvested for human consumption, the natural supply of nutrients in the soil must be refilled. This is why farmers add nutrients to their soils. Nutrients can be added from a variety of sources i.e. organic matter, chemical fertilizers, and even by some plants. This maintains the soil fertility, so the farmer can continue to grow nutritious crops and healthy crops.

Agriculture alters the natural cycling of nutrients in soil. Intensive cultivation and harvesting of crops for human or animal consumption can effectively mine the soil of plant nutrients. In order to maintain soil fertility for sufficient crop yields, soil amendments are typically required. Early humans soon learned to amend their fields with animal manure, charcoal, ash, and lime to improve soil fertility. Today, farmers add numerous soil amendments to enhance soil fertility, including inorganic chemical fertilizers and organic sources of nutrients, such as manure or compost, often resulting in surplus quantities of primary macronutrients. The efficiency of fertilizer application and use by crops is not always optimized, and excess nutrients, especially N and P, can be transported via surface runoff or leaching from agricultural fields and pollutes surface and groundwater (Moss, 2008; Sharpley *et al.*, 2002). Therefore, before adding fertilizer, farmers send a soil sample to a laboratory for baseline testing. By testing their soil, farmers know which nutrients and how much to apply to the soil. If too little is added, crops will not produce as much as they should.

So, while fertilizers serve an important purpose, farmers must be careful to use the right amount, at the right time, to avoid potential negative effects to the environment. For this reason, soil test-based quality fertilizer needs to be applied for profitable crop production along with management of soil fertility and productivity as well as improve soil health.

Objectives

1. To determine the physical, physico- chemical and chemical properties of soils.
2. To prepare soil test-based fertilizer recommendation for crops and cropping patterns.

3. To test and standardize the organic manure, chemical fertilizer and fertilizer related materials.
4. To identify the water quality in irrigation as well as other sources of water.
5. To analyze plant samples for measuring the nutrient content within the plant tissue.
6. To provide advisory services related to soil, fertilizers and crop.

Materials and Methods

A total of 24 static laboratories and 10 Mobile Soil Testing Laboratories (MSTLs) are being operated under the Analytical Services Wing (ASW) of Soil Resource Development Institute (SRDI). Among the static laboratories 07 are divisional (Dhaka, Rajshahi, Rangpur, Chittagong, Khulna, Syhlet, and Barisal), 16 are regional (Mymensingh, Jamalpur, Tangail, Faridpur, Kishoreganj, Gopalganj, Pabna, Bogra, Dinajpur, Comilla, Noakhali, Rangamati, Jessore, Kustia, Jhenaidah and Patuakhali) and 01 is Central laboratory. All static laboratories conduct physical, chemical and physicochemical analyses of soil and fertilizers samples collected by the survey team of SRDI and sent by different sources i.e., farmers, DAE, NARS organizations, universities, entrepreneurs and other GOs and NGOs. Static laboratories under ASW also conduct chemical analysis of water and plant samples. In addition, 10 MSTLs perform two programs at Rabi and Kharif season in a year for distributing soil test-based fertilizer recommendation card at farmers levels (Upazila). The activities of central laboratory under ASW are little bit different than other static laboratories. Central laboratory is conducting research work and quality control program as well as analytical works according to the direction of higher authority. So, the activities of central laboratory have been discussed separately.

The received soil, plant, water and fertilizer samples by different laboratories were prepared and analyzed following the Method mentioned in Analytical Methods: Soil, Water, Plant Material and Fertilizer (SRDI, 2016); Manual for Fertilizer Analysis (BARC, 2003) and Fertilizer Recommendation Guide (BARC, 2018). Analytical results of soil samples were interpreted for pH and salinity level and nutrient status on the basis of Fertilizer Recommendation Guide-2018 (FRG, 2018). Fertilizer Recommendation cards were also prepared following Fertilizer Recommendation Guide-2018. Advisory services were provided through face-to-face discussion and over telephone.

Result and Discussion

Soil sample

A total of 21,956 samples with 2,29,400 ingredients (Moisture, Texture, pH, EC, OC, N, P, S, K, Ca, Mg, B, Zn, Fe, Cu, Mn, Cd, Cr, Pb, Ni and others as per required) were analyzed in the division and regional laboratories of ASW (Table 1).

Table 1: Analyzed soil samples in divisional and regional laboratories of ASW.

Name of Division	Name of Laboratory	No. of Sample	No. of ingredient
Dhaka	Divisional Lab. Dhaka	5,855	46,322
	Regional Lab. Faridpur		
	Regional Lab. Jamalpur		
	Regional Lab. Mymensingh		
	Regional Lab. Kishoreganj		

	Regional Lab. Tangail		
	Regional Lab. Gopalganj		
Rajshahi	Divisional Lab Rajshahi	4,712	39,333
	Regional Lab. Bogura		
	Regional Lab. Pabna		
Khulna	Divisional Lab. Khulna	3,136	32,384
	Regional Lab. Jhenaidha		
	Regional Lab. Kushtia		
	Regional Lab. Jessore		
Chottagarm	Divisional Lab. Chattogram	5,177	52,584
	Regional Lab. Cumilla		
	Regional Lab. Noakhali		
	Regional Lab. Ragamati		
Sylhet	Divisional Lab. Sylhet	1,527	14,521
Barishal	Divisional Lab. Barishal	1,549	9,854
	Regional Lab. Potuakhali		
Rangpur	Divisional Lab. Rangpur	1,684	34,402
	Regional Lab. Dinajpur		
Total		**21,956**	**2,29,400**

Among the analyzed soil samples 32.63% was received from farmer 28.45% was received from SRDI program (Upazila Land and Soil Resource Utilization Guide), 1.06% was received from research institute, 4.04% was received from universities and 5.59% was received from different GOs (7.59%) and NGOs (2.65) to backup research/ educational activities (Figure 1). The highest number of total ingredient (5,855 sample with 46,322 ingredients) was analyzed in the laboratories of Dhaka division (Divisional Lab. Dhaka and Regional Lab. Faridpur, Jamalpur, Mymensingh, Kishoreganj, Tangail, and Gopalganj) whereas lowest number of samples (1,549 sample with 14,521 ingredients) was analyzed in the laboratories of Borishal division. Though, the variations of analyzed samples with ingredients among the laborites directly depend on manpower and instrumental facilities.

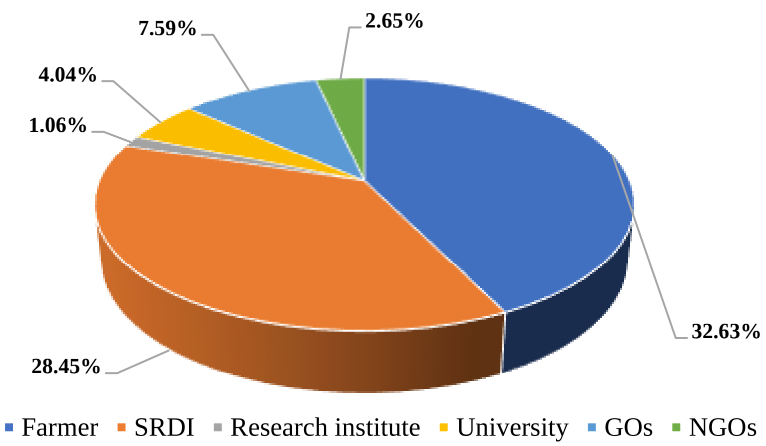


Figure 1: Sources of soil Samples

Fertility status of analyzed farmer's samples

Electrical conductivity (EC)

Electrical conductivity (EC) of received soil samples ranged from non-saline to very strongly saline. 54.7% of received soil samples of Khulna and Barishal Division were non-saline, 23.95% were very slightly saline, whereas 16.32, 2.37, 1.58 and 1.05% samples were slightly saline, moderately saline, strongly saline and very strongly saline, respectively (Table 2.1).

Table 2.1 Soil EC status of farmer's samples

Division	Sample	Non-saline	Very Slightly Saline	Slightly Saline	Medium Saline	Strongly Saline	Very strongly Saline
		0.0-2.0	2.1-4.0	4.1-8.0	8.1-12.0	12.1-16.0	>16.0
Khulana	330	198	87	30	5	6	4
	%	60.0	26.4	9.1	1.5	1.8	1.2
Borishal	50	10	4	32	4	-	-
	%	20.0	8.0	64.0	8.0	-7	-
Total	380	208	91	62	9	6	4
	%	54.74	23.95	16.32	2.37	1.58	1.05

Soil Reaction (pH)

Soil pH status ranged from very strongly acidic to very strongly alkaline. Among the analyzed soil samples 6.10% soils pH were very strongly acidic, 29.33% soils pH were strongly acidic and 20.05% soils pH were slightly acidic. Consequently, 15.67, 27.90 and 0.89% soils pH were neutral, slightly alkaline and strongly alkaline, respectively (Table 2.2). In Dhaka and Rajshahi division 16 to 33% soils pH ranged from very strongly acidic to strongly acidic. While in Khulna and Borishal Division 0 to 14% soils pH ranged from very strongly acidic to strongly acidic. In Sylhet and Rangpur Division 66 to 67% soils pH ranged from very strongly acidic to strongly acidic.

Organic Matter (OM)

Soil OM status ranged from very low to very high. Among the analyzed soil samples 23.79% soils OM were very low, 38.72% soils OM were low and 33.32% soils OM were medium. Consequently, 3.73 and 0.44% soils OM were high and very high respectively (Table 2.3). In Dhaka and Rajshahi Division 60 to 79 % soils OM ranged from very low to low. While in Khulna and Borishal Division 42 to 51% soils OM ranged from very low to low In Sylhet and Rangpur Division 27 to 37% soils OM ranged from very low to low.

Table 2.2 Soil pH status of analyzed farmer's samples

Division	Sample	Very strongly acidic	Strongly acidic	Slightly acid	Neutral	Slightly alkaline	Strongly alkaline	Very strongly alkaline
		<4.5	4.6-5.5	5.6-6.5	6.6-7.3	7.4-8.4	8.5-9.0	>9.0
Dhaka	1560	133	374	142	210	648	49	4
	%	9	24	9	13	42	3	0
Rajshahi	2040	9	335	568	326	785	16	1

	%	-	16	28	16	39	1	-
Khulana	1250	-	-	22	499	725	4	-
	%	-	-	1.8	39.9	58.0	0.3	
Borishal	50	-	7	33	10	-	-	-
	%	-	14.0	66.0	20.0	-	-	-
Sylhet	484	78	246	149	11	-	-	-
	%	16.12	50.82	30.78	2.27	-	-	-
Rangpur	2352	252	1307	637	156	-	-	-
	%	10.71	55.56	27.08	6.63	-	-	-
Total	7736	472	2269	1551	1212	2158	69	5
	%	6.10	29.33	20.05	15.67	27.90	0.89	0.06

Table 2.3 Soil OM status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	High	Very high
		<1.0	1.0-1.7	1.8-3.4	3.5-5.5	>5.5
Dhaka	818	100	392	310	16	0
	%	12	48	38	2	0
Rajshahi	2040	993	627	362	58	-
	%	48	31	18	3	-
Khulana	1250	159	631	446	14	-
	%	12.7	50.5	35.7	1.1	-
Borishal	50	3	21	26	-	-
	%	6.0	42.0	52.0	-	-
Sylhet	270	22	74	134	28	12
	%	8.15	27.41	49.63	10.37	4.44
Ranjpur	2352	336	880	981	137	18
	%	14.28	37.41	41.70	5.82	0.76
Total	6780	1613	2625	2259	253	30
	%	23.79	38.72	33.32	3.73	0.44

Total Nitrogen (TN)

Soil TN status ranged from very low to very high. Among the analyzed soil samples 47.76% soils TN were very low, 46.64% soils TN were low and 3.61% soils TN were medium. Consequently, 0.03 and 0.12% soils TN were high and very high respectively (Table 2.4). In All Divisions 80 to 100 % soils TN ranged from very low to low.

Table 2.4 Total N status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
Dhaka	818	466	303	30	9	2	8
	%	57	37	4	1	0	1
Rajshahi	2040	1492	470	58	20	-	-
	%	73	23	3	1	-	-
Khulana	1250	185	1029	34	2	-	-

	%	14.8	82.3	2.7	0.2	-	-
Borishal	50	25	25	-	-	-	-
	%	50.0	50.0	-	-	-	-
Sylhet	270	32	184	40	14	-	-
	%	11.85	68.15	14.81	5.18	-	-
Rangpur	2352	1038	1151	83	36	-	-
	%	44.13	48.93	3.52	1.53	-	-
Total	6780	3238	3162	245	81	2	8
	%	47.76	46.64	3.61	1.19	0.03	0.12

Available Phosphorus (P)

Available P status of received soils ranged from very low to very high. Available P status of 4.70% soils were very low, 9.60% soils were low, while 11.58, 11.25, 12.67 and 50.33% soils were medium, optimum, high and very high, respectively (Table 2.5). In Dhaka and Rajshahi division 16 to 20 % soils available P ranged from very low to low. While in Khulna and Borishal Division 0 to 12.9 % soils available P ranged from very low to low. In Sylhet and Rangpur Division 7 to 12% soils available P ranged from very low to low.

Table 2.5 Available P status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<5.25	5.25-10.5	10.51-15.75	15.76-21.0	21.1-26.25	>26.25
Dhaka	1560	111	205	164	134	105	841
	%	7	13	11	9	7	54
Rajshahi	1949	78	233	303	237	179	919
	%	4	12	16	12	9	47
Khulana	1250	47	115	217	216	260	395
	%	3.8	9.1	17.4	17.3	20.8	31.6
Borishal	40	-	-	-	12	22	6
	%	-	-	-	30.0	55.0	15.0
Sylhet	484	85	58	68	76	57	140
	%	17.56	11.98	14.05	15.70	11.77	28.92
Rangpur	2352	38	122	132	184	344	1542
	%	1.61	5.18	5.61	7.82	14.62	65.56
Total	7635	359	733	884	859	967	3843
	%	4.70	9.60	11.58	11.25	12.67	50.33

Exchangeable Potassium (K)

Exchangeable K status range of the received soil samples was very low to very high. Exchangeable K status of 6.76% soils were very low, 34.59% soils were low, while 26.22, 13.53, 7.07, and 11.83% soils were medium, optimum, high and very high, respectively (Table 2.6). In Dhaka and Rajshahi division 32 to 34 % soils exchangeable K ranged from very low to low. While in Khulna and Borishal Division 10 to 30 % soils exchangeable K ranged from very low to low. In Sylhet and Rangpur Division 41 to 43% soils exchangeable K ranged from very low to low.

Table 2.6 Exchangeable K status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
Dhaka	1560	138	365	416	241	142	258
	%	9	23	27	15	9	17
Rajshahi	1947	140	525	475	246	139	422
	%	7	27	24	13	7	22
Khulana	1250	33	338	409	313	98	59
	%	2.6	27.1	32.7	25.1	7.8	4.7
Borishal	50	-	5	17	12	7	9
	%	-	10.0	34.0	24.0	14.0	18.0
Sylhet	484	50	157	110	62	32	73
	%	10.33	32.44	22.73	12.81	6.61	15.08
Rangpur	2352	156	1254	577	160	122	83
	%	6.63	53.31	24.53	6.80	5.18	3.52
Total	7643	517	2644	2004	1034	540	904
	%	6.76	34.59	26.22	13.53	7.07	11.83

Available Sulphur (S)

Range of available S status of analyzed soils varied from very low to very high. Available S status of 26.84% soils were very low, 28.15% soils were low, whereas 17.38, 11.53, 5.72 and 10.29% soils were medium, optimum, high and very high in available S content, respectively (Table 2.7). In Dhaka and Rajshahi division 51 to 60 % soils Available S ranged from very low to low. While in Khulna and Borishal Division 39 to 42 % soils Available S ranged from very low to low. In Sylhet and Rangpur Division 55 to 67% soils Available S ranged from very low to low.

Table 2.7 Available S status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<7.5	7.51-15.0	15.1-22.5	22.51-30	30.1-37.5	>37.5
Dhaka	1560	329	467	308	172	87	189
	%	21	30	20	11	6	12
Rajshahi	1946	550	614	237	282	81	182
	%	28	32	12	15	4	9
Khulana	1250	280	205	225	163	138	239
	%	22.4	16.4	18.1	13.0	11.0	19.1
Borishal	50	3	18	20	6	3	-
	%	6.0	36.0	40.0	12.0	6.0	-
Sylhet	484	41	111	199	45	17	71
	%	8.47	22.93	41.11	9.29	3.51	14.67
Rangpur	2352	848	736	339	213	111	105
	%	36.05	31.29	14.41	9.05	4.71	4.46
Total	7642	2051	2151	1328	881	437	786
	%	26.84	28.15	17.38	11.53	5.72	10.29

Available Zinc (Zn)

Range of available Zn status of analyzed soils varied from very low to very high.

Available Zn status of 9.89% soils were very low, 27.48% soils were low, whereas 20.97, 13.21, 9.73 and 18.72% soils were medium, optimum, high and very high in available Zn content, respectively (Table 2.8). In Dhaka and Rajshahi division 13 to 40 % soils Available Zn ranged from very low to low. While in Khulna Division 29 % soils Available Zn ranged from very low to low. In Rangpur Division 48% soils Available Zn ranged from very low to low.

Table 2.8 Available Zn status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<0.45	0.451-0.9	0.91-1.35	1.351-1.8	1.81-2.25	>2.25
Dhaka	832	36	73	71	79	147	426
	%	4	9	9	9	18	51
Rajshahi	1908	113	652	528	226	98	291
	%	6	34	28	12	5	15
Khulana	1250	68	290	289	129	156	318
	%	5.4	23.2	23.1	10.3	12.6	25.4
Rangpur	2352	410	728	442	404	216	152
	%	17.43	30.95	18.79	17.17	9.18	6.46
Total	6342	627	1743	1330	838	617	1187
	%	9.89	27.48	20.97	13.21	9.73	18.72

Available Boron (B)

Range of available B status of analyzed soils varied from very low to very high. Available B status of 14.09 % soils were very low, 27.18% soils were low, whereas 17.13, 12.06, 10.46 and 19.08% soils were medium, optimum, high and very high in available B content, respectively (Table 2.9).

Table 3.9 Available B status of analyzed farmer's samples

Division	Sample	Very low	Low	Medium	Optimum	High	Very high
		<0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Dhaka	754	88	171	178	119	57	141
	%	12	23	24	16	8	19
Rajshahi	1904	211	660	303	215	173	342
	%	11	35	16	11	9	18
Khulana	1250	25	132	219	163	222	489
	%	2.0	10.6	17.5	13.0	17.8	39.1
Borishal	50	-	-	-	2	4	44
	%	-	-	-	4.0	8.0	88.0
Rangpur	1881	499	624	300	205	155	98
	%	26.52	33.17	15.94	10.89	8.24	5.20
Total	5839	823	1587	1000	704	611	1114
	%	14.09	27.18	17.13	12.06	10.46	19.08

In Dhaka and Rajshahi division 35 to 46 % soils Available B ranged from very low to low. While in Khulna and Borishal Division 0 to 13 % soils Available B ranged from very low to low. In Rangpur Division 60% soils Available B ranged from very low to low.

Plant and Water Sample

Nutrient content in plant tissue is a vital indicator of soil fertility, soil productivity as well as crop yield and nutrient deficiency. Moreover, quality water is an important input for agricultural production as well as human health. Divisional and regional laboratories under ASW analyzed a total of 365 plant samples and 423 water samples with the ingredient number 187 and 1844, respectively. The highest number of plant samples (201) and water samples (156) were analyzed by divisional laboratory, Dhaka (Table 3). The number of analyzed ingredients of plant and water sample was 353 and 423, respectively.

Table 3: Plant and water samples analyzed by divisional and regional laboratories of ASW

Name of Division	Name of Laboratory	Plant		Water	
		Sample	Ingredient	Sample	Ingredient
Dhaka	Divisional Lab. Dhaka	210	353	156	348
	Reginal Lab. Faridpur				
	Reginal Lab. Jamalpur				
	Reginal Lab. Mymensingh				
	Regional Lab. Kishoreganj				
	Regional Lab. Tangail				
	Regional Lab. Gopalganj				
Rajshahi	Divisional Lab Rajshahi	-	-	1	6
	Reginal Lab. Bogra				
	Regional Lab. Pabna				
Khulana	Divisional Lab. Khulana	-	-	74	318
	Reginal Lab. Jhenaidha				
	Reginal Lab. Kushtia				
	Regional Lab. Jessore				
Chittagong	Divisional Lab. Chittagong	-	-	-	-
	Reginal Lab. Comilla				
	Reginal Lab. Nokhali				
	Regional Lab. Ragamati				
Sylhet	Divisional Lab. Sylhet	119	910	124	528
Borisal	Divisional Lab. Borisal	20	624	56	644
	Reginal Lab. Potuakhali				
Rangpur	Divisional Lab. Rangpur	25	65	10	40
	Reginal Lab. Dinajpur				
Total		365	1,887	423	1,844

Fertilizer Recommendation Card

Soil test based balanced fertilizer application ensures optimum yield with minimum input maintaining soil health and environment. Divisional and regional laboratories under ASW had prepared 12,668 fertilizer recommendation card basis on soil test base (9118), online fertilizer recommendation system (780) and Upazila land and soil utilization guide (464) which were distributed to respective farmers (Table 4).

Revenue earning

Divisional and regional laboratories under ASW earned Tk. 65,97,538.00 as revenue by analyzing soil, water, plant and fertilizer samples (Table 5). The highest amount (Tk. 35,74,043.00) was earned from fertilizer analysis. Divisional laboratory, Dhaka with regional laboratories under the division was the most top position in revenue earning (Tk.

27,53,246.00)

Table 4: Fertilizer recommendation card prepared and distribution by divisional and regional laboratories of ASW

Name of Division	Name of Laboratory	No. of card			
		STB	OFRS	ULSUG	Total
Dhaka	Divisional Lab. Dhaka	1,893	207	164	2,264
	Reginal Lab. Faridpur				
	Reginal Lab. Jamalpur				
	Reginal Lab. Mymensingh				
	Regional Lab. Kishoreganj				
	Regional Lab. Tangail				
	Regional Lab. Gopalganj				
Rajshahi	Divisional Lab Rajshahi	1,910	-	-	1,910
	Reginal Lab. Bogra				
	Regional Lab. Pabna				
Khulana	Divisional Lab. Khulana	998	369	-	1367
	Reginal Lab. Jhenaidha				
	Reginal Lab. Kushtia				
	Regional Lab. Jessore				
Chittagong	Divisional Lab. Chittagong	-	-	-	2,286
	Reginal Lab. Comilla				
	Reginal Lab. Nokhali				
	Regional Lab. Ragamati				
Sylhet	Divisional Lab. Sylhet	907	105	-	1,012
Borishal	Divisional Lab. Borisal	1,046	-	250	1,296
	Reginal Lab. Potuakhali				
Ranjpur	Divisional Lab. Rangpur	2,364	99	50	2,513
	Reginal Lab. Dinajpur				
Total		9,118	780	464	12,648

Table 5: Revenue earning by divisional and regional laboratories of ASW

Name of Division	Name of Laboratory	Earning (Tk.)				
		Soil	Water	Plant	Fertilizer	Total
Dhaka	Divisional Lab. Dhaka	8,25,786	5,710	6,230	19,15,520	27,53,246
	Reginal Lab. Faridpur					
	Reginal Lab. Jamalpur					
	Reginal Lab. Mymensingh					
	Regional Lab. Kishoreganj					
	Regional Lab. Tangail					
	Regional Lab. Gopalganj					
Rajshahi	Divisional Lab Rajshahi	3,90,514	150	-	3,30,700	7,21,364
	Reginal Lab. Bogra					
	Regional Lab. Pabna					
Khulana	Divisional Lab. Khulana	3,04,432	12,440	-	4,37,451	7,54,323
	Reginal Lab. Jhenaidha					
	Reginal Lab. Kushtia					
	Regional Lab. Jessore					
Chittagong	Divisional Lab. Chittagong	-	-	-	-	8,55,019

	Reginal Lab. Comilla					
	Reginal Lab. Nokhali					
	Regional Lab. Ragamati					
Sylhet	Divisional Lab. Sylhet	1,92,560	3,4000	1,19,000	1,46,000	4,91,560
Borishal	Divisional Lab. Borisal	61,633	220	-	1,73,950	2,35,803
	Reginal Lab. Potuakhali					
Ranjpur	Divisional Lab. Rangpur	1,75,301	1,000	6,500	5,70,422	7,53,223
	Reginal Lab. Dinajpur					
Total		19,50,226	53,520	1,31,730	35,74,043	65,97,538

Fertilizer and fertilizer related materials

1n 2022-2023 fiscal year, 6,744 fertilizer samples were analyzed in different laboratories of ASW (Table 6), in which 1387 (67.92%) fertilizer samples were standard and 578 (30.08%) samples were adulterated (Table 7).

Table 6: Analyzed fertilizer in divisional and regional laboratories of ASW

Name of the fertilizers	Dhaka	Rajshahi	Khulna & Jessore	Chattogram & Comilla	Borishal	Sylhet	Rangpur	Grand total
Urea	8	0	34	56	30	20	9	157
$(NH4)_2SO_4$	8		1	42			6	57
TSP	30	39	29	205	42	23	27	395
DAP	35	14	30	195	41	23	19	357
Rock phosphate	0	0	0	2	0	0	0	2
MAP	1	0	0	4	0	0	0	5
MoP	33	21	19	170	32	24	17	316
K_2SO_4	24	3	1	109	2		2	141
Gypsum	113	28	23	195	20	21	58	458
NPKS	18	4	24	52	6	17	7	128
$MgSO_4$	251	98	59	598	16	26	164	1212
ZnSO4 (Mono.)	168	301	219	312	46	27	215	1288
ZnSO4 (Hepta.)	52	36	22	162	3	28	73	376
Chelated Zn	57	26	10	112	3	14	24	246
Solubor boron	112	101	54	210	21	25	117	640
Boric acid	110	91	23	202	11	13	124	574
Fertibor B15%	21	6	3	44	0		22	96
Organic fertilizer	106	25	16	38	0	32	38	255
Dolomite	15	0	1	0	0	3	6	25
Nutraphos- N	0	0	0	11	0	0	0	11
Nutraphos- 24	0	0	0	5	0	0	0	5
Total	1,162	793	568	2,724	273	296	928	6,744

Micronutrient fertilizers i.e., urea, DAP and MoP were around 100% standard. Besides, other macronutrient fertilizers like TSP, Gypsum and Potassium sulphate were 15.19%, 19.21% and 21.34% adulterated, respectively (Table 7). In contrast, micronutrient i.e., 73.29% zinc sulfate monohydrate, 41.10% zinc sulfate heptahydrate, 26.01% chelated zinc, 23.59% solubor boron and 44.60% boric acid were adulterated. Among the micronutrient fertilizer only magnesium sulphate ($MgSO_4$) was around 100% standard. The highest percent of sub-standard was observed for zinc sulfate monohydrate. The amount of adulterated organic fertilizers was 56.52% (Table 7). The adulteration was observed not only for the nutrient deficit but also for toxic level of heavy metals like cadmium (Cd), lead (Pb), Nickel (Ni) and Chromium (Cr).

Table 7: Quality of analyzed fertilizer in divisional and regional laboratories of ASW

Name of the fertilizers	Total	Standard	Sub-standard	Standard	Sub-standard
	No.			%	
Urea	157	157	0	100.00	0.00
$(NH4)_2SO_4$	57	53	4	92.98	7.02
TSP	395	335	60	84.81	15.19
DAP	357	350	7	98.04	1.96
Rock phosphate	4	2	2	50.00	50.00
MAP	5	5	0	100.00	0.00
MoP	316	312	4	98.73	1.27
K_2SO_4	164	129	35	78.66	21.34
Gypsum	458	370	88	80.79	19.21
NPKS	76	45	31	59.21	40.79
$MgSO_4$	1212	1202	10	99.17	0.83
ZnSO4 (Mono.)	1378	368	1010	26.71	73.29
ZnSO4 (Hepta.)	326	192	134	58.90	41.10
Chelated Zn	296	219	77	73.99	26.01
Solubor boron	640	489	151	76.41	23.59
Boric acid	574	318	256	55.40	44.60
Fertibor B 15%	96	69	27	71.88	28.13
Organic fertilizer	230	100	130	43.48	56.52
Dolomite	22	15	7	68.18	31.82
Nutraphos - N	11	7	4	63.64	36.36
Nutraphos - 24	5	3	2	60.00	40.00
Total	6,779	4,740	2,039	69.92	30.08

Table 8: Analyzed soil samples by MSTLs

MSTL	Working area		Upazila	Sample
	Division	District		
Jamuna	Dhaka	Munsiganj, Dhaka, Tangail, Netrokona Mymensingh, Kishoreganj, Narshindi, Narshindi, Mymensingh, Tangail	10	550
Brahmaputra	Dhaka	Jamalpur, Sherpur	4	112
Madhumoti	Dhaka	Faridpur, Rajbari, Sariyatpur, Madaripur, Gopalganj	6	237
Tista	Rajshahi	Naogaon, Chapainawabgonj, Rajshahi, Natore, Pabna, Sirajganj, Joypurhat, Gaibandha, Rangpur	10	545
Karatoa	Rajshahi	Gaibandha, Thakurgoan, Dinajpur, Nilphamari, Kurigram, Bogura, Dinajpur, Thakurgoan	8	468
	Rangpur	Lalmonirhat, Nilphamari, Gaibandha, Panchagor, Rangpur, Kurigram,		

Rupsa	Khulna	Kushtia, Chuadanga, Jhenaidah, Jashore, Narail, Khulna, Satkhira, Bagerhat, Chuadanga, Jhenaidah, Jashore,Khulna	14	615
Shurma	Sylhet	Sylhet, Sunamgonj, Moulavibazar, Habigonj	4	310
Kirtonkhola	Barishal	Bhola, Barguna, Patuakhali, Jhalokati	2	200
Total			58	3,095

Service of mobile soil testing laboratory (MSTL)

A total 3,095 soil samples were tested through 10 MSTLs namely Jamuna, Madhumoti, Brahmaputra, Tista, Karatoa, Rupsa, Karnophuly, Titash, Shurma and Kirtonkhola in Robi and Kharif season (Table 8). The tested soil samples were collected from farmer’s field of different Upazilas with the cooperation of Department of Agricultural Extension (DAE). After analysis soil test-based fertilizer recommendation cards were prepared and distributed to the respective farmers.

Conclusion

The natural soil fertility of Bangladesh is reducing rapidly hampering crop productivity. The farmers of Bangladesh have realized the importance and benefits of soil test-based fertilizer recommendation for crop cultivation though soil test-based fertilizer recommendation facility at farmer level is still inadequate and scanty. Furthermore, input costs are also getting higher step by step. In this situation, increase of recommended quality fertilizer uses through soil and fertilizer testing by the farmers with the support of SRDI and DAE could contribute in resource use efficiency and more economic return from cultivated crops. Nevertheless, managing the soil health and sustainable crop production soil test-based standard fertilizer application has to be ensured through soil and fertilizer testing

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4.2.2 Extent of Soil Fertility Deterioration in Matlab Upazila under Chandpur District

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Abstract

A comparative study was conducted to assess the soil characteristics and fertility status in Matlab dokkhin Upazila within the Chandpur District, covering two distinct zones: the Lower Meghna River Floodplain (AEZ-17) and the Young Meghna Estuarine Floodplain (AEZ-18). The primary objective was to evaluate the degradation of soil fertility over time by examining various parameters including soil pH, organic matter (OM), total N, available P, S, B, Zn, Cu, Fe, Mn, exchangeable K, Ca, and Mg. Over the years from 1992 to 2023, there were notable trends in soil properties. During the 1992s, the soil in the area exhibited a range of characteristics. The pH has turned very strongly acidic to slightly acidic from very strongly acidic to neutral. Over the observed period, the organic matter (OM) content in the soil exhibited an increase of approximately 16.21% from 1992 to 2023. The total nitrogen (N) content could not be compared as the determination process of N in 1992 was different from 2023. Available phosphorus (P) levels also experienced an increase, increasing from a medium 15.50 ppm to optimum 20.74 ppm. The availability of zinc (Zn) witnessed a decline, dropping from 2.00 ppm to 1.83 ppm. Additionally, sulfur (S) content increased from optimum 23.17 ppm to very high 79.72 ppm and boron (B) content also displayed a significant increase, rising from medium levels (0.28 ppm) to optimum (0.47 ppm). Exchangeable potassium (K), calcium (Ca), and available iron (Fe) exhibited an increase. On the other hand, exchangeable magnesium (Mg) and available copper (Cu) showed substantial decreases. In case of soil available manganese (Mn), it actually did not follow specific pattern. For three soil group Chandina, Chandpur, and Debidar it exhibited a decrease. Conversely, for Matlab, and Burichang the content of available manganese (Mn) was increased. In summary, the findings of the study strongly suggest that soil fertility has declined in the study area, particularly in the soils of the High Ganges River Floodplain and Ganges Tidal Floodplain in Bangladesh. These changes in soil properties and nutrient status have implications for agriculture and land management practices in the region.

Key words: Soil group, Soil reaction (pH), Organic matter (OM), Plant nutrients, Soil fertility.

Introduction

Bangladesh, a country known for its fertile deltaic plains and agricultural heritage, is heavily dependent on the agriculture sector, employing a significant portion of its population and contributing to its economy. However, with the increasing population, the demand for food in Bangladesh is constantly increasing and thus the practice of intensive agriculture using agrochemicals have been dominating the cropping systems for several decades. Unfortunately, in the pursuit of increased food production, sustainability, environmental concerns, and the issue of land degradation have often been overlooked. As a result, soil fertility has significantly declined, particularly in areas where land-use intensification is more pronounced and inefficient. Bangladesh's soils are subjected to/experience high temperatures, abundant rainfall, and the pressure of cultivating two or more crops in a year, sometimes without balanced fertilization practices. This has led to the widespread depletion of nutrients from the soil. The intensification of agricultural land use, coupled with the adoption of modern crop varieties, has contributed to the deterioration of soil fertility and the emergence of new nutrient deficiencies. As a result, soil fertility is deteriorating progressively (Islam, 2008; SRDI, 2010a, b). To address this challenge, it is imperative to assess the trend of soil fertility decline to ensure optimal nutrient management and the development of sustainable cropping systems in Bangladesh. Soil fertility levels vary across regions, necessitating variable fertilizer applications for different types of crops. Insufficient fertilizer application can reduce crop yields, while excessive use can result in economic losses and poses environmental risk.

A comprehensive understanding of soil fertility provides valuable insights into the current nutrient status, distribution patterns, and trends (Dafonte *et al.*, 2010). This knowledge is crucial for decision-making processes aimed at enhancing crop productivity. To assess the extent of soil fertility degradation, it is essential to compare and analyze the initial and current soil fertility status. Therefore, this study examines changes in soil pH, organic matter (OM), total nitrogen (TN), phosphorus (P), sulfur (S), potassium (K), calcium (Ca), magnesium (Mg), boron (B), zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn) over a period spanning from 1998 to 2023. This analysis aims to provide insights into the evolving nutrient dynamics in the soil over time. In summary, the availability of productive soil and land resources is crucial to meet the ever-increasing demand. Addressing this challenges Bangladesh requires a holistic approach that considers sustainable soil management practices, environmental protection, and the prevention of soil fertility degradation. Understanding the changing soil nutrient dynamics is crucial for making informed decisions in agriculture and ensuring long-term food security.

Materials and Method

Study location: The studied site, Matlab dokkhin Upazila under Chandpur district of Bangladesh covers an area of 131.69 km^2 in the southern-east part of the country and comprises Lower Meghna River Floodplain (AEZ-17) and Young Meghna Estuarine Floodplain (AEZ-18).

Soil sampling and analysis: Soil sampling was done under the national soil survey program of Soil Resource Development Institute, Bangladesh. Samples were collected based on soil series, land type and land use. Composite samples were collected from the upper 0-15 cm of depth. Collected soil samples were 68 in 2023. Soil pH was measured as described by Jackson (1962). Organic matter (OM) was determined by wet oxidation method (Page *et al.*, 1982). Available P was extracted by Bray and Kurtz (1945) methodology. The P in the extract was then determined by developing blue color absorbance with ammonium molybdate-ascorbic acid solution and measuring the color by Spectrophotometer at 890 nm wavelength. The S content in the extract was determined turbidimetrically and the turbid was measured by spectrophotometer at 535 nm wavelength (Alvarez *et al.*, 2001). Exchangeable K content was determined by extraction with 1M ammonium acetate, pH 7.0 solution followed by determination of extractable K by flame photometer (Thomas, 1982). Exchangeable Ca and Mg content were determined by extraction with 1M ammonium acetate, pH 7.0 solution followed by measurement by atomic absorption spectrophotometer (Thomas, 1982). Available Zn, Cu, Fe and Mn were extracted by 0.05M DTPA solution (pH 7.3) maintaining 1:2 soilextractant ratio. The extracted level was measured by flame AAS (Lindsay and Norvell, 1978). Available B was extracted by hot water-0.02M $CaCl_2$ solution (1:2). The extractable B was determined by spectrophotometer following azomethine-H method (Keren, 1996).

Soil nutrient changes: The trends of soil nutrient status were determined and interpreted, and the nutrients critical levels are shown in appendix according to FRG (2018). However, the rates of change in soil nutrient for different soils have been calculated following the formula of Hartermink (2003):

$$\Delta = \left(\frac{\mathcal{X}2 - \mathcal{X}1}{\mathcal{X}1}\right) \times 100\%$$

Where, Δ = %the rate of change

x_1 = the initial value of the variable at sampling time (1992)

x_2 = the final value of the variable at sampling time (2023)

Results and Discussion

Soil reaction (pH): There was a noticeable increase in soil acidity from the year 1992 (Strongly acidic - eutral; 5.0-7.2) to 2023 (Very strongly acidic - Slightly acidic; 3.5-6.3) in different soil groups with land types (Table1). The highest soil pH values decreased by 0.6, 0.7, 0.9, and 1.5 unit in Chandina- MLL, Chandpur- MLL, Debidar- MLL, and Matlab- MLL, while the highest soil pH values increased by 0.4, and 0.2 unit in Matlab- LL and Burichang- LL soils. The lowest soil pH values decreased by 1.3, 1.0, 0.1, 0.3, 1.0, and 0.2 unit in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 1). Over the course of three decades, from 1992 to 2023, efforts to intensify crop production have led to a notable rise in the application of chemical fertilizers. Unfortunately, this surge in fertilizer use, marked by imbalances and excessive quantities, particularly stemming from improper utilization of ammonia-based acid-forming fertilizers, appears to be the primary factor contributing to the increasing levels of soil acidity in the study area.

Table1: Change of soil pH from the year 1992 to 2023

Soil group	Land type	pH Range		Change of highest pH	Change of lowest pH
		2023	1992		
Chandina	MLL	3.5-5.6 (VSTA-SLA)	4.8-6.2 (VSTA-N)	-0.6	-1.3
Chandpur	MLL	4.6-5.8 (STA-SA)	5.6-6.5 (SLA)	-0.7	-1.0
Debidar	MLL	4.6-6.3 (STA-SLA)	4.7-7.2 (VSTA-N)	-0.9	-0.1
Matlab	MLL	4.2-5.7 (VSTA-SLA)	4.5-7.2 (VSTA-SA)	-1.5	-0.3
	LL	4.0-6.2 (VSTA-SLA)	5.0-5.8 (VSTA-SLA)	0.4	-1.0
Burichang	LL	4.6-5.5 (STA)	4.8-5.3 (VSTA)	0.2	-0.2
Overall range		3.5-6.3 (VSTA-SLA)	5.0-7.2 (STA-N)	-0.9	-1.5

*VSTA= Very strongly acidic, STA = Strongly acidic, SLA= Slightly acidic, N= Neutral, SLAL= Slightly alkaline, STAL = Strongly alkaline, VSTAL= Very strongly alkaline. Soil test value was interpreted according to FRG, 2018.

Organic matter (OM) and total nitrogen (TN): The OM content was increased during the time span of 1992 to 2023, for the year 1992 it was found 1.65-2.80% (Low - Medium), while it was observed 2.31-3.04% (Medium) by the year 2023 in different soil groups with land types. Mean OM values increased by 26, 9, 2, 16.08, 58.18, and 14% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 2).

Increasing use of organic amendment, leaving crop residues in the field after harvest or incorporating them into the soil and cover cropping might be the cause of increased amount of organic matter in that region.

Table 2: Change of soil OM and TN from the year 1992 to 2023.

Soil group	Land type	Mean OM		Change		Mean TN
		2023	1992			2023
		%		Value	%	%
Chandina	MLL	2.73 (M)	2.17 (M)	0.56	26	0.16 (L)
Chandpur	MLL	3.04 (M)	2.80 (M)	0.24	9	0.18 (L)
Debidar	MLL	2.76 (M)	2.72 (M)	0.04	2	0.15 (L)
Matlab	MLL	2.31 (M)	1.99 (M)	0.32	16.08	0.25 (M)
	LL	2.61 (M)	1.65 (L)	0.96	58.18	0.15 (L)
Burichang	LL	2.42 (M)	2.80 (M)	-0.38	-14	0.14 (L)
Mean		2.65(M)	2.36 (M)	0.29	16.21	0.17 (L)

*CL = Critical level, VL = Very low, L= Low, M= Medium, O = Optimum, H = High, VH = Very high. Soil test value was interpreted as per loamy to clayey following FRG, 2018.

The TN content was found between 0.14- 0.25% (Low) in the year 2023. The ammonium nitrogen was observed between 15- 37% (Low) by the year 1992 in different soil groups with land types. As the process of nitrogen determination was different in 1992 from that of 2023, there is no scope of observing the change of nitrogen content of the respective soil.

Phosphorus (P): The change in available P content was increased during the time span of 1992 to 2023. For the year 1992 it was found 5 - 33 ppm (Low-Very high), whereas it was observed 9.31 -30.72 ppm (Medium-Very high) by the year 2023 in different soil groups with land types (Table 3). Mean available P values decreased by 7% in Chandina- MLL, whereas P values increased by 8.7, 3.97, 9.46, 2.31, and 9.26% in Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 3). Increase in soil available phosphorus might be the adoption of practices such as liming acidic soils, application of organic amendments in both alkaline and acidic soils, tillage practices and regulation of time and method of P fertilizer application.

Table 3: Change of available P from the year 1992 to 2023

Soil group	Land type	Available P		Change	
		2023	1992		
		ppm		Value	%
Chandina	MLL	30.72 (VH)	33(VH)	-2.28	-7
Chandpur	MLL	27.70 (VH)	19(O)	8.7	46
Debidar	MLL	27.69 (VH)	21(O)	3.97	19
Matlab	MLL	17.46 (O)	8(L)	9.46	118.25
	LL	9.31 (M)	7(L)	2.31	33
Burichang	LL	14.26 (M)	5(L)	9.26	185.20
Mean		20.74 (O)	15.50 (M)	5.24	65.74

*VL = Very low, L= low, M= Medium, O = Optimum, H = High, VH = Very high. Soil test value was interpreted as per loamy to clayey following FRG, 2018.

Exchangeable K, Ca, and Mg: For the year 1992 exchangeable K was found between 0.14-0.27 cmole+/kg (Low-Medium), while it was observed between 0.19-0.28 cmole+/kg (Medium-Optimum) by the year 2023 in different soil groups with land types (Table 4). The status of exchangeable K did not follow any specific pattern for each soil group and land type. Overall, it was found to be increased in 2023 comapre to 1992 except in Debidar- MLL, it was decreased slightly, whereas in Chandina- MLL no change was found. Indicating depletion mean exchangeable K values changed by -5% in Debidar- MLL, while indicating build up mean exchangeable K values changed by 4, 12, 64.28, 16% in Chandpur- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 4).

Table 4: Change of Exchangeable K and Ca and Mg from the year 1992 to 2023

Soil group	Land type	Exchangeable K		Change	Exchangeable Ca		Change	Exchangeable Mg		Change
		2023	1992		2023	1992		2023	1992	
		(Cmole$^+$/kg)		%	(Cmole$^+$/kg)		%	(Cmole$^+$/kg)		%
Chandia	MLL	0.24 (O)	0.24 (M)	0	8.42 (VH)	6.4 (H)	32	2.04 (VH)	3.13 (VH)	-35
Chandpur	MLL	0.28 (O)	0.27 (M)	4	8.58 (VH)	7.5 (H)	15	2.11 (VH)	3.81 (VH)	-45
Debidar	MLL	0.20 (M)	0.21 (M)	-5	10.14 (VH)	5.7 (O)	78	2.93 (VH)	2.87 (VH)	2.09
Matlab	MLL	0.19 (M)	0.17 (L)	12	9.10 (VH)	5.9 (O)	54.23	2.55 (VH)	3.69 (VH)	-31
	LL	0.23 (M)	0.14 (L)	64.28	8.04 (VH)	5.6 (O)	44	3.48 (VH)	3.63 (VH)	-4.13
Burichang	LL	0.22 (M)	0.19 (M)	16	12.57 (VH)	7.6 (VH)	65.39	2.18 (VH)	4.48 (VH)	-51.33
Mean		0.23 (M)	0.20 (M)	15.21	9.48 (VH)	6.45 (H)	48.10	2.55 (VH)	3.60 (VH)	-27.40

*VL = very low, L= low, M= medium, O = optimum, H = high, VH = very high. Soil test value interpretation was done as per loamy to clayey soils according to FRG-2018.

In 1992, exchangeable Ca was found between 5.6-7.6 cmole+/kg (Optimum-Very high), while it was observed between 8.04-12.57 cmole+/kg (Very high) by the year 2023 in different soil groups with land types (Table 4). The status of exchangeable Ca was increased in 2023 in comparison to 1992. Mean exchangeable Ca values increased by 32, 15, 78, 54.23, 44, and 65.39% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 4).

The change of exchangeable Mg was found from 2.87- 4.48 cmole+/kg (Very high) in 1992 to 2.04 -3.48 cmole+/kg (Very high) by the year 2023 in different soil groups with land types (Table 4). The status of exchangeable Mg was found to be decreased in 2023 in comparison to 1992 except in Debidar- MLL. Mean exchangeable Mg values decreased by 35, 45, 31, 4.13, and 51.33% in Chandina- MLL, Chandpur- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively, while indicating build up mean exchangeable Mg values increased by 2.09% in Debidar- MLL (Table 4).

Sulfur (S) and Boron (B): Available S was found between 19-29 ppm (Medium- Optimum) in 1992, while it was observed between 36.89-151.40 ppm (High-Very High) by the year 2023 in different soil series with land types (Table 5). The status of available S was found to be increased sharply in 2023 in comparison to 1992. Mean available S values increased by 76, 163.20, 55.11, 156, 495, and 657% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively (Table 5). Mean available B was found between 0.16- 0.47 ppm (Low to Optimum) in 1992, while it was observed between 0.21-0.85 ppm (Low to Very high) by the year 2023 in different soil groups with land types. Mean available B values increased by 27, 240, 200, 100, 17, and 15% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively over time from 1992 to 2023 (Table 5).

Table 5: Change of soil S and B from the year 1992 to 2023

Soil group	Land type	Mean S		Change		Mean B		Change	
		2023	1992			2023	1992		
		%		Value	%	%		Value	%
Chandina	MLL	36.89 (H)	21(M)	15.89	76	0.38 (M)	0.30(M)	0.08	27
Chandpur	MLL	76.33 (VH)	29(O)	47.33	163.20	0.85(VH)	0.25(M)	0.60	240
Debidar	MLL	41.88 (H)	27(O)	14.88	55.11	0.48 (O)	0.16(L)	0.32	200
Matlab	MLL	58.82 (VH)	23(O)	35.82	156	0.36 (M)	0.18(L)	0.18	100
	LL	113.01(VH)	19(M)	94.01	495	0.21 (L)	0.18(L)	0.03	17
Burichang	LL	151.40(VH)	20(M)	131.40	657	0.54 (O)	0.47(O)	0.07	15
Mean		79.72 (VH)	23.17(O)	56.56	267.05	0.47 (O)	0.28	0.21	99.83

*VL = Very low, L= Low, M= Medium, O = Optimum, H = High, VH = Very high. Soil test value was interpreted as per loamy to clayey following FRG, 2018.

Available Zn, Cu, Fe and Mn: Over time from 1992 to 2023, soil available Zn reserve had been depleted except in Chandpur- MLL, and Matlab- LL (Table 6). In 1992, mean available Zn was found between 1.4-2.5 ppm (Optimum to Very high), whereas it was observed between 1.15-2.63 ppm (Optimum-Very high) in 2023 in different soil group-land types.

Table 6: Change of available Zn, Cu, Fe and Mn from the year 1992 to 2023

Soil group	Land type	Available Zn		Available Cu		Available Fe		Available Mn	
		2023	1992	2023	1992	2023	1992	2023	1992
		ppm							
Chandina	MLL	1.96 (H)	2.10 (H)	2.45 (VH)	7.60 (VH)	291.09 (VH)	254 (VH)	28.39 (VH)	194.30 (VH)
Chandpur	MLL	2.10 (H)	1.40 (O)	2.64 (VH)	6.50 (VH)	182.76 (VH)	102 (VH)	15.02 (VH)	18.40 (VH)
Debidar	MLL	1.49 (O)	1.60 (O)	2.79 (VH)	7.60 (VH)	277.89 (VH)	231 (VH)	22.25 (VH)	29.60 (VH)
Matlab	MLL	1.67 (O)	2.10 (H)	3.60 (VH)	9.60 (VH)	224.62 (VH)	202 (VH)	46.01 (VH)	29.60 (VH)
	LL	2.63 (VH)	2.10 (H)	2.60 (VH)	6.60 (VH)	232.65 (VH)	165 (VH)	51.70 (VH)	36.60 (VH)
Burichang	LL	1.15 (O)	2.50 (VH)	2.94 (VH)	8.50 (VH)	241.19 (VH)	158 (VH)	39.36 (VH)	25 (VH)
Mean		1.83 (H)	2.00 (H)	2.84 (VH)	7.73 (VH)	241.70 (VH)	185.33 (VH)	33.79 (VH)	55.58 (VH)

*VL = Very low, L= Low, M= Medium, O = Optimum, H = High, VH = Very high. Soil test value was interpreted as per loamy to clayey following FRG, 2018.

Mean Available Zn values decreased by 7, 7, 21, and 54% in Chandina- MLL, Debidar- MLL, Matlab- MLL, and Burichang- LL soils respectively, while the Zn values increased by 5, and 25.23% in Chandpur- MLL, and Matlab- LL. Similarly soil available Cu reserve had been depleted from 1992 to 2023 (Table 6). Mean available Cu was found between 6.5-9.6 ppm (Very high) in 1992, whereas it was observed between 2.45-3.60 ppm (Very high) by the year 2023 in different soil groups with land types. Mean available Cu values declined by 68, 59.38, 63.28, 62.5, 61 and 65.41% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively.

The change in available Fe content was increased during the time span of 1992 to 2023 (Table 6). Mean available Fe was found between 158-254 ppm (Very high) in 1992, though it was observed between 182.76-291.09 ppm (Very high) by the year 2023 in different soil groups with land types. Overtime from 1992 to 2023, soil available Fe reserve had been increased by 15, 79.17, 20.29, 11.20, 41 and 53% in Chandina- MLL, Chandpur- MLL, Debidar- MLL, Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively.In 1992 mean available Mn was found between 18.40- 194.30 ppm (Very high), and it was observed between 15.02-51.70 ppm (Very high) by the year 2023 in different soil groups with land types (Table 6). Overtime from 1992 to 2023, soil available Mn reserve had been depleted by 85.38, 18.36, and 29.6% in Chandina- MLL, Chandpur- MLL, and Debidar- MLL soils, respectively.soil, respectively. On the contrary, soil available Mn had been increased by 56, 41.25, and 58% in Matlab- MLL, Matlab- LL and Burichang- LL soils, respectively.

The findings of this study were consistent with the results reported by various authors. Siddique *et al.* (2014) found that the soil pH ranged from 5.4 to 6.0 in the year 1991, but it was observed to be in the range of 4.4 to 5.4 by the year 2012 in the northeastern piedmont soil. A comparison between the soil pH maps of BARC for the years 2005 and 2012 revealed that there was an expansion of 0.15 million hectares of very strongly acidic soil (pH < 4.5) and 0.44 million hectares of strongly acidic soil (pH 4.5-5.5) over time. The increasing rate of SOC indicates increase of organic matter in soils of Bangladesh over the time. According to SRDI, medium organic matter content of organic matter comprises 55.57% of arable land in 2010, which increases to 59.19% in 2020 (*Soil fertility trends in Bangladesh* 2010 to 2020, 2020). This may be because of rice-rice cropping system, increasing cropping intensity and awareness of the farmers on incorporation of organic manures to their land. Additionally, soil available P, K, S, and B content have arisen in that study area which is a good indication considering our soil health. Increase in soil available phosphorus might be the adoption of practices such as liming acidic soils, application of organic amendments in both alkaline and acidic soils, tillage practices and regulation of time and method of P fertilizer application. The exchangeable K content in the study area might be increased due to the use of organic amendments. Zahid *et.al.,* 2020, reported that soil productivity may reduce to 10-25% if soil sulphur is in the range of 18.1-23.5 ppm. In the study area the Sulphur content was 36.89 to 151.40 ppm which indicates that the soil of the study area undergoing a change for the management of crop production. Besides, the Ca content of the study area was increased whereas the Mg content was decreased. However, soil magnesium content in loamy to clayey soils both of upland crops and wetland rice crops across the country declined alarmingly over the years. Hasan *et.al.,* 2015, reported that there is a considerable leaching of base materials such as Ca, Mg and K from top soils and subsequent accumulation in sub soils.

Nonetheless, a significant proportion of Bangladeshi farmers opt to apply nitrogen (N) fertilizers due to the immediate and noticeable effects on soil and crop production (Biswas *et al.,* 2008). This preference for N fertilizers contributes to nutrient imbalances that can adversely affect soil characteristics and overall crop production. The decline in soil fertility in regions with intensive cropping practices, as highlighted by Jahiruddin and Satter (2010), suggests that the replenishment of essential nutrients is not occurring, or it exceeds the soil's capacity to provide the necessary nutrients for the cultivation of high-yield crop varieties. There are evidences that Zn contents have been depleted severely from 1991 to 2012 in some selected areas of Bangladesh and thus crop productivity is declining (Siddique *et al.,* 2014). Depletion of available micronutrients (Zn, and Cu) might be caused due to the intensive agriculture and without any further nutrient supplements. During prolonged flooding, as soil Eh reduction continues, pH decreases while zinc availability increases leading to high tissue zinc concentrations (Pavanasasivam, and Axley,1980) and reduced ferric and manganic forms that are soluble (Ponnamperuma, 1972). Increased solubility of Zn, Fe and Mn may result increased movement of these micronutrients to lower horizons from surface horizons, thereby depleting the surface horizons.

Conclusion

The findings of this study highlight significant changes in soil characteristics and agricultural practices in Bangladesh. The study noted a decline in soil pH levels over the years, with an expansion of very strongly acidic and strongly acidic soils in some areas. This shift may have implications for crop production and soil health. The research indicates a positive trend in SOC, suggesting an increase in organic matter in Bangladeshi soils. Soil available phosphorus, potassium, sulfur, and boron content showed an increase, which is beneficial for soil health and agriculture. This rise may be due to various practices, including liming acidic soils, organic amendments, and regulated phosphorus fertilizer application. The study identified depletion of zinc (Zn) content in selected areas between 1991 and 2012, potentially causing a decline in crop productivity. This depletion may be linked to intensive agricultural practices and a lack of micronutrient supplementation. This is an indication for the need to reverse or restore the soil natural fertility status from current critical nutrients status to increase crop productivity through efficient farming. Soil test based balanced fertilization by quality organic, inorganic and bio fertilizers, judicious and efficient use of acid forming fertilizers like urea and di-ammonium phosphate (DAP), crop diversification, inclusion of green manuring crops and incorporation of crop residue might be some effective tools for soil fertility restoration.

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4.2.3 Research Work

Title: Calibration of Buffer pH Method for Acid Soil Management and Sustainable Crop in Bangladesh

Introduction

Acid soils are wide-spread in Bangladesh. Comparing the two soil reaction maps of BARC, 2005 and 2018 it is revealed that 0.15 m ha of very strongly acidic (Extremely acidic as per USDA) soils (pH < 4.5) and 0.44 m ha strongly acidic (Very strongly acid and strongly acid soils as per USDA) soil (pH 4.5 - 5.5) have been developed. The chemical analysis of these soils suggests that the soils are grossly deficient in P, Ca, and Mg, low in CEC with higher levels of exchangeable Fe and Al at the surface (Rahman *et al.*, 2013). Crop productivity on such a soil is mostly constrained by Al and Fe toxicity, P deficiency, low base saturation, impaired biological activity and other acidity-induced soil fertility and plant nutritional problems (Manoj-Kumar, 2012). Amelioration of soil acidity is, therefore, accorded top priority for enhancing crop productivity and ensuring food security of these regions.

There is a general impression among the farmers and agricultural extension workers that soils with low pH require high amount of lime application, which may not be always correct. In fact, the existing soil pH is just an indication of whether lime is required or not; it does not suggest the actual amount of lime required to raise the soil pH to a desired level. Accurately estimating lime requirements (LR) of acidic soils has been a concern since liming practices began. Lime requirement (LR) for acidic soils is determined by direct titration, incubation, or buffer equilibrations (Godsey *et al*., 2007).

Incubation of the soil with [$CaMg(CO_3)_2$] could be used to estimate the LR of a soil. Discrepancies in the literature exist about what is the most appropriate method to determine the actual LR of an acid soil. Lime requirement (LR) for acidic soils is determined by direct titration, incubation, or buffer equilibrations (Godsey *et al*., 2007). Therefore, incubation study has been conducted to i) determine lime requirement for amending soil acidity, and ii) compare the suitability of the buffer methods for accurate determination of LR to a target pH of the Bangladesh soil using –[$CaMg(CO_3)_2$] incubation as a reference method.

Materials and Methods

Soil sample collection

Acidic soils from 02 Agro-ecological Zones of Bangladesh were collected with wide variation in physical, chemical and physic-chemical properties with the help of Upazila Soil Property Maps developed by SRDI. The soil series were Goainghat, Balagonj, Ramgonj, Bijipur, Srimongal, Borolekha. Soil samples were collected from 0-15 cm depth of the selected locations using the zigzag method (Carter and Gregorich, 2008). After collection, the soils were made free from the plant debris and unnecessary materials and air dried under shade for four days. Then the soils were ground and mixed up thoroughly and sieved through 2 mm sieve. Composite soil samples were kept in polythene bag for initial physical and chemical analysis, and incubation study.

Analysis of soil samples

Soil samples were analyzed for pHH2O(1:2.5), OM, Ca, Mg, Fe and Mn. The pH of each soil sample was measured in distilled water at the ratio of 1:2.5using the combined glass electrode (SI Analytics Lab 845), after calibration based on standard solutions in a pH range of 4.01-7.01 or 10.01 (SI Analytics). Organic carbon was estimated by modified method of Walkley and Black (1934). Available phosphorus according to the procedure of Bray and Kurtz (1945). The exchangeable cations (Ca2+ and Mg2+) were analyzed using 1M Ammonium acetate at pH of 7.0 (Schollenberger, 1945). The levels of available Fe and Mn were determined by DTPA extraction (Lindsay and Norvell, 1978). Available iron (Fe2+) and manganese (Mn2+) were measured by Atomic Absorption Spectrophotometer (Model Shimadzu AA-7000).

Incubation

An incubation study was conducted in the Regional laboratory, SRDI, Dhaka for 4 months. Two hundred gram of the soil was placed into each pot and arranged in completely randomized design (CRD). The incubation study consisted of field capacity condition, having 5 (five) treatments. Treatments used for this study were as follows: (1) 50%, (2) 75%, (3) 100%, (4) 125%, and (5) 150% of lime rate. The rates of lime applied were determined so as to achieve the target pH values of 6.5 based on Keeney and Corey (1963). The rates of Ca, Mg (CO3)2 was converted from tons/acre to kg ha-1 (meq Ca, Mg (CO3)2 100 g-1 of soil) assuming the soil density to be 1.33 g cm-3 and the soil depth to be 15 cm. Two hundred g of soil were incubated at field capacity for a period of 4 month with different lime rate including a zero control. The various rates of lime were first mixed thoroughly with the dry prepared soil. Then they were wetted to field capacity and incubated at room temperature (25 ±1 °C) in open plastic jars. The clods formed in the soil were broken and rewetted to field capacity every 1 to 2 weeks. At the end of 2, 4, 6, 8, 10, 12, and 16 weeks of the incubation, the clods formed in the soil were ground and passed through a 2-mm sieve, and 5 g of soil were used to determine the pH (1:2.5) of the soil. A linear regression equation was fitted to the data of lime application rate and the pH obtained after incubation for a period. This equation was used to determine the actual LR for each of the 6 soil samples to reach a specific target pH. Graphs were generated in Microsoft Word (Microsoft Corporation 2003). The incubation LRs (to achieve pH 6.5) were obtained by graphing the applied liming rates against the ensuing soil pH after incubation period.

Results and Discussion

Determination of lime requirement

The lime rates needed to bring the different soils to the target pH values of 6.5 was determined from the lime response equations. The regression equations obtained between the lime application rates and soil pH after incubation were linear (Table 1).

Table 1. Regression equations relating meq Ca Mg $(CO_3)_2$/100 g of soil (lime rate applied) to the pH

Soil series	Regression equation (x = meq Ca, Mg $(CO_3)_2$/100g of soil y = pH of soil)	R^2	LR (t ha^{-1})
Balagonj	y = 0.005x +4.781	R^2 = 0.948	6.86
Goainghat	y = 0.004x + 4.632	R^2 = 0.986	9.32
Ramgor	y = 0.004x + 5.184	R^2 = 0.986	6.56
Bijipur	y = 0.005x + 5.527	R^2 = 0.989	3.88
Srimongal	y = 0.003x + 5.486	R^2 = 0.956	6.74
Borolekha	y = 0.008x + 4.843	R^2 = 0.958	4.13

Figure 1 shows the effect of increasing levels of lime on soil pH. In all soils the pH increased with the increasing levels of lime. A straight-line equation was fitted to all the curves and the coefficients of determination (r^2) obtained for soils were 0.948, 0.986,0.986, 0.989, 0.956, and 0.958, respectively. This straight-line equation permits the estimation of lime requirement to raise the pH to any desired level of all the soils.

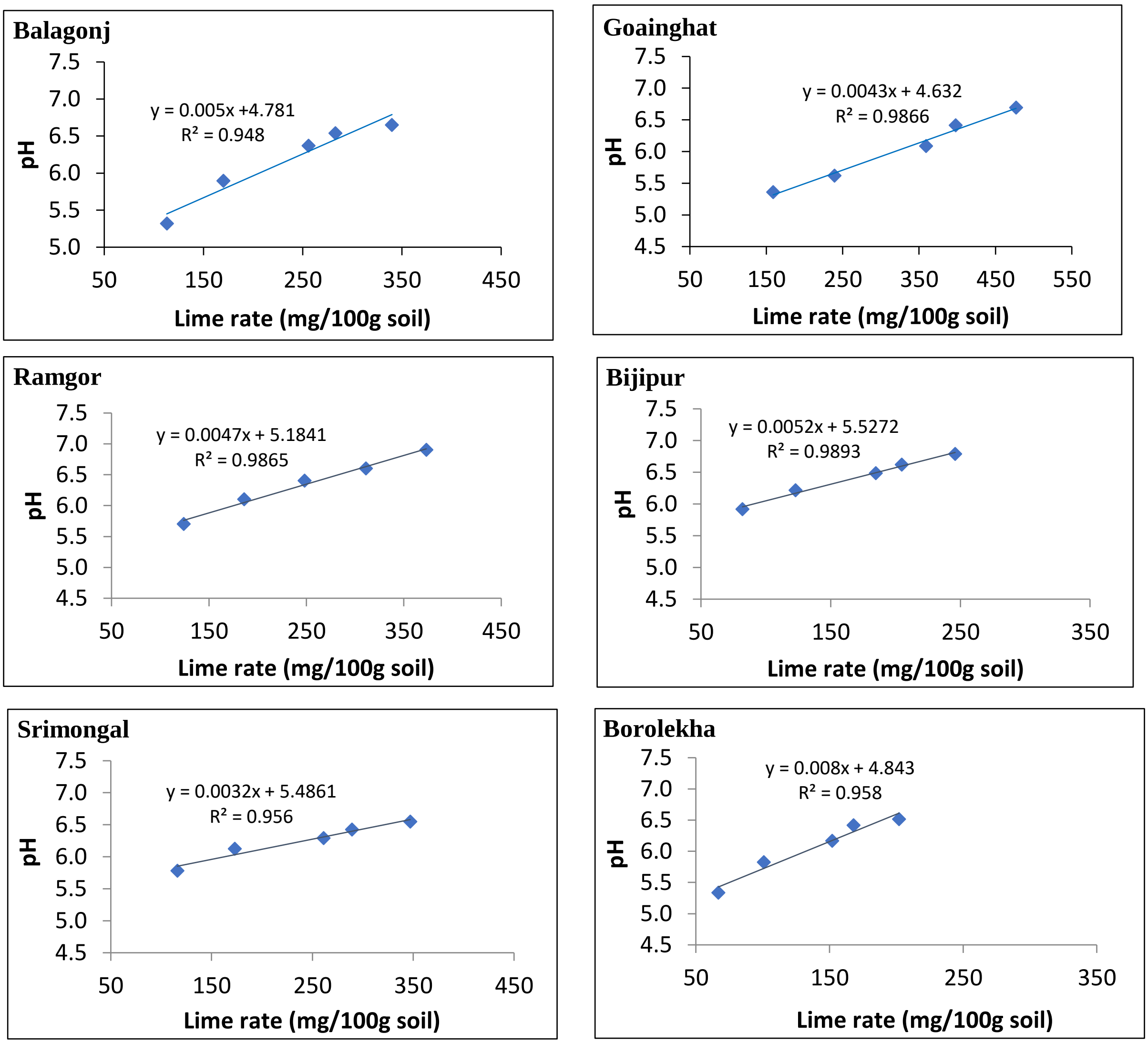

Figure 1. Lime requirement determination graph

Differences in rate and magnitude of pH increase over time varied by soil and incubation period. Figure 3 shows how the $CaMg(CO_3)_2$ increased soil pH for all the incubation periods. Soil pH increased faster and reached a higher maximum value for the higher rate. Higher rate showed the fastest increase in pH and the largest pH increase throughout all incubation periods.

Evaluation of Buffer Solutions

This study was done to verify the applicability of the buffers that do not contain any hazardous constituents and to calibrate these buffers for predicting lime requirement needs for Bangladesh soils. The buffer pH measurements were performed with three replicates for each sample. Buffer solutions were prepared using published methodologies [SMP, Watson and Brown (1998); Woodruff, Woodruff (1948); modified Mehlich, Hoskins and Erich (2008); modified Adams-Evans, Huluka (2005)]. The buffer pH determination procedures were adapted from Sims (1996) and van Lierop (1990). The actual LR rates of the soils to reach the target pH 6.5 were then regressed with the BpH values of these soils to obtain a linear relationship between them. The BpH values obtained for each buffer solution are reported for the 6 soils in Table 2.

Table 2. Measured soil buffer pH values of the 28 soils used in the study

Agro-ecological Zone	Series	SMP	Woodruff	Modified Mehlich	Modified Adams-Evans
20. Esttern Surma Kushyara Floodplain	Balagonj	6.1	6.6	6.0	7.4
	Goainghat	5.9	6.4	5.8	7.2
29. Northern And Eastern Hills	Ramgonj	5.8	6.2	5.7	7.2
	Bijipur	6.3	6.5	6.0	7.5
	Srimongal	6.0	6.3	5.8	7.4
	Borolekha	6.5	6.6	6.2	7.6

Table 2 summarizes test results for buffer pH due to lime application for each soil series included in the study. The Modified Mehlich soil buffer pH values (5.7 to 6.2 were consistently lower than SMP (5.9-6.5) or Woodrof (6.2-6.6) or Modified Adams-Evans (7.2-7.6) values for all soil series included in the study. Except Modified Adams-Evans the buffer pH differences do not seem large, but could result in considerably different estimates of LR and lime application.

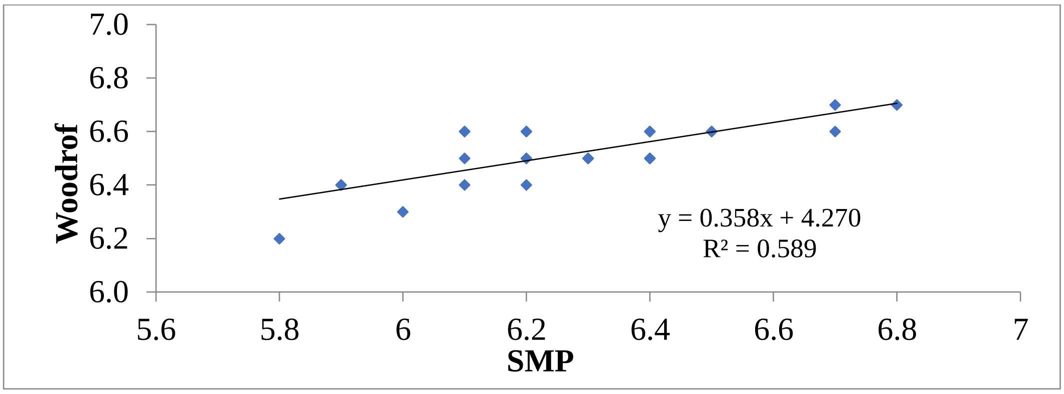

Figure 2.1 Correlation between the BpH values of the Woodruff and SMP buffers

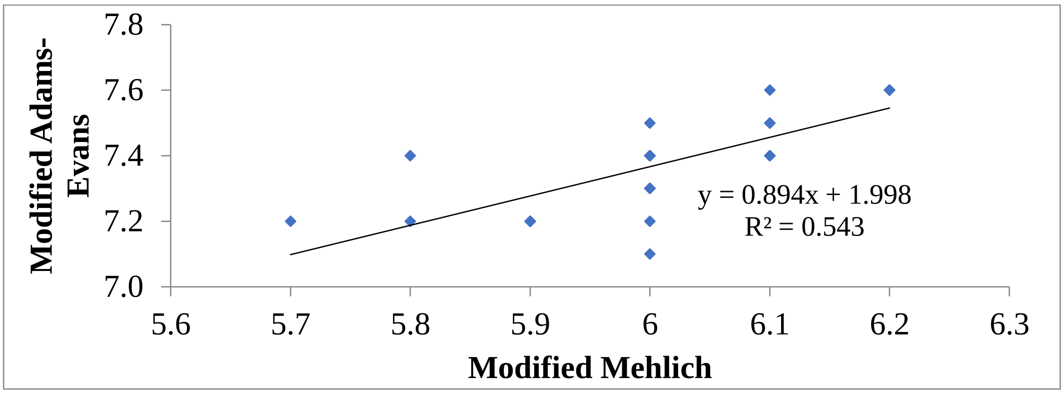

Figure 2.2 Correlation between the BpH values of the Modified Adams-Evans and Modified Mehlich buffers

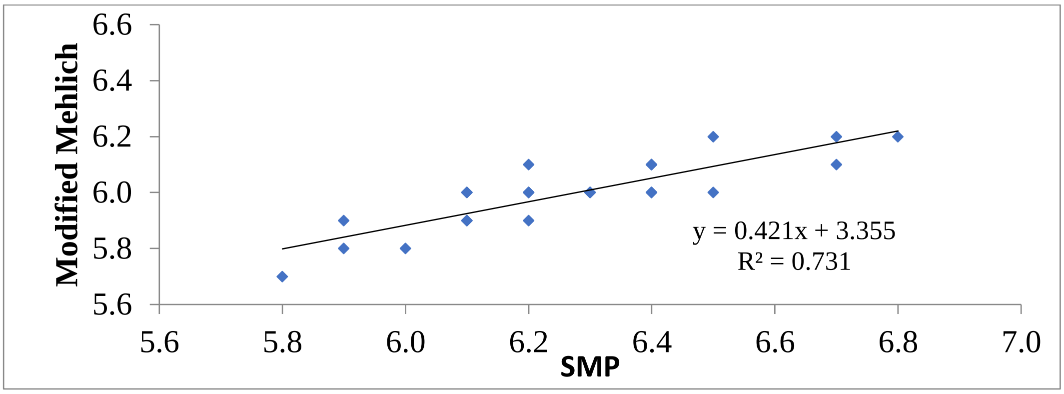

Figure 2.3 Correlation between the BpH values of the Modified Mehlich and SMP buffers

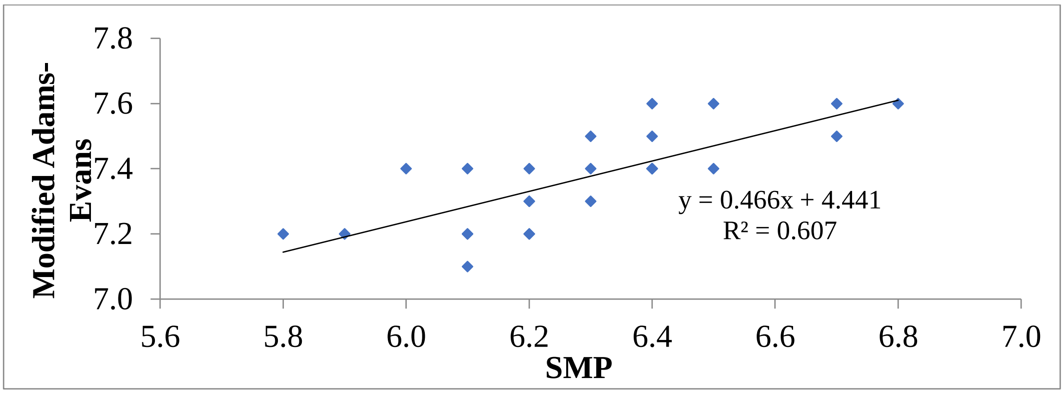

Figure 2.4 Correlation between the BpH values of the Modified Adams-Evans and SMP buffers

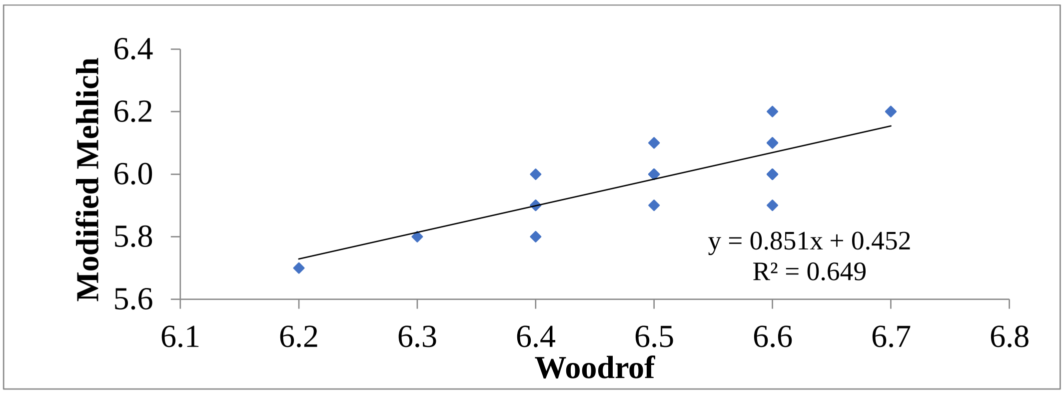

Figure 2.5 Correlation between the BpH values of the Mehlich and Woodruff buffers

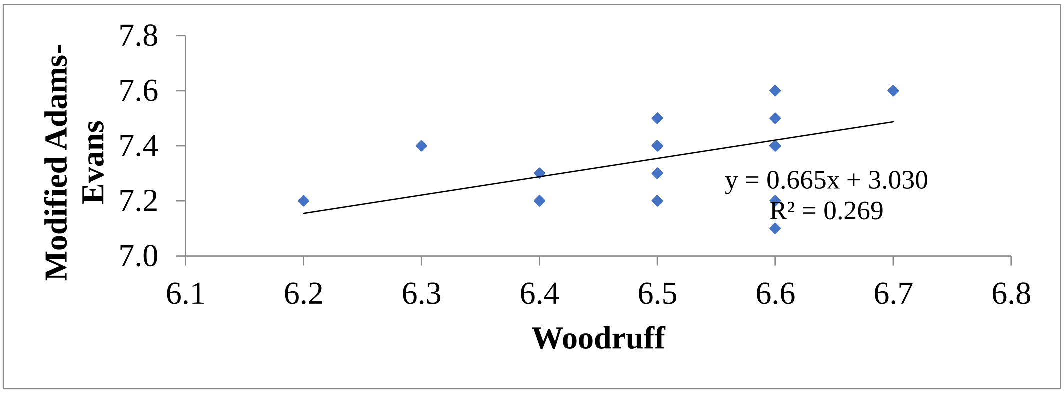

Figure 2.6 Correlation between the BpH values of the Modified Adams-Evans and Woodruff buffers

Figure 2.1-2.6 shows relationships between the four buffer pH methods across all soil samples. Except buffer pH values for Woodruff and Modified Adams-Evans the buffer pH values for the four methods were linearly related ($P < 0.01$). The r^2 of the relationships was lowest between Woodruff and Modified Adams-Evans (0.269), and higher and approximately similar between Modified Mehlich and Woodruff (0.731), SMP and Woodruff (0.589), SMP and Modified Adams-Evans (0.607), Woodrof and Modified Mehlich (0.659). The intercept and slope coefficients of the regression line between Woodruff and Modified Mehlich did not differ from 0 and 1 ($P > 0.05$), respectively, which would suggest that both methods yield statistically similar results across many samples and fields. The Modified Mehlich buffer pH method resulted in significantly lower values than the SMP and Woodruff methods (intercept and slope were lower than 0 and 1, respectively).

Table 3. Calibration equations relating LR and BpH of the soils for target pH

Buffer	pH target	LR (meq CaCO3 /100 g of soil) vs. BpH equation	r^2
1. SMP	6.5	y = 1.512x - 1.082	$R^2 = 0.692$
2. Woodruff		y = 1.245x + 0.871	$R^2 = 0.696$
3. Modified Mehlich		y = 0.941x + 0.360	$R^2 = 0.651$
4. Modified Adams-Evans		y = 1.063x + 2.154	$R^2 = 0.540$

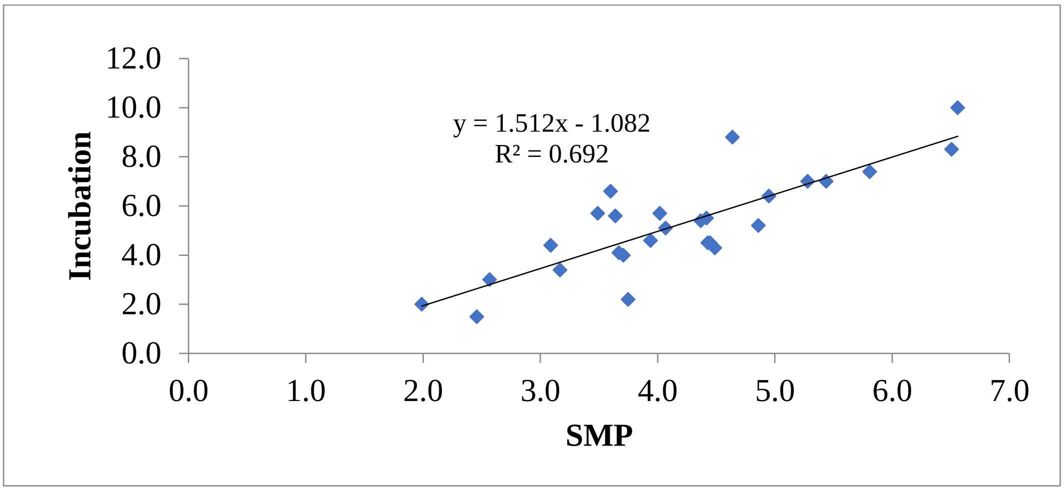

Figure 3.1 Correlation between the LR of the incubation and SMP buffers

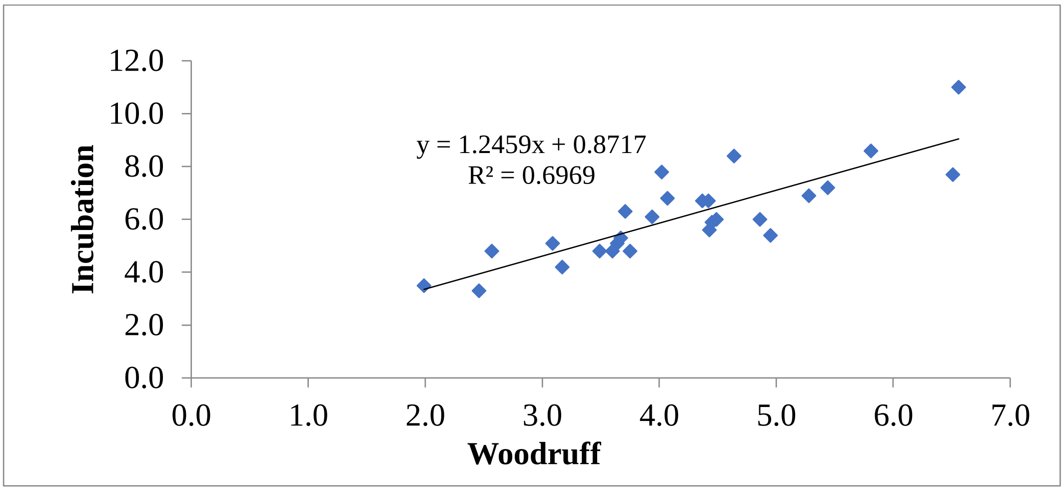

Figure 3.2 Correlation between the LR of the incubation and Woodruff buffers.

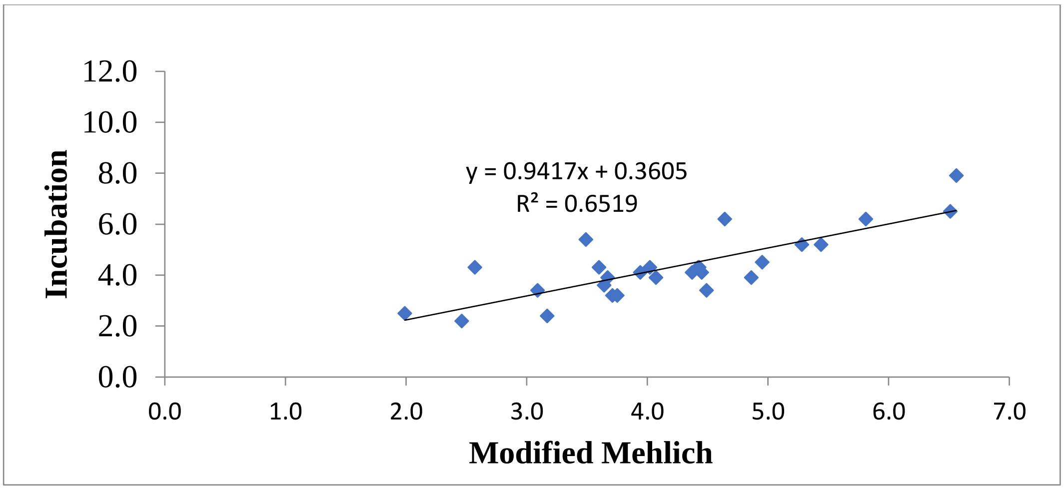

Figure 3.3 Correlation between the LR of the incubation and Modified Mehlich buffers

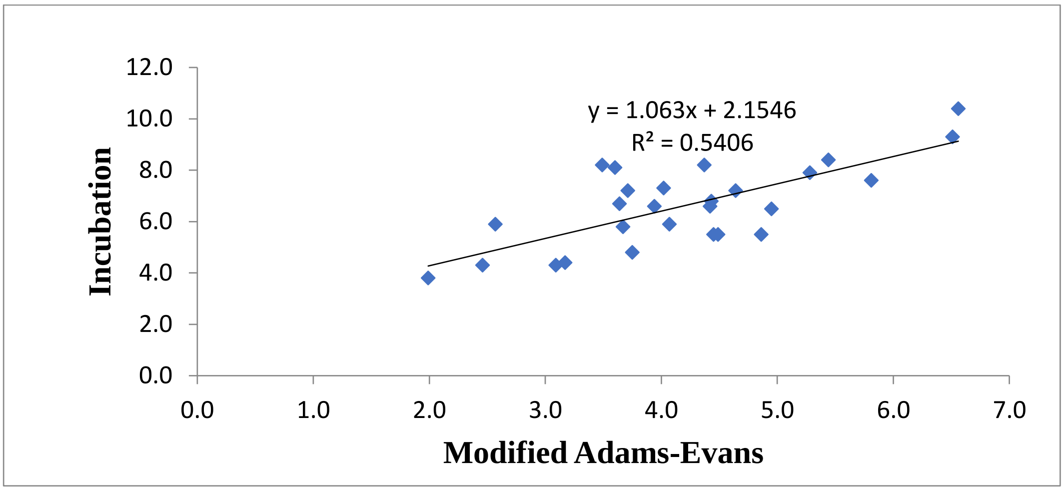

Figure 3.4 Correlation between the LR of the incubation and Modified Adams-Evans buffers

Using the lime rates determined from the incubation study and the corresponding buffer pHs of the soils, regression equations relating the LR and buffer pHs were developed (Table 3). Consistently, the lime requirement obtained using the woodruff buffer were most highly correlated with the incubation-determined LR across all target pHs (Figure 3.2). The SMP and Modified Mehlich buffer performed almost as well as the Woodruff at predicting the LR for the soils used in this study. The Modified Adams-Evans buffers did not perform as well as the Woodruff or SMP and Modified Mehlich.

Conclusions

Mean SMP, Woodruff, and Mehlich and Modified Adams-Evans soil buffer pH values across all sites were 6.44, 6.38, and 5.78. The Mehlich and Woodruff buffer methods were highly correlated; values did not differ significantly across most soil series included in the study. The Mehlich buffer method requires a different calibration for all soils, however, because its values always were much lower and related to pH change across all soils with a different slope compared with SMP or Woodruff. An advantage of Woodruff and Mehlich is that they include no hazardous chemicals. Therefore, use of pH and OM together and Woodruff or Mehlich buffer methods would provide the best prediction of LR for the soils and conditions similar to those included in this study.

Upcoming Work

Field Experiments will be conducted in Old Himalayan Piedmont plain (AEZ 1), Brind Tract (AEZ 28) and Eastern Surma Kushiyara floodplain (AEZ 20). Wheat, maize, mustard, cabbage, spinach, Lady's finger, will be cultivated following Wheat - Maize - T aman, Mustard-Aus rice- T aman, Cabbage- Lady's finger- Ash gourd cropping sequence. The experiment will be one factorial with 5 lime rates L_1 = Control (no lime), L_2 = FRG (1tha^{-1}), L_3 = 60% lime, L_4 = 80% lime and L_5 = 100% lime of Mehlich buffer method, and laid out in Randomized Complete Block Design with three replications. For liming, dolomite [$CaMg(CO_3)_2$], agricultural lime] will beapplied in treatment wise before the experiment and the land will kept fallow for reaction with soil constituents. Intercultural operations will be done properly. Data on growth yield and yield contributing character will be being recorded. Post harvest soil will be analyzed.

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Chapter 5: Achievement of Projects & Programmes

1. Name of the Project: Strengthening of Soil Research and Research Facilities (SRSRF)

Duration: January, 2018 to December, 2022

Objectives:

1. Development of user-friendly brochures (Union Handbook etc.) for users of Soil Information Repository services.
2. Enhancing digital service delivery (ICT) activities for service users and upgrading outdated information technology services.
3. Research on problem soil and soil management of hilly, saline and acidic soil and creation of digital database.
4. Setting up web based virtual soil museum
5. Establishment of demonstration plots with applied research through the recommendation of balanced fertilizers from upazila guidelines and union assistants
6. Modernization of research laboratories
7. Training of farmers, extension and NGO workers on technology and knowledge transfer
8. Training for skill enhancement of SRDI officials

Type of activities	Target	Achievement
Research on soil conservation & watershed management	15	Completed
Research on soil salinity management	20	
Research on acid soil management	9	
Adaptuve trial+Field Day	42+42	Completed
SAAO training on the use of Upazila Nirdeshika	13 batch	Completed
Priniting of Union Shahayika	300	Completed
Preparing festoon for local level fertilizer recommendation	300	Completed
Transformation of SRDI's central laboratory into accredited laboratory		Completed
Purchase of laboratory equipment	45	Completed
Virtual soil museum softwere upgrade and data entry	1	Completed
Seminar and Workshop	3	Completed

2. Name of the Project: Gopalgonj, Khulna, Bagerhat, Satkhira and Pirojpur Agricultural Development Project (GKBSP) (SRDI Part) (1st revised)

Duration: July, 2018 to June, 2024

Objectives:

1. To identify nutrient status and extent and intensity of problem soil of project area.
2. To publish surface water, use guide for safe irrigation of 37 Upazilas of project area.
3. To conduct research on problem soil management.

4. Conduct training of extension workers and farmers for increase consciousness on soil management.
5. To prepare union guide for using balanced fertilizer.

Types of Activities	Target	Achievements
Upazila Surface water salinity survey	6	Completed
Union Survey	20	Completed
Printing of Upazila Surface water user guide	6	Completed
Printing of Union Sohayeka	20	Completed
Establishment of adaptive trial/research plot	350	Completed
DAE/SRDI Officer training	1 batch	Completed
Farmers Training	120 batch	Completed
Procurement of laboratory equipment	8	Completed

3. Name of the Project: Construction and Capacity Building of SRDI (CCBS)

Duration: January, 2020 to December, 2023

Objectives:

The project is aimed to development of physical and technical facilities of SRDI personnel. Human resources and support staff is the key role player for achieving the goal, hence this service procurement will help project activities definitely.

Specific Objectives:

a. Construction of SRDI Head Office-6 Storied building with two basements; 6 storied building at Rajshahi, Khulna and Cumilla.

b. Boundary wall and internal road at SMRC, Batiaghata, Khulna and SCWMC, Bandarban.

c. ICT backbone built at different sections of SRDI Head Office and modernization of GIS.

Progress of the activities in 2022-23:

i) **SRDI Head Office Dhaka:** Old office building broken down and removed. New building preparation work going on. Shore pile driven is completed. Tie beam rod binding going on.
ii) **Rajshahi:** Second Roof casting going on.
iii) **Khulna:** Pile driven completed.
iv) **Cumilla:** Great beam casting completed. Column casting going on for first roof casting
v) **SMRC, Batiaghata, Khulna:** Electrical work, internal road and boundary wall completed.
vi) **SCWMC, Bandarban:** Electrical work completed, Internal Road and boundary wall work order is given.

4. Name of the Programme: Acidic soil management and sustainable crop production & improvement of soil fertility by practicing climate smart agricultre in Barind area

Duration: January, 2020 to June, 2023

Objectives:

5. Encouraging farmers to increase cropping intensity in barren land by managing acidic soils of Barendra region through use of climate smart agriculture technologies (lime, biofertilizers and SRDI developed technologies) and in fallow areas to produce a variety of crops in a well-planned way throughout the year.
6. Increasing production of crops with low water demand (eg wheat, lentil, chickpea, linseed, cotton etc.) in upland regions.
7. Distribution of 1800 Fertilizer Recommendation Cards to farmers based on Upazila Guidelines/Union Helper/Online/Soil Test for use of Organic Fertilizers and Balanced Fertilizers for maintaining soil health.
8. Alleviating poverty and ensuring food security for the people of Barendra region through increased crop production.
9. Training of about 160 Sub-Assistant Agricultural Officers/Extension Workers/Progressive Farmers on Soil Testing and Use of Fertilizers and Technology in Field for Increasing Crop Production and Managing Soil Fertility by Managing Acidic Soils in Barendra Region.

Types of Activities	Target	Achievements
Conducting field trial	Adaptive trial-7 Nos.	Completed
	Research trial-5 Nos.	Completed
Two days SAAO training on Acid Soil Management and Sustainable crop Production	SAAO-20 (1 batch)	Completed

5. **Name of the Programme**: **Assessment of Cultivated Land Area for Different Crops by Using Remote Sensing and Upazila Nirdeshika**

Duration: 1st July 2020 to 30 June 2023 (proposed for extension up to 30 June 2024)

Objectives: To asses of Cultivated Land Area for Different Crops by Using Remote Sensing and Upazila Nirdeshika

Detail Objectives:

- **To asses of cultivated land area for different crops according to Upazila.**
- To estimate the requirement of fertilizers according to soil nutrients for different season's crops.
- To develop of a GIS web portal using soil and land physical and chemical data.
- To display the location and area of cultivated crops on maps using GIS web portal and dashboard.

Activities	Target	Achievement
Database development	Update of Upazila Land and Soil form Map	Projection of soil data base had been changed to WGS
	Land use and Land cover Map development	Map has been produced for Boro, Wheat, Potato and mustard
	Development of GIS portal	A GIS portal named gis.srdi.gov.bd has been created.

Publication	Publication	Reconnaissance Soil Survey (RSS) Report of Kurigram and Moulavibazar
Training	Training on data entry and data collection using apps	35 training has been conducted
	Training on map preparation using GIS and Remote sensing software	30 officers have been trained on GIS and Remote sensing
Resource collection	Procurement Computer and computer accessories	ArcGIS Pro (Basic and Advance license), ArcGIS Enterprise, ENVI Image analysis software with SAR Scape extension have been procured
	Procurement of GIS and Remote sensing software	

6. Name of the Programme: Achievement of "Strengthening of Three Newly Created Laboratories" Programme (STNCLP)

Duration: July 2021-June 2023 (Two years)

Objectives:

a) Core objective:

To increase crop production and reduce production costs through soil test based balanced fertilization and conserve soil health

b) Specific objectives

i) Procurement of equipment's, chemicals, glassware and others materials for three newly created laboratories included approved organogram of SRDI for strengthening farmer services activities and soil research in different regions.

ii) To provide crop-based fertilizer recommendations through analyzing soil samples

iii) To organize training on related issues for farmers and agricultural extension workers

iv) Provide technical training of laboratory staffs as a part of human resource development

Types of Activities	Target	Achievements
i. Chemical and Filter papers	24 items	100%
ii. Glassware and safety materials	18 items	100%
iii. Lab Equipment's:		
a. EC Meter	3 pcs	100%
b. Digital Titer/Digital Burrette	3 pcs	100%
c. Digital Hot plate	1 pc	100%
d. Bottle Top Dispenser (Various types)	7 pcs	100%
e. Micropipette, (Various Types)	16 pcs	100%
f. Ultrapure water purification system	3 pcs	100%
g. Atomic Absorption Spectroscopy (AAS)	3 pcs	100%
iv. Training:		
a. Staffs:	01 batch	100%
b. Farmer & others	04 batch	100%

Chapter 6: Activities of Research Centers

6.1 Soil Conservation and Watershed Management Center (SCWMC) SoilResource Development Institute Bandarban

EXPT. No. 1

STUDYING BROOM GRASS FOR CONTOLLING SOIL EROSION AND ITS ECONMIC VALUE AT CHT.

Md. Mahbubul Alam

Abstract

Soil erosion is a major concern all over the world. Grasses are generally used to reduce soil erosion. Grasses develop rapidly and produces humus too. They can recover from damage and completer burial. Grasses are the key component in many ecosystems of the world. Broom grass *(Thysanolaena Maxima)* is a multipurpose perennial cash crop suitable for minimizing erosion hazard. It has also medicinal value as well as fuel, fodder and others domestic use. The main objectives of the research are to find out a significant source of income, to prevent frequent landslides, retain ground moisture and to increase soil fertility, to provide green forage for livestock and to rehabilitate the endangered animals and to keep ecological balance. There are two treatments. In one treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 1.00 m. In another treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 2.00 m. there was 1.00 m distance in between two double rows for both plots. Selling broom grass can be financially beneficial. Row to row distance of 2 meters is more effective in horizontal contours on hill slopes in broom grass cultivation. Broom Grass may open the door of enrichment for the poor hill dwellers' and be an important method for rehabilitation of degraded land.

Introduction

Soil erosion is accelerated due to high rainfall intensities (Keesstra et al., 2016), steep slopes (Beskow et al., 2009) and the fragile nature of topsoil (Lal, 1998; Rodrigo Comino et al., 2016; Ochoa et al., 2016). Soil erosion is a naturally occurring process on all land. Soil erosion is a major concern all over the world. It may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil (HIMCAT News Letter #2, Spring-2008). Soil loss by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity (Larson *et al.* 1985 and Sur *et al.* 1994). Worldwide loss of water and sediment due to soil erosion is a major environmental threat (Prosdocimi et al., 2016; Pimentel, 1993). Water erosion is the main cause of land degradation, affecting an area of about 2 billion ha throughout the world, with the largest part in tropics, and affecting the two most important natural resources, namely soil and water (Mandal and Sharda,2011a; DeOliveriaetal.,2010; Keesstraetal.,2014; Novara et al., 2011, 2016; Seutloali and Beckedahl, 2015). Water plays a vital role in the ecosystem. The precipitation over the country is not only unevenly distributed, but also uneven with regard to seasonal distribution as well as within season. Steep slope and terrain in hilly areas quickly releases the flow towards the outlet and thus creates scarcity of water. Geomorphology and the way land surface is managed, strongly influences the movement of water over and below the ground (Ashok Kumar and Bhanupriya Sharma-2017). In our Bangladesh have high annual rainfall confined to only 4 to 5 months (June–October). During the 7–8-month dry period, scarcity of water causes a severe shortage of fodder in farmlands, which leads to an increase in grazing pressure on forest and community lands. Vegetation resources are required for different local needs including grazing, fuel-wood, timber and non-timber forest products. These resource needs are closely linked with each other and several hot spots have been identified by Lempelius (2007). Soil conservation is an important requirement in sustainable farming. Basics of soil erosion control are to reduce detachment and transportation capacity of the eroding agents (water and wind) through different agronomic, vegetative measures generally known as conservative measures (Amatya and Shrestha, 2002). Good crop husbandry is an effective soil conserving practice (Joshi, 1992). Grasses are generally used to reduce soil erosion. Grasses develop rapidly and produces humus too. They can recover from damage and complete burial. In India most of the studies on the role of grasses as vegetative/ filter strips have been done in isolation with fewer slope categories and with limited objectives restricted to soil erosion (Njoroge and Rao, 1994).. Strategies to reverse land degradation are critical since soil is a non-renewable source (Mandal and Sharda, 2011b; Mandal et al., 2010). Soil erosion rates more than tolerance values are considered unacceptable (Mandal and Sharda, 2013), which leads to irreversible land degradation and need to be reduced through appropriate soil conservation measures (SCMs) (Biswas et al., 2015). Generally, soil conservation planning requires knowledge of soil loss tolerance values, which show the higher limit of soil erosion rate that can be allowed without long-term land degradation (Jha et al., 2009). Perennial grasses provide ground cover throughout the year and help in reducing runoff and soil loss when used as barriers along the contour, particularly in hill slopes (Dhruvanarayana and Rambabu, 1983). Grasses are the key component in many ecosystems of the world (ParrasAlcántara et al., 2015; Hu et al., 2016; Mekonnen et al., 2016). Soils typically account for 70–90% of the total carbon sequestered in a grassland ecosystem (Batjes, 2001). It is known from different studies conducted in India that the inclusion of grasses in the agricultural landscape often improves the productivity of system while providing opportunities to create carbon (C) sinks (Ghosh et al., 2009; Cogle et al., 2011; Huang et al., 2010; Mutegi et al., 2008).

Thysanolaena maxima is a genus of plants in the grass family, the only genus in the tribe. It is locally known as Broom grass, Jharuful, Fuljharu, Foruin etc. Its other names are Tiger Grass, Nepalese Broom Grass, Broom stick, Nepali amliso or kuchcho, jhadu (phooljhadu) in Hindi. Broom grows well in hot and temperate climate of South Eastern Asia. It grows up-to 3 meters in height, has sharp leaves in long branches. Broom grass received its name because people construct sweeping brooms out of the large flower heads. It is a multi-purpose plant. Besides creating hillside stabilization and serving as household brooms, its leaves provide fodder for livestock during the dry season, and people can burn the stalks as fuel or use the broom grass as mulch to protect the soil.

Nepalese broom grass (Thysanolaena Maxima) is a multipurpose perennial cash crop that belongs to the family Poecea (Bisht and Ahlawat, 1998). It is found growing along steep hills, sandy banks of rivers and damp steep banks along ravines (Bisht and Ahlawat, 1998). It is widely distributed throughout Nepal but only up to an altitude of 2000 metres (Bisht and Ahlawat, 1998). The grass can be grown on severely degraded and marginal lands (SatNet Asia, 2014). Broom grass tends to grow in tussocks, with 4-5 tussocks in a 100-metre radius and is harvested during the winter seasons between January and March (Bisht and Ahlawat, 1998). Broom grass is a significant source of income for subsistence communities, primarily for the women who collect it to manufacture and sell them as brooms across Nepal (Llewellyn, 2015). In addition to providing cash income when sold as brooms the plant provides a variety of uses to the farmers such as, the leaves provide green forage for livestock, the roots promote soil conservation, and the dried-up stems can be used as stakes to support growing vegetables (Llewellyn, 2015). Broom grass has had a direct impact in preventing frequent landslides, helping retain ground moisture and fertility, and improving soil quality by reducing soil erosion (Llewellyn, 2015). Broom Grass can moderately support the soil mass by its strong and long fibrous roots. Broom Grass can bind average 3.8 cu. m. soil, and that for napier, stylo, and molasses are 0.37 cu. m., 0.45 cu. m. and 0.04 cu. m. soil respectively. Broom grass has the ability to crowd out invasive species when intercropped and is beneficial in retaining soil nutrients to regrow vegetation (Llewellyn, 2015). The grass also possesses numerous medicinal properties that are essential in subsistence communities (SatNet Asia, 2014). Gautam, 2015 wrote that it is very helpful to grow others vegetation rapidly on shushed and burnt cultivated land and thus save the endangered animals like barking dears and monkeys. The start of Nepalese farmers growing broom grass has increased the local biodiversity in the communities (SatNet Asia, 2014). Broom grass does not compete for land with cereal crops so they can be grown simultaneously (SatNet Asia, 2014). The farming of broom grass has had a sincere impact on the women in the communities (Gautam, 2015). It has helped women become more empowered by raising their financial status and lessening the burden of other tasks (Gautam, 2015). Brooms are required in most households across the world so there is a large market for the product. Producing good quality brooms at low prices gives the product a comparative advantage and makes it very marketable. In Nepal, brooms sold on the local market sell for an average of $0.48, while in Canada it can range from $10-20$ (SatNet Asia, 2014). It has been noted that broom grass has been tried by paper and pulp industries to make paper, which means once that method of manufacturing becomes more popular Nepalese farmers can mass produce broom grass to be sold to these companies (Bisht and Ahlawat, 1998). The brooms can be transported quite easily as cargo because it is a finished product.

Nepalese broom grass *(Thysanolaena Maxima)* is a multipurpose perennial cash crop suitable for minimizing erosion hazard. It has also medicinal value as well as fuel, fodder and others domestic use. But sufficient Research is not conducted yet on this plant (Grass) in our country. Considering all, Soil Conservation and Watershed Management Centre (SCWMC), Bandarban has taken a small scientific effort in its Research Area under Bandarban Sadar Upazila in fiscal year 2017-2018 to conduct a study on broom grass" Effectiveness on controlling soil erosion and economic value at CHT).

This proposed research program was designed to study the quantity of soil loss, surface run-off, nutrient status and also the yield of broom in different replication. Broom Grass may open the door of enrichment for the poor hill dwellers' and be an important method for rehabilitation of land degraded by shifting cultivation or slush and burn agriculture.

Objectives

a. To find out a significant source of income.
b. To prevent frequent landslides, retain ground moisture and to increase soil fertility.
c. To provide green forage for livestock.

Materials and Methods

The research was conducted near multi-fruits garden situated by the side of multi-purpose dam at the Research Area of Soil Conservation and Watershed Management Centre (SCWMC), SRDI under Bandarban Sadar Upazila, Bandarban. The experimental plots were selected in such a way that the area individually can be treated as a micro watershed. Prior to selection of the plots, the area was cleaned. Jungles were removed. Slope percentage of the land was measured by Abney's level. To conduct the study, two plots of 100 m² (5m x 20 m) each were selected on a degraded land of steep slope having 48 % slope. Brick masonry plot boundary was constructed for each plot. Contour lines were marked maintaining 1.00 m. vertical interval from a distance of 0.50 m. from the upper plot boundary. A set of multi-slot devisor was set up in connection of each plot to determine the soil loss and runoff calculation.

Prior to plantation of broom's saplings (stump), composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil characteristics. There are two treatments. In one treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 1.00 m. In another plot, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 2.00 m. there was 1.00 m distance in between two double rows for both plots. Saplings were planted just following minimum tillage system during June-2018. Extra fertilizer or manure has not been added to the pits before or during plantation of saplings. Jungles were cleaned around the year when it was necessary.

Results and Discussion

Prior to plantation of broom's saplings (stump), composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil characteristics. After cultivation of broom, composite top soil samples are being taken for analysis and the result were shown in table-1. Soil loss and run-off data were collected after each and every shower. Soil loss and run-off data were collected after each and every shower. Total soil loss and runoff from 100.0 m² plot were presented in table-3 & 4 and Height Total soil loss and runoff was recorded in row to row 2m distance plot. Average plant height and number of plant per clump was recorded after winter in each year. Broom planted in 2.0 m. distance (row to row) grows better than that of 1.0 m. row to row distance (as shown in Table-6). Yield defers from row to row distance (shown in Table-7). Economical return from broom grown in 2m row to row distance plot were Tk. 1,35,500/-, Tk. 2,01,000/- Tk. 2,11,500/-, Tk 2,28,000/-& Tk 2,44,500/-per hectare per year during FY 2018-19, 2019-20, 2020-21, 2021-22 & 2022-23 and average return was 2,04,100/- for five years. while those were Tk. 90,000/-, Tk. 1,83,000/- Tk. 1,92,000/-, Tk 2,07,000/- and Tk 2,10,00/- during FY. 2018-19, 2019-20, 2020-21, 2021-22 & 2022-23 and average return was 1,76,400/- for five years when it was planted 1.0 m. row to row distance. Economical return of leaves used as fodder and residual sticks used for house activities or handicraft use and others benefits like biodiversity has not been calculated.

Table-1: Initial fertility status and fertility status after broom cultivation

Para-meter	Year	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		µg/g soil			meq/100g soil		µg/g soil		
Broom 1 Meter	2017	4.6	4.24 H	0.212 M	2.65 VL	0.42 H	2.82 VL	1.87 H	0.29 L	5.54 O	1.98 VH	0.74 H	69.16 VH	14.27 VH
	2018	4.1	4.2 H	0.210 M	1.12 VL	0.53 VH	19.11 M	0.45 VL	0.58 O	6.16 M	2.57 VH	0.31 M	40.51 VH	15.53 VH
	2017	5.7	4.64 H	0.232 M	0.34 M	0.54 VH	0.002 VL	2.22 H	0.34 M	7.28 H	2.35 VH	0.77 VH	81.17 VH	16.08 VH

Broom 2 Meter	2018	4.1	3.8 H	0.190 M	1.05 VL	0.50 VH	17.44 M	0.28 VL	0.46 O	7.04 H	2.22 VH	0.27 L	38.68 VH	10.21 VH

Note: VL=very low; L=low; M= medium; O=optimum; VH=very

Table-2: Soil Texture

Particulars	Soil Textural Class	San	Sli	Clay
		%		
Broom 1	Silt Loam	23	59	18
Broom 2	Silt Loam	20	59	21

Table-3: Soil loss under the cultivation of broom grass hill different treatments-2018-23 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total S0il loss (T/ha)	Average S0il loss (T/ha)
Broom-1 Meter	2018-19	_	_	_	_	_	3.24	3.97	2.90	1.98	2.34	_	_	14.43	**10.46**
	2019-20	_	_	_	_	_	1.60	5.84	1.41	1.83	0.65	_	_	11.33	
	2020-21	-	-	-	-	0.96	1.05	1.18	2.36	1.74	1.88			9.17	
	2021-22	-	-	-	-	0.25	2.32	1.28	2.89	1.36	0.95	-	-	9.05	
	2022-23	-	-	-	-	0.20	2.96	1.86	0.85	1.58	0.89	-	-	8.34	
Broom-2Meter	2018-19	_	_	_	_	_	4.16	4.78	3.56	2.47	3.68	_	_	18.65	**13.01**
	2019-20	_	_	_	_	_	1.96	7.63	1.92	2.21	0.92	_	_	14.64	
	2020-21					0.94	1.31	1.63	3.33	1.69	2.76			11.66	
	2021-22	-	-	-	-	0.32	2.86	1.54	3.45	1.61	1.20	-	-	10.98	
	2022-23	-	-	-	-	0.39	3.46	1.39	1.28	1.32	1.26	-	-	9.10	
Rainfall	2018-19	3	0	0	67	207	607	691	256	249	266	-	14	2360.00	-
	2019-20	0	57	9	72	234	244	1024	398	411	141	43	9	2642.00	
	2020-21	40.0	-	-	133.0	217.0	297.0	380.0	410.0	361.0	405.0	23.0		2266.00	
	2021-22	-	-	-	-	108.0	545.0	531.0	585.0	376.0	203.0	-	-	2348.00	

	2022-23	7	-	-	-	207	364	264	145	352	216	-	18	1573	

Table-4: Run off (%) under the cultivation of broom grass hill different treatments- 2018-23 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Broom 1 Meter	2018-19	-	-	-	-	-	28.87	42.38	38.46	40.12	39.56	-	-
	2019-20	-	-	-	-	-	27.56	46.67	37.72	44.93	30.72	-	-
	2020-21	-	-	-	-	22.50	24.82	25.70	35.42	31.20	33.20	-	-
	2021-22	-	-	-	-	10.60	26.45	25.96	34.70	30.24	28.40	-	-
	2022-23	-	-	-	-	9.60	20.25	21.29	20.6	23.60	20.80	-	-
Broom 2 Meter	2018-19	-	-	-	-	-	31.7	45.37	43.56	41.36	44.25	-	-
	2019-20	-	-	-	-	-	32.15	51.37	41.31	48.95	34.37	-	-
	2020-21	-	-	-	-	25.60	26.35	28.92	41.82	33.69	39.38	-	-
	2021-22					12.50	28.56	29.30	36.20	34.15	35.42	-	-
	2022-23	-	-	-	-	11.20	24.75	23.40	23.50	25.22	22.10	-	-

Table 5. Nutrient loss (tha^{-1}) from plots under different treatments.

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Broom 1 Meter	4.3	0.00206	0.32844	0.00618	0.00082	0.00016	1.76	0.6048	0.0004	0.0173
Broom 2 Meter	4.3	0.00212	0.37536	0.1576	0.00164	0.00054	1.952	0.588	0.00086	0.0179

Table: 6. Comparative growth study of the Broom grass in different treatments.

Treatment	No. of Sticks /Sheaf	Av. height of sticks (cm)	Av. Nos. of flower /Sheaf
Treatment 1. (Row to row distance 1 m)	18.00 b	146.88	11.15 b
Treatment 2. (Row to row distance 2 m)	33.33 a	148.38	22.95 a
CV (%)	12.73	12.05	12.99
CD (0.05)	11.48	NS	7.79

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability.

NS- Non –significant, CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Table-7: Yield and Return (BDT) of the broom grass in different treatments.

Year	Treatment-1 (1. 0 m. distance)			Treatment-2 (2.0 m. distance)			Total return in BDT. per ha/yr		Average Total return in BDT. per ha/yr	
	Nos. of sticks	Nos. of	Sale value	Nos. of sticks	Nos. of	Sale value	Treatment-1	Treatment-2	Treatment-1	Treatment-2
2018-19	960	60	900/-	1440	90	1350/-	90.000/-	1,35,500/-	**1,76,400/-**	**2,04,100/-**
2019-20	1892	122	1,830/-	2085	134	2010/-	1,83,000/-	2,01,000/-		
2020-21	1994	128	1,920/-	2198	141	2,115/	1,92,000/-	2,11,500/-		
2021-22	2064	138	2070/-	2278	152	2280/-	2,07,000/-	2,28,000/-		
2022-23	2080	140	2100/-	2450	163	2445/-	2,10,000/-	2,44,500		

Conclusions

Broom Grass are particularly useful in preventing soil erosion and landslides in hilly areas. Broom Grass play an effective role in bringing eroded hill slopes and fallow land under cultivation. Broom Grass leaves are used as fodder for cattle, house fences and residual stems are used as fuel. Selling broom grass can be financially beneficial. Row to Row distance of 2 meters is more effective in horizontal contours on hill slopes in broom grass cultivation.

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EXPT. No. 2

EFFECT OF PLANTATION OF BAMBOO FOR EROSION CONTROL AND ITS ECONOMICAL PURPOSES. MULI/PAIYA: *GIGANTOCHLOA ROBUSTA* AND ORA: *FARGESIA ROBUSTA.*

Md. Mahbubul Alam

Abstract

The potential of bamboo in erosion control and slope stabilization has been proven worldwide. Bamboos are being used as living plants as well as construction material in different soil bioengineering techniques in many countries. Bamboo shoots are crisp, tender, and have a mild, corn-like taste. Two indigenous types of bamboo were selected so that those can be surviving with the local climatic condition. Between two, one is locally called Paiya/Muli bamboo and another is called Ora bamboo. Locally fabricated multi-slot devisor was installed at each plot for estimating Soil Loss and Runoff from those plots. It was recorded that the highest soil loss was recorded on Paiya bamboo and lowest soil loss was recorded on 0ra bamboo plot. Bamboo has evergreen leaves, dense canopy and numeral culms which can help to intercept considerable amount of rainfall. Bamboo is also helpful against landslides and soil loss by preventing erosion. Payia bamboo takes more time for sprouting and harvesting as compared to ora bamboo. Lowest soil loss and highest return comes from ora bamboo. So ora bamboo cultivation is more profitable or effective in hilly areas.

Introduction

Land degradation is one of the major ecological issues of the globe. Land degradation means loss in the capacity of given land to support growth of useful plants on a sustained basis *(Singh, 1994)*. Due to different type of land degradation, Bangladesh lost a substantial amount of production which in terms of money may be thousands of billion takas in every year (BARC, 1999). The potential of bamboo in erosion control and slope stabilization has been proven worldwide. Bamboos are being used as living plants as well as construction material in different soil bioengineering techniques in many countries. The soil and water bioengineering approach is combined with bamboo traits and mechanical properties. The existing accumulated experiences of using bamboo in soil and water bioengineering works along with the existing standards and design guidelines make bamboo species an essential and cost-effective material for erosion control and slope stabilization works.

Bamboo belongs to the grass family and has an aerial part characterized by a jointed stem called a culm. The culms are typically hollow with the exception of certain bamboo species which have solid culms. The underground part of the plant is built from rhizomes growing normally at a shallow depth (up to a maximum of 150 mm) from where the roots develop. These roots can grow deep into the soil up to 500 mm. The rhizomes are the main form of spreading of the plant by growing horizontally away from the plant and, because they have a similar structure as the culm with vegetative nodes developing either roots or buds, originate new shoots and new individuals.

Bamboo is the fastest growing perennial, evergreen, arbores cent plant with a resulting high productivity: the dry weight yield per hectare could total as much as 32–38 or even 47 tons of biomass per hectare per year but averaging 8–18 tons per ha per year in normal conditions according to the different species and locations. This productivity, expressed both for the aerial and the root parts of the plant, illustrates the ability of bamboo to cover the terrain very rapidly, to develop a dense network of sub superficial rhizome and root system which would structure and consolidate the upper soil layer.

Bamboo is globally distributed between 51°N and 47°S, particularly in subtropical, tropical and equatorial regions. It also covers a high-altitude range, reaching up to 4000 m above sea level and thriving at temperatures as low as −20°C. The main area of occurrence is Asia where the largest number of species can be found. There is also a growing interest for bamboo as an ornamental plant, which brought the spread of several species to areas outside their natural ecological areas. This also raised some problems such as turning into invasive species and threatening natural habitats. The reinforcement effect ensured by bamboo roots can be expressed in engineering terms as an 'additional cohesion' added to the strength of the non-rooted soil Eq. Therefore, the total cohesion of a rooted soil will be the sum of the uprooted soil cohesion plus the cohesion increase due to the presence of roots in the soil. The rooted soil strength value is then used in traditional slope stability analysis methods (e.g. limit equilibrium methods) to determine the overall slope stability:

A case study conducted under a research project from the University of Natural Resources and Life Sciences Vienna (BOKU) and the Tribhuvan University Kathmandu, Nepal [44]. Bamboo made crib walls are comparatively cheaper than gabion or stone masonry wall (construction costs only ¼ of gabion and 1/5 of masonry wall) but provide the same technical stability. Experiences of using bamboo in soil and water bioengineering works, together with the existing standards and design guidelines, make specific bamboo species an essential and cost-effective material for erosion control and slope stabilization works where these species are native.

Objectives

a. Reclamation of gullied land by minimizing erosion hazard.

b. Raising socio-economic condition of hill dwellers;

c. To mitigate the demand of food and fodder,

d. To promote off farm activities through handy craft.

Materials and Methods

Two indigenous types of bamboo were selected so that those can be surviving with the local climatic condition. Between two, one is locally called Paiya/Muli bamboo and another is called Ora bamboo whose scientific names are *Gigantochloarobusta* and *Fargesiarobusta.* The experiment was carried out non replicable condition. Two experimental plots having area of 100 sq.m (5m x 20m) each on a degraded land (very steep to extreme steep slope) were selected in the SCWMC's Research area at Bandardarban Sadar upazila, Bandarban. Bamboo seedlings were collected from the culms situated in the nearby areas and planted in the month of July-

2018 following contour lines maintaining row to row distance 2.0 m and plant to plant distance 1.0 m. Before plantation, jungles were cleaned and composite Top soil samples were taken for nutrient studying. Locally fabricated multi-slot devisor was installed at each plot for estimating Soil Loss and Runoff from those plots. The seedlings were planted by dibbling method. Only one seedling was planted in each pit. After plantation of the seedlings, intercultural operation has been done when necessary. No fertilizer and manure were applied to the seedlings.

Soil loss and run-off from each 100 sq.m (20 m. x 5 m.) experimental plot were measured after each shower throughout the rainy season. Daily and eventually monthly soil loss and run-off were estimated from each plot by processing aliquot of sample every day. Every morning (if rains previos day) amount of run-off water has been measured in multi-slot divisors and aliquot of about 2 litre of homogeneous sample has been collected from each tank. Suspended sediment in the sampled aliquot has been measured by simple lab. filtering and oven drying. Corresponding rainfall was recorded by manual type and ordinary rain gauge installed in SCWMC meteorological station where climatic data like rainfall, temperature, humidity, evaporation etc. are being recorded regularly.

Results and Discussion

Table 8. Initial soil fertility status and fertility status after crop harvest.

Para-meter	Year	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		µg/g soil			meq/100g soil		µg/g soil		
Payia Bamboo	2017	5.4	2.76 M	0.138 L	2.65 VL	0.41 H	66.69 VH	2.50 VH	0.56 O	7.72 VH	1.53 H	0.97 VH	97.80 VH	24.54 VH
	2018	4.1	5.5 H	0.275 O	1.03 VL	0.51 VH	26.01 O	6.99 VH	0.40 M	8.93 VH	2.81 VH	3.23 VH	77.68 VH	21.39 VH
Ora Bamboo	2017	4.8	3.09 M	0.155 L	2.05 VL	0.33 O	0.001 VL	2.03 H	0.29 L	5.26 O	1.04 M	0.92 VH	92.45 VH	17.68 VH
	2018	4.1	5.8 VH	0.290 O	0.96 VL	0.47 VH	36.08 H	7.05 VH	0.16 L	7.44 H	2.00 VH	4.25 VH	66.03 VH	20.71 VH

Note: VL=very low; L=low; M= medium; O=optimum; VH=very high

Table-9: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Payia Bamboo	Silt Loam	23	62	15
Ora Bamboo	Silt Loam	28	54	18

Table 10: Soil loss under Paiya/Muli bamboo and Ora bamboo *Gigantochloa robusta* and Fargesia robusta during 2018-2019 to2022-23 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Payia Bamboo	2018-19	-	-	-	-	-	2.35	6.93	6.97	2.81	4.22	-	-	23.28	
	2019-20	-	-	-	-	-	1.97	6.78	4.53	3.32	1.87	-	-	18.47	**16.77**
	2020-21	-	-	-	-	1.24	1.86	2.59	3.22	2.38	3.08			14.37	
	2021-22					0.25	2.25	4.65	3.74	2.52	1.87			15.28	
	2022-23					1.16	2.64	1.34	1.49	3.25	2.58			12.46	
Ora Bamboo	2018-19	-	-	-	-	-	1.91	6.13	6.20	1.66	1.83	-	-	16.07	
	2019-20	-	-	-	-	-	0.91	5.20	3.86	2.75	1.14	-	-	13.86	**11.77**
	2020-21	-	-	-	-	0.82	1.24	1.69	2.72	1.44	2.38			10.29	
	2021-22					0.16	1.56	2.78	3.08	1.65	1.15			10.38	
	2022-23					0.74	1.40	1.11	0.90	2.45	1.65			8.25	

Soil loss under different bamboo species on degraded and gullied plots during 2018-2019 to 2022-23 sessions are being presented in table 10. Which was recorded throughout the rainy season. It was recorded that the average highest soil loss was 16.77 t/ha (23.28, 18.47, 14.37, 15.28 & 12.46 $tonh^{-1}y^{-1}$ in 2018-19 to 2022-23) on Payia bamboo and lowest average soil loss was 11.77 t/ha on Ora Bamboo plot (16.07, 13.86, 10.29, 10.38 & 8.25-ton $h^{-1}y^{-1}$ in 2018-19 to 2022-23). Run-off percentage under different bamboo species on degraded and gullied plots during 2018-2019 to 2022-23 sessions are being presented in table 11. Which was recorded throughout the rainy season.

Table 11 : Run-off under Paiya/Muli bamboo and Ora bamboo *Gigantochloa robusta* and *Fargesia robusta during* 2018-2019 to 2022-2023.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Paiya Bamboo	2018-19	-	-	-	-	-	21.53	36.03	50.76	53.07	45.13	-	-	-
	2019-20	-	-	-	-	-	21.35	54.18	41.85	42.42	33.36	-	-	-
	2020-21	-	-	-	-	20.21	23.62	35.72	55.78	52.19	55.64	-	-	-
	2021-22	-	-	-	-	9.58	20.60.	33.48	39.36	25.45	32.12	-	-	-
	2022-23	-	-	-	-	13.4	30.24	26.75	22.89	33.36	28.50	-	-	-
Ora Bamboo	2018-19	-	-	-	-	-	21.47	33.86	58.84	50.27	38.27	-	-	-
	2019-20	-	-	-	-	-	22.64	50.83	39.73	41.92	32.08	-	-	-

	2020-21	-	-	-	-	23.50	25.68	40.18	65.23	60.82	58.70	-	-	-
	2021-22	-	-	-	-	7.2	19.47	29.70	31.53	22.45	24.36	-	-	-
	2022-23	-	-	-	-	10.6	25.6	24.30	20.12	30.58	23.20	-	-	-
Rainfall (m.m)	2018-19	3	0	0	67	207	607	691	256	249	266	0	14	2360
	2019-20	0	57	9	72	234	244	1024	398	411	141	43	9	2642
	2020-21	40	0	0-	133	217	297	380	410	361	405	23.	0	2266
	2021-22	-	-	-	-	108	545	531	585	376	203	-	-	2348
	2022-23	7	-	-	-	207	364	264	145	352	216	-	18	1573

Table 12. Nutrient loss (tha^{-1}) from plots under different land use.

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Payia Bamboo	5.2	0.00266	0.71944	0.00604	0.00088	0.0005	2.716	0.7776	0.00042	0.02118
Ora Bamboo	4.9	0.00208	0.30498	0.014	0.00058	0.00036	1.912	0.6	0.00034	0.01974

Table-13: Yield and Return (BDT) of the Bamboos (Payia & Ora Bamboo).

Financial year	**Stage and Yield**		**Economical return**		**Remarks**
	Payia Bamboo	Ora Bamboo	Payia Bamboo	Ora Bamboo	**Payia bamboo takes more time for sprouting & harvesting as compared to Ora bamboo.**
2018-2019	Seedling stage	Seedling stage	Seedling stage	Seedling stage	
2019-2020	Growing stage	Growing stage	Growing stage	Growing stage	
2020-2021	Selection harvesting Stage	Selection harvesting Stage	Tk. 2,250/- (150 Nos. @ Tk. 15/- each)	Tk. 4,000/- (200 Nos. @ Tk. 20/- each)	
2021-2022	Harvesting Stage, 180 nos.	Harvesting Stage, 250 nos.	180 nos. x 15/- =2,700/- per plot (100m2) =2,700/- x100 **=2.70.000/-**	250 nos. x 20/- =5,000/- per plot (100m2) =5,000/- x100 **=5,00,000/-per ha**	

Conclusions

Bamboo is also helpful against landslides and soil loss by preventing erosion. Payia bamboo takes more time for sprouting and harvesting as compared to ora bamboo. Lowest soil loss and highest return comes from ora bamboo. So ora bamboo cultivation is more profitable or effective in hilly areas.

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EXPT. No. 3

STUDYING BRUSHWOOD CHECK DAM FOR MINIMIZING EROSION HAZARD AND RECLAMATION OF GULLIED LAND.

Md. Mahbubul Alam

Abstract

Gullies are the common features throughout the areas where the land comprises with high and slopping lands all over the world. The hilly region receives a huge amount of precipitation which is not well distributed. Due to different type of land degradation by rain, Bangladesh lost a substantial amount of production which in terms of money may be thousands of billion takas in every year. Brushwood check dams made of posts and brush are placed across the gully. Check-dams are constructed across the gully bed to stop channel bed erosion. The main objectives of brushwood check dams are to reduce the velocity of run-off, to prevent

deepening and widening of the gully and to collect sedimentation and recharge the water table. Its catchment area was nearly 0.12 hectares. The types of Brush wood check were double row brush-wood check dam across the gully bed. The potential of the check dam to deposit the soil was evaluated by using leveling Instrument to observe the change of gully depth, cross sectional area and soil loss data were collected. Result obtained after five years indicates that the gully bed was filled with eroded soil from its catchment area of 0.12hac is 0.748 m which is equivalent to 164.588 ton/ha. The check dam interrupt surface run-off velocity, it also increases the permeability of water in to the soil

Introduction

Gullies are common features throughout the Highlands. Induced environmental degradation comprises not only the loss of soil volume and of arable lands, but also the triggering of landslides (Nyssen et al., 2002) or off-site sedimentation problems (Nigussie et al., 2005). The phenomenon of gully development is not restricted to Highlands, but seems to be a phenomenon on sub-continental scale all over the world (Moeyersons, 2001). Land degradation, comprising degradation of the natural vegetation cover, soil erosion, loss of soil fertility and moisture stress is a well-known problem in hilly regions of Bangladesh as well as all over the world (Herweg and Stillhardt, 1999). Land degradation, particularly by water erosion, is an important factor in both the long-term decline and the seasonal reduction in food crop production (FAO, 1986). Soil erosion in Highlands degrades the soil resources on which agricultural production are based (Hurni, 1986, Nyssen, 1995 and many others). This threat stems from the depletion and degradation of the vegetation cover of the country, especially forest and exploitative farming practices. Water plays a vital role in the ecosystem. The precipitation over the country is not only unevenly distributed, but also uneven with regard to seasonal distribution as well as within season. Steep slope and terrain in hilly areas quickly releases the flow towards the outlet and thus creates scarcity of water.

Brushwood check dams made of posts and brush are placed across the gully. The main objective of brushwood check dams is to hold fine material carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective. Temporary physical and structural measures such as gully brushwood dam are used to dissipate the energy of runoff and to keep the gully stable. Check-dams are constructed across the gully bed to stop channel bed erosion. By reducing the original gradient of the gully channel, check-dams reduce the velocity and erosive power of runoff. Run-off during peak flow is conveyed safely by check-dams. The structures can be either temporary or permanent.

The main requirement of temporary gully control structures is that, they must be quick and easy to construct, should be made by using cheap and readily available material in nearby areas. In areas where the soil in the gully is deep enough, brushwood check-dams can be used if proper construction is assured. The gradient of the gully channel may vary from 5 to 12 percent, but the gully catchment area should not be as such huge which produces high amount of runoff volume.

Objectives

a. To reduce the velocity of run-off.
b. To prevent deepening and widening of the gully.

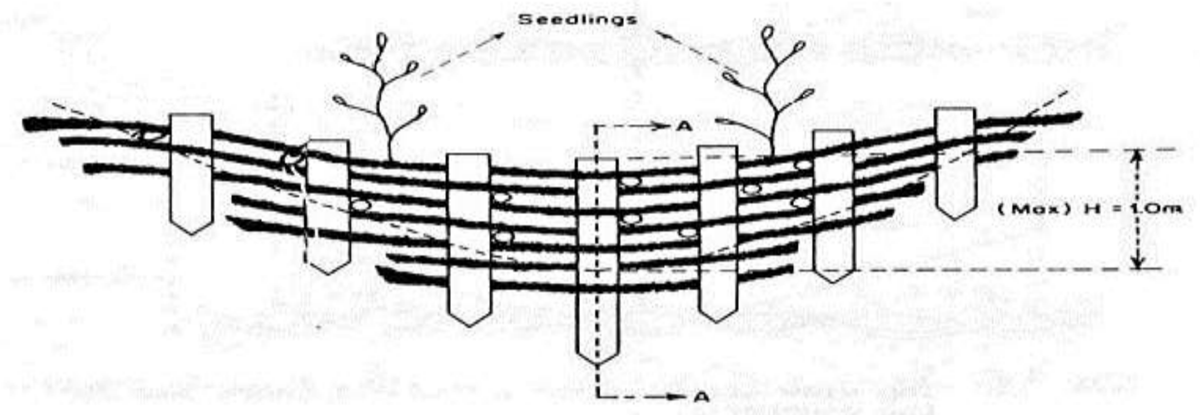
c. To collect sedimentation and to recharge the water table.

Materials and Methods

The study has been introduced at SCWMC research area to minimize erosion hazard and reclamation of a gully formed by the South-east side of the Administrative Building of SCWMC, SRDI, Bandarban. The length of the gully is 16.50 m. and width were variable with 1.80 m. near head and 5 m. where the Brush-wood check dams were constructed. It is situated in between two small hills. Average width of the gully in front of upper check dam is 2.30 m. Its catchment area was nearly 0.12 hectares. The gully head was very adjacent to the Administrative Building which was increasingly extending towards the Administrative Building. So, it was a future threat for the stability of the Administrative Building.

Brushwood check-dams made up of posts and brushes are placed across the gully. The main objective of brushwood check-dams is to hold fine materials carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check-dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective. The main requirement of temporary gully control structures is that, they must be quick and easy to construct, should be made by using cheap and readily available material in nearby areas.

There are two types of brushwood check-dams: these are single row and double row brush wood check-dams. Following the principle for construction of Brush-wood check dam, a decision had been taken to construct two nos. double row brush-wood check dam across the gully bed in series to reclamation of this gully.



The construction of the dam started with an excavation in the floor and into the sides of the gully to a depth of 0.30 m to 0.50 m. Two rows of living posts 5-10 cm in diameter and 1-20 m in length were placed into the holes maintaining a distance from post to post 0.60 m across the floor of the gully to a depth of 0.50 m to 0.60 m. The spacing between two rows was 1.00 m for upper check dam and 0.70 m for lower one. The width of the upper and lower brush wood check dam was 1.10 m. and 0.80 m, and height was 1.20. Brushwood and branches are packed between the posts. The height of the posts in the center was kept in such a way that it should not exceed the height of the spillway so that the flow would be blocked and water may be forced to move to the gully sides. The distance between upper and lower check dam was 6.00 m. Deposition of eroded soil from the catchment area is observed carefully.

Results and Discussion

Average width and length of the gully was 2.30 m. and 16.50m. adjacent to the upper Brush wood check dam. Soil deposited length in the gully was 8.20 m. and average width was 2.30 m. where the eroded soil was deposited in various depth. Soil deposition area was (8.20 m. x 2.30 m.) = 18.86 Sq.m. The Reduced Level (RL) of the gullied land wad measured by Theodolite Instrument. Before construction of the brush-wood check dam, the altitudes of the gully bed were being recorded in June-2018. Average RL of the gully was 94.102 m. (June-2018). After one rainy season during 2018-19, the RL of the gully bed was observed and it was found 94.418m. in March-2019. It was found that the average deposition height (by eroded soil from the catchment area) was 0.316 m. which is equivalent to 69.533 tonh^{-1}y^{-1}. After 2^{nd} year, the average RL of gully bed was again measured and found that the average RL was 94.54 m. Hench, the deposition depth by eroded soil carried from the upper catchment was 0.122 m. which is equivalent to 26.842 tonh^{-1}y^{-1}., The average R.L. gully bed was measured in April-2021 and after 3^{rd} year it was found that the average R.L. of the bed is 94.62 m. It shows that the deposition depth of eroded soil from the upper catchment is 0.080 m. which equivalent to 17.605 tonh^{-1}y^{-1}. Finally, the average R.L. gully bed was measured in April-2022 and after 4th year it was found that the average R.L. of the bed is 94.73 m. It shows that the deposition depth of eroded soil from the upper catchment is 0.110 m. which equivalent to 24.208 tonh^{-1}y^{-1}. After Four years' total deposition depth of eroded soil is 138.188 ton/ha and after five years' total deposition depth of eroded soil is 164.588ton/ha. Amount of deposited soil is shown in Table-14. Weight of deposited soil was assumed to be on average 1400 kg per cubic meter.

Table-14: Amount of soil deposited by Brush wood Check Dam.

Location	Cross Sectional Area of the Gully bed	Catchment area of the gully (check dam) in hac.	RL of gully bed(m)						Depth of deposition (m)	Amount of deposited soil (m³)	Deposi-ted amount from the catchm-ent each year (ton)	Deposited amount tonh^{-1}y^{-1}	Total Depo-sition (ton/ha)
	(m².)		June-18	March-19	April-20	April-21	April-22	April-23					
Upper check dam	8.20x2.30 = 18.86	0.12	94.10 (Initial)	94.418	94.54	94.62.	94.73	94.85	0.316 (2019)	5.96 (2019)	8.344 (2019)	69.533 (2019)	**164.588**
									0.122 (2020)	2.301 (2020)	3.221 (2020)	26.842 (2020)	
									0.080 (2021)	1.509 (2021)	2.113 (2021)	17.605 (2021)	
									0.110 (2022)	2.075 (2022)	2.905 (2022)	24.208 (2022)	

									0.120 (2023)	2.263 (2023)	3.168 (2023)	26.400 (2023)	

Note: Weight of 1.0 m^3 soil = 1.3 to 1.7 ton. Here considered 1.4 ton per m^3 of soil.

Conclusions

The gully bed has been raised up 0.748 m which proves that the check dam is capable to check 164.588 ton/hac sedimentation carried from the upper catchment area. Not only that, as the check dam interrupt surface run-off velocity, it also increases the permeability of water in to the soil. It also very cost effective for using locally available materials which are cheap and effective to rehabilitate gully.

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EXPT. No. 4
EFFECT OF INDIGENOUS &ZERO TILLAGE CULTIVATION METHODS OF PINEAPPLE ON SOIL EROSION, RUN OFF, NUTRIENT MINING IN HILLY AREAS.

Md. Mahbubul Alam

Abstract

The study was conducted at the Soil Conservation and Watershed Management Centre (SCWMC), Soil Resource Development Institute (SRDI), Bandarban. The present research work was undertaken to introduce an eco-friendly productive crop production system that is zero tillage cultivation system in sloping lands of CHT which will mitigate the process of land degradation due to digging up cultivation as well as take care of food security of Hill people. The main objectives of the research are to estimate & compare soil loss, runoff and nutrient mining under indigenous and zero tillage cultivation systems of pineapple, to calculate effect of soil loss on soil chemical properties and to create awareness about soil conservation & watershed management among hill dwellers. There are four treatments such as (1) Digging up across the slope (2) Digging up along the slope (3) Zero tillage across the slope and (4) Zero tillage across the slope. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. Nutrient loss was calculated in every experimental plot from eroded soil. Tillage is not recommended on hill slopes. Soil erosion increases by tillage cultivation in hilly areas. Zero tillage farming maintains soil fertility by controlling soil erosion. Pineapple cultivation of zero tillage system on hillsides, soil erosion is much less and yields are high than other practices. Use of indigenous methods of pineapple cultivation has created negative effect on soil.

Introduction

The Chittagong Hill Tracts comprising the three districts of Bandarban, Rangamati and Khagrachhari has an area of 13181sq km endowed with natural beauty and high economic potentiality. The tribal along with the Bengali people are living there for long maintaining their distinct socio-cultural identities and harmony. The area is hilly with mild to very steep slopes (from 15% to over 70%) often breaking or ending in cliffs. More than 90 percent of the area is covered by hills with only 129,000 hectares (ha) of cropped land. About 87 per cent of the land is covered with forest (totaling 11,475 sq.km) mostly owned by the government (Das Gupta and Ahmed, 1998). Presently, it is increasingly becoming denuded due to unplanned management of hills and agricultural practices at steep slope without any conservation measure. There are hills with altitudes of more than 3000 feet (Brammer, 1986) having steep and long slope. The total annual precipitation is also high (2000-3550mm). Continuous depletion of soil fertility is the major constraint to sustainable crop production in the hilly areas of Bangladesh.

The impact of soil erosion on the productive potential of agricultural lands is well known (Pathak*et al*., 2004), but the magnitude depends on local circumstances. In the study areas, the organic matter depletion was also observed irrespective of land use. The loss of the essential plant nutrients (N, K, S, Zn, B, Ca, Mg and Mn) in association with the suspended sediments and runoff during the measurement period was remarkable. The selective erosion of plant nutrients in runoff is a well-known phenomenon (Sharpley, 1985), and the sediment lost from the experimental plots on the micro-watershed was clearly enriched in all elements except P, relative to the topsoil of the watershed. The highest loss was displayed by Mn, Zn and S possibly resulting from reductive dissolution of oxides caused by sudden saturation of the soils in the earlier heavy rainfalls of the season. The results are in partial conformity with Gafur *et* *al*. (2003). This suggests that soil conservation control efforts should be prioritized in areas with high soil and nutrient loss potential so that their productivity is maintained.

Keeping the above views in mind the present research work was undertaken to introduce a eco-friendly productive crop production system that is zero tillage cultivation system in sloping lands of CHT which will mitigate the process of land degradation due to digging up cultivation as well as take care of food security of Hill people.

Objectives

a. To estimate & compare soil loss, runoff and nutrient mining under indigenous and zero tillage cultivation systems of pineapple.
b. To evaluate effect of soil loss on soil chemical properties.
c. To create awareness on soil conservation among hill dwellers.

Materials and Methods

The experiment was carried out under non-replicated condition. Four experimental plots of 100 sqm. (5 m x 20 m) on steeply (32%) were selected in the SCWMC, Bandarban. There were four treatments such as (1) Digging up across the slope (2) Digging up along the slope (3) Zero tillage across the slope and (4) Zero tillage across the slope. Pineapple suckers are inserted in double row. The distance between single row to row was 30 cm and double row to row was70 cm. Fertilizers were applied as per recommendation of soil test value. Cultural operations were done as usual in all the plots. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. Soil loss and run-off from each 100sqm (5m x 20m) experimental plots were measured after each shower throughout the rainy season. Daily and eventually monthly soil loss and run-off were estimated from each treatment by processing aliquot of sample every day. Every morning (if rains previous day) amount of run-off water is measured in the multi-slot and aliquot of about 2 Litre is sampled from each tank. Suspended sediment in the sampled aliquot is measured by simple filtering and oven drying. Corresponding rainfall is recorded from the automatic and ordinary rain gauge of SCWMC. Climatic data like rainfall, temperature, humidity, evaporation etc. were recorded daily. Different agronomic practices were done when it was necessary. Nutrient loss was calculated in every experimental plot from eroded soil.

Table 15. Initial soil fertility status and fertility status after crop harvest.

Para-meter	Year	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		µg/g soil			meq/100g soil		µg/g soil		
Digging Up Across	2017	5.1	3.56 H	0.178 L	9.82 L	0.39 H	0.001 VL	1.41 O	0.19 L	3.81 M	0.78 M	0.79 VH	65.00 VH	28.38 VH
	2018	4.0	4.2 H	0.210 M	1.05 VL	0.44 H	11.15 L	0.38 VL	0.53 O	4.30 O	1.15 O	0.33 M	47.27 VH	10.50 VH
Digging Up Along	2017	5.7	3.63 H	0.182 M	3.48 VL	0.37 H	0.002 VL	4.18 VH	0.17 L	3.60 M	0.77 M	0.83 VH	66.46 VH	34.02 VH
	2018	4.1	3.5 H	0.175 L	1.07 VL	0.46 VH	22.30 O	0.27 VL	0.30 L	8.01 VH	0.88 M	0.18 L	39.80 VH	11.48 VH
Zero Tillage Across	2017	6.0	3.50 H	0.175 L	1.63 VL	0.36 O	0.001 VL	6.30 VH	0.15 VL	4.34 M	0.86 M	1.04 VH	65.00 VH	28.84 VH
	2018	4.0	4.3 H	0.275 L	1.21 VL	0.55 VH	18.53 M	0.50 L	0.60 O	6.52 H	1.59 H	0.25 L	37.55 VH	12.69 VH
Zero Tillage Along	2017	5.7	3.90 H	0.195 M	3.21 VL	0.42 H	1.15 VL	5.75 VH	0.26 L	5.18 O	0.93 M	0.84 VH	93.90 VH	33.84 VH
	2018	4.0	5.5 H	0.275 O	1.04 VL	0.52 VH	17.54 M	1.17 M	0.32 M	5.92 O	1.79 H	0.56 M	50.15 VH	18.18 VH

Note: VL=very low; L=low; M= medium; O=optimum; H= High,VH=very high

Table-16: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Digging Up Across	Silt Loam	15	57	28
Digging Up Along	Silt Loam	18	56	26
Zero Tillage Across	Silt Loam	17	57	26
Zero Tillage Along	Silt Loam	18	56	26

The highest soil loss recorded in digging up along the slope were 68.59, 60.19, 52.55, 40.21 & 30.90 ton/ha/yr. in the year of 2018-19,2019-20 ,2020-21, 2021-22, & 2022-23 respectively and finally the average highest soil loss was 50.49 ton/ha/yr. The lowest soil loss recorded in practicing zero tillage cultivation method across the hill slope were 8.69 ,7.48, 6.45 , 6.21 & 5.52 ton /ha/yr. in the year of 2018-19, 2019-20 ,2020-21 ,2021-22 & 2022-23 respectively and finally the average lowest soil loss was6.87ton/ha/yr. On the other hand, soil loss recorded in digging-up across the slope were 52.04, 49.91, 43.35 ,34.12 & 25.15 ton/ha/yr. in the year of 2018-19, 2019-20, 2020-21, 2021-22 & 2022-23 respectively and average was 41.03 ton/ha and zero tillage cultivation method along the hill slope were 14.48, 13.19 ,12.41, 11.38 & 7.40 ton/ha/yr in the year of 2018-19, 2019-20, 2020-21, 2021-22 & 2022-23 respectively and average was 11.77 ton/ha.

Table 17. Total Soil Loss (ton/ha/yr) under indigenous & Zero Tillage cultivation methods of Pineapple for 2018-19, 2019-2020, 2020-21, 2021-2022 and. 2022-23.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Digging up Across	2018-19	-	-	-	-	-	6.83	15.52	11.85	10.27	8.16	-	-	52.63	**41.03**
	2019-	-	-	-	-	-	4.12	22.3	8.89	10.12	4.40	-	-	49.91	
	2020-	-	-	-	-	3.55	5.12	6.13	10.64	8.55	9.26	-	-	43.35	
	2021-	-	-	-	-	1.54	6.85	7.69	8.08	5.76	4.24	-	-	34.12	
	2022-	-	-	-	-	1.80	6.55	3.93	4.60	4.95	3.32	-	-	25.15	
Digging up Along	2018-19	-	-	-	-	-	7.71	19.83	16.25	14.83	9.97	-	-	68.59	**50.49**
	2019-	-	-	-	-	-	4.84	27.6	9.52	11.91	6.23	-	-	60.19	
	2020-	-	-	-	-	4.23	7.68	8.04	11.50	10.05	11.0	-	-	52.55	
	2021-	-	-	-	-	2.89	8.79	8.23	9.49	6.65	4.25	-	-	40.21	
	2022-	-	-	-	-	2.80	7.80	5.44	4.92	5.84	4.10	-	-	30.90	
Zero tillage Across	2018-19	-	-	-	-	-	0.96	3.49	2.29	0.72	1.23	-	-	8.69	**6.87**
	2019-20	-	-	-	-	-	0.85	2.83	2.29	0.82	0.69	-	-	7.48	
	2020-21	-	-	-	-	0.61	0.89	1.25	1.46	0.77	1.37	-	-	6.45	
	2021-22	-	-	-	-	0.25	1.32	0.94	1.66	1.25	0.84	-	-	6.21	
	2022-23	-	-	-	-	0.38	1.51	1.02	0.52	1.37	0.72	-	-	5.52	
Zero tillage Along	2018-19	-	-	-	-	-	1.4	6.22	3.57	1.76	1.53	-	-	14.48	**11.77**
	2019-	-	-	-	-	-	0.87	6.62	2.81	2.28	0.61	-	-	13.19	
	2020-	-	-	-	-	1.14	1.56	2.34	2.95	1.33	3.09	-	-	12.41	

	2021-22	-	-	-	-	0.35	2.64	2.39	3.11	1.70	1.24	-	-	11.38	
	2022-23	-	-	-	-	0.54	1.79	1.34	0.88	1.63	1.22	-	-	7.40	
Rainfall (m/m)	2018-19	3	0	0	67	207	607	691	256	249	266	0.0	14	2360	-
	2019-20	-	57	9	72	234	244	1024	398	411	141	43	9	2642	
	2020-21	40	-	-	133	217	297	380	410	361	405	23	-	2266	
	2021-22	-	-	-	-	108	545	531	585	376	203	-	-	2348	
	2022-23	7	-	-	-	207	364	264	145	352	216	-	18	1573	

Table-18: Run off (%) under the cultivation indigenous & Zero Tillage cultivation methods of Pineapple. (2018-19, 2019-2020, 2020-2021, 2021-22 and 2022-23).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Rain fall (m/m)
Digging up Across	2018-19	_	_	_	_	_	29.48	61.10	61.12	63.39	63.36	_	_	2360
	2019-20	_	_	_	_	-	40.78	51.99	50.26	44.28	34.37	_	_	2642
	2020-21	_	_	_	_	26.49	42.45	46.54	45.65	30.56	68.95	-	_	2266
	2021-22	-	-	-	-	11.35	23.56	21.45	24.75	22.45	20.12	-	-	2348
	2022-23	-	-	-	-	15.20	22.42	20.24	11.42	21.10	16.63	-	-	1573
Digging up Along	2018-19	_	_	_	_	_	27.26	59.24	68.66	65.75	57.15	_	_	2360
	2019-20	_	_	_	_	-	45.01	53.75	53.50	47.42	38.03	_	_	2642
	2020-21	_	_	_	_	28.42	45.25	49.37	46.10	33.82	70.38	_	_	2266
	2021-22	-	-	-	-	12.4	30.25	28.70	31.32	27.85	23.54	-	-	2348
	2022-23	-	-	-	-	20.40	30.65	33.44	15.82	28.34	21.60	-	-	1573
Zero Tillage Across	2018-19	_	_	_	_	_	25.78	56.77	65.75	53.93	54.05	-	_	2360
	2019-20	_	_	_	_	-	33.39	49.72	46.38	38.64	30.72	-	_	2642
	2020-21	_	_	_	_	19.43	23.90	37.03	39.99	26.23	57.62	-	_	2266
	2021-22	-	-	-	-	9.4	22.70	20.45	23.20	19.80	18.50	-	-	2348

	2022-23	-	-	-	-	10.35	15.44	12.35	9.72	13.41	11.44	-	-	1573
Zero Tillage Along	2018-19	_	_	_	_	_	26.52	55.53	57.15	58.66	50.94	_	_	2360
	2019-20	_	_	_	_	_	36.56	51.24	50.91	41.15	32.55	_	_	2642
	2020-21	_	_	_	_	23.36	39.76	41.11	43.76	29.14	60.16	_	_	2266
	2021-22	-	-	-	-	10.5	24.30	22.8	26.80	21.64	19.60	-	-	2348
	2022-23	-	-	-	-	12.22	18.54	16.29	10.69	16.35	12.55	-	-	1573

Rainfall and its pattern have a vital role on surface run off and soil loss hazard. Annual rainfall was measured by manual type rain gauge. Total Annual Rainfall was 2360 mm, 2642 mm, 2266 mm , 2348mm & 1573 mm in the year of 2018-19, 2019-20 ,2020-21 , 2021-22 & 2022-23 respectively. The impact of soil erosion on the productive potential of agricultural lands is well known (Pathak*et al*., 2004), but the magnitude depends on local circumstances. In the study areas, the organic matter depletion was also observed irrespective of land use. The loss of the essential plant nutrients (N, K, S, Zn, B, Ca,Mg and Mn) in association with the suspended sediments and runoff during the measurement period was remarkable.

Table.19. Nutrient loss (tha^{-1}) from plots under different land use.

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Digging up Across	4.0	0.00384	0.2737	0.00264	0.00216	0.0007	1.912	0.4656	0.00096	0.0291
Digging up Along	4.4	0.00502	0.3128	0.0059	0.00224	0.00084	2.072	0.4752	0.001	0.03164
Zero tillage Across	3.0	0.00222	0.1955	0.00198	0.00064	0.00024	1.328	0.3072	0.00038	0.02242
Zero tillage Along	3.6	0.00284	0.24242	0.00258	0.00128	0.0004	1.64	0.4152	0.00062	0.022852

It was observed that highest nitrogen loss i.e., 4.4 tha^{-1}occurred from digging up along the plot and the lowest (3.0tha^{-1}) from Zero Tillage Across the plot along with other nutrient elements. In case of digging up across and Zero Tillage Along the plot nitrogen loss was 4.0 and 3.6 tha^{-1} along with other nutrient elements.

Table.20. Yield Study of Pineapple under different Cultivation Practices:

Cultivation practices	**Yield per Plot (Nos).**					**Sale Value per plot / Total Earning (tha^{-1})**					**Average Earning for 5 yrs.(tha^{-1})**
	2018-19	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2018 -19**	**2019 -20**	**2020 -21**	**2021-22**	**2022-23**	
Digging up Across	12	187	214	225	220	216/-	3366/-	3,852/-	4050/-	3,960/-	**3,08,880/-**
						21,600/-	3,36,600	3,85,200	4,05,000/-	3,96,000	
Digging up Along	10	190	196	200	202	150/-	2850/-	2,940/-	3000/-	3,030/-	**2,39,400/-**
						15,000/-	2,85,000/-	2,94,000	3,00,000/-	3,03,000/-	
Zero tillage Across	15	255	270	280	294	300/-	5,100/-	5,400/-	5,600/-	5,880/-	**4,45,600/-**

						30,000/-	5,10,000/-	5,40,000/-	5,60,000/-	5,88,000/-	
Zero tillage Along	13	205	212	228	233	234/-	3690/-	3,816/-	4104/-	4,194/-	**3,20,760/-**
						23,400/-	3,69,000/-	3,81,600/-	4,10,400/-	4,19,400/-	

For judging economic viability, the input & output cost of pineapple cultivation in different practices are also being studied. It was observed that the height average return comes from Zero Tillage Across the slope 4,45,600/- and the lowest average return comes from Digging up Along the slope 2,39,400/- for four years. On the other hand, average return comes from Zero Tillage Along the slope was 3,20,760/- and digging-up across the slope was 3,08,880/- for four years.

Conclusions

Tillage is not recommended on hill slopes. Soil erosion increases by tillage cultivation in hilly areas. Zero tillage farming maintains soil fertility by controlling soil erosion. Pineapple cultivation of zero tillage system on hillsides, soil erosion is much less and yields are high than other practices. Use of indigenous methods of pineapple cultivation has created negative effect on soil.

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EXPERIMENT- 05

UP SCALING OF QUESUNGUAL SLASH AND MULCH AGRO-FORESTRY SYSTEM (QSMAS) FOR ENHANCING CROP YIELDS AND SOIL QUALITY IN CHITTAGONG HILL TRACTS.

Md. Mahbubul Alam

Abstract

The Chittagong Hill Tracts region is of great importance for growing various crops, which are different from the plains. Farmers practice traditional Jhum culture for their livelihood. They slash and burn the vegetation on hills and go for Jhum cultivation which contributes to soil and nutrient loss. The hill dwellers generally practiced shifting cultivation in the same area with a fallow period of 15–20 years in the past. But now a day the jhum cycle is reduced in 3-4 years, sometimes it is even 1 year too. The experiment was conducted in moderate hill slope of Soil Conservation and Watershed Management Center, SRDI, Bandarban. The main objective of the research was to evaluate the soil erosion hazard, productivity, economic return & fertility status practicing jhum under different treatment having the land abandoned for 3 years. Experimental site comprised of four plots- QSMAS model, modern Jhum with hedge row, traditional Jhum and control (secondary forest). All the data like soil fertility status, soil loss, surface run off, crops' yield etc. are in conformity with the previous research. System productivity of QSMAS plot was much higher than that of other plots. It was observed that highest total soil loss occurred in traditional Jhum plot followed by Jhum with hedge row and QSMAS model. The lowest total soil loss was observed in control plot (secondary forest).

Introduction

The Chittagong Hill Tracts comprising the three districts of Bandarban, Rangamati and Khagrachhari has an area of 13181sq km endowed with natural beauty and high economic potentiality. The tribal along with the Bengali people are living there for long maintaining their distinct socio-cultural identities and harmony. The area is hilly with mild to very steep slopes (from 15% to over 70%) often breaking or ending in cliffs. More than 90 percent of the area is covered by hills with only 129,000 hectares (ha) of cropped land. About 87 per cent of the land is covered with forest (totaling 11,475 sq.km) mostly owned by the government (Dasgupta and Ahmed, 1998). Presently, it is increasingly becoming denuded due to unplanned management of hills and agricultural practices at steep slope without any conservation measure. There are hills with altitudes of more than 3000 feet (Brammer, 1986) having steep and long slope. The total annual precipitation is also high (2000-3550mm). Continuous depletion of soil fertility is the major constraint to sustainable crop production in the hilly areas of Bangladesh. According to Banglapedia (2009) about 20,000 hectares of land are being brought under Jhum cultivation every year.

Jhum cultivation, sloppiness, heavy rainfall and improper management of soil enhanced nutrient depletion through erosion. Accelerated soil erosion is the greatest hazard for the long term maintenance of soil fertility. Gafur *et al*. (2003) carried out a research to find out runoff and losses of soil and nutrients from small watersheds under shifting cultivation in the CHT. Borggaard *et al*. (2003) carried out a study to analyze the sustainability appraisal of shifting cultivation in CHT. Dewan (2008) conducted a survey work to analyze the socio-economic status of Jhum cultivators. The Chittagong Hill Tracts region is of great importance for growing various crops, which are different from the plains. But unfortunately few eco-friendly sustainable agriculture practices for CHT have so for been developed.

Slash and burn practices, also known as shifting cultivation, swidden agriculture, or simply jhum chash, is an ancient form of agriculture practiced by 200 to 500 million people around the world currently. The people in the uplands of eastern Bangladesh have been practicing shifting cultivation from time immemorial and it is closely related with their socio-cultural identity (Miah and Islam, 2007). However, in the past, they practiced shifting cultivation in the same area with a fallow period of 15–20 years, which ensured the long-term sustainability of soil fertility, and ensured forest regrowth. With the rapid growth in population, the fallow period has been dramatically reduced to 3–4 years, allowing very little time for soil or vegetative regeneration (Riessen, 2000). The decrease in fallow period has led to the deterioration of faunal and microbial organisms, top soil loss, and erosion during periods of heavy rainfall (Gafur, 2001).

The two key components of slash and burn agriculture are the use of fire to prepare fields for cultivation and the subsequent abandonment of those fields as productivity declines. The inevitable decline in productivity is a result of the depletion of soil nutrients and also a result of the invasion of weed and pest species (Cornell, 2011). Slash and burn contributes to global warming by acting as a major source of greenhouse gas emissions, and by depleting reserves of carbon both above and below-ground. It can also lead to land degradation if population pressure reduces the fallow periods needed for the recovery of natural resources. With the increasing population pressure several alternatives to shifting cultivation have been suggested (FAO, 1984) which include: (1) tree crop plantation, (2) agro-forestry, (3) planted fallow system (tree and shrub fallows plus arable crop sequence), (4) livestock production, and (5) special commercial horticulture.

Eco-efficient agriculture uses resources more efficiently to achieve sustainable increases in productivity, reduces the degradation of natural resources, and creates opportunities for boosting incomes and employment in rural areas. The Quesungual Slash and Mulch Agro-forestry System (QSMAS) is one example of eco-efficient crop production for tropical sub-humid regions. It has reduced erosion and improved crop yields and quality of life for over 6,000 local families while allowing regeneration of about 60,000 hectares of secondary forest (*New Agriculturalist* 2009).

QSMAS is a smallholder production system with a group of techniques for the sustainable management of vegetation, soil, and water resources in drought-prone hillsides. The system was developed in the early 1990s in close collaboration with farmers and technicians from FAO and other institutions, as an alternative to traditional and widespread slash and burn agriculture.

It has had an extraordinary impact on the livelihoods of farmers growing maize, beans, and sorghum in Central America, and has great potential to be used in other regions.

Past research reports indicate that little work has been undertaken so far on replacing the traditional Jhum system with modern techniques to reduce soil erosion, biodiversity loss, deforestation, factors that contribute to environmental degradation and impacts on environment due to shifting (Jhum) cultivation practice.

Keeping the above views in mind the present research work was undertaken to introduce a eco-friendly productive crop production system in sloping lands of CHT which will mitigate the process of land degradation due to Jhum culture as well as take care of food security of Hill people.

Objectives:

a. To evaluate the soil erosion hazard, productivity, economic return & fertility status practicing jhum under different treatment having the land abandoned for 3 years.
b. To create awareness on soil conservation among hill dwellers.

Materials and Methods

The hill dwellers generally practiced shifting cultivation in the same area with a fallow period of 15–20 years in the past. With the rapid growth in population, the fallow period has been dramatically reduced to 3–4 years. Moreover, now a day, it is observed that jhum is being practiced even in every year in the same land. In this circumstance, a land having abandoned for 3 years was selected for this research at SCWMC Research Area.

To validate the principles of Quesungual agro-forestry system in Soil Conservation and Watershed Management Centre, SRDI, Bandarban watershed four land use systems were established: traditional Jhum (slash-and-burn), Jhum with modern management, Quesungual slash and mulch agro-forestry systems (QSMAS), and demarcated areas of secondary forest as a control. Crops like rice, maize; millet, cotton, sesame and common beans, marfa, yard long bean, sweet gourd, ginger and turmeric were accommodated in a traditional system, application of slashed vegetation/crop residues as mulch and QSMAS, to measure and compare differences among production systems. Soil sampling for initial fertility assessment and determine change in fertility status after each cropping season for three years.

Soil sampling consisted of digging test pit of 50 cm depth and sampling of soil at 0-13, 13-43, 43-63 cm depths just before sowing every year. Composite soil samples will be collected from each plot for fertility determination. Chemical characterization included determination of pH, organic matter (OM), N, P, K, S, Zn, B, Ca, Mg, Mn, Fe, Cu. In the field, productivity of rice, maize; cotton, sesame and common beans, marfa, sweet gourd, ginger and turmeric will be evaluated for three cropping season from 2020. All the data like soil fertility status, soil loss, surface run off, crops' yield etc are being observed and recorded. Finally, all these will be compared and evaluated with the same of the year 2015, 2016 and 2017.

Results and Discussion

Soil fertility Status

Initial fertility status was compared with fertility status of each plot after crop harvest. Soils are mostly highly acidic to slightly acidic in nature. Initial Organic matter status was low to medium while it was high to medium after crop harvest. Initial Nitrogen status was very low to low while it was low to medium after crop harvest. Phosphorus status was very low. Initial Potassium status is medium to optimum while it was medium to very high after crop harvest. Sulfur status was reduced from medium to low to low to very low. Zinc status was also reduced from initial status i.e. low to medium. Boron status reduced from very high to low to medium. Calcium, Magnesium, Copper, Iron and Manganese status is remained almost unchanged (Table 21). Physical analysis was done to determine the soil texture (Table 22). CEC, which indicates soil fertility, seems to be improved over time under QSMAS and secondary forest system. Highest CEC increase was observed in QSMAS plot (Figure -1). Whereas, CEC was reduced in Jhum with hedge and Traditional Jhum system.

Table 21. Initial soil fertility status and fertility status after crop harvest.

Plot No./ Year	Depth of soil sample	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		μg/g soil			meq/100g soil		μg/g soil		
1/2015	0-13	4.9	1.82 M	0.10 L	2.85 VL	0.33 O	15.0 M	1.10 M	0.93 VH	2.53 L	1.40 O	1.06 VH	75.93 VH	15.18 VH
1/2016		4.5	4.13 H	0.24 M	5.32 VL	0.52 VH	6.05 VL	1.01 M	0.18 L	5.82 O	2.46 VH	0.72 H	71.80 VH	11.22 VH
2/2015	0-13	5.7	1.62 L	0.09 VL	1.21 VL	0.35 O	8.17 L	0.64 L	0.86 VH	1.77 L	1.16 M	0.81 VH	76.28 VH	12.67 VH
2/2016		4.5	2.88 M	0.17 L	3.88 VL	0.26 M	6.08 VL	0.09 VL	0.22 L	2.20 L	1.08 M	0.42 M	11.72 O	2.34 H
3/2015	0-13	4.9	1.32 L	0.07 VL	1.38 VL	0.32 O	9.17 L	0.88 L	0.92 VH	3.21 M	1.37 O	0.99 VH	86.34 VH	10.20 VH
3/2016		4.5	3.12 M	0.18 L	6.86 VL	0.42 H	7.35 VL	0.96 M	0.16 L	2.50 L	1.17 O	0.44 M	43.8 VH	14.3 VH
4/2015	0-13	4.9	1.10 L	0.06 VL	2.19 VL	0.26 M	5.20 VL	0.78 L	0.79 VH	2.18 L	1.16 M	0.88 VH	81.15 VH	7.80 VH
4/2016		4.5	3.24 M	0.19 M	6.80 VL	0.46 VH	8.42 L	1.02 M	0.21 M	1.25 VL	1.04 M	0.14 VL	42.2 VH	2.80 O

Note: VL=very low; L=low; M= medium; O=optimum; VH=very high

Table22. Mean, standard error, correlation coefficient and significance of soil fertility indicators over time.

Soil nutrients	Mean ± SE		Correlation	significance
	2015	2016		
pH	5.10±0.20	4.50±0.00	0.00	0.00
OM	1.47±0.16	3.34±0.27	0.53	0.47

N	0.08±0.01	0.20±0.02	0.53	0.47
P	1.91±0.38	5.72±0.71	0.19	0.81
K	0.32±0.02	0.42±0.06	-0.49	0.51
S	9.39±2.05	6.98±0.57	-0.73	0.27
Zn	0.85±0.10	0.77±0.23	0.72	0.28
Ca	2.42±0.31	2.94±1.00	0.24	0.77
Mg	1.27±0.07	1.44±0.34	0.71	0.29
Cu	0.94±0.06	0.43±0.12	0.68	0.32
Fe	79.93±2.45	42.38±12.27	0.01	0.99
Mn	11.46±1.59	7.67±3.01	0.28	0.72

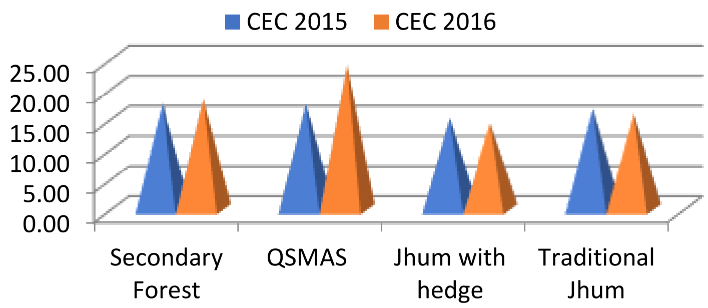

Figure : 01: Comparative CEC data of experimental plots over time

Table 23. Soil texture analysis data.

Plot No.	Sampling depth (cm)	Soil texture	Sand (%)	Silt (%)	Clay (%)
1	0-13	Sil loam	17	59	24
2	0-13	Silt loam	19	59	22
3	0-13	Silt loam	20	58	22
4	0-13	Silt loam	18	58	24
Layer wise sample					
0-13		Silt loam	13	61	26
13-43		Clay loam	24	44	32
43-63+		Clay loam	21	40	39

Crop yield and system productivity

Each plot had the same crop combination except control (secondary forest). Rice (local), maize (local), sesame, millet, sweet gourd, chilly, marfa, yard long bean, country bean, cotton, ginger, turmeric were planted in mixture. But in QSMAS model the crops were arranged in sub plots within the main plot. Grafted fruit trees-mango, carambola and seedlings of papaya were planted in the plot.

After harvestings crop yield data were recorded and analyzed. It was observed that rice yield was higher in traditional Jhum practice than other practices. But system productivity of QSMAS model

plot was much higher than other plots (Table 24,25,26,27,28 &29).

Table 24. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2015).

Sl.No	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	Traditional Jhum	Jhum with hedge row	QSMAS model		Traditional Jhum	Jhum with hedge row	QSMAS model	
1	Rice (local)	15.00	10.00	6.00	15.00	225.00	150.00	90.00	QSMAS model out yielded all the other plots
2	Maize (local)	3.00	5.00	6.00	50.00	150.00	250.00	300.00	
3	Sesame	1.00	1.50	1.50	60.00	60.00	90.00	90.00	
4	Millet	1.00	0.50	0.60	80.00	80.00	40.00	48.00	
5	Sweet gourd	4.00	5.00	6.00	35.00	140.00	175.00	210.00	
6	Chilly	0.40	0.50	0.50	120.00	48.00	60.00	60.00	
7	Marpha	3.00	4.00	4.00	40.00	120.00	160.00	160.00	
8	Yardlongbean	4.00	5.00	6.00	40.00	160.00	200.00	240.00	
9	Countrybean	-	-	6.00	60.00	-	-	360.00	
10	Cotton	1.50	2.00	3.00	200.00	300.00	400.00	600.00	
11	Ginger	3.00	5.00	7.00	60.00	180.00	300.00	420.00	
12	Turmeric	12.00	15.00	17.00	20.00	240.00	300.00	340.00	
13	Mango (4)							-	No fruiting was observed
14	Papaya (5)							-	
15	Carambola							-	
					Total =	**1703.00**	**2125.00**	**2918.00**	

Table 25. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2016).

Sl.No.	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	Traditional Jhum	Jhum with hedge row	QSMAS model		Traditional Jhum	Jhum with hedge row	QSMAS model	
1	Rice (local)	14.00	13.00	8.00	15.00	210.00	195.00	120.00	QSMAS model out yielded all the other plots
2	Maize (local)	3.00	5.00	4.00	50.00	150.00	250.00	250.00	
3	Sesame	0.80	1.00	0.90	60.00	48.00	60.00	54.00	
4	Millet	0.90	0.80	0.50	80.00	72.00	64.00	40.00	
5	Sweet gourd	3.50	4.00	5.00	35.00	122.00	140.00	175.00	
6	Chilly	1.20	1.00	0.70	80.00	96.00	80.00	56.00	
7	Marpha	2.50	4.00	3.00	40.00	100.00	160.00	120.00	
8	Yardlongbean	5.00	9.00	6.00	35.00	175.00	315.00	210.00	
9	Countrybean	-	-	4.00	40.00	-	-	160.00	
10	Cotton	1.00	1.50	1.20	200.00	200.00	300.00	240.00	
11	Ginger	3.00	6.00	4.00	50.00	150.00	300.00	200.00	
12	Turmeric	12.00	17.00	14.00	10.00	120.00	170.00	140.00	
13	Mango (4)	-	4 nos.	2.00	80.00	-	-	160.00	

14	Papaya (5)	-	5 nos.	40.00	15.00	-	-	600.00	
15	Carambola (3)	-	3 nos.	3.00	10.00	-	-	30.00	
					Total =	1443.00	2034.00	2505.00	

Table 26. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2017).

Sl.No.	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**		**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**	
1	Rice (local)	9.00	10.00	7.00	22.00	198.00	220.00	154.00	QSMAS model out yielded all the other plots
2	Maize (local)	2.00	4.00	5.00	50.00	100.00	200.00	250.00	
3	Sesame	0.70	0.80	1.00	60.00	42.00	48.00	60.00	
4	Millet	0.60	0.80	0.90	40.00	24.00	32.00	36.00	
5	Sweet gourd	3.00	5.00	6.00	35.00	105.00	175.00	210.00	
6	Chilly	0.50	0.70	0.90	80.00	40.00	56.00	72.00	
7	Marpha	2.00	3.00	4.50	40.00	80.00	120.00	180.00	
8	Yardlongbean	3.00	5.00	6.00	35.00	105.00	175.00	210.00	
9	Countrybean	-	-	5.00	40.00	-	-	200.00	
10	Cotton	0.60	0.80	1.00	200.00	120.00	160.00	200.00	
11	Ginger	2.50	3.50	4.00	50.00	125.00	175.00	200.00	
12	Turmeric	9.00	14.00	12.00	10.00	90.00	140.00	120.00	
13	Mango (4)	-	4.00	7.00	80.00	320.00	320.00	560.00	
14	Papaya (5)	-	20.00	26.00	15.00	300.00	300.00	390.00	
15	Carambola (3)	-	5.00	7.00	10.00	50.00	50.00	30.00	
					Total =	**1699.00**	**2171.00**	**2912.00**	

Table 27. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2020).

Sl.No	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**		**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**	
1	Rice (local)	11.00	10.00	5.00	25.00	275.00	250.00	125.00	QSMAS model out yielded all the other plots
2	Maize (local)	1.80	3.00	3.00	60.00	108.00	180.00	180.00	
3	Sesame	0.70	0.80	0.90	80.00	56.00	64.00	72.00	
4	Millet	0.75	0.70	0.50	90.00	67.50	63.00	45.00	
5	Sweet gourd	2.50	3.50	3.50	30.00	75.00	105.00	105.00	
6	Chilly	0.50	0.40	0.30	140.00	70.00	56.00	42.00	
7	Marpha	2.00	1.50	1.50	40.00	80.00	60.00	60.00	
8	Yardlongbean	4.00	4.50	3.00	40.00	160.00	180.00	120.00	
9	Countrybean	-	-	5.00	60.00	-	-	300.00	
10	Cotton	0.80	1.00	1.50	200.00	240.00	200.00	300.00	
11	Ginger	2.00	3.00	3.50	80.00	160.00	240.00	280.00	
12	Turmeric	7.00	10.00	9.50	20.00	140.00	200.00	190.00	
13	Papaya							-	No fruiting was observed
14	Banana							-	
15	Pineapple							-	

	Total =	1431.50	1578.00	1822.00	

Table 28. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2021).

Sl.No	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**		**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**	
1	Rice (local)	12.00	10.50	6.00	26.00	312.00	273.00	156.00	QSMAS model out yielded all the other plots
2	Maize (local)	2.00	1.80	3.00	65.00	130.00	117.00	195.00	
3	Sesame	0.60	0.50	0.80	80.00	48.00	40.00	64.00	
4	Millet	0.60	0.75	0.80	95.00	57.00	71.25	76.00	
5	Sweet gourd	2.80	3.60	3.80	35	98.00	126.00	133.00	
6	Chilly	0.30	0.40	0.50	120.00	36.00	48.00	60.00	
7	Marpha	2.20	2.00	2.50	45.00	99.00	90.00	112.50	
8	Yardlong bean	3.00	3.20	4.00	45.00	135.00	144.00	180.00	
9	Country bean			5.00	50.00	-	-	250.00	
10	Cotton	0.60	0.80	0.70	250.00	150.00	200.00	175.00	
11	Ginger	2.00	2.50	2.50	85.00	170.00	212.50	212.50	
12	Turmeric	6.00	8.50	8.00	20	120.00	170.00	160.00	
13	Papaya							-	No fruiting was observed
14	Banana							-	
15	Pineapple							-	
					Total =	**1355.00**	**1491.75**	**1774.00**	

Table 29. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2022).

Sl.No	Yield (kg/100 sq m)				Price (BDT /Kg)	Return in BDT			Remarks
	Crops	**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**		**Traditional Jhum**	**Jhum with hedge row**	**QSMAS model**	
1	Rice (local)	10.00	9.50	5.00	26.00	260.00	247.00	130.00	QSMAS model out yielded all the other plots
2	Maize (local)	1.50	2.00	2.20	60.00	90.00.	120.00	168.00	
3	Sesame	0.70	0.80	0.90	80.00	56.00	64.00	72.00	
4	Millet	0.70	0.60	0.50	90.00	63.00	54.00	45.00	
5	Sweet gourd	2.80	3.00	3.50	30.00	84.00	90.00	105.00	
6	Chilly	0.50	0.40	0.30	160.00	80.00	64.00	48.00	
7	Marpha	2.50	3.00	3.50	30.00	75.00	90.00	115.00	
8	Yardlongbean	3.50	4.00	4.50	45.00	157.50	180.00	202.50	
9	Countrybean	-	-	4.50	60.00	-	-	270.00	
10	Cotton	1.00	1.00	1.50	200.00	200.00	200.00	300.00	
11	Ginger	2.00	2.50	2.50	80.00	160.00	200.00	200.00	
12	Turmeric	6.00	7.00	8.00	20.00	120.00	140.00	160.00	
13	Papaya	-	12.00	15.00	18.00	-	21.00	270.00-	
14	Banana	-	1.00	2.00	250.00	-	250.00	500.00-	
15	Pineapple	-	12.00	-	30.00	-	360	-	
					Total =	**1,345.50**	**2,275.00**	**2,549.50**	

Soil loss from experimental plots

As Bandarban is a high rainfall area if the soil surface is exposed due to deforestation it becomes vulnerable to water erosion. Soil loss from hills depends on surface cover, rainfall intensity, nature of slope and aspects of slope. Bandarban experienced a significant amount of rain every year though its distribution uneven over months. Rainfall intensity is higher in the months of May to August. Multi-slot divisor was established at the bottom of each plot. Total surface run–off and total soil loss was calculated per shower and cumulative figure was made by adding each observation. The financial years of 2015-2017 & 2020-2022 it was observed that highest total soil loss occurred in traditional Jhum plot followed by Jhum with hedge and mulch and QSMAS model.

The lowest total soil loss was observed in control plot (secondary forest). In 2017 &2022 similar trends were observed. The finding is in conformity with that of CIAT (2010). Gafur *et al.* (2003) conducted a research to find out the runoff and losses soil and nutrients from small watersheds under shifting cultivation in the Chittagong Hill Tracts. In similar studies, Shoaib *et al.*(1998) recorded total soil loss to be 40-45t $ha^{-1}y^{-1}$ in traditional Jhum culture highest being observed in steep slope and the lowest in gentle slope. There is an evidence that the use of contour hedgerows on steep slopes (40-50%) can reduce erosion by 55-80% and run off by 30-70% compared to shifting cultivation (Khisa, 2001). It was observed that QSMAS protects soil by markedly reducing soil erosion in comparison to Jhum plots. This result is in conformity with the findings of CIAT (2010).

Table 30: Total soil loss from experimental plots (t ha^{-1} y^{-1}) in 2015, 2016 and 2017.

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total (t $ha^{-1}y^{-1}$)
Control	2015	-	-	-	-	0.80	3.32	3.12	3.14	1.09	0.67	-	-	12.14
	2016	-	-	-	-	-	2.28	1.53	0.83	0.52	0.63	-	-	5.79
	2017	-	-	-	-	0.45	1.12	1.47	0.82	0.51	0.72	0.5	-	5.59
QASMAS	2015	-	-	-	-	1.68	6.18	4.52	4.49	1.52	1.65	-	-	20.04
	2016	-	-	-	-		4.55	2.57	1.63	0.96	0.72	-	-	10.43
	2017	-	-	-	-	1.11	1.98	2.67	1.42	1.04	1.10	0.79	-	10.11
Jhum with hedge row	2015	-	-	-	-	2.15	7.84	5.58	5.67	1.96	1.90	-	-	25.10
	2016	-	-	-	-	-	7.01	4.34	1.89	1.06	0.86	-	-	15.16
	2017	-	-	-	-	1.64	3.14	3.54	1.92	1.68	1.84	1.30	-	15.06
Traditional Jhum	2015	-	-	-	-	2.68	10.52	9.18	9.49	4.07	3.23	-	-	39.17
	2016	-	-	-	-	-	9.4	8.4	2.77	1.25	1.36	-	-	23.18
	2017	-	-	-	-	2.55	4.40	5.80	2.82	2.46	2.86	2.41	-	23.30

Table 31: Total soil loss from experimental plots (t ha^{-1} y^{-1}) in 2020, 2021 & 2022.

Particulars		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total (t ha^{-1} $^{y-1}$
Control	2020-21	-	-	-	0.48	097	1.45	2.09	2.66	2.52	2.98	-	-	10.33
	2021-22	-	-	-	-	0.45	2.10	1.35	1.95	1.39	0.90	-		8.14

	2022-23	-	-	-	-	0.83	1.46	0.61	0.49	1.28	0.92			5.59
QASMAS	2020-21	-	-	-	0.76	1.45	2.66	3.38	3.52	3.21	3.78	-	-	18.76
	2021-22	-	-	-	-	0.57	3.31	3.25	4.83	2.80	1.42		-	16.18
	2022-23					0.66	2.24	2.73	1.27	2.55	1.38		-	10.83
Jhum with hedge row	2020-21	-	-	-	0.89	1.88	3.44	3.98	4.41	4.07	4.55	-	--	23.22
	2021-22	-	-	-	-	0.79	4.16	3.92	5.59	3.16	2.52	-	-	20.14
	2022-23					0.92	3.29	2.64	1.91	2.86	2.43	-	-	14.05
Traditional Jhum	2020-21	-	-	-	1.63	3.57	5.83	6.34	7.16	6.57	7.35	=	-	38.45
	2021-22	-	-	-	-	3.12	6.82	7.50	7.90	5.45	4.86	-	-	35.65
	2022-23					2.81	4.17	4.42	2.89	5.21	4.74	-		24.24
Rainfall	2020	40	-	-	133	217	297	380	410	361	405	23	-	2266
	2021	-	-	-	-	108	545	531	585	376	203	-	-	2348
	2022	-	7	-	-	207	364	264	145	352	216	-	18	1573

Runoff and sediment load

The total runoff per hectare during 2015, 2016, 2017, 2020, 2021 & 2022 cropping season was highly variable between experimental plots, although there was no difference in terms of the rainfall received during the same period. The distribution of runoff during the years is shown in Table 32 & 33 as monthly values. The distribution of runoff follows the rainfall amount and intensity pattern with the maximum monthly runoff occurring in June, irrespective of land use. On average, the highest runoff volume was from traditional Jhum. The runoff from the watersheds and the sub-watersheds seems to have been influenced by factors such as topographic characteristics, land use and management practices implemented (Hartantoa *et al*., 2003; Gary and Carmen, 2007).

Table -32. Total surface run off (%) from experimental plots in 2015, 2016 and2017.

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	**Dec**
Control	2015	-	-	-	-	4.40	35.61	65.30	41.74	47.40	17.73	-	-
	2016	-	-	-	-	-	35.92	29.65	30.17	29.40	50.43	-	-
	2017	-	-	-	-	7.07	36.69	17.69	18.17	14.27	11.73	15.24	
QASMAS	2015	-	-	-	-	4.87	46.05	67.41	51.63	57.71	21.80	-	-
	2016	-	-	-	-	-	41.17	47.90	39.53	30.84	35.63	-	-
	2017	-	-	-	-	8.42	41.14	20.31	21.29	16.18	13.82	17.61	
Jhum with hedge row	2015	-	-	-	-	5.18	50.31	69.22	60.62	66.73	22.82	-	-
	2016	-	-	-	-	-	44.73	55.74	47.30	32.28	40.57	-	-
	2017	-	-	-	-	9.43	43.57	22.40	22.86	20.02	16.60	19.97	

Traditional Jhum	2015	-	-	-	-	5.87	52.19	71.03	72.90	75.76	23.84	-	-
	2016	-	-	-	-	-	49.20	64.54	51.65	33.72	45.50	-	-
	2017	-	-	-	-	10.45	48.02	25.80	24.42	25.77	17.99	22.34	-

Table 33. Total surface run off (%) from experimental plots in 2020, 2021 and 2022

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Control	**2020-21**	-	-	-	5.87	24.54	28.62	35.71	38.39	32.48	41.54	-	-
	2021-22	-	-	-	-	5.20	35.92	34.60	42.70	22.70	18.20	-	-
	2022-23					11.19	30.65	33.11	34.21	34.43	24.08	-	-
QASMAS	**2020-21**	-	-	-	7.45	31.62	34.44	41.44	48.88	39.53	46.67	-	-
	2021-22	-	-	-	-	7.12	39.54	37.65	50.85	25.64	20.52	-	-
	2022-23					13.36	32.98	38.67	36.54	38.62	26.34	-	-
Jhum with hedge row	**2020-21**	-	-	-	6.39	34.72	37.44	39.67	52.48	46.33	55.23	-	--
	2021-22	-	-	-	-	6.54	41.44	40.39	55..36	30.87	23.49	-	-
	2022-23					14.93	36.15	41.29	39.44	43.87	28.58	-	-
Traditional Jhum	**2020-21**	-	-	-	8.85	38.15	39.24	43.36	54.81	51.46	57.29	=	-
	2021-22	-	-	-	-	8.30	46.91	45.72	60.85	32.94	26.85	-	-
	2022-23					18.62	42.17	47.12	42.36	48.73	35.25	-	-

CONCLUSION

Data on soil fertility status, soil loss, surface run off, crops' yield etc. are in conformity with the previous research. System productivity of QSMAS plot was much higher than that of other plots. It was observed that highest total soil loss occurred in traditional Jhum plot followed by Jhum with hedge row and QSMAS model. The lowest total soil loss was observed in control plot (secondary forest).

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EXPT. No. 06

STUDYING PERFORMANCE OF WATER MELON IN RAINY SEASON AT HILL SLOPES USING SOIL CONSERVATION TECHNIQUE.

Md. Mahbubul Alam

Abstract

A study on performance of Watermelon in rainy season at hill slope using Soil Conservation Technique has been taken by Soil Conservation and Watershed Management Centre, Bandarban .Its main objective is to find out the sustainability and challenges of cultivation of watermelon on sloping lands during rainy season. Three types of sloping land like gentle, moderate and steep sloping has been selected for this study. There were three plots on three sloping lands having an equal area. Soil conservation technique like pineapple hedge and Vetiver hedge were introduced following contour. Bamboo made colored pegs were inserted into the soil to estimate the soil erosion hazard. Local bamboos made platforms (Macha) were used for cultivation of watermelon during rainy season. Height yields and lowest soil loss were gained from the managed plot by pineapple hedge and gentle slope. Lowest yields and Height soil loss were gained from the control plot and steep slope. Hedge always plays a vital role on plant growth, crops productivity, no of fruit & weight as well as minimizing of soil erosion. soil conservation technique is must for any agricultural practice on the slopping land.

Introduction

Watermelon (*Citrullus lanatus*) belongs to the family Cucurbitaceae. It is one of the most widely cultivated crops in the world with global production reaching about 89.9 million ton per year. Its centre of origin has been traced to both Kalahari and Sahara Desert in Africa and these areas have been regarded as point of diversification to other parts of the world. The crop has wide distribution as a garden crop while as a commercial vegetable production; its cultivation is confined to drier Savanna region of the Nigeria. It is horticultural crop that provide high return and has relatively low water requirement compared to other crops. It is traditional food plant in Africa with potential to improve nutrition, boost food security, foster rural development and support sustainable land cares. Smallholder farmer in different semi-arid zones of the world grow watermelon mostly under rainfed conditions and to lesser suplimental furrow irrigation. Now a day the demand of watermelon is increasingly growing up day by day. *Citrullus lanatus* is an important Cucurbitaceous Vegetable/Fruit in our neighboring country India. It is an excellent desert fruit and its juice contains 92% water along with proteins, minerals and carbohydrates. Now it is going to be extended day by day. In India, Watermelons are mainly cultivated in Maharashtra, Karnataka, Tamil Nadu, Panjab, Rajasthan, Madhya Pradesh and Uttar Pradesh.

The growth and development of watermelon describes the sequential order of the different stages of growth attained by this crop. The growth phase of watermelon includes the emergence stage, vegetative stage, flowering stage, yield formation stage and the ripening stage. However, crop growth and development depend largely on climatic factors such as precipitatin, relative humidity, solar radiation, evaporation etc. Each of these climatic factors affects the growth of crops, most especially in the tropics. For instance, the presence or absence of precipitation will have either positive or negative impact on the crop growth and productivity. Climate is also responsible for seasonal variation in the tropic.

A well drained soil of loamy type is preferred for Watermelon. It is important that soil should be fertile and rich in organic matter. The most suitable P^H range is between 6.0 and 7.0. It is noted that soil should not be water logged in the rainy season. Watermelon is warm season crop and do not withstand even light frost and strong wind. Seed do not germinate below 11^0 C , optimum germination occurs at 18^0 C and germination increases with the rise of temperature till 30^0 C. Watermelon grows best at temperature 18^0 C - 24^0 C. It prefers tropical climate with high temperature during fruit development with day temperature of 35^0 C-40^0 C. But excess chillness occures hamper. Cool nights and warm days give better quality fruits in watermelon. There are many varieties of watermelon like Seminis Apoorva Watermelon, Mayco Super Sakkar Watermelon, Suger Pack Watermelon, Aishwariya Watermelon, Anmol Yellow Watermelon, Arun Watermelon, Dragon King Watermelon, Black Magic Watermelon, NS 292 Watermelon, Jaguar F1 Watermelon etc. The crop duration ranges from 55 days to 120 days depending on the varieties.

Chittagong Hill Tracts Comprising the three districts of Bandarban, Rangamati and Khagrachari has an area of 13,181 Sq. Km. endowed with natural beauty and high economic potentiality. The tribal along with the Bengali people are living there for long maintaining their district socio-cultural identities and harmony. The area is hilly with mild to very steep (15% to over 70%) often breaking or ending cliffs. More than 90% of the area is covered by hills with only 1’29’000 ha. of cropped land. About 87% of the land is covered with forest mostly owned by the Government (Dasgupta and Ahmed. 1998). According to Banglapedia (2009) about 20,000 hectares of land are being brought under jhum cultivation each year.

Jhum cultivation, sloppiness, heavy rainfall and improper management of soil enhanced nutrients depletion through erosion. Accelerated soil erosion is the greatest hazard for the long term maintenance of soil fertility. Gafur *et al*. (2003) carried out a research to find out runoff and losses of soil and nutrients from a small watershed under shifting cultivation in CHT. Borggaard et al. (2003) carried out a study to analyze the sustainability the sustainability appraisal of shifting cultivation in CHT. Dewan (2008) conducted a survey work to analyze the socio-economic status of jhum cultivators. The Chittagong Hill Tract region is of great importance for various crops which are different from the plains. But unfortunately few eco-friendly sustainable practices for CHT has so for been developed.

Land degradation is one of the major ecological issues of the world. Land degradation means loss in the capacity of given land to support growth of useful plants on a sustained basis (Singh, 1994). Erosion hazard caused by water in the rainy season is one of the mostly responsible for land degradation in Bangladesh. In the hilly region of Bangladesh received huge amount of rainfall in this time. This amount of excess rainfall drains out along with eroded soil materials through numerous channels, canals and rivers of the hilly regions without natural or artificial obstacle. Thus following heavy downpour of the rainy season, the area suffers from severe draught and water scarcity in the dry season. Vegetation and land use play an important role controlling the intesity and frequency of overland flow and surface erosion (Mitchel, 1990; Gafur el at 2001b). Cultivation of watermelon in the rainy season using hedge of different species established across the slope could be introduced to mitigate the demand of food, to improve the socio-economic status of the hill dwellers and to minimize the land degradation.

In these circumstances, a very little scientific effort has been taken in hand to study the performance in cultivation of watermelon in the rainy season using soil conservation technique at the Research Area of Soil Conservation and Watershed Management Centre, SRDI, Bandarban. If the challenges along with other difficulties can be overcome, it would be a mile stone of eco-friendly sustainable agriculture of this hilly region.

Objectives:

a. To find out the suitability of water melon without irrigation (rainy season) at hill slopes.
b. To compare soil loss, runoff and nutrient mining under different hedge species & different slopes.
c. To find out a significant source of income.

Materials and Methods

The research was conducted at the Research Area of Soil Conservation and Watershed Management Centre (SCWMC), SRDI under Bandarban Sadar Upazila, Bandarban. Three types of slopping land like Gentle, Moderate and Steep Slopes were selected for this research to have comparative data. There are 3 plots in every individual slopping land having an area of 100 m^2 (5m x 20 m) for each plot. Total area of each slopping land was 300 m^2. The experimental plots were selected in such a way that the area individually can be treated as a micro watershed. Prior to selection of the plots, the area was cleaned. Jungles were removed. Slope percentage of the land was measured by Abney's level. To conduct the study, 3 plots of 100 m^2 (5m x 20 m) in each slopping land were selected for applying different soil conservation technique. Among the three plots- one was controlled and remaining others two were pineapple hedge and vetiver hedge. Slope gradient of the selected three types of sloping lands were: 12%, 26% and 36% respectively. Each plot is separated by plot boundary in such a way that runoff from one plot cannot enter to another plot. On 25th of April-2021, Pineapple and Vetiver hedge in single row were established following contour at 5.0 m horizontal interval in each plot. There are four lines of hedge row in each plot. A number of bamboo made pegs painted by different colors were inserted in to the soil plot to determine the soil loss.

On 5th May-2021, seeds of watermelon placed in soil filled poly packet for germination and to have seedlings. Digging up pits for transplantation of watermelon seedlings were started from 7th of May-2021. Prior to Digging up pits, composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil nutrients status. Pit size was 15″x15″ having 1′-0″ depth. During preparation of pits, at least one kg of dried cow dung along with 100 gr. TSP and 50 gr. MOP (Murat of Potash) were applied in each pit. Hill method or raised bed was practiced to avoid excess amount of water which causes root rot diseases. On 29th of May-2021, the seedlings of watermelon (having the seedlings age at 21 days) were transplanted from poly packs to pits. Two seedlings were planted in each pit/bed. In the rainy season, weeding is very necessary as this season promotes weed growth and the incidence of pest and diseases. When 25 to30 days has passed after plantation of the seedling, 2nd dose of fertilizer @50 gr. urea, 100 gr. TSP and 50 gr. MOP was applied in each pit.

Intercultural operation was done when necessary. Mulching practice around the plant was applied to prevent the rainwater from splashing soil onto the plants, reducing the chance of bacterial or fungal infection that might come from the soil. Bamboo made platform (Mancha) was placed for climbing up the plants and to protect melon bursting for excess water. During the fruiting time of the watermelon 3rd dose of fertilizer @ TSP 125 gr. and MOP 50 gr. in each pit was applied.

To estimate the soil loss on different slopping land under different treatment peg method was followed. In this practice, each plot was divided into three parts namely- Upper part, middle part and lower part. At the beginning of the monsoon, 9 nos. bamboo made pegs having marked by different color of paint were inserted in the soil for each part. Soil loss near each peg was measured by using leveling instrument and recorded. Average of nine pegs was calculated for each part. Insecticides, Pesticides and fungicides were applied depending upon the symptom of the plants at 3rd week, 5th week, 7th week, 9th week and 11th week after planting. When the fruits were in growing stage, those were supported to hang from the platform by using cotton made net bags.

Results and discussion

. Maximum soil loss 20.734 ton/ha.y^{-1} & 17.920 ton /ha y^{-1} were recorded at controlled plot on steep slope in the years of 2021-22 & 2022-23. whereas minimum soil loss was 8.834 ton/ha.y^{-1} & 7.322 ton /ha y^{-1} at pineapple hedge plot on gentle slope in the years of 2021-22 & 2022-23.. On field yield data was recorded. Only the ripen watermelon those were collected from field was included in yield data. Maximum number of fruits with maximum weight was recorded on pineapple hedge plot on gentle slope. On the other hand, minimum number of fruits with average minimum weight was recorded at controlled plot on steep slope. Maximum yield was.12.844 & 14.040 ton/hac.y^{-1} at pineapple hedge plot on gentle slope and minimum yield was 8.505 & 7.680 ton/hac.y^{-1} at controlled plot on steep slope for the years of 2021-22 & 2022-23..

Table-34: Soil Loss under the cultivation of Watermelon in different treatments & different slope for the year 2021-22.

Year.	Slope Class	Treatments	Average soil loss in each row (mm)			Average Soil Loss of all row (mm.)	**Total soil loss (ton/ hac)**
			Upper Row	Middle Row	Lower Row		
2021-22	Gentle	Pineapple	0.585	0.623	0.685	0.631	8.834
		Vetiber	0.600	0.684	0.720	0.668	9.352
		Controlled	0.690	0.75	0.810	0.750	10.500
	Moderate	Pineapple	0.695	0.790	0.840	0.775	10.850
		Vetiber	0.780	0.864	0.914	0.853	11.942
		Controlled	1.000	1.100	1.20	1.100	15.400
	Steep	Pineapple	1.140	1.200	1.260	1.200	16.800
		Vetiber Hedge	1.190	1.243	1.32	1.251	17.514
		Controlled	1.410	1.470	1.563	1.481	20.734

Table-35: Soil Loss under the cultivation of Watermelon in different treatments & different slope for the year 2022-23.

Year.	Slope Class	Treatments	Average soil loss in each row (mm)			Average Soil Loss of all row (mm.)	**Total soil loss (ton/ hac)**
			Upper Row	Middle Row	Lower Row		
2022-23	Gentle	Pineapple	0.443	0.516	0.610	0.523	7.322
		Vetiber	0.510	0.605	0.715	0.610	8.543
		Controlled	0.649	0.694	0.760	0.701	9.820
	Moderate	Pineapple	0.695	0.790	0.840	0.775	9.459
		Vetiber	0.780	0.864	0.914	0.853	10.386
		Controlled	0.924	1.013	1.108	1.015	14.210
	Steep	Pineapple	0.942	1.086	1.200	1.076	15.064
		Vetiber Hedge	1.06	1.125	1.220	1.135	15.890
		Controlled	1.160	1.270	1.410	1.280	17.920

Table-36: Yield of the Watermelon in different treatments in financial year 2021-22

Sl. No.	Slope Class	Treatments	Number of fruits (Nos.)	Av. weight per fruit (Kg)	Yield per plot (Kg.)	Yield per hectare (Ton)
1	Gentle	Pineapple hedge	76	1.69	128.44	12.844
		Vetiver Hedge	75	1.65	123.75	12.375

		Controlled	73	1.61	117.53	11.753
2	Moderate	Pineapple hedge	74	1.64	121.36	12.136
		Vetiver Hedge	72	1.62	116.64	11.664
		Controlled	70	1.56	109.20	10.920
3	Steep	Pineapple hedge	74	1.50	111.00	11.100
		Vetiver Hedge	73	1.45	105.85	10.585
		Controlled	63	1.35	85.05	8.505

Table-37: Yield of the Watermelon in different treatments in financial year 2022-23

Sl. No.	Slope Class	Treatments	Number of fruits (Nos.)	Av. weight per fruit (Kg)	Yield per plot (Kg.)	Yield per hectare (Ton)
1	Gentle	Pineapple hedge	78	1.80	140.40	14.040
		Vetiver Hedge	76	1.73	131.48	13.148
		Controlled	69	1.54	106.26	10.626
2	Moderate	Pineapple hedge	78	1.62	126.36	12.636
		Vetiver Hedge	75	1.61	120.75	12.075
		Controlled	71	1.45	102.65	10.265
3	Steep	Pineapple hedge	72	1.48	106.56	10.656
		Vetiver Hedge	69	1.47	101.43	10.143
		Controlled	60	1.28	76.80	7.680

Conclusion

Hedge always plays a vital role on plant growth, crops productivity, no of fruit & weight as well as minimizing of soil erosion. Height yields and lowest soil loss were gained from the managed plot by pineapple hedge and gentle slope. Lowest yields and Height soil loss were gained from the control plot and steep slope. soil conservation technique is must for any agricultural practice on the slopping land. Fungal, bacterial and virus diseases are more during rainy season which affects badly on growing watermelon and its yields and quality. Attract of white flies hampers the production of watermelon during rainy season.

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EXPT. No. 7:

STUDY ON MANAGEMENT AND ECONOMIC VALUE OF ***SCHUMANNIANTHUS DICHOTOMA*** **(*MURTA*/ PATIBET) IN HILLY JHIRI LAND AT CHT.**

Md. Mahbubul Alam

Abstract

Schumannianthus dichotoma (*Murta*/Patibet) is widely grown in wetland areas of Bangladesh, providing the raw materials for prayer and bed mats and also minimizing soil erosion. A suitable field situated in a Jhiri locating of the South-south-east side of the SCWMC administrative Building has been selected for cultivation of *Patibet.* The main objectives of the research program was to study the suitability and yield or productivity of Murta in Hilly Region of Bangladesh, to ensure the fallow lands of hilly Jhiri in to productive and minimize soil erosion hazard & to strengthen the economical efforts of the hill dwellers by increasing off farm activities & to supplement the traditional Jhum Practices. Propagation was from rhizomes and branch cutting, and little intensive management was required. Harvesting was usually done annually, from mid-September to the end of March. Soil has been made up for proper propagation. Weeding is needed only for vines and climbing weeds, generally before the rainy season. Weeding, especially of the main weed, Asam lata (*Eupatorium odoratum*), should usually be carried on along with harvesting, or occasionally. There were no significant pest and disease attacks in *Patibet* plantations. *Patibet* can play a vital role in the economy and environment CHT of Bangladesh. These lands are not suitable for cultivation of other cash crops. The cultivation of *Patibet* is inexpensive and does not conflict with the production of agricultural crops.

Introduction

*Schumannianthus dichotoma*is popular cultivated species with local names in different regions of Bangladesh, such as *Patipata*and *Pati-jung*in Chittagong, *Mostak*in Noakhali, *Pat-bat* and *Murta* in Sylhet and Tangail and *Paitrabon*in Barishal (Rashid *et al*. 1993; Islam 2005). It is in the Marantaceae (Hooker 1892; Prain 1903), with 20 species in the genus *Schumannianthus*. It is a shrub with oblong or oblong lanceolate leaves 1.5–3.0 ×1.0 cm, broadly rounded at the base (Mohiuddin and Rashid 1988), erect, conspicuous glossy green and dichotomously branched stems 3–5 m high, and basal diameter of 2–5 cm (Prain 1903; Anon 1950; FMP 1992). It has a tuberous rootstock (Hooker 1892) with stem buds on culms (new shoot buds). The species is found in Northeast India,West Bengal, the Coromandal Coast and the Malay Peninsula (Hooker 1892; Anon 1950; Chowdhury and Konwar 2006). In Bangladesh, it covers sizeable areas in the Sylhet Division forests (Anon 1970) and grows well in swampy areas (Rao and Verma 1972; Ara*et al*. 2000); it is grown in partial shade, and prefers clay or clay-loam soil with high moisture. The plant cannot tolerate direct sun. It is propagated from rhizomes that are planted directly in the field at 1 × 1 m spacing (Merry 2001). *Murta* is cheaper to grow than jute or rice, and gives a good economic return (Mohiuddin and Rashid 1988) as the raw material for *Shitalpati*(Chowdhury and Konwar 2006; Chowdhury*et al*. 2007), a traditional bed mat in Bangladesh, and other mats. The mat is woven from the dyed fibres, 3–5 mm wide, with coloured designs on a natural beige background. Bed mats made of *Murta*are attractive and comfortable, Especially during the hot summer months(Banik 2001).

A growing body of research suggests that non-woody forest products (NWFPs) can help communities to meet basic needs without destroying forest resources. In local, urban, national and international markets, forest goods and medicines contribute substantially to national economic growth (FAO 1995). NWFPs complement wood-based forest management and can contribute to integrated forms of development that yield higher rural incomes and conserve biodiversity without competing with agriculture (Sharma 1995). According to the FAO (1995), NWFPs are important to three main groups: i) rural populations (the largest group) who have traditionally used these items; ii) urban consumers (the smallest group, but increasing) who purchase these items; and iii) traders and product processors whose numbers are increasing as urban markets for these products grow.

As a NWFP, *Murta* generated significant revenue for the Forest Department of Bangladesh. 100 ha of *Murta* is worth US$91,783 annually, rising to more than US$35,3012 after processing (Anon 1990), US$706/ha more than paddy (Rashid *et al*. 1993). From 1981 to 1991, the average annual revenue collected by the government was US$6057 (US$1 = Tk. 70) (Banik 2001). Only a small percentage of *Murta* products are exported and most are for domestic consumption. In 1992, BSCIC (Bangladesh Small Cottage Industries Corporation) reported 175 *Sitalpati* processing units consuming materials worth US$37,571 at a production cost of US$61,428. The resultant products were sold for US$11,6714 (Banik 2001). *Murta* plays a vital role in the economy and environment of the country (Rashid *et al*. 1993), if properly managed, and products can be exported abroad. From 1999 to 2003, the Bangladesh government received average annual revenue of US$4567 from *Murta* (BBS 2001), less than in the previous decade. To maximise income, it is necessary to undertake intensive research on the management, cultivation and marketing of *Murta* and its products (Merry 2001; Chowdhury *et al*. 2007). For instance, the effect of collecting rhizomes on the productivity of parent plants; costs of raising seedlings; enthusing local people to cultivate *Murta* (Merry 2001); and marketing (Banik 2001).

The vast areas of *Murta* in the northern Sylhet forests annually trap huge amounts of mud and silt, saving nearby low-lying areas from flash floods. *Murta* also has a positive role in the regeneration of tree species by trapping seeds and providing protection to young plants (Banik 2001). Mohiuddin and Rashid (1988) found that the number of new culms and their height is higher in Sylhet than in other sites. Although the use of *Murta* has recently expanded (Banik 2001), the cultivated area has decreased (Rashid *et al*. 1993). The deteriorating condition of this resource demands immediate attention for its scientific management (Mohiuddin and Rashid 1988; Chowdhury *et al*. 2007). Consequently, this study was carried out in the Chittagong Hill Tracts region to ascertain traditional management practices and their contribution to sustainable development of the rural economy.

Objectives

a. To study the suitability and yield or productivity of Murta in Hilly Region of
Bangladesh.
b. To ensure the fallow lands of hilly Jhiri in to productive and minimize soil erosion hazard.
c. To strengthen the economical efforts of the hill dwellers by increasing off farm activities & to supplement the traditional Jhum practice.

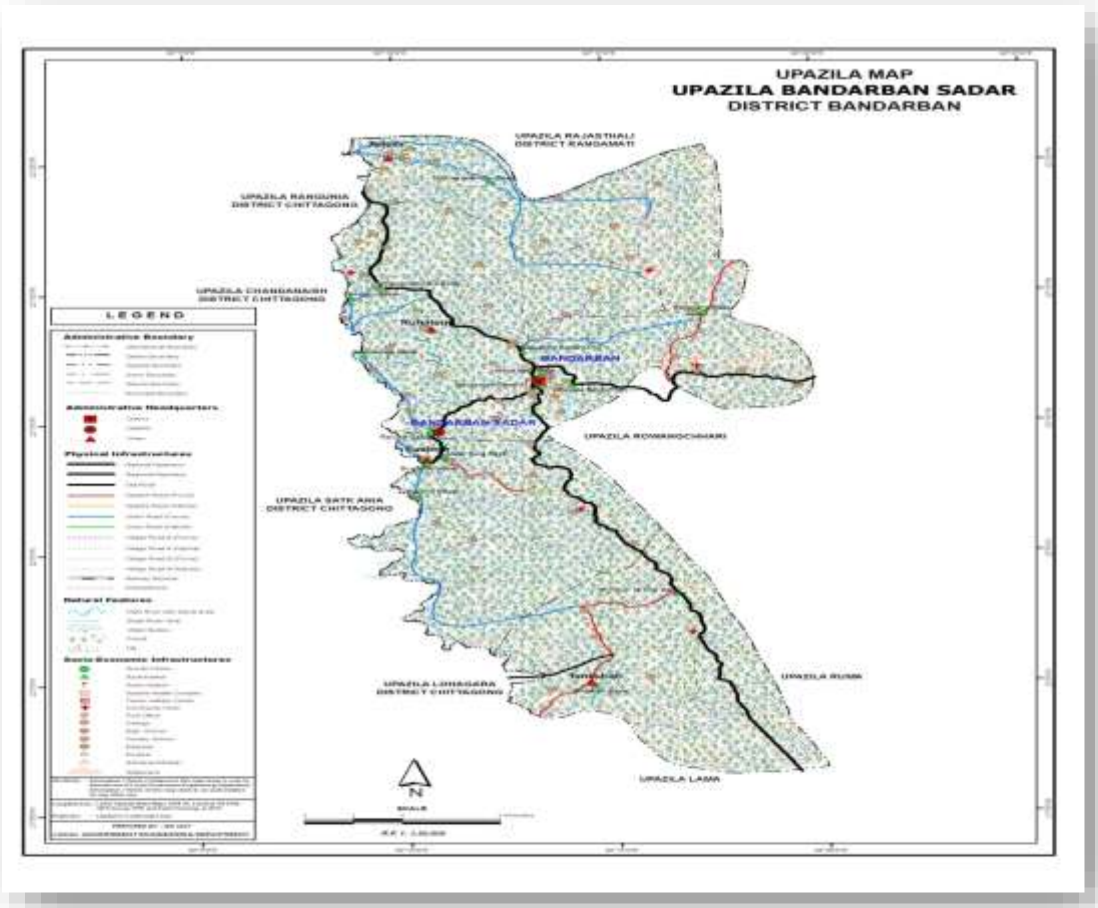

Figure 2: Map of the study area

Materials and methods

The study was conducted in financial year 2016-2017. A suitable field situated in a Jhiri locating of the South-south-east side of the SCWMC administrative Building was selected for cultivation of *Patibet.* For Judging the adaptability with the climatic condition of this region, in the primary stage about 500 rhizomes covering an area of 85'-0" x 20'-0" = 1700.00 sft. was planted in rows maintaining contour lines. Rhizomes were collected from nearby Upazila of Chittagong district. Soil was made up for proper propagation. Necessary intercultural operation with applying proper fertilization was done accordingly. After completion of 3 years observation, the activity will be transferred to public field. Then a multistage random sampling method will be applied to relocate at least two village and households of Bandarban Sadar Union for the study within as the primary sampling and ultimate sampling units, respectively. Two villages would be selected randomly and, from each, one village would be selected for detailed investigation. The total number of households in the two villages will be obtained from the District Census, conducted to assess the socio-economic status of households in the villages. From each village, 20 households will be selected for survey by random sampling. A semi-structured questionnaire will be used to collect data from the heads of the households to assess the area allocated for cultivation of *Patibet*, propagating materials, different silvicultural techniques, and contribution of *Murta* to the household economy. New avenues of questioning would be pursued as the interviews developed. To analyse the data obtained from field. Three propagating materials, rhizomes, branch cuttings and seeds, may be used for *Murta* (Rashid *et al*. 1993). All the farmers used rhizomes and branch cuttings, as also found by Chowdhury *et al*. (2007). One third (33%) of farmers used only rhizomes and 23% used branch cuttings, while 44% used both rhizomes and branch cuttings, and none used seeds. Bangladesh Forest Research Institute has developed a method of raising seedlings from seed (Merry *et al*. 1997), the farmers have not accepted it yet. It noted that there are difference in survival for rhizomes, rooted cuttings and seedlings was insignificant.

According to the criteria for cultivation of *Schumannianthus dichotoma (Murta)* is going on. The plantation site *Schumannianthus dichotoma (Patibet)* should be weeded twice a year Rashid *et al*. (1993), Merry (2001) and Chowdhury *et al*. (2007). Weeding is needed only for vines and climbing weeds, generally before the rainy season. Weeding, especially of the main weed, Asam lata (*Eupatoriumodoratum*), should usually be carried on along with harvesting, or occasionally.

Cultivation of *Schumannianthus dichotoma (Patibet)* is needed both addition of soil and application of fertilizer. Soil should be done during the dry season, usually after harvesting and before the onset of the monsoon. Soil addition should be done throughout the *Patibet* plantation, and particularly within and around the *Murta* clumps. Soil should be dug to enhance aeration Chowdhury *et al*. (2007). *Patibet* cultivation is needed application for organic fertilizer. Application of cow dung is the best as fertilizer Mohiuddin and Rashid *Ahmed et al.*1988), Rashid *et al*. (1993) and Chowdhury *et al*. (2007).

The field in where the *Schumannianthus dichotoma (Patibet)* is cultivated under this Research is almost a table top plain lands in cross sectional abut a sloping land in longitudinally. The elevation difference from upper end to lower end is 3'-0". The field is divided in to three plots. Elevation difference from upper plot to middle plot is 1'-9" and from middle plot to lower plot is 1'-3". The plots are located in the valley land in between two hills which is locally known as Jhiri. This type of land generally remains abandoned all the times (years after years). Soil moisture varies for its difference of elevation. The moisture content of soil of the lower part of the hill is generally higher than that of higher. *Schumannianthus dichotoma* (*Murta*/Patibet) is widely grown in wetland areas. No additional soil is added to the rows of

Murta plants as it can interrupt the natural surface flow during the rainy season. Intercultural operation including applying inorganic fertilizer has been done as per recommendation. Growth of plants and number of plants per Culm were observed closely. No irrigation is done in the draught season.

Results and discussion

There was a significant difference in growth of plants and number of plants per culm of Murta in different plots. Plants height was also different in difference plots. Plants height of the lower plot is higher than that of immediate upper plot. Plants of Murta in the upper most plot were thin and pale where the plants growth of the second plot was satisfactory and green to dark green in colour. The plants of the lower plot were healthier and vigorous than second plot with dark green in colour. There was a significant change of appearance, leaf per plant, height and plant diameter depending on the location of the plats (shown in table-38). Yield difference was also observed in different plots. Total **Average return (in BDT)** in financial value was recorded Tk. **625**-, Tk. **1158**/- and **1543**/- from upper, middle and lower plots for 1700sft. jhiri land from 2018-19 to 2021-22. (shown in table -38). The immediate lower plot’s response was better than that of upper one.

Table 38: Comparative growth Study & return from *Murta*/ Patibet plants in different plot in different elevation.

Plot No	Year	Appearance	Av. plant Height	Av.plants Diameter (mm)	Av. Leaf per plant (Nos.)	Av. Plants per Culm (Nos.)	Return (in BDT)	Average Return (in BDT)	Remarks
1. Upper	2017-18	Yellowish green	1’-6” to 2’-0”	4- 6	4 to 6	7 to 9	-	625	
	2018-19	Green	3’-6” to 6’-6”	8- 20	8 to 12	12 to 16	300/-		150 sticks @ Tk.2/- each
	2019-20	Green	3′-6′′ to 7′-0′′	10 - 22	11-20	16-20	625/-		250 sticks @ Tk.2/50 each
	2020-21	Green to dark green	3′-6′′ to 7′-0′′	12 - 26	11-25	18-26	750/-		300 sticks @ Tk.2/50 each
	2021-22	Green to dark green	3′-6′′ to 7′-0′′	14-28	12-24	20-28	825/-		330 sticks @ Tk.2/50 each
2. Middle	2017-18	Green	3’-0” to 4’-0”	5 - 8	5 to 9	10-14	-	1158	-
	2018-19	Green	4’-0” to 7’-0”	10- 22	8 to 14	15- 20	700/-		280 sticks @ Tk.2/50 each
	2019-20	Green to dark green	3′-6′′ to 7′-6′′	10-22	12-22	16-25	1,170/-		390 sticks @ Tk.3/- each
	2020-21	Green to dark green	3′-6′′ to 7′-6′′	14-28	14-28	16-30	1,320/-		440 sticks @ Tk.3/- each
	2021-22	Green to dark green	3′-6′′ to 7′-6′′	15-30	16-30	18-32	1440		480 sticks @ Tk.3/- each
3. (Lower)	2017-18	Dark green	4’-0” to 5’-0”	7 -12	9 to 14	12- 16	-	1543	-
	2018-19	Dark Green	4’-0” to 7’-0”	12 -22	10 to 16	20- 22	1250/		417 sticks @ Tk.3/- each
	2019-20	Dark green	4′-0′′ to 7′-6′′	10-24	14-24	24-36	1,710		570 sticks @ Tk.3/- each
	2020-21	Dark green	3′-6′′ to 7′-6′′	14-28	14-28	18-35	1,530/-		510 sticks @ Tk.3/- each
	2021-22	Dark green	4′-0′′ to 8′-7′′	16-32	18-30	20-38	1680		560 sticks @ Tk.3/- each

Total Taka for 1700 sft. =	3,326/-

Table 39: Average number of articles sold annually and expected income per household

Articles	Articles sold/industry	**Income (US$)** (no. articles ¥ net average profit per article)
Simple prayer mat (36″ × 45″, 0.12–0.25″ thick)	13	4.64
Prayer mat with colour strip (same size, = 0.12″ thick)	16	22.17
Prayer mat with colour design (same size, 36″ × 45″, = 0.12″ thick)	10	18.14
Simple bed mat (63″ × 81″, 0.12–0.25″ thick)	200	142.86
Bed mat with colour strip (63″ × 81″, = 0.12″ thick)	15	28.86
Total		216

Table 40: Variation in price for different products from producer to retailer

Articles	**Selling Price (US$)**				**Difference between Artisan and Retailer (US$)**
	Artisan	**Middlemen**	**Wholesaler**	**Retailer**	
Simple prayer mat	0.60	Not involved	Not involved	Not involved	–
Prayer mat with colour strip	1.93	2.07	2.14	2.29–2.43	0.36–0.50
Prayer mat with colour design	2.57	2.80	2.86	3.14–4.29	0.57–1.71
Simple bed mat	1.57	–	–	–	–
Bed mat with colour strip	3.14	3.36	3.43	3.71–5.00	0.57–1.86

Source: "Management and economic value of *Schumannianthus dichotoma* in rural homesteads in sylhet region of Bangladesh."Romel Ahmed, A.N.M Fakhrul Islam, Mostafizur Rahman& Md. Abdul Hakim.International Journal of Biodiversity Science & Management.

Table-41: Chemical properties of Soil before setting the experiment.

Particulars	pH	OM %	K	Ca	Mg	TN (%)	P	S	B	Cu	Fe	Mn	Zn
		Meq/100g soil					u gm/g soil						
Experi-mental Plot	5.9 Slightly Acidic	4.44 High	0.28 Opt.	8.37 V.H	2.87 V.H	0.222 Opt.	5.65 Low	9.40 Low	0.18 Low	5.20 V.H	139.60 V.H	79.60 V.H	2.04 High

Table-42: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Experimental Plot	Silt Loam	26	64	10

Conclusions

Patibet can play a vital role in the economy and environment CHT of Bangladesh. It can easily be cultivated in hilly Channel/Jhiri that remain fallow and remain wet even in the dry season. These lands are not suitable for cultivation of other cash crops. The cultivation of *Patibet* is inexpensive and does not conflict with the production of agricultural crops. This program will minimize soil erosion hazard in Chittagong Hill Tracts. This study will ensure income generating crops instead of hazardous jhum cultivation. It is necessary to develop effective propagation methods which will lead to higher production. Adequate training and motivation is required to encourage people to cultivate *Patibet* elsewhere in Bangladesh, and infrastructure should be developed to support *Patibet*-based cottage industries and community based marketing facilities, complemented by access to adequate knowledge and information, to ensure that the economic and environmental benefits to the rural people are maximized.

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EXPT. No. 8

STUDYING EFFECT OF NATURAL VEGETATIVE STRIP (NVS) FOR MINIMIZING SOIL EROSION IN CULTIVATION OF VEGETABLES.

Md. Mahbubul Alam

Abstract

Natural Vegetative Strips (NVS) are narrow strips of naturally growing grasses and herbs intentionally left unplowed along the contours of slope land farms. These strips serve as buffers that prevent the soil from eroding during heavy rains and intensive cultivation. Over time, these strips form stable terraces along the contours. , The specific objectives of the present study were to examine the effect of NVS on the maintenance of soil fertility and reducing soil erosion in moderate hill slope, to examine the effect of NVS on vegetables productivity in hill slope. The test crops of the experiment were Okra and yard long bean. There were four treatments and these were as: T_1 = Okra in Natural vegetative strip, T_2 = Okra in control (no NVS), $T_{3=}$ Yard long bean in Natural vegetative strip, T4 = Yard long bean in Control (no NVS). Soil erosion was measured through Spike layout method. The topsoil loss was the highest in Yard long bean in Control (29.22 t ha^{-1})which was significantly different from the NVS used plots. Among the NVS applied plots, soil erosion was the lowest in Okra in Natural vegetative strip plot (10.69 t ha-1).Soil loss from the Okra in control plot was 28.95t $ha^{-1}$and Yard long bean in Natural vegetative strip plot was 11.03t ha^{-1} .The highest yield (8.993 t/ha) was obtained in Okra in NVS managed plot and the lowest yield (6.007 t/ha), was observed in Okra in Control managed plot. On the other hand the highest yield (9.593 t/ha) was obtained in Yard long bean in NVS managed plot and the lowest yield (6.606 t/ha), was observed in Yard long bean in Control managed plot.

Introduction

The CHT covers an area about 13,181 km^2 and occupies about 76% of total 12% upland areas of the country (Khisa.2006) endowed with natural beauty and economic potentiality. Hum, the dominant form of land use in CHTs, widely practiced by tribal communities and remain as major source of livelihood for most of the hill people. About 1.0 million peoples in CHT of which 13 different ethnic groups are directly or indirectly depend on Jhum (Shoaib,2000).Generally, after one year harvest in general, sometimes two year, the land was left fellow for 20-30 years, which at present has been shorten to 3-4 years (DANIDA,2000).It is estimated that1,02,468 areas (4.3 percent area of the CHT) is cleared every year for jhum cultivation.Gafur *et al*.(2003) cited approximately 2.5% area of CHT remains under jhum in each year. Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. When runoff occurs, less water enters the ground, thus reduces the crop productivity. Soil erosion

also reduces the levels of the basic plant nutrients needed for crops, trees and other plants and decreases the diversity and abundance of soil organisms(Olson et al.1999;Schumacher et al.1999; Irvine and Kirkby2004).Effective control of soil erosion lies in reducing direct impact of rain drops, maintaining maximum soil infiltrability by decreasing surface sealing, increasing the surface storage,imporving soil structure and decreasing the velocity and transport capacity of runoff, which can only be achieved through good land use management.Joshi et al.(2004) reported that the grass cultivation on barren terraces and bund of agriculture land proved effective in reducing erosion hazards for hill farming to maintain the nutrient balance under different land use systems.

The physical and chemical properties of soils are significantly affected by the land use patterns.. One of the best ways of solving those problems could be adoption of Natural Vegetative Strip during crop cultivation. Natural Vegetative Strips (NVS) are narrow strips of naturally growing grasses and herbs intentionally left unplowed along the contours of slope land farms. These strips serve as buffers that prevent the soil from eroding during heavy rains and intensive cultivation. Over time, these strips form stable terraces along the contours. Natural Vegetative strips are easy to establish. They are incorporated during land preparation, and thus require minimal labor. They do not entail additional cost as there is no need for additional planting materials, since the grasses naturally grow on the farm. The strips filter pesticides, nitrates and soluble phosphorus, thus prevent runoff. They control soil erosion by more than 90%.They improve water infiltration during heavy rains. Subsequently land preparation and crop management become easier. Farmers are provided with food foundation, and farms evolve into complex agro forestry systems, thereby increases the productivity. The NVS reduces the available cropping area by about 10 to 15%.However; the cropping area utilized for strips basically depends on the steepness of the slope. The steeper slope used the greater of area for strips. Basically, the strips do not cause weed problems as long as the farmers regularly maintain the NVS area and about 50 cm of its surrounding through continuous cultivation. If farmer-maintenance is good, no weed problems will occur.

Minimization of soil through (NVS) is an indigenous technology which used by the hill dwellers since time immemorial. In the rural areas the poor, who struggle for survival, cannot be expected to pay heed to the conservation strategy unless their daily needs of food, fiber and fuel are met. Still a more urgent need is for assured and full employment for all the peoples. Though soil erosion in Chittagong Hill Tract is a great threat for crop cultivation, the practice of Natural Vegetative Strip application is still very limited. In this manner a land use system should be developed to control soil erosion and sustain crop productivity and aware the people as well as the peoples who involved develop the people of this remote area. So, the specific objectives of the present study were as follows:

a. To examine the effect of NVS on the maintenance of soil fertility and reducing soil erosion in moderate hill slope.

b. To examine the effect of NVS on vegetables productivity in hill slope.

Materials and Methods

The experiment was conducted in the experimental farm of the Soil Conservation and Watershed management Center (SCWMC); Soil Resource Development Institute (SRDI), Bandarban. The site was located in south-southeast hilly region of Bangladesh. The location of the site is between $22^0$09´16 to $22^0$10´32 north latitude and $92^0$11´17 to $92^0$11´34 east longitudes with an elevation 92-133 m above mean sea level (SRDI,2005).The experiments were set up on the 26% hill slope areas. The climate of the experimental site is sub-tropical characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The area has an erratic monsoon climate, with periodic flooding in the valleys and drought in the mountains, hot rainy summer and a pronounced dry season in the cooler months. January is the coolest month of the year and April is the warmest one. The detail records of air temperature, humidity and rainfall for the study period were collected from meteorological station of Soil Conservation and Watershed Management Center, Bandarban.The mean annual rainfall of the study site was 3000 mm and monthly mean air temperature ranged from 25 to 34 ^{0}c and mean relative humidity was 79.3%.

The test crops of the experiment were Okra and yard long bean. There were four treatments and these were as: T_1 = Okra in Natural vegetative strip, T_2 = Okra in control (no NVS), $T_{3=}$Yard long bean in Natural vegetative strip, T4 = Yard long bean in Control (no NVS).The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 (three) replications. The treatments were randomly allotted in each block. The dimension of each plot was 20m x 5m (100 m^2).The seeds were sown in following dibbling method . Necessary agronomic management practices for all crops were followed. Plots were prepared manually. Intercultural operations like weeding and fertilizer application were done equally in all treatments to get better results. In every plot after 4 meter intervals a 1 m width NVS were made naturally. So, there were four NVS in each plot. In Natural Vegetative Strips area there were different types of shrubs and grasses, which were germinated and developed naturally. The area of NVS was kept just to leave the cultivated area in cropping time without cleaning.

Soil erosion was measured through Spike layout method. In every plot, four spikes were inserted-two were near upper side (top of the plot) and another two were near bottom side of the plots. The spikes were made by mule bamboo and these were colored by normal paints. These bamboo spikes were divided into two parts by using two different colors (red and white).

Different intercultural operations like –weeding, insect and disease control, harvesting were done properly and timely for successful completion of the experiments.

Composited Soil samples were collected and just before land preparation to determine the physical and chemical properties of the experimental field. Soil samples were also collected treatment-wise after the final harvest of the crop. The collected samples were air-dried, grained and passed through a 2 mm sieve for physical and chemical analysis. Soil samples were analyzed following standard analysis method in central laboratory of SRDI.

Results and Discussion

Table 43. Initial soil fertility status and fertility status after crop harvest.

Parameter	Year	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		µg/g soil			meq/100g soil		µg/g soil		
NVS Okra	2017	6.7	3.09 M	0.155 L	26.81 VL	0.30 O	0.003 VL	1.52 O	0.30 L	3.42 M	0.69 L	0.82 VH	80.62 VH	42.11 VH
	2018	6.1	3.6 H	0.180 L	30.57 VH	0.37 H	7.58 L	6.48 VH	0.30 L	2.78 L	1.11 M	2.77 VH	37.16 VH	18.50 VH
Control Okra	2017	6.3	3.16 M	0.158 L	17.89 O	0.38 H	0.30 VL	1.60 O	0.23 L	5.29 O	1.16 O	0.81 VH	67.90 VH	37.68 VH
	2018	4.0	3.6 H	0.180 L	5.20 VL	0.43 H	11.59 L	0.52 L	0.03 VL	2.67 L	1.39 O	0.40 M	40.45 VH	16.61 VH
NVS Yard long bean	2017	6.1	3.50 H	0.175 L	0.54 VL	0.54 VH	31.69 H	1.71 O	0.26 L	4.80 O	1.33 O	0.77 VH	63.90 VH	42.32 VH
	2018	4.0	4.0 H	0.200 M	2.02 VL	0.9 VH	4.38 VL	0.39 L	0.30 L	3.12 M	1.81 H	0.38 M	55.67 VH	17.23 VH
Control Yard Long bean	2017	5.9	3.70 H	0.185 M	9.08 L	0.50 VH	7.99 L	1.91 H	0.35 M	4.21 M	1.25 O	0.73 H	66.23 VH	41.56 VH
	2018	4.0	4.2 H	0.210 M	1.73 VL	0.86 VH	3.60 VL	0.48 L	0.14 VL	3.36 M	1.94 VH	0.35 M	41.28 VH	13.37 VH

Note: VL=very low; L=low; M= medium; O=optimum; VH=very high

Table-44: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
NVS Okra	Silt Loam	23	59	18
Control Okra	Silt Loam	22	60	18
NVS Yard Long Bean	Silt Loam	20	62	18
Control Yard Long Bean	Silt Loam	23	59	18

Soil erosion is considered as one of the most important parameters as well as the main constraints for crop production in slopping lands. In this study, the soil erosion parameter was assessed based on the soil losses or washed out (eroded) at a given (prefixed) location of the study area. The total soil erosion based on the loss of top soil (i.e depth created due to erosion) in the experimental treatments as shown in table 23& 24. The soil loss varied considerably with the use of NVS systems. The topsoil loss was the highest in Yard long bean in Control (29.22 t ha^{-1})which was significantly different from the NVS used plots. Among the NVS applied plots, soil erosion was the lowest in Okra in Natural vegetative strip plot (10.69 t ha-1).Soil loss from the Okra in control plot was 28.95t $ha^{-1}$and Yard long bean in Natural vegetative strip plot was 11.03t ha^{-1} This statement was supported by Paningbatan and Rosario (1990) who observed that alley cropping with mulching contouring and minimum tillage greatly reduced surface run-off and soil losses and erosion rates ranging from 36 to 200 t/ha on erosion plots cultivated up and down the slope. The surface cover crop barriers do not channelize runoff, as do engineered systems. Woo and Luk (1990) observed that if the vegetative cover decreases both the interception and infiltration decreases which increase the overland flow and soil loss.

Table 45: Soil loss under the cultivation of Okra in Natural vegetative strips

Treatments	Average soil loss in mm	Total soil loss (ton/ha)
Okra in NVS	0.8220 b	10.69 b
Okra in Control	2.227 a	28.95 a
CV (%)	26.04	2.98
CD (0.05)	1.40	4.79

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Table 46: Soil loss under the cultivation of Yard long bean in Natural vegetative strip.

Treatments	Average soil loss in mm	Total soil loss (ton/ha)
Yard long bean in NVS	0.8487 b	11.03 b
Yard long bean in Control	2.248 a	29.22 a
CV (%)	11.32	5.31
CD (0.05)	0.62	8.67

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Mean performance of NVS on yield & yield component of Okra.

Fruit Length: All the treatments significantly influenced fruit length of Okra cultivation. The height fruit length (18.60cm) was obtained in Okra in NVS managed plot. The lowest fruit length (14.47cm), was observed in Okra in Control managed plot (Table 47).

Fruit Weight: All the treatments significantly influenced fruit weight of Okra cultivation. The height fruit weight (18.24gm) was obtained in Okra in NVS managed plot. The lowest fruit length (12.46gm), was observed in Okra in Control managed plot (Table 47).

Table 47: Mean performance of NVS on yield & yield component of Okra.

Treatments	Fruit length (cm)	Fruit weight (gm)	Fruit/plant	Plot Yield (kg)	Yield(t/ha)
Okra in NVS	18.60 a	18.24 a	16.10 a	59.76 a	8.993 a
Okra in Control	14.47 b	12.46 b	12.27 b	47.78 b	6.007 b
CV (%)	1.73	5.09	4.90	2.551	7.591
CD (0.05)	1.00	2.75	2.44	4.814	2.005

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Fruit per Plant: The height fruit /plant (16.10) was obtained in Okra in NVS managed plot and the lowest fruit /plant (12.27), was observed in Okra in Control managed plot (Table 47).

Plot Yield (Kg): The Maximum plot yield (59.76 kg) was obtained in Okra in NVS managed plot. The lowest plot yield (47.78 kg) was observed in Okra in Control managed plot (Table-47).

Yield (t/ha): All the treatments significantly influenced yield of Okra cultivation. The highest yield (8.993 t/ha) was obtained in Okra in NVS managed plot and the lowest yield (6.007 t/ha), was observed in Okra in Control managed plot (Table 47).

Mean performance of NVS on yield & yield component of Yard long bean

Pod Length: All the treatments significantly influenced pod length of Yard long bean cultivation. The height pod length (50.65 cm) was obtained in Yard long bean in NVS managed plot. The lowest pod length (40.57cm), was observed in Yard long bean in Control managed plot (Table-48).

Pod diameter: All the treatments significantly influenced pod diameter of Yard long bean cultivation. The height pod diameter (0.9900 cm) was obtained in Yard long bean in NVS managed plot. The lowest pod diameter (0.8967 cm), was observed in Yard long bean in Control managed plot (Table -48).

Table 48: Mean performance of NVS on yield & yield component of Yard long bean

Treatments	Pod length (cm)	Pod diameter (cm)	Pod wt. (gm)	No. of pod/ plant	No. of seed/ Pod	Plot Yield (kg)	Yield (t/ha)
Yard long bean in NVS	50.65 a	0.9900 a	18.91 a	20.17 a	19.00 a	66.20 a	9.593 a

Yard long bean in Control	40.57 b	0.8967 b	13.53 b	14.00 b	12.67 b	54.86 b	6.606 b
CV (%)	3.35	0.26	3.64	1.13	2.09	1.94	2.206
CD (0.05)	5.38	0.01	2.07	0.67	1.17	4.13	0.625

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability.
CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Pod wt.: The height pod wt. (18.91 gm.) was obtained in Yard long bean in NVS managed plot and the lowest pod wt. (13.53 gm), was observed in Yard long bean in Control managed plot (Table 48).

No. of pod/ plant: The height No. of pod/ plant (20.17.) was obtained in Yard long bean in NVS managed plot and the lowest No. of pod/ plant (14.00), was observed in Yard long bean in Control managed plot (Table-48).

No. of seed/ pod: The height No. of seed/ pod (19.0) was obtained in Yard long bean in NVS managed plot and the lowest No. of seed/ pod (12.67), was observed in Yard long bean in Control managed plot (Table-48).

Plot Yield (Kg): The Maximum plot yield (66.20 kg) was obtained in Yard long bean in NVS managed plot. The lowest plot yield (54.86 kg) was observed in Yard long bean in Control managed plot (Table-48).

Yield (t/ha): All the treatments significantly influenced yield of Yard long bean cultivation. The highest yield (9.593 t/ha) was obtained in Yard long bean in NVS managed plot and the lowest yield (6.606 t/ha), was observed in Yard long bean in Control managed plot (Table-48).

Conclusions

Minimization of soil erosion through natural vegetative strip (NVS) is an indigenous technology which used by the hill dwellers since time immemorial. Use of natural vegetative strip (NVS) has created positive effect on the morphological and reproductive characteristics as well as at the yield of crops. Natural vegetative strip (NVS) always plays a vital role on plant growth, crops productivity, fruit length & weight as well as minimizing of soil erosion. More yields were gained from the managed plots by NVS, though the number of total plant was comparatively less in those plots than the controlled one. The conservation of soil and water is essential for sustainable production, environment preservation and balanced eco system. Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity.

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TRANSFERABLE TECHNOLOGY / ADAPTIVE RESEARCH

PROGRAME-1

INTRODUCTION OF BENCH TERRACE FOR DEMONSTRATION AND YEAR ROUND CROP PRODUCTION.

Objectives

a. To reduce the quantum of overland flow/sheet flow or runoff, and their velocity.

b. To minimize the soil erosion and conserve soil moisture.

c. To conserve soil fertility and to facilitate farming operations such as ploughing, irrigation etc. on sloping land.

d. To promote intensive land use, permanent agriculture and checking shifting cultivation on steep lands.

Justification:

Terracing is one of the most accepted measures of controlling erosion on sloping and undulated lands. It is widely adopted in many countries of the world. Suitable bench terrace will facilitate intensive cultivation make the land suitable for multiple use in hilly areas. It is also helpful to increase the beauty of the land along with increasing the stability. At present most of the farmers are practicing Jhum on hill slope, which accelerate erosion. On sloping lands farmers usually can’t use fertilizer or other input to produce more crops per unit of land. Bench terrace helps in proper water management, application of fertilizers or manure. It will also help to increase cropping intensity within a stable farming system. Now a day, Bench Terrace are widely being used in the hilly areas of India, Nepal, Srilanka, Tamilnadu etc. But the hill dwellers are not concerned about the construction, use and benefit of the Bench Terrace. Considering above factors study of sustainability of Bench terrace has been taken account in the farmer's field. As the measure is very cost effective, so widely subsidy is very essential to popularize the Bench Terracing mainly in the hilly areas in our country.

PROGRAME-2:

REHABILITATION OF DEGRADED/ERODED SLOPING LAND BY JUTE GEO-TEXTILE ON DIFFERENT HILL SLOPES OF CHT.

Objectives

1) To study the effectiveness of geo-jute (untreated) in controlling soil erosion.
2) To rehabilitate degraded/eroded/landslide hilly areas
3) To stabilize/rejuvenate degraded/landslide areas of CHT

Justification:

1. Like any other natural fibre, jute geo-textile gets biodegraded in soil.
2. The live poll will give vegetation coverage and soil losses will be minimized at the area treated with jute geo textile.
3. The decomposition of the fibre will takes place within the ecological process that assists in the retention of moisture, improvement of soil permeability and establishment of vegetation.

PROGRAME-3

ESTABLISHMENT OF DIFFERENT HEDGE SPECIES IN FARMERS' FIELD AS TRANSFERABLE TECHNOLOGY IN CHT.

Objectives

a. To introduce modern hill cultivation and suitable technology for soil conservation and watershed management.

b. To minimize soil erosion hazard.

c. To increase bio-mass in soil properties.

d. To accelerate the infiltration and water holding capacity of soil.

Justification:

The conservation of soil and water is essential for sustainable production, environment preservation and balanced ecosystem. Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity. Contour hedgerows are also effective in controlling run off and soil erosion and improve soil physical properties. Controlled plots have higher run off and soil loss than those plots with hedge row. Hill slope may be divided into a series of alley separated by hedgerow on contour lines, because hedgerow plants are effective in controlling soil erosion and reducing run off.

Trees and shrubs have several functions to control erosion like (i) increase soil cover, by liter and pruning (ii) provide partly permeable hedgerow barriers (iii) lead to the progressive development of terraces, through soil accumulation upslope of hedgerows (iii) increase soil resistance to erosion, by maintenance of organic matter (iv) stabilize earth structures by root systems and (v) make productive use of the land occupied by the conservation works . This study was, therefore, designed to select suitable hedge species and their alley width in respect to slope which minimized soil loss and increase crop yield.

PROGRAME-4

TITLE: GULLY CONTROL BY GABION CHECK DAM & VEGETATIVE MEASURES FOR THE RECLAMATION OF DEGRADED LANDS IN THE HILLS OF CHT.

Objectives

a. To check widening & head extension of gully.

b. To reduce runoff and subsequently retain washed out sediments/debris at the gully head and increase filtering effect of the run-off sediment.

c. To /reclaim the degraded land.

Justification:

Construction of Gabion check dam needs no high-tech technology. Locally available materials can be used for construction of gabion. Others high tech construction materials except 10 SWG and 22 SWG GI wire are not required for Gabion. So, it can be constructed even at remote areas. After achieving the target, the used materials can be shifted to another place without any wastage. As this structure is considered as a flexible structure, there is a less possibilities to be damaged except scouring. If the well graded local stone bolder is used in gabion, it works well to check the sediments carried with and is finally very good for rehabilitation of degraded land by plugging the gully head.

PROGRAME-5

INTRODUCTION OF HALF-MOON TERRACE, STAGGERED TRENCHING, CONTOUR GRASSED WATERWAYS, AND CONTOUR TRENCHING IN FARMER’S FIELD.

Objectives

a. To minimize the soil erosion hazard.
b. To increase the optimum soil moisture capacity.
c. To convert the eroded land in to productive land.
d. To rehabilitate the degraded land.
e. To increase moisture holding capacity and to create scope for applying fertilizers, manure and irrigation on the sloping land.

Justification:

HALF MOON TERRACE

Half-moon terrace is a kind of terrace used for planting of fruit and horticultural purposes. It is called the Half Moon Terrace for its shape. Construction of Half Moon Terrace is easier than others. It is made by cutting the upside soil of the plant in half moon shape to create a circular level bed having 1.0-1.5 m. diameter. The dug-out soil is deposited on down side of the plants to make ridges for retaining moisture. Mulch materials are used in the terraced area which will add organic matter in to the soil. It also provides facilities for all

intercultural operation like application of fertilizer and manure along with irrigation in the drought. This type of terrace is generally made just before the end of monsoon when the soil is saturated. It also helpful for healthy growth of plants.

STAGGERED TRENCHING

The staggered trenches are constructed for shorter length, as compared to the graded trenches. These trenches are arranged in staggered form (i.e. not in straight line). Staggered trenches are generally constructed at the land slope greater than 33% receiving high rainfall to prevent erosion and absorb rain water for horticulture and forestry land . The trenches run level for distance of maximum 90 to 120 m, than on the gradient increasing from 1 in 500 to 1 in 300 at the outlet. The bunds are constructed at closer interval about 3 to 5 m. The important points about this type of trench are as follows:

The trenches have shorter length; and are arranged in the row along the Contour with interspace between them.

a. The vertical interval between two successive trenches is decided on the basis of expected runoff from the area, above,
b. In staggered sequence, the alternate rows trench are located directly below one another;
c. The length of row and slope between them are fixed based on the Concept that there should be greater length of unprotected or uninterrupted slope to cause unexpected runoff and erosion.

CONTOUR GRASSED WATERWAYS

A grassed waterway is a natural or constructed channel that is shaped or graded to carry surface water at a nonerosive velocity to a stable outlet. The required dimensions are those needed for the waterway to convey runoff from the design storm, generally the 10-year, 24-hour storm. The grassed waterway is designed to ensure that the velocity of runoff water is not excessive.

The primary purpose of a grassed waterway is to convey runoff from terraces, diversions, or other areas of water concentration without causing erosion or flooding. Another purpose is to improve water quality. Grassed waterways are natural drainage ways that are graded and shaped to form a smooth, bowl-shaped channel. They are seeded to sod-forming grasses. Runoff water that flows down the drainage way flows across the grass rather than tearing away soil and forming a larger gully. An outlet is commonly installed at the base of the drainage way to stabilize the waterway and to keep a new gully from forming. The most critical time for successful installation of a grassed waterway is immediately following construction, when the channel is bare and unprotected from runoff. Waterways are generally planted to perennial grass and then mulched with straw. In some areas silt fences or straw bales in the waterway reduce the velocity of the runoff, thereby reducing the risk of gully formation in the new waterway.

A grassed waterway provides a vegetative strip that benefits the environment in several ways in addition to the primary benefit of providing a non-erosive waterway. These additional benefits include diversity of wildlife habitat, corridor connections, vegetative diversity, non-cultivated strips of vegetation, and improved esthetics. An additional grassed width on each side of the grassed waterway allows the waterway to better serve as a conservation buffer.

Contour Trenching

Contour trenching is excavating trenches along a uniform level across the slope of the land in the top portion of catchment. Bunds are formed downstream along the trenches with materials taken out of them. The main idea is to create more favorable moisture condition and thus accelerate the growth of vegetation.

Contour trenches break the velocity of runoff. The rain water percolates through the soil slowly and travels down and benefits the better types of land in the middle and lower section of the catchment. Where the lower fields are bunded, these trenches also protect the bunds from the runoff from the upper portion of the catchment. It also traps and stores the soil particles carried from the upper ends with runoff.

PROGRAME- 6
GULLY CONTROL BY BRUSHWOOD CHECK DAM FOR MINIMIZING EROSION HAZARD AND RECLAMATION OF GULLIED LAND.

Objectives

a. To reduce the velocity of run-off.
b. To prevent deepening and widening of the gully.
c. To collect sedimentation and to recharge the water table.

Justification:

In the hills of CHT, stone is not generally available everywhere, but brushes and unused trees are available Where stones are not readily available, brushwood check dam can be constructed for slowly reclamation of the gullied land. Brushwood check dam increases absorption and infiltration of water into the soil. It also reduces the speed of runoff and consequently reduces the erosive power of surface flows. Brushwood check dams create scope for planting of crops once the dam is established. Brushwood check dam can be built easily. But it needs regular maintenance and repairing.

6.2 Salinity Management and Research Center (SMRC)
Soil Resource Development Institute
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Effect of Different types of organic matter on Soil Salinity and Yield of Sweet gourd in Coastal Saline Soil

A Biswas, Md. Z Islam

Abstract

Salinity causes serious cellular damage and limits crop productivity. Accumulation of organic matter is one of the best adaptive mechanisms to reduce salinity affect in plants. By reducing soil salinity and for obtaining a better sustainable yield, a low-cost and farmer-ecofriendly method is required for sweet gourd, a well known vegetable. Accordingly, a field experiment was carried out in Salinity Management and Research Center, Soil Resource Development Institute, Batiaghata, Khulna during Kharif-1 season in 2023 to investigate the effect of different types of organic matter on soil salinity and yield of sweet gourd. The experiment includes five treatments viz. no organic matter (control), cow dung, saw dust, poultry manure and vermi-compost. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Field Soil salinity was recorded at 30 days intervals. Organic matter has showed that this causes effectively reduction the salt accumulation in the plant body and some modification accelerated. After three months of seed sowing, the highest soil salinity (15.7 dS/m) and lowest soil salinity (9.3 dS/m) were found at no organic matter (control) and poultry manure treatment respectively in the month of May. Organic matter treatments obviously have increased the growth and yield attributes of sweet gourd. The highest value of four growth parameters i.e., fruit length (23.40 cm), fruit diameter (80.40 cm), fruit weight (3.78 kg) and total yield (31.32 t/h) was found on poultry manure as compared to control. Again, the lowest value of four growth parameters i.e., fruit length (15.40 cm), fruit diameter (43.40 cm) , fruit weight (2.12 kg) and total yield (12.34 t/h) were found on saw dust treatment. The results revealed that the use of organic matter decrease soil salinity strength and also increases the yield of sweet gourd in saline soil. These findings suggest that the application of organic matter not only reduces soil salinity but also increases the structure of soil, regulate microbes and yield of sweet gourd.

Keywords: Salinity; cow dung; saw dust; poultry manure; yield; sweet gourd.

Introduction

Salinity as a whole is very dangerous problem at present situation of crop production of southern part of Bangladesh. Soil salinity stress increases the accumulation of toxic ions such as Na+ and Cl- in different plant parts, tissues, cells and cell organelles (Gadallah, 1999). Soil salinization is a major process of land degradation that decreases soil fertility and crop productivity. There is a report that coastal regions of Bangladesh are quite lower in soil fertility (Haque, 2006; Kibria et al., 2015). All soils contain a few water-soluble salts, but when these salts happen in sums that are harmful for the germination of seeds and plant development, they are called saline (Conway, 2001). Salt affected soils generally exhibit poor structural stability due to low organic matter content. Many researchers have suggested that the structural stability of soil can be improved by the addition of organic materials (e.g. saw dust, vermin compost, cow dung and poultry manures). Soil salinity is a major barrier to crop production all over the world that affects probably all plant activities. Million hectares of land throughout the world are too saline to produce economic crops, and more land is becoming nonproductive each year due to salinity build up. Approximately 7% of the world's land area, 20% of the world's cultivated land and nearly half of the irrigated land are affected by soil salinity (Zhu, 2001; FAO, 2008; Mali et al., 2012). In view of another projection, 2.1% of the global dry land agriculture is affected by salinity (FAO, 2008). Besides this, increasing soil salinity of arable land is expected to have devastating global effects, resulting in up to 50% land losses by the middle of the twenty-first century (Mahajan and Tuteja, 2005). Out of total agricultural land about 2.86 million hectares of coastal and offshore lands of Bangladesh , about 10.56 lakh hectares are affected by varying degrees of soil salinity (SRDI, 2010). Among the environmental stresses, soil salinity is the most devastating (Shahbaz and Ashraf, 2013) which not only affect the plant growth and metabolism but also poses a foremost limitation to sustainable agricultural production (Tayyab et al., 2016). Important practice is the application of organic manure which can both ameliorate and increase the fertility of saline soil (Melero et al., 2007). Organic mulches can reduce the effect of salt toxicity on plant growth (Ansari et al. 2001; Landis 1988; Yobterik and Timmer, 1994) or actively accelerate soil desalinization (Dong et al. 1996). Considering the above fact, applying organic matter is one of the suitable technologies for reducing soil salinity, it reduces evapotranspiration and helps soil salinity remains lower in the soil. There are evidences that soil amendments with organic matter reduce the toxic effects of soil salinity in various plant species (Idrees et al., 2004; Abou El-Magd et al., 2008; Leithy et al., 2010; Raafat and Thawrat, 2011). Yield characteristics like diameter of fruit, weight of fruit and fruits per vine showed significant results with black polyethylene mulch in case of different high value vegetables in Bangladesh (Islam F, et al., 2010). Organic matter amendments improve physical, chemical and biological properties of soils under saline conditions. This experiment is designed to find out the effect of different organic matter on soil salinity management and to observe the yield performance of sweet gourd.

Materials and Methods

Study location

This experiment was conducted at the Salinity Management and Research Centre (SMRC), Soil Resource Development Institute, Batiaghata, Khulna, Bangladesh during the Kharif-1 season of 2023. Geographically, the study site was at 22°46'01.8" N latitude and 89°24'15.2" E longitude and under AEZ-13. With an average yearly temperature of 79.3 °F and monthly mean temperatures ranging from 54.3 °F in January to 93.7°F in May, the area is among the warmest in Bangladesh. The land type of experimental plot was medium high land, land form was basin, land use was Fallow-kharif vegetable-transplanted aman, depth of flooding was 11/2-2 feet & duration of flooding was 3-4 months, soil series was barisal.

Layout of Experiment and Management of crop

The following expecting experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Sweet gourd (variety: Bengal sweet gourd-2) was taken as an experimental crop. Five experimental treatments were considered: (T_1) control (no organic matter), (T_1) cow dung, (T_2) vermi-compost, (T_3) saw dust and (T_4) poultry manure with 3 replication. For gaining good tilt of soil condition, the experiment plot was prepared by several ploughing and cross ploughing followed by laddering and harrowing with tractor and power tiller. Weeds and other stables were removed carefully from the experimental plot and leveled properly. Basal doses of fertilizer were applied during land preparation.

Pit preparation

Total land was designed according to achieving the expected yield. The measurement of pit was One foot length x one foot breadth according to experimental demand. Then five experimental treatments were considered (T_1) control (no organic matter), (T_1) cow dung, (T_2) vermi-compost, (T_3) saw dust and (T_4) poultry manure. Then pit soil and treatments materials were mixed with soil very properly, leveling and marked for data collection. After processing the pit area, sweet gourd seeds were sown in the pit with experimental need. Proper care and management were taken when pit was prepared. Necessary care and other intercultural operations were done when necessary. Data were recorded in accordance with the requirements. Soil salinity was measured by using an EC Meter at 30 days intervals. All the intercultural operations like watering, gap filling, staking, weeding, and plant protection measures were executed carefully.

Measurement of Growth and Yield attributes

Four growth and yield parameters such as fruit length (cm), fruit diameter (cm), fruit weight (kg) and total yield (ton/ hectare) were taken into consideration to analyze the effect of organic matter on yield of sweet gourd. Total yield (t/ha) was calculated by measuring the total fruit weight of the plot.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				μg/g			
7.6	2.98	0.37	0.17	10.72	14.98	2.96	0.52
Slightly Alkaline	M	H	L	L	L	VH	O

Statistical Analysis

The collected data were tabulated and statistically analyzed using Statistix10 software. The treatment means were separated statistically at a 5 % level of significance using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Effects of Different organic matter on Soil Salinity reduction

Salinity controlling in root zone area in saline soil fields is highly considered beneficial to seed emergence and stand establishment" (Dong et al., 2010). In modern studies has shown that organic matter is a promising technique for salinity control in present agriculture. An upward trend of soil salinity at all treatments was observed from February to May (Table 1). In the month of February, the lowest soil salinity was found at poultry manure (4.10 dS/m) while the highest soil salinity was observed at control (4.3 dS/m) where no organic matter was used and saw dust (4.3 dS/m). Since soil salinity increases gradually from the month of February to May, the lowest salinity was found in the month of February (4.10 dS/m) as compared to the highest in the month of May (15.7 dS/m). In the month of May, the lowest soil salinity was found at poultry manure (9.3 dS/m) in comparison with the highest soil salinity found in control condition (15.7 dS/m) (Table 1). This data revealed that soil salinity can be reduced by using different organic matter in which poultry manure has a great significant effect on reducing soil salinity. some authors emphasized These results and reported that all organic matter effectively reduced salt accumulation in the root zone (Taia A, et al., 2016).

Table 1: Month wise soil salinity of the experimental plot

Treatment	Month wise Soil salinity (EC: dS/m)			
	Feb	Mar	April	May
T_0 (Control)	4.3	7.4	11.2	15.7
T_1 (Cow dung)	4.2	6.4	9.2	12.4
T_2 (Vermi-compost)	4.2	5.1	8.9	10.2
T_3 (Saw dust)	4.3	7.3	11.1	15.4
T_4 (Poultry manure)	4.1	4.3	7.5	9.3

Effects of different organic matter on Yield Attributes of sweet gourd

Fruit length of sweet gourd

This experiment shows that, fruit length and other fruit length related parameters varies a lot that were statistically analyzed as shown in Table 2. They showed a significant variation in relation to different organic matter. The fruit length at control condition was 16.23 cm, at the saw dust treatment it was about 15.40 cm and at treatment with cow dung it was 17.33 cm but at vermi compost treatment it was 22.50 cm of fruit length. The highest fruit length (23.40 cm) was found at poultry manure, while the lowest (15.40 cm) was found where saw dust was applied. The highest fruit length (23.40 cm) was observed at poultry manure in comparison with the saw dust treatment where the lowest fruit length (15.40 cm) was found (Table 2).

Table 2: Yield and Yield attributes of sweet gourd in saline soil

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Fruit weight (kg)	Yield (t/ha)
T_0 (Control)	16.23b	61.20c	2.45b	16.78c
T_1 (Cow dung)	17.33b	67.20b	2.79b	22.34b
T_2 (Vermi-compost)	**22.50a**	**78.30a**	**3.62a**	**30.43a**
T_3 (Saw dust)	15.40b	43.40d	2.12b	12.34d
T_4 (Poultry manure)	**23.40a**	**80.40a**	**3.78a**	**31.32a**
CV (%)	5.67	3.79	12.35	5.07
LSD	2.02	4.71	0.68	2.16

Fruit Diameter of sweet gourd

Fruit diameter manipulated in accordance with the organic matter treatment at the plot. So that continuing experiment showed that, fruit diameter and other components of creating fruit diameter quality enhance related parameters varies to a wide that were statistically analyzed as shown in Table 2. Those attributes showed a significant variation in relation to different organic matter. The fruit diameter at control condition was 61.20 cm, at the saw dust treatment the diameter was about 43.40 cm and at treatment with cow dung it was 67.20 cm but at vermi compost treatment, the fruit diameter was 78.30 cm. The highest fruit diameter (80.40 cm) was found at poultry manure, while the lowest fruit diameter (43.40 cm) was found where saw dust was applied. The highest fruit diameter (80.40 cm) was observed at poultry manure in comparison with the saw dust treatment where the lowest fruit diameter (43.40 cm) was found (Table 2). It had been observed that fruit diameter (cm) and other fruit diameter contributing characteristics to plant of sweet gourd were significantly superior to poultry manure organic matter while plants without organic matter (control situation) resulted in poor growth and fruit diameter.

Fruit weight of sweet gourd

Different growth stages and developmental indicators of sweet gourd varied at the different plot. It was happened due to application of different organic matter to plants. The fruit weight of different plants of various plot of sweet gourd grown under different organic matter treatments are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these were significantly varied due to different organic matter. The fruit weight at control condition was 2.45 kg, at the saw dust treatment the weight was about 2.12 kg and at treatment with cow dung it was 2.79 kg but at vermi compost treatment, the fruit weight was 3.62 kg. The highest fruit weight (3.78 kg) was found at poultry manure, while the lowest fruit weight (2.12 kg) was found where saw dust was applied. The highest fruit weight (3.78 kg) was recorded in poultry manure whereas the lowest fruit weight (2.12 kg) was found in saw dust treatment (Table 2). That experiment indicated that plants under different organic matter treatment, produce larger fruit and have higher fruit weight per plant because of the better plant growth that is due to a favorable hydrothermal regime of soil and a completely weed free environment. Organic matter changes the micro environment of the plant and thus it enhances plant growth and vigor as well as production and yield. This result may be due to the improvement of soil physical properties as well as increasing soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption.

Total yield of sweet gourd

Properly completion of sweet gourd growth stages and developmental process varied at the different plot. It was occurred due to application of different organic matter to plants. The total yield of different plants of various plot of sweet gourd grown under different organic matter treatments are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these were significantly varied due to different organic matter. The total yield of sweet gourd at control condition was 16.78 t/ha, at the saw dust treatment the total yield was about 12.34 t/ha and at the treatment with cow dung it was 22.34 t/ha but at vermi compost treatment, the fruit yield was 30.43 t/ha. The highest fruit yield (31.32 t/ha) was found at poultry manure, while the lowest fruit weight (12.34 t/ha) was found where saw dust was applied (Table 2). The doing experiment showed that plants under different organic matter promotes larger fruit and have higher fruit yield per plant because of the better plant growth that is due to a favorable nutrient channel through the soil and a completely symbiosis environment. This result may be due to the improvement of soil physical properties as well as increasing soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption. Organic matter changes the micro environment of the plant and thus it enhances plant growth and vigor as well as production of total yield of sweet gourd.

Fig. -Control Plot

Fig.- Cow dung Plot

Fig. - Vermi compost plot

Fig- Saw dust plot

Fig.- poultry manure Plot

Conclusion

Sustainable soil management practices and the maintenance of soil salinity are central issues to agricultural sustainability. It may be concluded from that experiment's findings that using organic matter prompt to a noticeable decrease in the accumulation of soil salinity. Maximum soil salinity was reduced by using poultry manure in comparison with the control treatment where no organic matter was applied. This experiments point out that, soil salinity reduce by the following order of treatment: poultry manure > vermi-compost > cow dung > saw dust > control. Different growth and yield attributes were significantly impacted due to different organic matter treatments. This results showed that, poultry manure treatments gave the highest yield (31.32 t/ha) whereas, the lowest yield (12.34 t/ha) was recorded in saw dust treatment. Among five of organic treatment, poultry manure can be used at the farmer's level to reduce soil salinity strength and increase the yield of sweet gourd. However, further research is still needed to work out a cost effective technology to reduce soil salinity and increase the yield of sweet gourds.

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Avoiding soil salinity through different sowing method of sweet gourd in coastal saline soil

A Biswas, Md. Z Islam

Abstract

A field experiment was conducted at Salinity Management and Research Center, Soil Resource Development Institute, Batiaghata, Khulna during 2023 in kharif-1 season to study the impact of saline water in the saline soil on the economics of sweet gourd (*Cucurbita pepo*) yield and soil salinity after the end of the crop. There were three treatments having early pit method, tray seedling transplanting method and conventional method. The design of the experiment was Randomized Complete Block Design (RCBD) with three replications. Every plot received recommended rate of nitrogen, phosphorus and potash fertilizer. The promising text crop was sweet gourd. Field Soil salinity was recorded at 15 days intervals. The treatments were early pit method, tray seedling transplanting and seed sowing directly conventional method. After three months of seed sowing into early pit method, tray seedling transplanting and conventional method the highest soil salinity (13.6 dS/m) and the lowest soil salinity (2.8 dS/m) were found at conventional method plot and early pit method plot respectively in the month of May. Early pit method treatment obviously has increased the growth and yield attributes of sweet gourd. The highest value of four growth parameters viz., fruit length (20.30 cm), fruit diameter (82.06 cm) , single fruit weight (3.98 kg) and total yield (34.56 t/h) were found on early pit method as compared to other method. Again, the lowest value of four growth parameters i.e., fruit length (15.20 cm), fruit diameter (69.56 cm) , single fruit weight (2.72 kg) and total yield (25.22 t/h) were found on conventional method respectively. The changing of crop production time and method has a positive effect on fruit yield. Application of different

time of cultivation and method increase soil moisture content and reduce electrical conductivity therefore it is recommended for sustainable yield of sweet gourd in saline soil and reduces soil salinity related land degradation and have a great potential under saline prone areas.

Keywords: salinity; pit method; tray; conventional; potential

Introduction

Limitation in crop productions in south and south western area due to salinity problem in soil and water is a very serious problem. In the coastal saline belt with short winter season timely sowing/planting of Rabi (winter season) crops is essential but this is restricted by late harvest of aman rice. Rainy water storing in land causes late water recession from the cropping land. This water inundation condition makes the 'Joe' stage occurring in late in soil. And when Joe comes in cropping soil, at the same time salinity starts to increase in soil and water. Evaporation, evapotranspiration, hydrolysis, and leakage are the causes of salt accumulation when mineralized ground water near the ground surface continually evaporates and causes minerals to precipitate and by evapotranspiration where infiltrating recharge water is continually taken up by plants and salt is concentrated in the unsaturated root zone. It is very difficult to control of salinity existing in soil and water. It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost. If planting date or seedling transplantation may change in early or time may convert in different sowing time, it will cause the crop production in early without any damage of yield. It will prohibit salt storing and upward in top soil by breaking down the capillary action that increases starts from last of February. Ground water depth and salinity are affected by the sea and river water level and river water salinity. Since groundwater is the lower boundary condition of surface soil salinity, and also groundwater is closed related to river water, it is the important link between soil and river water. As the river water level and salinity changes, groundwater environment and soil salinity would be affected. Salinity level increases starts from February to May and decrease starts from the starting of rainy season in every year. It has a great effect on crop yield in dry season due to increased salinity level. If fresh water supply may increase in dry season, it reduces the salinity effect in crop production in Khulna. Rainfall also reduces the surfaces soil salinity. Soil salinity adversely influences seed germination, agricultural productivity, and soil and water quality, particularly in semiarid and arid regions, bringing about loss of arable areas and land degradation (Balkanlou et al., 2020; Bennett et al., 2019; Buthelezi-Dube et al., 2020). Soil salinization is the main reason for land degradation and crop yield reduction (Ivushkin et al., 2019; Makinde & Oyelade, 2019). In dry irrigated regions, the combination of elevated evapotranspiration (ET), little precipitation and soil factors hamper infiltration. Agricultural land use in these areas is very poor, which is much lower than a country's average cropping intensity that cause hydrological situation that restrict the normal crop production throughout the year. The factors which contribute significantly to the development of saline soil are tidal flooding during wet season (June to October), direct inundation by saline water, and upward or lateral movement of saline ground water during dry season (February to May). The severity of salinity problem in Bangladesh increases with the desiccation of the soil. In general, soil salinity is believed to be mainly responsible for low land use as well as low cropping intensity in the area (Rahman & Ahsan, 2001). Salt accumulation in the root zone or soil surface results in loss of soil fertility and alters the soil properties and therefore harmfully impacts soil's environmental functions (Fu et al., 2020). For instance, it restricts water intake and soil water capacity limit to plant uptake, which prompts surface runoff and erosion (Gorji et al., 2020). The occurrence of parent materials and physical or chemical weathering of minerals and seawater intrusion is the leading natural cause of soil salinization (Ramos et al., 2020). Saltwater intrusion is a natural process where seawater mix with coastal groundwater aquifers due to the density difference between saline and fresh waters, creating a barrier that evolves landward (Barlow and Reichard, 2010). Since, soil "joe" condition comes late in coastal area, thus farmer starts cultivation in late and that is why that crop faced high salinity. But if we start cultivation early, then we can avoid salinity. Thus, the study was carried out to find out the yield of sweet gourd by avoiding the soil salinity.

Materials and Methods

Study location

This experiment was conducted at the Salinity Management and Research Centre (SMRC), Soil Resource Development Institute, Batiaghata, Khulna, Bangladesh during the Kharif-1 season of 2023. Geographically, the study site was at 22°46'01.8" N latitude and 89°24'15.2" E longitude and under AEZ-13. With an average yearly temperature of 79.3 °F and monthly mean temperatures ranging from 52.4 °F in January to 99.8°F in May, the area is among the warmest in Bangladesh (AEZ-13). The land type of experimental plot was medium high land, land form was basin, land use was Fallow-kharif vegetable-transplanted aman, depth of flooding was 11/2-2 feet & duration of flooding was 3-4 months, soil series was barisal.

Experimental design

The following expecting experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Sweet gourd (variety: Bengal sweet gourd-2) was taken as an experimental crop. Three experimental treatments were considered: (a) early pit method, (b) Tray seedling transplanting method, (c) Conventional pit preparation method with five replications.

Preparation of early pit

Water recession condition of south west part of Bangladesh is late. Thus "joe" condion comes at first week of March. Before that soil keep moist. In early pit method, pit was prepared in 01-02-2023 in moist soil without ploughing the land. Then pit was kept fallow in sunshine. The "joe" condition of pit came in 10-02-2023. Then sweet gourd seed was sown in 10-02-2023.

Tray seedling preparation

The second method was transplanting of tray seedling. Seedlings were grown early in tray. Seed was sown in tray in 25-02-2023. 15 days old seedlings were transplanted in main field in 13-03-2023.

Conventional pit preparation

In conventional method land was plough and made pit. Then pit soil and other fertilizer treatments were mixed with soil very properly. After processing the pit area, seeds were sown in the pit in 13-03-2023. Soil salinity was measured by using an EC Meter at 15 days intervals. All the intercultural operations like watering, gap filling, staking, weeding, and plant protection measures were executed very carefully.

Measurement of Growth and Yield attributes

Experiment was carried out for four growth and yield parameters such as fruit length (cm), fruit diameter (cm), single fruit weight (kg) and total yield (t/ha) were taken into consideration to analyze the effect of different pit method on yield of sweet gourd. Total yield (t/ha) was calculated by measuring the total fruit weight of the plot.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			
7.6	2.98	0.37	0.17	10.72	14.98	2.96	0.52
Slightly Alkaline	M	H	L	L	L	VH	O

Statistical Analysis

The collected data were tabulated and statistically analyzed using Statistix10 software. The treatment means were separated statistically at a 5 % level of significance using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Soil salinity condition of different types of pit

When seed was sown (10-02-2023) in pit that made early method, then soil salinity was 2.8 dS/m. At the time of tray seedling transplanting and normal seed sowing (13-03-2023), then soil salinity was 4.2 dS/m (Table 1). Soil salinity of early pit method at harvesting time (28-04-2023) was 8.1 dS/m, whereas other two method pit crops were in growing condition. In 13-05-2023 tray seedling crops were harvested and that time salinity was increasing at that time. Crops grown in conventional method harvested in 28-05-2023, faced long period high salinity. At harvesting time of conventional method the salinity was 13.6 dS/m.

Table 1: EC (dS/m) at different sowing/transplanting date in the field

Treatment	EC (dS/m)					
	10-02-2023	13-03-2023	13-04-2023	28-04-2023	13-05-2023	28-05-2023
T_1 (Early pit method)	2.8	4.2	6.3	8.1	-	-
T_2 (Tray seedling method)	-	4.2	6.3	8.1	11.3	-
T_3 (Conventional method)	-	4.2	6.3	8.1	11.3	13.6

EC: Electrical Conductivity

EC determined by 1: 1 extraction Method

Effects of different sowing method on Yield Attributes of sweet gourd

Fruit length of sweet gourd

The research showed that, the fruit length varies to a great extent that was statistically analyzed as shown in Table 2. Fruit length showed a significant variation in relation to different pit method treatment. After production with different pit method, the fruit length at early pit method (seed sown in 10-02-2023) was 20.30 cm, the fruit length at tray seedling method (transplanted in 13-03-2023) was 17.60 cm and the fruit length at conventional method (seed sown in 13-03-2023) was 15.20 cm. The highest fruit length (20.30 cm) was found at early pit method while the lowest fruit length (15.20 cm) was found where conventional method was followed. It was also found that fruit length (cm), numbers of fruit per plant of sweet gourd were significantly superior in early pit method to other treatments plot. Other planting treatments resulted in poor growth and yield of sweet gourd.

Table 2: Yield and Yield attributes of sweet gourd at different sowing method

Treatment	Fruit length (cm)	Fruit diameter (cm)	Single fruit weight (kg)	Total yield (t/ha)
T_1 (Early pit method)	20.30a	82.06a	3.98a	34.56a
T_2 (Tray seedling method)	17.60b	78.50b	3.11b	30.18b
T_3 (Conventional method)	15.20c	69.56c	2.72c	25.22c
CV	5.96	1.41	4.95	1.10
LSD	2.39	2.44	0.36	0.74

Fruit Diameter of sweet gourd

Salts affect plant growth due to increasing soil osmotic pressure and to interference with plant nutrition. A high salt concentration in soil solution reduces the ability of plants to acquire water, which is referred to as the osmotic or water deficit effect of salinity. The highest fruit diameter (82.06 cm) was found at early pit method. In case of tray seedling method, the fruit diameter was 78.50 cm and in case of conventional method, the fruit diameter was 69.56 cm. The highest fruit diameter (82.06 cm) was observed at early pit method in comparison with the conventional planting method where the lowest fruit diameter (69.56 cm) was found (Table 2). It is a great sign that shows different pit method cultivation positively affect the soil salinity and manipulates the soil structure, texture, biochemical reaction and soil fertility. It is also found that fruit diameter, numbers of fruits per plant and other growth of sweet gourd were significantly superior in early pit method to other method of another plot. Salinity lowers the total photosynthetic capacity of the plant through decreased leaf growth and inhibited photosynthesis limiting its ability to grow.

Single fruit weight of sweet gourd

Sweet gourd yield parameters and single fruit weight grown under different methods are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these are significantly varied due to different planting method. The single fruit weight 3.98 kg was found in early pit method. In case of tray seedling method, the single fruit weight was 3.11 kg and in case of conventional method, the single fruit weight was 2.72 kg. The highest single fruit weight 3.98 kg was observed in early pit method in comparison with the conventional method where the lowest single fruit weight 2.72 kg was found (Table 2). That experiment indicated that plants under different planting method produce larger fruit and have higher single fruit weight per plant because of the better plant growth that is due to a favorable agro climate environment of soil and a completely moderate environment. Different planting method changes the micro environment of the plant and thus it enhances plant growth and vigor as well as production.

Total yield of sweet gourd

Soil salinity works against the growth of plants and developmental structure that varies of sweet gourd due to different planting method at different plot. The total yield and yield attributes grown under different pit method are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these are significantly varied due to different pit method. The total yield of fruit (34.56 t/ha) was found in early pit method. In case of tray seedling method, the total yield of fruit was 30.18 t/ha but in case of conventional method, the total yield of fruit was 25.22 t/ha. The highest total fruit yield (34.56 t/ha) was observed in early pit method in comparison with the conventional method where the lowest total fruit yield (25.22 t/ha) was found (Table 2).

Fig.-Conventional method

Fig.- Tray seedling method

Fig. - Early pit method

Conclusion

Soil salinity is becoming a major constraint to vegetable crop production. This experiments point out that, soil salinity remain by the following order of planting method: early pit method > tray seedling method > conventional method. Different growth and yield attributes were significantly impacted due to different pit method. This results showed that, early pit method gave the highest total yield (34.56 t/ha) whereas, the lowest total yield (25.22 t/ha) was recorded in conventional method. It may be conclude that early pit method may be helpful for avoiding soil salinity.

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Effect of Different doses of gypsum on Soil Salinity and Yield of Sweet gourd in Coastal Saline Soil

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Abstract

Soil salinity obviously is a major threat for growing sweet gourd vegetables in the coastal zone of Bangladesh. A noticeable experiment was conducted at Salinity Management and Research Center, Soil Resource Development Institute, Batiaghata, Khulna during Kharif-1 season in 2023 to investigate the effect of different doses of gypsum on soil salinity and yield of sweet gourd to find out if gypsum fertilizer can reduce soil salinity related degradation of soil and increase sweet gourd yield. There were five treatments having control (no application of gypsum/pit), gypsum fertilizer (5 g/pit), gypsum fertilizer (10 g/pit), gypsum fertilizer (15 g/pit) and gypsum fertilizer (20 g/pit). The design of the experiment was Randomized Complete Block Design (RCBD) with three replications. Every plot received recommended rate of nitrogen, phosphorus and potash fertilizer. The promising text crop was sweet gourd. Field Soil salinity was recorded at 30 days intervals. After three months of seed sowing, the highest soil salinity (15.5 dS/m) and lowest soil salinity (9.2 dS/m) were found at no gypsum application plot (control) and 20 g/pit of gypsum application treatment respectively in the month of May. Gypsum (20 g/pit) treatments obviously have increased the growth and yield attributes of sweet gourd. The highest value of four growth parameters viz., fruit length (24.10 cm), fruit diameter (81.80 cm) , fruit weight (3.92 kg) and total yield (32.13 t/h) were found on gypsum treatment (20 g/pit) as compared to other treatments. Again, the lowest value of those

four growth parameters i.e., fruit length (12.50 cm), fruit diameter (50.20 cm) , fruit weight (2.45 kg) and total yield (16.67 t/h) were found on control (no gypsum application) respectively. The gypsum application has a positive effect on fruit yield when it is applied with precise rate. Application of gypsum reduces soil salinity related land degradation in salt affected region of Bangladesh.

Introduction:

Soil salinity impedes soil and crop productivity in over 900 million hectare of arable lands worldwide due to the excessive accumulation of salt (NaCl) (Kumar,et al., 2018, Wani, et al., 2020). For utilizing saline soils in agriculture, halophytes (salt-tolerant plants) are commonly cultivated. Most food crops are glycophytes (salt-sensitive). Thus, to enhance the productivity of saline soils, gypsum ($CaSO_42H_2O$) has been continuously recognized to improve the biological, physical and chemical properties of saline soils. Gypsum ($CaSO_42H_2O$) regulates the exchange of sodium (Na+) for calcium (Ca_2+) on the clay surfaces, thereby increasing the Ca_2+/Na+ ratio in the soil solution (Pitman, et al., 2002). gypsum has been reported several times to sustain optimal K+/Na+ and Ca_2+/Na+ ratios, reduced pH as well as furnish crops with the required S nutrition in saline soils (Ahmed, et al., 2016; Abdel Hamid et al., 2013, Abdel-Fattah, M.K, 2015). Intracellular, Ca_2+ also promotes a higher K+/Na+ ratio (Almeida, et al., 2017). Simultaneously, gypsum furnishes crops with sulfur (S) for enhanced growth and yield through the increased production of phytohormones, amino acids, glutathione and osmoprotectants, which are vital elicitors in plants responses to salinity stress (Gadallah, 1999). Gypsum as a cheapest source of reclamation has been reported by many workers (Mohammad et al., 1969; Ghafoor & Muhammed, 1981; Ramzan et al., 1982). The use of gypsum as a reclaim agent is the most economic one compared to rest of other chemical reclaim agent. Its rate of dissolution in the irrigation water is very low and therefore its application needs large amount of irrigation water (Richards, 1954; Murphy, 2018). Oster and Halvorson (1978) however, have shown that the solubility of gypsum may increase more than other fertilizer when an amendment mixed with highly saline soils. Through the provision of S, gypsum increases plants' tolerance and resistance to both biotic and abiotic stress factors by aiding the synthesis of proteins, chlorophyll-containing compounds as well as an increased uptake of P and N (Capaldi, et al., 2015,Wiedenfeld, et al., 2011). Soil salinity could be a major restricting factor that imperils the capacity of agricultural crops to sustain the developing human population. It is characterized by a high concentration of solvent salts that significantly decreases the yield of most crops (Sharma A, et al., 2016).The ameliorating effect of gypsum on saline soils, sweet gourd was selected to monitor its response to various levels of gypsum doses under saline conditions, as sweet gourd influenced by the gypsum amendment. In this respect the residual effect of gypsum was also evaluated by next growing crop in the same land.

Keywords: salinity; gypsum; sulfur; halophytes; glycophytes.

MATERIALS AND METHODS

Study location

This experiment was conducted at the Salinity Management and Research Centre (SMRC), Soil Resource Development Institute, Batiaghata, Khulna, Bangladesh during the Kharif-1 season of 2023. Geographically, the study site was at 22°46'01.8" N latitude and

89°24'15.2" E longitude and under AEZ-13. With an average yearly temperature of 79.3 °F and monthly mean temperatures ranging from 52.4 °F in January to 99.8°F in May, the area is among the warmest in Bangladesh (AEZ-13). The land type of experimental plot was medium high land, land form was basin, land use was Fallow-kharif vegetable-transplanted aman, depth of flooding was 11/2-2 feet & duration of flooding was 3-4 months, soil series was barisal.

Fertilizer at experimental plot

The following expecting experiment was carried out in Randomized Complete Block Design with three replications. Sweet gourd (variety: Bengal sweet gourd-2) was taken as an experimental crop. Five experimental treatments were considered: (a) control (no gypsum application), (b) Gypsum at 5g/pit, (c) Gypsum at 10g/pit, (d) Gypsum at 15g/pit and (e) Gypsum at 20g/pit with 3 replications. For gaining good tilt, soil condition, the experiment plot was prepared by several ploughing and cross ploughing followed by laddering and harrowing with tractor and power tiller. Weeds and other stables were removed carefully from the experimental plot and leveled properly. Basal doses of fertilizer as soil test base were applied during land preparation.

Pit preparation

Total land was designed according to achieving the expected yield. Pit was made by measuring one foot length x one foot breadth that was determined in earlier. Then five experimental treatments were considered: (a) control (no gypsum application), (b) Gypsum at 5g/pit, (c) Gypsum at 10g/pit, (d) Gypsum at 15g/pit and (e) Gypsum at 20g/pit. Then pit soil and gypsum treatments were mixed with soil very properly, leveling and distinguished according to the gypsum treatments. After processing the pit area, seeds were sown in the pit with experiments need. Proper care and management were taken when pit was prepared. Necessary care and other intercultural operations were done when necessary. Data were recorded in accordance with the requirements. Soil salinity was measured by using an EC Meter at 15 days intervals. All the intercultural operations like watering, gap filling, staking, weeding, and plant protection measures were executed timely and carefully.

Measurement of Growth and Yield attributes

Four growth and yield parameters such as fruit length (cm), fruit diameter (cm), fruit weight (kg) and total yield (ton/hectare) were taken into consideration to analyze the effect of gypsum treatments on yield of sweet gourd. Total yield (t/ha) was calculated by measuring the total fruit weight of the plot.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			
7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical Analysis

The collected data were tabulated and statistically analyzed using Statistix10 software. The treatment means were separated statistically at a 5 % level of significance using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Effects of Different gypsum treatments on Soil Salinity reduction

Soil salinity strength is a most carrier of harmful effect for crop production in salt based land. In modern studies has shown that gypsum is a promising technique for soil salinity control in present agriculture. An upward trend of soil salinity at all treatments was observed from February to May (Table 1). In the month of February, the lowest soil salinity was found at gypsum treatments at 15g/pit and 20g/pit (4.0 dS/m) respectively, while the highest soil salinity was observed at control (4.2 dS/m) where no gypsum was applied. Since soil salinity increases gradually from the month of February to May, the lowest salinity was found in the month of February (4.0 dS/m) as compared to the highest in the month of May (15.5 dS/m). In the month of May, the lowest soil salinity was found at gypsum application at 20g/pit (9.2 dS/m) in comparison with the highest soil salinity found in control there was no application of gypsum (15.5 dS/m) (Table 1). This data proved that soil salinity can be reduced by using different doses of gypsum. Application of gypsum has a great significant effect on reducing soil salinity. Gypsum is a salt reducing chemical that protect the upward movement of salinity capillary action to the top soil and promote the crop production.

Table 1: Month wise soil salinity of the experimental plot

Treatment	Month wise Soil salinity (EC: dS/m)			
	Feb	Mar	April	May
T_0 (Control)	4.2	7.5	11.0	15.5
T_1 (5 gm/pit)	4.1	6.9	9.8	11.2
T_2 (10 gm/pit)	4.1	6.7	8.7	9.8
T_3 (15 gm/pit)	4.0	6.5	8.6	9.3
T_4 (20 gm/pit)	4.0	6.5	8.5	9.2

Effects of different doses of gypsum on Yield Attributes of sweet gourd

Fruit length of sweet gourd

This experiment proved that, the fruit length varies to a great extent that was statistically analyzed as shown in Table 2. Fruit length showed a significant variation in relation to different doses of gypsum application. After treating with gypsum, the fruit length at control treatment (no gypsum was applied) was 12.50 cm, the fruit length at 5 gm/pit of gypsum application was 19.60 cm, the fruit length at 10 gm/pit of gypsum application was 23.40 cm, the fruit length at 15 gm/pit of gypsum application was 23.80 cm, but the highest fruit length (24.10 cm) was found at 20 gm/pit of gypsum application, while the lowest (12.50 cm) was found where no gypsum was applied. It is also found that fruit length (cm), numbers of fruit per plant of sweet gourd were significantly superior at 20 gm/pit of gypsum treatments to other non amendments plot or other fertilizer treatments, while plants without gypsum treatments (control condition) resulted in poor growth and yield sweet gourd.

Table 2: Yield and Yield attributes of sweet gourd in saline soil

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Fruit weight (kg)	Yield (t/ha)
T_0 (Control)	12.50c	50.20c	2.45b	16.67c
T_1 (5 gm/pit)	19.60b	75.30b	2.97b	25.45b
T_2 (10 gm/pit)	23.40a	80.40ab	3.78a	30.97a
T_3 (15 gm/pit)	**23.80a**	**81.20ab**	**3.90a**	**31.52a**
T_4 (20 gm/pit)	**24.10a**	**81.80a**	**3.92a**	**32.13a**
CV (%)	5.96	4.43	8.67	4.41
LSD	2.31	5.99	0.55	2.27

Fruit Diameter of sweet gourd

The application of gypsum in soil maintains a good soil condition and decrease the level of salinity strength. The fruit diameter (50.20 cm) found at control condition where no gypsum was applied. In case of 5 gm/pit of gypsum application, the fruit diameter was 75.30 cm and in case of 10 gm/pit of gypsum application, the fruit diameter was 80.40 cm, but at the rate of 15 gm/pit of gypsum application it was found that the fruit diameter was 81.20 cm. The highest fruit diameter (81.80 cm) was observed at 20 gm/pit of gypsum application in comparison with the control treatment (no gypsum treatment was applied) where the lowest fruit diameter (50.20 cm) was found (Table 2). It is a great sign that shows different doses of gypsum positively affect the soil salinity and manipulates the soil structure, texture, biochemical reaction and soil fertility. It is also found that fruit diameter (cm), numbers of fruits per plant and other growth of sweet gourd were significantly superior in gypsum treatments to other non amendments of another plot or other fertilizer treatments, while plants without gypsum treatments (control condition) resulted in poor growth and total yield components sweet gourd.

Fruit weight of sweet gourd

Different growth stages and development structure that was expected varies of sweet gourd due to different doses of gypsum application at the different plot. Sweet gourd yield parameters and fruit weight grown under different gypsum treatments are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these are significantly varied due to different doses of gypsum. The fruit weight (2.45 kg) found at control condition where no gypsum was applied. In case of 5 gm/pit of gypsum application, the fruit weight was 2.97 kg and in case of 10 gm/pit of gypsum application, the fruit weight was 3.78 kg, but at the rate of 15 gm/pit of gypsum application it was found that the fruit weight was 3.90 kg. The highest fruit weight (3.92 kg) was observed at 20 gm/pit of gypsum application in comparison with the control treatment (no gypsum treatment was applied) where the lowest fruit weight (2.45 kg) was found (Table 2). That experiment indicated that plants under gypsum treatments produce larger fruit and have higher fruit weight per plant because of the better plant growth that is due to a favorable agro climate environment of soil and a completely moderate environment. The data depicted that the highest fruit weight (3.92 kg) was found at 20 gm/pit of gypsum application while the lowest (2.45 kg) was found where no gypsum was applied. Application of gypsum changes the micro environment of the plant and thus it enhances plant growth and vigor as well as production. This result may be due to the improvement of soil physical properties as well as increasing soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption. It also helps to uptake of others nutrient by making easy soil metabolism.

Total yield of sweet gourd

Soil salinity works against the growth of plants and developmental structure that varies of sweet gourd due to different doses of gypsum application at the different plot. The total yield and yield attributes grown under different gypsum treatments are presented in Table 2. Statistical analysis was carried out on yield and yield attributes which revealed that these are significantly varied due to different doses of gypsum. The total yield of fruit (16.67 t/ha) was found at control condition where no gypsum was applied. In case of 5 gm/pit of gypsum application, the total yield of fruit was 25.45 t/ha and in case of 10 gm/pit of gypsum application, the total yield of fruit was 30.97 t/ha, but at the rate of 15 gm/pit of gypsum application it was found that the total fruit yield was 31.52 t/ha. The highest fruit yield (32.13 t/ha) was observed at 20 gm/pit of gypsum application in comparison with the control treatment (no gypsum treatment was applied) where the lowest fruit yield (16.67 t/ha) was found (Table 2) The experimental data indicated that the plants under gypsum treatments produce larger fruit and have higher fruit yield per plant because of the better plant growth that is due to a favorable agro climate environment of soil and a completely moderate environment. The data showed that the highest total yield (32.13 t/ha) was found at 20 gm/pit of gypsum application while the lowest (16.67 t/ha) was found where no gypsum was applied. Application of gypsum changes the micro environment of the plant and thus it enhances plant growth and vigor as well as production and total yield. This result may be due to the improvement of soil physical properties as well as increasing soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption. Gypsum reaction in soil makes it good nutrient uptaking condition and helps to yield contributing parameters high.

Fig.- Control Plot

Fig.- 5gm/pit Plot

Fig. - 10gm/pit plot

Fig.- 15gm/pit Plot

Fig.- 20gm/pit plot

Conclusion

Soil salinity management practices and the overcoming from soil salinity are central issues to agricultural productivity. It may be resolved from the experiment's findings that using gypsum prompts to a noticeable decrease in the accumulation of soil salinity. Maximum soil salinity reduced by using 20 gm/pit of gypsum in comparison with the control treatment where no gypsum was applied. This experiments point out that, soil salinity reduce by the following order of treatment: 20 gm/pit of gypsum > 15 gm/pit of gypsum > 10 gm/pit of gypsum > 5 gm/pit of gypsum > control. Different growth and yield attributes were significantly impacted due to different gypsum treatments. This results showed that, 20 gm/pit of gypsum treatment gave the highest yield (32.13 t/ha) whereas, the lowest yield (16.67 t/ha) was recorded in control (no application of gypsum) treatment. Among five of gypsum treatment, 10, 15 and 20 gm/pit of gypsum treatment gives statistically similar result in Barisal soil. Thus 10 gm/pit gypsum can be used at the farmer’s level to reduce soil salinity strength and increase the yield of sweet gourd. For increasing the yield of sweet gourd and reclamation of saline soil further research is still needed to work out a cost effective technology.

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Effect of different strength of soil salinity on growth and yield of cauliflower

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Abstract

Salt concentration in saline soil is a serious agricultural problem in south and south-western part of Bangladesh. This salt intensity creates a vital obstruction for cauliflower

(*Brassica* *oleracea* Lin.) and other crops production. The experiment was conducted in the Salinity Management and Research Center under Soil Resource Development Institute at Batiaghata, khulna to observe the effect of soil salinity strength management on growth and yield of cauliflower hybrids. The research work was conducted in a completely randomized design (CRD) with three replication of salt concentration (2,4,6,8,10,12 dS/m EC). Result of the experiment showed that the different combinations of soil salinity significantly influenced all the indicators that studied. Yield performance per plant was investigated for Plant height (cm), numbers of leaves/ plant, leaves length (cm), spreading diameter (cm), Curd diameter (cm), Curd yield/plant (gm) and gross yield/plant (gm).The yield data were recorded at harvest time. The parameters were significantly varied due to soil salinity management. Higher curd yield/plant (636 gm) was found in T_1 treatment (2 dS/m EC). It was demonstrated that salinity strength affect to decrease all the indicators that impact directly to the cauliflower yield with the increasing salt intensity.

Introduction

Cauliflower (*Brassica* *oleracea* Lin.) is one of the popular cole crops (botrytis Group) belonging Brassicaceae family (or Cruciferae) in the world. In the cultivation time excess salt level in saline soil causes serious physiological functional disorders, limiting vegetative and reproductive growth of vegetables and causes fertilization disorders decreases in marketing values, and also causes plant death (Dolarslan and Gul, 2012). Soil Salinity tolerance levels that affect yield are between 1.0-2.5 dS/m EC (Machado and Serralheiro, 2017). Cauliflower is a moderate salt sensitive vegetable, and the soil salinity uptaking level of irrigation water yield of cauliflower starts to decline between 1.9 and 2.7 dS/m EC (Snapp et al., 1991; Kotuby et al., 1997). The optimum temperature for cauliflower with stands is 10° to 15°C. Soil salinity strength effects the extensive number of observations on the physiology of plant salt tolerance to a genetic basis and particular modification (Zhu, 2000; Pardo, 2010). Soil salinity is a serious problem in arid and semi-arid region of the world where poor quality water is available for irrigation (Tanji, 1990; Maas and Grattan, 1999). The yield of cauliflower is low due to lack of proper management practices and nutrients deficiency in the saline soil. National production of cauliflower was 268.48 thousand MT from 19.42 thousand ha (BBS, 2016). It was estimated that about 20% (45 million ha) of irrigated land, producing one-third of the world's food, is salt-affected (Shrivastava, P.; Kumar, R; 2015). The amount of world agricultural land destroyed by salt accumulation each year is estimated to be 10 million ha (Pimentel, D et al., 2004). It is estimated that, by 2050, 50% of the world's arable land will be affected by salinity (Bartels, D.; Sunkar, R, 2005) . In saline region it is almost impossible to cultivate more than one crop for salt concentration in soil and water. Farmer can not supply fresh and salt free irrigation in their field at crops demand time due to salinity problem in soil and water. The proper management of adequate soil physical, chemical and biological properties in saline environments may be gain by using irrigation water and soil amendments and proper cultural practices (Grattan and Oster, 2003). Short duration vegetables can be introduced in that region of medium high land. There is a huge scope in saline areas for vegetable cultivation through intensification and diversification of technology in the medium high land during winter. The shortage of fresh water and soil salt level, negatively effects on plant growth (Asık et al., 2009). Cauliflower would be a promising crop for that region. After recession of saline water and minimum salt concentration in soil and water, cauliflower and other winter vegetables could be grown easily in south saline area. Soil salinity generally stresses plant growth responses from specific salt tolerance properties (Dalton et al., 2000). Salinity inhibits photosynthesis by decreasing CO_2 availability as a result of diffusion limitation (Flexas, J, et al., 2007) and a reduction of the contents of photosynthetic pigments. Salt accumulation in cauliflower inhibits photosynthesis, primarily by decreasing stomatal and mesophyll conductance to CO_2 (Di Martino, C.; Delfine, S.; Alvino, A.; Loret, 1999) and reducing chlorophyll content, which can affect light absorbance (Thompson et al., 2007).Appropriate saline water and soil management would play an important role in plant growth and curd formation especially in saline soil in winter crops production. In saline soil condition, Saline water should be used optimally and carefully to get the desire results from the irrigated crops (Alsaadawi and Mohamed ,2000). Research showed that saline soil and water management enhanced curd yield/plant, gross yield/plant and yield attributes substantially. Utilization of saline water has been well documented to improve physical, chemical and biological properties of soil. But the farmers of saline area are not habituated of cauliflower cultivation with proper soil salinity management of the crop. The goal of this study was to test the salt tolerance of cauliflower at different soil salinity level. As a result, the current study was designed to evaluate the impacts of saline soil on cabbage growth and yield.

Materials and methods

The experiment was carried out at the salinity management and research center, under soil resource development institute, Batiaghata, Khulna to test the effect of different strength of saline soil on emergence, growth and yield of cabbage plant. Plastic pots were used in conducting the experiment. The plastic pots were firstly washed and followed by rinsing with distilled water. Then those pots were dried in air. After drying the plastic pots were ready for the experiment. Finely prepared soil was filled up to 4.5 cm of the pot by saline soil. Necessary amount of salt treatment was given to create saline environment by saturating the soil before placing the cabbage seedling. The trial included the following treatments: T_1 = 2±0.2 dS/m EC, T_2 = 4±0.2 dS/m EC, T_3 = 6±0.2 dS/m EC, T_4 = 8±0.2 dS/m EC, T_5 = 10±0.2 dS/m EC and T_6 = 12±0.2 dS/m EC. The single factor experiment used completely Randomized design (CRD) with three replications. The experiment was divided into three equal replication blocks, each with six plots. As a result, the total number of unit plots was 18. The experiment's treatment combinations were randomized at random to 18 plots, each with three replications. Proper management about salinity control over the pot and growth of plants were observed. Time to time weeding, fertilizer application, irrigation, pot checking and special care to plant proper growth were following upto yield harvesting. Every three days later water application, pest controlling chemical and abiotic affect was observed. The data was collected at 60 days after cauliflower was fully matured. Intercultural operations were carried out when needed. The following yield related indicators were measured: plant height (cm), numbers of leaves/plant, leaves length (cm), spreading diameter (cm), curd diameter (cm), days required for head formation /plant, curd yield/plant (gm) and gross yield/ plant (gm).

Preparation of saline soil

For developing the expected soil salinity of 2 to 12 dS/m EC, salt affected soil was collected from different place of saline affected area. Different concentrations of soil salinity (2, 4, 6, 8, 10 and 12 ds/m) was applied to the transplanted seeding on plastic pot. The salinity level was maintained by assessing the salt level from laboratory test.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			

7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical analysis

The data obtained for different characters were statistically analyzed. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' test by using statistix software, version 10.

Results and discussions

Plant height

Cauliflower showed significant variation in plant height at 20, 40 and 60 days after transplanting (DAT) (Table 1). Significant variation of plant height was found due to management at different soil salinity strength to plants growth stages. At 20 DAT, 40 DAT and 60 DAT, the highest plant height of 14.60 cm, 24.60 cm and 32.83 cm respectively which was statistically similar (32.23) to T_2 (4dS/m EC) respectively was observed when the plants received recommended saline water (T_1) of 2 dS/m EC, and the lowest plant height at 20 DAT, 40 DAT and 60 DAT was 10.23 cm, 12.60 am and 21.33 cm respectively at T_5 (10 dS/m EC). At 60 DAT, the longest plant (32.83 cm) was found in T_1 treatment of 2 dS/m EC. The main causes of above result are the presence of available salinity strength of soil in sole application to pot for plant growth.

Table 1: Different plants parameter of different growth stages at different Soil salinity strength.

Treatment	PH			NL			LL
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	
T_1 (2±0.2 dS/m)	14.60a	24.60a	32.83a	11.66a	21.00a	30.33a	37.70a
T_2 (4±0.2 dS/m)	12.10b	20.80b	32.23a	10.33b	15.66b	27.00b	36.63a
T_3 (6±0.2 dS/m)	11.30bc	18.16c	29.66b	9.33c	13.33c	21.33c	30.06b
T_4 (8±0.2 dS/m)	10.50c	15.53d	26.76c	6.33d	10.66d	16.00d	25.83c
T_5 (10±0.2 dS/m)	10.23c	12.60e	21.33d	3.66e	8.33e	14.66d	16.70d
T_6 (12±0.2 dS/m)	0.00d	0.00f	0.00e	0.00f	0.00f	0.00e	0.00e
LSD	1.55	1.78	2.24	0.93	1.10	2.05	2.53
CV	8.94	6.58	5.30	7.65	5.42	6.34	5.83

*EC determined by 1: 1 extraction Method

Plant height (cm)=PH, Numbers of leaves/plant=NL, leaves length (cm)=LL

Number of leaves per plant

Number of leaves per plant for every cauliflower plants at different DAT has been shown in Table 1, because of the influence of different salinity strength of soil, a significant difference in number of leaves per plant was observed that was statistically significant at different DAT. At 20 DAT, the plants treated with T_1 (2dS/m EC) had the highest number of leaves per plant (11.66), at 40 DAT the plants treated with T1 had number of leaves per plant (21), at 60 DAT the plants treated with T_1 had the highest number of leaves per plant (30.33). But the lowest number of leaves per plant (3.66) treated with T_5 (10 dS/m EC) at 20 DAT, and at 60 DAT, the lowest number of leaves per plant (14.66) treated with T_5 (10 dS/m EC). Effect of saline soil showed significant variations in leaf number to every plant.

Leaf length

Cauliflower showed significant variations in leaf length at 20, 40 and 60 DAT (Table 1). Significant variation on leaf length was found due to application of different saline water strength. The maximum length of leaves (37.70) was found in T_1 treatment which was statistically similar to T_2. But the lowest number of leaves length (16.70) treated with T_5. Due to different soil salinity preparation, the increase salt concentration hit to cell elongation and cell division probably influenced the leaf growth of cauliflower.

Table 2: Different plants parameter of different growth stages at different Soil salinity strength.

Treatment	SD			CD	CY	GY
	20 DAT	40 DAT	60 DAT			
T_1 (2±0.2 dS/m)	13.80a	21.40a	43.03a	17.13a	636.00a	974.00a
T_2 (4±0.2 dS/m)	11.96b	17.20b	37.23b	15.63b	545.67b	876.67b
T_3 (6±0.2 dS/m)	10.10c	15.00c	22.46c	9.06c	422.00c	742.00c
T_4 (8±0.2 dS/m)	9.13cd	13.40c	18.86cd	4.90d	81.33d	269.00d
T_5 (10±0.2 dS/m)	8.43d	9.76d	15.50d	0.00e	0.00e	42.00e
T_6 (12±0.2 dS/m)	0.00e	0.00e	0.00e	0.00e	0.00e	0.00e
LSD	1.15	1.63	3.60	0.81	36.25	62.62
CV	7.32	7.17	8.86	5.88	7.26	7.27

*EC determined by 1: 1 extraction Method,
Spreading Diameter (cm)=SD, Curd Diameter (cm)=CD, Gross yield (gm)=GY, Curd yield (gm)=CY

Spreading diameter

The higher spreading diameter of cauliflower was observed at 20 DAT, 40 DAT is 13.80 cm, 21.40 cm respectively shown (Table 2) and the maximum spreading diameter at 60 DAT was 43.03 cm at T_1 (2 dS/m EC). The lowest spreading diameter was 8.43 cm at T_5 (10 dS/m EC) at 20 DAT, at 40 DAT it was 9.76 cm with T_5 (10 dS/m EC) and the spreading diameter was 15.50 cm at T_5 (10 dS/m EC) in 60 DAT. The interaction effects of cauliflower and saline soil showed significant variation in spreading diameter.

Yield contributing characters of cauliflower

Curd diameter

The maximum curd diameter was recorded at T_1 and it was 17.13cm shown (Table 2) while the lowest curd diameter (4.9 cm) was recorded with the T_4 with recommended saline soil management, Curd size has a positive response towards the proper irrigation and salt management. It is a mass message that, at 10, 12 dS/m EC facing cauliflower has not given any curd formation due to high soil salinity.

Curd yield

Curd yield of cauliflower drastically affected by soil salinity. When the soil and water becomes saline then curd production get seriously low. The highest curd yield was recorded shown (Table 2) at T_1 was 636.00 gm and the lowest curd yield was recorded at T_4 of 81.33 gm. Combination of different saline soil gives result to curd yield goes down due to higher strength of saline soil.

Gross yield per/plant

Saline soil hardly perform for plant growth. The gross yield per plant was significantly influenced by different soil salinity strength (Table 2). The maximum gross yield/plant (974 gm) was observed in T_1 treatment, while the lowest gross yield/plant (42gm) was observed in the plants treated with T_5 (10 dS/m EC). At T_6 (12 dS/m EC) of saline soil does not give any gross yield.

Fig. -2 dS/m

Fig.- 4dS/m

Fig. 6 dS/m

Fig.- 8 dS/m

Fig. -10 dS/m

Fig. - 12 dS/m

Conclusion

This research results revealed that the cauliflower plants grow better with 2 dS/m EC soil salinity strength condition. The objective of the experiment was to determine the influence of different levels of soil salinity strength performance on cauliflower growth and production. From the results, it can be concluded that applying different levels of saline soil have a significant effects on cauliflower growth and yields. The highest gross obtained yield from lower level of soil salinity and gives the maximum gross yield (974 gm) per plant is helpful for increasing the growth and yield of cauliflower. The findings of the research may be applicable to other region of the southern area of the country. However, further research work at different doses of salinity strength of saline soil on the growth and yield of cauliflower will need to be performed in different saline area of Bangladesh to suggest specific conclusions and recommendations.

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Effect of different strength of soil salinity on growth and yield of cabbage

A Biswas, Md. Z Islam

Abstract

Salinity of soil is a major problem in south and south-western part of Bangladesh. An investigation was made on growth and yield performance of cabbage (*Brassica oleracea* var. *capitata*) under different soil salinity strength to plants by saline soil at salinity management and research center. The experiment was laid out in a completely randomized design (CRD) with three replications of salt concentration (2, 4, 6, 8, 10, 12 dS/m EC). Result of the experiment revealed that the different combinations of saline soil significantly influenced all the parameters that studied. Yield performance per plant was investigated for plant height (cm), numbers of leaves/plant, fresh weight of loose leaves/plant (gm), diameter of head (cm), thickness of head (cm), fresh weight of head/plant (gm), days required for head formation/

plant, numbers of folded leaves/plant and gross yield/ plant. It was proved that soil having salinity 2 dS/m gives best result for all parameter of cabbage.

Introduction

Continuous rising of global temperature and associated climate changes are creating severe abiotic stresses that are seriously hampering crop yields and quality in many salt affected areas. Among those sufferings, major is soil salinity. Yield and quality traits of vegetable crops are adversely affected by environmental factors such as drought and/or high salinity of the root zone (Goyal et al., 2003). It is recognized that water and ions are the main physiological catalogue of processing plants physiology that need to optimize to resume growth in saline environments (Lauchli and Luttge, 2002). Over 9% of the world's total land and approximately 20% of irrigated land is affected by high salinity barrier. The problem is particularly severe in the Mediterranean, semi-arid and arid areas (Zhang et al., 2014; Munns and Gilliham, 2015). Cabbage (*Brassica oleracea var. capitata* L.) is a popular green leafy vegetable of the family Brassicaceae. It is an herbaceous, biennial, dicotyledonous flowering plant distinguished by a short stem crowned with a mass of leaves, typically green but in some varieties red or purple, which while immature form a characteristic compact, globular cluster (cabbage head). Photosystem II (PSII) is the most sensitive part of the apparatus to salt stress (Kalaji et al., 2011; Jajoo, 2014; Oukarroum et al., 2015). Cabbage is a great source of vitamin C, with a moisture content of 60.6%. It also contains vitamin B complex, potassium, and calcium (Haque KMF, 2006). Soil contributes to the maintenance of cells' redox systems and the regulation of stomatal aperture in drought and salinity responses (Sharma et al., 2017). Saline soil play crucial roles in plants' physiological responses and adaptation to salinity stress (Fahad et al., 2015). Cabbage ranks second in terms of production and area among all vegetables grown in Bangladesh. It is grown on an 18 thousand hectares area with a total production of 312 thousand tons (BBS, 2017), but the yield is poor. In south and south-western part of Bangladesh is facing a huge constraint of salt problem. Every year farmers are losing their hope for cabbage cultivation for soil salinity. The main reason is NaCL toxicity in soil (Almeida et al., 2017). The reason for such low cabbage production are due to a lack of fresh water for cultivation. This low cabbage yield could be increased by adopting improved saline soil management research. It is very important to determine the limit of soil salinity that crops can tolerate and determine if they can uptake and accumulate salts to use them for soil desalination. This may encourage and motivate farmers to introduce cabbage plants into their cropping system. The goal of this study was to test the salt tolerance of Cabbage (*Brassica oleracea var. capitata* L.) at different soil salinity level. As a result, the current study was designed to evaluate the impacts of saline soil on cabbage growth and yield.

Materials and methods

The experiment was carried out at the salinity management and research center, under soil resource development institute, Batiaghata, Khulna to test the effect of different strength of saline soil on emergence, growth and yield of cabbage plant. Plastic pots were used in conducting the experiment. The plastic pots were firstly washed and followed by rinsing with distilled water. Then those pots were dried in air. After drying the plastic pots were ready for the experiment. Finely prepared soil was filled up to 4.5 cm of the pot by saline soil. Necessary amount of salt treatment was given to create saline environment by saturating the soil before placing the cabbage seedling. The trial included the following treatments: T_1 = 2±0.2 dS/m EC, T_2 = 4±0.2 dS/m EC, T_3 = 6±0.2 dS/m EC, T_4 = 8±0.2 dS/m EC, T_5 = 10±0.2 dS/m EC and T_6

= 12±0.2 dS/m EC. The single factor experiment used completely Randomized design (CRD) with three replications. The experiment was divided into three equal replication blocks, each with six plots. As a result, the total number of unit plots was 18. 30 days cabbage seedlings were transplanted. The experiment's treatment combinations were randomized at random to 18 plots, each with three replications. Proper management about salinity control over the pot and growth of plants were observed. Time to time weeding, fertilizer application, irrigation, pot checking and special care to plant proper growth were following upto yield harvesting. Every three days later water application, pest controlling chemical and abiotic affect was observed. The data was collected at 60 days after cabbage transplanting. Intercultural operations were carried out when needed. The following parameters were measured: plant height (cm), numbers of leaves/plant, fresh weight of loose leaves/plant (gm), diameter of head (cm), thickness of head (cm), fresh weight of head/plant (gm), days required for head formation /plant, numbers of folded leaves/plant and gross yield/ plant.

Preparation of saline soil

For developing the expected soil salinity of 2 to 12 dS/m EC, salt affected soil was collected from different place of saline affected area. Different concentrations of soil salinity (2, 4, 6, 8, 10 and 12 ds/m) was applied to the transplanted seeding on plastic pot. The salinity level was maintained by assessing the salt level from laboratory test.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			
7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical analysis

The data obtained for different characters were statistically analyzed. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' test by using statistix software, version 10.

Results and Discussions

All the contributing parameters at different DAT have been shown. The influence of different saline soil of different strength caused a considerable variation in plant height and numbers of leaves per plants which was statistically significant at 20 DAT, 40 DAT, 60 DAT. Initial Salinity of pot soil was 1.54 dS/m EC. After applying different strength of soil salinity to different pot, the evaluating indicator was different.

Plant height

The highest plant height was found from T_1 (2 dS/m EC). The highest plant height at 20, 40 and 60 DAT was 12.40 cm, 19.53 cm and 27.66 cm respectively (Table 1). The lowest plant height at 20, 40 and 60 DAT was 9.86 cm, 11.60 cm and 11.71 cm respectively.

Number of leaves per plant

Number of leaves per plant at different DAT has been shown in Table 1. Due to the influence of different soil saline strength, a significant difference in Number of leaves per plant was observed that was statistically significant at different DAT. At 20 DAT the plants treated with T_1 had the highest number of leaves per plant (11.33), at 40 DAT the plants treated with T_1 had number of leaves per plant (26.00), at 60 DAT the plants treated with T_1 had the highest number of leaves per plant (50.33). But the lowest number of leaves per plant (6.66) treated with T_4 at 20 DAT, and at 60 DAT, the lowest number of leaves per plant (30.00) treated with T_4.

Table 1: Different growth stages of different plants after applying different strength of saline soil.

Treatment	PH			NL			FLL	DH	TH
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT			
T_1 (2±0.2 dS/m)	12.40a	19.53a	27.66a	11.33a	26.00a	50.33a	245.33a	20.33a	17.90a
T_2 (4±0.2 dS/m)	11.50a	17.43b	27.33a	10.33b	22.33b	41.33b	232.33a	16.33b	14.86b
T_3 (6±0.2 dS/m)	10.53b	15.10c	21.10b	9.33c	20.00c	35.33c	150.00b	10.63c	10.10c
T_4 (8±0.2 dS/m)	9.86b	11.60d	11.716c	6.66d	19.33c	30.00d	122.67c	0.00d	0.00d
T_5 (10±0.2 dS/m)	0.00c	0.00e	0.00d	0.00e	0.00d	0.00e	0.00d	0.00d	0.00d
T_6 (12±0.2 dS/m)	0.00c	0.00e	0.00d	0.00e	0.00d	0.00e	0.00d	0.00d	0.00d
LSD	0.95	1.16	1.53	0.83	1.87	2.81	15.23	0.94	0.76
CV (%)	7.24	6.15	5.87	7.51	7.21	6.04	6.85	6.71	6.00

*EC determined by 1: 1 extraction Method

Plant height (cm) =PH,
DAT- Days After Transplanting
Numbers of leaves/plant=NL,
Fresh weight of loose leaves (gm) =FLL,
Diameter of head (cm) =DH,
Thickness of head (cm) =TH,

Fresh wt. of loose leaves (gm)

The effects of different saline strength of soil on fresh weight of loose leaves were significant (Table 1). The plants grown under the soil saline treatment of T_1 (2 dS/m EC) had the highest fresh wt. of loose leaves (245.33 gm), however the plants grown under the treatment of T_4 (8 dS/m EC) had the lowest fresh wt. of loose leaves (122.67 gm).

Diameter of head (cm)

Different saline strength of soil of pot culture and management had a significant effect on head diameter (Table 1). The plants with the largest diameter of head (20.33 cm) were grown with T_1 treatment (2 dS/m EC) while the plants with the smallest diameter of head (10.63 cm) were grown with the treatment of T_3 (6 dS/m EC). It is noticed that at 8, 10, 12 dS/m EC of soil, Cabbage crop has not given any head formation due to soil salinity.

Thickness of head

It would appear that the various soil saline conditions had a significant effect on the thickness of the head (Table 1). The T_1 treatment showed the highest thickness of head (17.90 cm), whereas the T_3 gave the lowest thickness of head (10.10 cm). It is noticed that at 8,10,12 dS/m EC of soil tolerant cabbage has not given any head formation due to soil salinity.

Fresh weight of head/plant (gm)

The highest fresh weight of head (680 gm) was found in plants grown with T_1 treatment (2 dS/m EC) (Table 2), while the lowest fresh weight of head (282.33 gm) was found in plants grown with T_3 (6 dS/m EC), and this difference was statistically significant. At different soil saline strength of 8, 10, 12 dS/m EC, any cabbage plants has not given any head.

Number of folded leaf/plant

The highest number of folded leaves/plant (51.66) was found in plants grown under treatment T_1 (2 dS/m EC) (Table 2), while the lowest number of folded leaves/plant (20) was found in plants grown under treatment T_3 (6 dS/m EC), and the difference was found. At different soil salinity strength of 8, 10, 12 dS/m EC, any cabbage plants has not given any folded leaves per plant.

Table 2: Different plants of different growth stages after applying different strength of soil salinity.

Treatment	FWH	NFL	GY
T_1 (2±0.2 dS/m)	680.00a	51.66a	945.33a
T_2 (4±0.2 dS/m)	538.33b	43.00b	768.67b
T_3 (6±0.2 dS/m)	282.33c	20.00c	429.00c
T_4 (8±0.2 dS/m)	0.00d	0.00d	117.33d
T_5 (10±0.2 dS/m)	0.00d	0.00d	0.00e
T_6 (12±0.2 dS/m)	0.00d	0.00d	0.00e
LSD	35.16	1.82	38.73
CV (%)	7.90	5.38	5.78

*EC determined by 1: 1 extraction Method

Fresh weight of head/plant (gm) =FWH, Number of folded leaves/plant=NFL, Gross yield (gm)/Plant=GY

Gross yield per/plant

The gross yield per plant was significantly affected by different saline soil intensity (Table 2). The maximum gross yield (945.33 gm) per plant was observed in T_1 treatment (2 dS/m EC), while the lowest gross yield/plant (117.33 gm) was observed in the plants treated with T_4 (8 dS/m EC). At 10 and 12 dS/m EC of soil saline condition has not formed any gross yield.

Fig.- 2 dS/m

Fig.- 4 dS/m

Fig.- 6 dS/m

Fig.- 8 dS/m

Fig.- 10 dS/m

Fig.- 12 dS/m

Conclusion

The purpose of the experiment was to determine the influence of different levels of soil saline strength effect on cabbage growth and production. From the results, it can be concluded that management of different levels of saline soil have a significant effect on cabbage growth and yields. The highest gross and marketable yield were obtained at the combination from the application of T_1 treatment (2 dS/m EC) of soil and gives the maximum fresh weight of head (680.00 gm) per plant and gross yield (945.33 gm) per plant is helpful for increasing the growth and yield of cabbage. The findings of the study may be applicable to other locations of the southern region of the country as well. However, further research work at different cultivated land of different soil salinity strength on the growth and yield of cabbage will need to be performed in different saline area of Bangladesh to reach a specific conclusions and recommendations.

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Effect of different strength of soil salinity on growth and yield of knol khol

A Biswas, Md. Z Islam

Abstract

Salinity is a crucial agricultural constraint for crops production in saline area. In south and south-western area of Bangladesh is overcoming a huge barrier of salt accumulation to soil and problematic condition for different agricultural activities. So for solving such a curse a field experiment was carried out to investigate the effect of different soil salinity strength on the growth and yield of knol khol (Brassica oleracea var. caulorapa L.) during Rabi season. The experiment was laid out in Completely Randomized Design (CRD) comprising of 18 treatments viz., T_1- 2±0.2 dS/m EC, T_2 -4 ±0.2 dS/m EC,T_3 –6 ±0.2 dS/m EC, T_4 –8±0.2 dS/m EC, T_5 –10 ±0.2 dS/m EC, T_6 - 12±0.2 dS/m EC. Each replication was three times repeated. Treatments were randomly arranged in each replications, that divided into 18 pots. The results revealed that the application of T_1- 2 dS/m EC gave maximum plant height, highest number of leaves per plant, Diameter of stem/plant, diameter of knob, Fresh weight of the knob/plant, Gross yield per/plant. So, we can consider 2 dS/m EC for our soil health, environmental benefits and ecological safety.

Keywords: Knol khol, Growth, saline water, diameter of knob, knob yield.

Introduction

Soil salinity problem is the most abiotic barrier for crop production for arid and semi arid region in the world now a days. Soil salinity has great detrimental effects on crop production, especially in arid and semi-arid regions (Moud and Maghsoudi 2008; Keshavarzi 2011). High soil salinity is deleterious to most Knol khol (Brassica oleracea var. caulorapa L.), as it is a cole crops that produced worldwide, but very popular in Bangladesh also. The soil salinity of coastal saline soil is sometimes high, and with the same ion composition compared to sea water (Khan et al., 1996). In the other hand, the groundwater table of that saline region is quite shallow and the soil salinity changes seasonally (Shi et al., 2005).Different soil salinization process causes soil erosion on a global scale and reduces crop productivity (Acosta JA, Boris J, Karsten K, Martínez SM, 2011). Salt accumulation in soil is one of the most destructive environmental pressures in the uncultivated area, crop production and quality cause deficit (Yamaguchi, T., Blumwald, E., 2005, Lugtenberg, at all.,2002). There are long light green colored round shape structures, which come out as its shoots. Knol khol (Brassica oleracea var. caulorapa L.) also is known as kohlrabi belongs to the family cruciferae. It is a cold, hardy crop and can tolerate well in extremely cold weather and saline condition also. The fleshy portion of the stem develops entirely above the ground, called knob and is used as a vegetable(Raj et al., 2014). It is an excellent vegetable if it is used before it becomes tough and fibrous. It is high in minerals and vitamins A and C. It contains adequate amount of water (85.9 g), calories (28.5.0 g), protein (2.10 g), carbohydrate (7.6 g), fibre (1.0 g)) per 100 g of edible stem (Kamal et al., 2013). It also contains satisfactory amount of calcium, phosphorus , iron, sodium, potassium and vitamin A and C (Dadhich et al., 2015). Basically edible part of knol khol is knob, which is form swelling of the stem tissue above the plants. The crop has miracle medicinal value like, acidosis, asthma, cancer, cholesterol level, heart problems, indigestion, muscle and nerve functions, prostate and colon cancer, skin problems, weight loss etc. The fleshy turnip like portion of the stem develops entirely above the ground. The modern nutrient management policy has changed its focus towards the concept of sustainability and eco-friendliness and productivity (N and P Mehta et al.,2015). The increasing use of chemical fertilizers and soil saline condition in Bangladesh has a great impact to increase vegetable production. Plant growth decreases significantly under the influence of salt stress however, the plants differ considerably in their sensitivity and ability to tolerate salinity stress (Amzallag et al., 1993). For irrigation purposes, saline water should be used optimally and carefully to get the desire results from the irrigated crops (Alsaadawi and Mohamed (2000). It has been widely recognized but its long run impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil microorganism for crop production. However, at high level of crop production, these saline environment are not congenial to plant growth and yield. Ground soil salinity is known to inhibit plant growth (Paul, D., 2012). Soil salinity strength has a negative effect on the yield and quality of beet crops like sugar beet,turnip, knol khol etc especially from the excessive absorption of sodium (Mekki and El Gazaar 1999; Cheggour and Fares 2002).This saline movement can also hamper soil physical and biological fertility, making it non ideal for land application as a working microclimate. Soil salinity is also a major problem in areas where high ground salt water is used for irrigation (Rausch, T., at all, 1996). The agricultural practices in saline soil is considered as a bad management practice in any agricultural production system because of its negatively stimulation of soil microbial growth and activity, subsequent convertion of plant nutrients, and promote to loss soil fertility and quality for any types of crops production. Bangladesh is a developing country. Most of the people living here are suffering from nutrient deficit i.e., malnutrition. Fresh knol khol can be a cheap and safe vegetables for health and that is our ultimate destination to produce crop. So, cultivation of knol khol in saline soil deserve great importance. In fine, the studied was undertaken to observe the evaluation of comparative effects of different soil salinity strength on growth and yield of Knol khol and to find out best intensity of soil salinity strength for obtaining higher economic yield.

Materials and Methods

The experiment was carried out at the salinity management and research center, under soil resource development institute, Batiaghata, Khulna to test the effect of different strength of saline soil on emergence, growth and yield of cabbage plant. Plastic pots were used in conducting the experiment. The plastic pots were firstly washed and followed by rinsing with distilled water. Then those pots were dried in air. After drying the plastic pots were ready for the experiment. Finely prepared soil was filled up to 4.5 cm of the pot by saline soil. Necessary amount of salt treatment was given to create saline environment by saturating the soil before placing the cabbage seedling. The trial included the following treatments: T_1 = 2±0.2 dS/m EC, T_2 = 4±0.2 dS/m EC, T_3 = 6±0.2 dS/m EC, T_4 = 8±0.2 dS/m EC, T_5 = 10±0.2 dS/m EC and T_6 = 12±0.2 dS/m EC. The single factor experiment used completely Randomized design (CRD) with three replications. The experiment was divided into three equal replication blocks, each with six plots. As a result, the total number of unit plots was 18. The experiment's treatment combinations were randomized at random to 18 plots, each with three replications. 30 days knol khol seedlings were transplanted. Proper management about salinity control over the pot and growth of plants were observed. Time to time weeding, fertilizer application, irrigation, pot checking and special care to plant proper growth were following upto yield harvesting. Every three days later water application, pest controlling chemical and abiotic affect was observed. The data was collected at 60 days after knol khol transplanting. Intercultural operations were carried out when needed. The following parameters were measured: plant height (cm), numbers of leaves/plant, diameter of stem (cm), diameter of knob (cm), fresh weight of knob/plant (gm), days required for head formation /plant and gross yield/ plant.

Preparation of saline soil

For developing the expected soil salinity of 2 to 12 dS/m EC, salt affected soil was collected from different place of saline affected area. Different concentrations of soil salinity (2, 4, 6, 8, 10 and 12 ds/m) was applied to the transplanted seeding on plastic pot. The salinity level was maintained by assessing the salt level from laboratory test.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			
7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical analysis

The data obtained for different characters were statistically analyzed. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' test by using statistix software, version 10.

Results and Discussions

All the characters of promoting vegetative growth and yield performance parameters at different DAT have been shown (table 1 and 2). Results on main and combined effect of different soil salinity strength and fertilizer management practices and their interactions have been presented and discussed here. The influence of different soil salinity caused a considerable variation in plant growth, production of yield and economic benefits of plants which was statistically significant at 20 DAT, 40 DAT, 60 DAT. After applying different strength of soil salinity in different pot, the expected parameters were changed.

Table 1: Different plants of different growth stages at different soil salinity strength.

Treatment	PH			NLP		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_1 (2±0.2 dS/m)	12.70a	28.46a	38.10a	6.66a	11.66a	20.00a
T_2 (4±0.2 dS/m)	11.80ab	21.46b	27.00b	6.66a	11.66a	14.33b
T_3 (6±0.2 dS/m)	11.30ab	14.03c	26.10b	5.66b	8.66b	12.33c
T_4 (8±0.2 dS/m)	10.50b	13.70c	25.16b	4.66c	6.66c	11.33c
T_5 (10±0.2dS/m)	10.23b	12.80c	14.16c	3.33d	5.33d	6.33d
T_6 (12±0.2dS/m)	0.00c	0.00d	0.00d	0.00e	0.00e	0.00d
LSD	1.67	1.47	1.98	0.93	0.94	1.10
CV (%)	10.00	5.48	5.12	11.71	7.19	5.82

*EC determined by 1: 1 extraction Method

Plant height (cm)= PH, Number of leaves/ plant= NLP

Plant height

The outside variation in plant height due to different soil salinity strength was statistically significant in Knol khol at 20, 40 and 60 days after transplanting (DAT) (Table 1). At 20 DAT the maximum plant height was 12.70 cm found in the treatment T_1 and the minimum plant height was found in the treatment T_5 10.23 cm. In case of 40 DAT the maximum and the minimum plant height was 28.46 cm and 12.80 cm for the treatments T_1 and T_5 respectively. The highest plant height was 38.10 cm for the treatment T_1 and the lowest plant height was 14.16 cm was found in the treatment T_5 respectively at 60 DAT. It is stated that 12±0.2 dS/m of soil salinity strength knol khol plant had not given any plant growth at all.

Number of leaves per plant

A lots of ingredients helps to produce plant leaves. The production of different numbers of leave per plant at different DAT has been shown in Table 1. Due to the influence of different soil salinity strength, a significant difference in number of leaves per plant was observed that was statistically significant at different DAT. At 20 DAT, the plants irrigated with T_1 and T_2 had the highest number of leaves per plant (6.66 leaves), but the lowest numbers of leaves per plant (3.33) was T_5, at 40 DAT the plants treated with T_1 had number of leaves per plant (11.66 leaves) and it was statistically similar to T_2 and the lowest numbers of leaves per plant (5.33) for treatment of T_5. At 60 DAT the plants treated with T_1 had the highest number of leaves per plant (20.00). But the lowest number of leaves per plant (6.33 leaves) treated with T_5 (10 dS/m EC). T_6 (12 dS/m EC) had not given any plant.

Table 2: Different plants of different growth stages at different soil salinity strength.

Treatment	DS	DK	FWK	GY
T_1 (2±0.2 dS/m)	2.40a	12.16a	566.00a	947.67a
T_2 (4±0.2 dS/m)	2.16b	10.53b	454.33b	875.67b
T_3 (6±0.2 dS/m)	1.73c	8.23c	215.00c	579.67c
T_4 (8±0.2 dS/m)	1.1d	4.86d	62.33d	247.00d
T_5 (10±0.2dS/m)	0.96d	0.00e	0.00e	107.33e
T_6 (12±0.2dS/m)	0.00e	0.00e	0.00e	0.00f
LSD	0.14	0.72	29.77	54.04
CV (%)	5.86	6.82	7.74	6.61

*EC determined by 1: 1 extraction Method
Diameter of Stem (cm) 60 DAT= DS, Diameter of knob (cm)=DK, Fresh weight of knob (gm)=FWK,
Gross Yield/Plant (gm) =GY

Diameter of stem (cm)

Soil salinity strength has a profound effect on plant canopy and yield production characters and management had a significant effect on stem diameter (Table 2). The plants with the largest diameter of stem (2.40 cm) was grown with T_1 treatment while the plants with the smallest diameter of head (1.1 cm) was grown with the treatment of T_4 (8 dS/m EC). It is shown that at 10,12 dS/m EC of salinity strength tolerant knol khol had not given any stem formation due to soil salinity.

Diameter of knob (cm)

Effect of different soil salinity strength had a great significant influence on the diameter of knob (Table 2). The maximum diameter of knob (12.16 cm) was found with the treatment T_1 and the minimum diameter of knob (4.86 cm) was obtained from T_4 (8dS/m EC) treatment. As knol khol is a short duration crops and highly feeding crops it was not grow under 10 and 12 dS/m EC.

Fresh weight of knob/plant (gm)

Different intensity of saline soil salinity had a great significant effect on fresh weight of knob per plant (Table 2). The maximum fresh weight of knob per plant (566.00 gm) was obtained from the treatment T_1 and the minimum fresh weight of knob (62.33 gm) was found from the T_4 treatment. The maximum weight of single tuber might be due to soil salinity effect and plant growth resistant. Interaction effects of different strength of soil salinity treatment were significant on fresh weight of knob.

Gross yield/plant (gm)

Application of different saline soil to knol khol plant for economic yield per plant revealed that variation among different soil salinity strength was statistically significant. It is obvious from the present study that the maximum marketable gross yield (947.67 gm) resulted from T_1 and the lowest marketable gross yield (107.33 gm) was found from treatment T_5 treatment. It was observed that the interaction effect of different soil salinity strength on economic yield per plant was statistically significant.

Figure: Knol khol growth at different soil salinity

Conclusion

From the above discussion it is clear that, higher yield could be obtained by cultivating the knol khol variety early in different saline prone area under saline region of Bangladesh. Recommended soil salinity strength 2 dS/m produced maximum vegetative growth and economic yield (947.67 gm). So, we can consider the treatment T_1 (2dS/m EC) of soil salinity for our soil health, environmental benefits and crops production. Further experiment may be carried out before giving final recommendation.

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Effect of different strength of saline water on growth and yield of indian spinach

A Biswas, Md. Z Islam

Abstract

Water salinity and nutrient depletion in soil are major constraints to crop production, especially for vegetable crops. The effects of salinity in saline water and nutrient deficiency on indian spinach (*Basella alba* L.) was evaluated in pot cultures under shade conditions. This review emphasized the restoring abilities of plants from salt stress after rewatering or dilution of salted water. Saline water and soil salinity is a most obstruction for crop production in salt affected area. Salinity causes probably very dangerous situation in soil microclimate level when crops are produced those affected region. To find out a solution for such a vast systematic problem a field experiment was carried out to investigate the effect of different water salinity strength on the growth and yield of indian spinach in kharif-1 season. This experiment was laid out in Completely Randomized Design (CRD) comprising of 18 treatments viz., T_1- 2 dS/m EC, T_2 - 4 dS/m EC, T_3 – 6 dS/m EC, T_4 – 8 dS/m EC, T_5 – 10 dS/m EC, T_6 - 12 dS/m EC of saline water. Each replication was three times repeated. Saline water treatment was randomly arranged in each replications, that was divided into 18 pots. The results showed that the application of T1- 2 dS/m EC of saline water gave the maximum higher plant height at 45 DAT (63.50 cm), number of leaves/plant at 45 DAT (76 leaves), length of green leaf (18.26 cm), vine diameter of green indian spinach was 9.40 cm and fresh weight of leaves, stem and root was 573 gm. So, it may count that 2 dS/m EC of saline water for crop production can be practiced as a sustainable technology for better growth, yield and quality of a plant, also to improve the soil health and environment in long run.

Keywords: vegetable crops; salinity threshold; crop salt tolerance; ion imbalance; irrigation;

Introduction

High strength of water salinity conditions in agricultural production and irrigation water is one of the most serious challenges faced by agricultural crops in the world. Indian spinach is cultivated for its fresh and green leaves ready to harvest in about 45-50 days after transplanting. Indian spinach has been used from a long time back for the treatment of many diseases like dysentery, diarrhea, anemia, cancer etc (R. Adhikari, 2012). Fresh leaves of Indian spinach are rich sources of several vital carotenoid pigment antioxidants such as ß-carotene, lutein, zea-xanthin. These compounds play a healing role in aging and various disease processes (Annonymous, 2013). Indian spinach is characterized by high nutritive values and has a high content of dietary fibre and vitamins as well as mineral components. The nutritive value of Indian spinach is very high with a good content of minerals, vitamins and substantial amount of fibers (Ghosh and Guha, 1993). It is estimated that salt affected soils impact nearly 10% of the land surface and 50% of irrigated land in the world (Ruan et al., 2010). The response of plants to salinity is complex and involves changes in morphology, physiology, and metabolism. Salinity effects on plants include cellular water deficit, ion toxicity, nutrient deficiencies, and oxidative stress, leading to growth inhibition, molecular damage, and even plant death (Orcutt and Nilsen, 2000). Salt stress reduced spinach germination, root elongation, seedling growth, chlorophyll content and photosynthesis, and increased membrane permeability (Delfine et al., 1998; Downton et al., 1985; Kaya et al., 2002; Robinson et al., 1983). Salinity affects photosynthesis by decreasing CO_2 availability as a result of diffusion limitations (Flexas, J. et al., 2007) and a reduction of the contents of photosynthetic pigments (Delfine, S., et al., 1999; Ashraf, M., et al., 2013). Salinity is a major abiotic constraint curtailing crop growth and yield all over the world. The soil salinity is a widespread global concern caused as a result of abundant seawater intrusion in coastal areas, occurrence of saline groundwater and inadequate irrigation and/or drainage (Souza Filho et al., 2003; Nadeem et al., 2014; Yepes et al., 2018). Water scarcity and salinity are two major constraints which affect the agricultural production all over the world and the adoption of different irrigation regimes is the key requisite to improve water use efficiency in agricultural practices (Nangare et al., 2016; Mosaffa and Sepaskhah, 2018). Therefore, knowledge on the understanding of the physiological responses that define the plants' tolerance to surpass salinity stress is essential. Vegetable crop production in arid and semiarid region with low rainfall and high temperature require a larger input of fresh water irrigation. However, water salinity increase is closely related to irrigation and management practices. Therefore, the objective of this review is to analyze the effects of water salinity on indian spinach growth and management practices of saline water irrigation in soil and how to mitigate the adverse effect of water salinity.

Materials and Methods

Pot experiment

This study was carried out at the salinity management and research center, under soil resource development institute, Batiaghata, Khulna to determine the effect of saline water irrigation on growth, yield and ions content of existing indian spinach cultivars. An effort was made to alleviate the effects of water salinity in spinach by applying salt water treatment. The findings of current research will be helpful to describe the level of saline water that can be used to attain acceptable spinach yield and to highlight the spinach cultivar that is tolerant to salinity. This is very important for saline area that if salinity is capable of producing production then a lot of land will come under cultivation. That's why this experiment was carried to test the effect of different water salinity strength on growth and vigor of indian spinach plant. For this experiment, Plastic pots were used in conducting the experiment. Those plastic pots were washed at starting time by washing powder and followed by rinsing with distilled water. Then those pots were dried in air. After drying the plastic pots were ready for the experiment. Finely prepared different saline water was used as a medium for plant growing. Up to 12 cm of the pot was filled up by soil. Necessary amount of treatment was given to create saline environment by saturating the soil before placing the indian spinach seedling transplanting. The trial included the following treatments: T_1 = 2 dS/m EC, T_2 = 4 dS/m EC, T_3 = 6 dS/m EC, T_4 = 8 dS/m EC, T_5 = 10 dS/m EC and T_6 = 12 dS/m EC of saline water. The single factor experiment used completely randomized design (CRD) with three replications. The experiment was divided into three equal replication blocks, each with six plots. As a result, the total number of unit plots was 18. The experiment's treatment combinations were randomized at random to 18 plots, each with three replications. Intercultural operations and saline water application were carried out according to experiment. The following parameters were measured: Plant height (cm), Number of laves/plant at 45 DAT, Leaf length (cm), Vine diameter (cm), Fresh weight of leaves and stem and root at 45 DAT (gm). Treatments were randomly arranged in each replication, divided into 18 plots. The data recording of observation was done at 15 days after transplanting (DAT). The first light irrigation of saline water is given soon after transplanting to ensure proper growth and the subsequent saline water irrigation were given at the interval of 3-4 days. Plant protection measures were followed to control the pest and diseases. Soil treatment with proper fungicide was done to protect the seedling from fungal infection and pest attack.

Preparation of different strength of saline water

Application of saline water for the experiment of expected water salinity strength was 2 to 12 dS/m EC. Saline water was collected from different saline sources and then it was mixed with another sample of saline water for achieving the expected sample. Then different saline water sample was made for pot experiment. Different concentrations (2, 4, 6, 8, 10 and 12 ds/m EC) of saline water was applied to pot for the strong transplanting and plant growth. The salinity level was maintained by calculating the salt level, using EC meter. The experiment was laid out in the Completely Randomized Design (CRD) with three replications. The following treatments were 2, 4, 6, 8, 10 and 12 dS/m EC of saline water. The seedlings were transplanted to the planting medium. Disinfected and healthy seedlings were placed in plastic pots. Each Plastic pot was treated by 2, 4, 6, 8, 10 and 12 dS/m EC saline water.

Plant growth observation

Internal growth activity was monitored from the days of transplanting till yield collection carefully. The plant height and other parameters of plant of seedlings were recorded after 15 DAT (Days After Transplanting). The plant height (cm), Number of laves/plant at 45 DAT, Leaf length (cm), Vine diameter (cm), Fresh weight of leaves and stem and root at 45 DAT (gm) were recording very carefully. From each of the plastic pot the plant parameters were taken randomly and averaged. Centimeter (cm) scale was used for measuring plant parameters. Proper management about the pot and growth of plants were observed. Time to time weeding, fertilizer application, pot checking and special care to plant proper growth were following up to yield harvesting. After three days later prepared saline water was applied, pest controlling chemical and abiotic affect was observed. The data was collected at 45 days after indian spinach was fully matured. Then yield contributing data was collected and then analyzed.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				μg/g			
7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical analysis

The data obtained for different characters were statistically analyzed. The mean values of all the characters were evaluated and analysis of variance was performed by the ‘F’ test by using statistix software, version 10.

Results and Discussions

Soil salinity (EC: dS/m) of Experimental pot

Initial Soil Salinity of pot soil was 1.74 dS/m. After applying different strength of saline water soil salinity of different pot was increased.

Table 1: Soil salinity of different pot after applying different strength of saline water.

Treatment	Soil Salinity (EC*: dS/m) of pot			
	5 DAT**	15 DAT	30 DAT	45 DAT
T_1 (2dS/m)	1.77	1.83	1.91	2.17
T_2 (4dS/m)	1.87	1.90	2.89	3.91
T_3 (6dS/m)	1.90	2.12	3.45	5.19
T_4 (8dS/m)	2.04	2.78	4.21	6.48
T_5 (10dS/m)	2.55	3.19	5.30	7.42
T_6 (12dS/m)	2.94	4.14	6.21	8.34

*EC determined by 1: 1 extraction Method
** DAT - Days after Transplanting

Indian spinach is such a good productive and edible appealing vegetable. The characters of indian spinach of promoting vegetative growth and yield performance parameters at different DAT have been shown (table 2). The growing attributes and other results on main and combined effect of different strength of saline water and other management practices and their interactions have been presented and discussed here. The influence of different level of saline water salinity caused a considerable variation in plant growth, production of yield and economic benefits of plants which was statistically significant at different DAT. After applying different strength of water salinity in different pot, the expected parameters were changed and noticed that saline water created a vulnerable environment for yield.

Table 2: Indian spinach plant growth of different stages at different strength of water salinity

Treatment	Plant height (cm) at 45 DAT	Number of laves/plant at 45 DAT	Leaf length (cm)	Vine diameter (cm)	Fresh weight of leaves, stem and root at 45 DAT (gm)
T_1 (2dS/m)	63.50a	76a	18.26a	9.4a	573a
T_2 (4dS/m)	52.30b	63b	15.26b	8.5a	456b
T_3 (6dS/m)	31.50c	33c	12.40c	6.7b	291c
T_4 (8dS/m)	0d	0d	0d	0c	0d
T_5(10dS/m)	0d	0d	0d	0c	0d
T_6(12dS/m)	0d	0d	0d	0c	0d
LSD	4.49	3.91	1.72	1.03	42.49
CV (%)	10.30	7.67	12.64	14.19	10.86

*EC determined by 1: 1 extraction Method

Plant height

The plant height is considered to be the most important morphological character of growth of plant. The height of Indian spinach was measured from base of plant to tip of top leaf. It was observed that the height of plants at different growth stages was significantly affected by saline water. The different variation of indian spinach plant height at different strength of water salinity was statistically significant at 45 days after transplanting (DAT) (Table 2). Plant height depends on several factors like genetic makeup, nutrient availability, climate, water salinity and up taking soil micro environment etc. The maximum plant height (63.50 cm) was found at the treatment of T_1 (2 dS/m EC of saline water) but the plant height

(52.30 cm) was found at the treatment of T_2 (4 dS/m EC of saline water) and the minimum plant height was found (31.50 cm) in the treatment of T_3 (6 dS/m EC of saline water).

Numbers of leaf/plant

The number of leaves/plant of Indian spinach was recorded at 45 DAT (days after transplanting). The analysis of variance showed that the differences in the number of leaves/plant of Indian spinach under different strength of saline water were statically significant and the values are presented in table 2. It was evident from the results that the maximum number of leaves/plant (76 leaves) was obtained with applying of saline water at the treatment of T_1 (2 dS/m EC of saline water) at 45 DAT but the numbers of leaves/plant was (63 leaves) found at the treatment of T_2 (4 dS/m EC of saline water), while the minimum number of leaves/plant (33 leaves) was found with the treatment of T_3 (6 dS/m EC of saline water). The maximum numbers of leaves/plant (76) was found at the treatment of T_1 (2 dS/m EC of saline water) but the lowest numbers of leaves/plant (33) was found in the treatment of T_3 (6 dS/m EC) respectively at 45 DAT. It is discussed that 8 dS/m EC, 10 dS/m EC and 12 dS/m of saline water salinity strength had not given any plant growth.

Leaf length

The leaf length of a indian spinach depends on plant vigour and growth habit. Indian spinach is a vigorous growing plant and water salinity at irrigation has a great significant effect on the length of leaves. In accordance with the present study, the negative role of saline water in enhancing leaves length was reported. Water salinity was statistically significant at 45 days after transplanting (DAT) (Table 2). Leaves length depends on several factors like genetic makeup, nutrient availability, climate, water salinity and up taking soil micro environment etc. The maximum leaf length (18.26 cm) was found at the treatment of T_1 (2 dS/m EC of saline water) but the leaf length 15.26 cm was found at the treatment of T_2 (4 dS/m EC of saline water) and the minimum leaf length was found (12.40 cm) in the treatment of T_3 (6 dS/m EC) of saline water.

Vine diameter

The significant increase in growth parameter of Indian spinach is due to application of different strength of saline water. Indian spinach can grow under different conditions of soil but moderate soil fertility is decreased with the application of saline water. Indian spinach is a vigorous growing plant and nitrogen had a significant effect on the diameter and length of vine. The maximum vine diameter (9.40 cm) was found at the treatment of T_1 (2 dS/m EC of saline water) but the vine diameter (8.50 cm) was found at the treatment of T_2 (4 dS/m EC of saline water) and the minimum vine diameter was found (6.70 cm) in the treatment of T_3 (6 dS/m EC of saline water).

Fresh weight of leaves, stem and root

The variation in growth response of Indian spinach in terms of fresh weight of leaves, stem and root is presented in table 2. Fresh weight of leaves, stem and root varied from transplanting to yield collection. Application of saline water to different growth stages resulted in significantly decrease in fresh weight of leaves, stem and root. The highest fresh weight of leaves, stem and root (573 gm) was found with the treatment of T_1 (2 dS/m EC of saline water) but application of T_2 (4 dS/m EC of saline water) doses, The fresh weight of leaves, stem and root (456 gm) was found, while the lowest values was (291 gm) of these characters were found with T_3 (6 dS/m EC of saline water) treatment. However, they were significantly different in fresh weight of leaves, stem and root among the treatments of saline water.

Conclusion

The results obtained in the present study indicated that applying different strength of saline water to indian spinach significantly affected the plant height, number of leaves/plant at 45 DAT, leaf length, vine diameter, fresh weight of leaves, stem and root. From the experiment it is clear that, the higher plant height at 45 DAT was 63.50 cm, number of leaves/plant at 45 DAT was 76 leaves, length of green leaf was 18.26 cm, vine diameter of green indian spinach was 9.40 cm, fresh weight of leaves, stem and root was 573 gm and higher potential yield could be obtained by cultivating the indian spinach crop at T_1 (2 dS/m EC of saline water) treatment early in different saline prone area under saline region of Bangladesh. The recommendation after that experiment, the strength of water salinity (T_1- 2dS/m EC of saline water) produced the maximum vegetative growth and total economic yield. So, we can consider the treatment T_1 (2dS/m EC) of water salinity for our soil health, environmental benefits and crop production. Further experiment may be carried out in different area of saline zone of Bangladesh before giving final recommendation. On the basis of the results it is suggested generally that saline water had the potential adverse effect for growth and yield characters of Indian spinach comparing with other sources of fresh water.

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Effect of different strength of saline water on growth and yield of okra

A Biswas, Md. Z Islam

Abstract

Saline water and soil salinity is a most obstruction for crop production in salt affected area. Salinity causes probably very dangerous situation in soil microclimate level when crops are produced those affected region. In south and south-western area of Bangladesh is overcoming a huge barrier of salt accumulation to soil and problematic condition for different agricultural activities. And for solving such a vast systematic problem a field experiment was carried out to investigate the effect of different water salinity strength on the growth and yield of okra (*Hibiscus esculentus L.)* kharif-1 season. This experiment was laid out in Completely Randomized Design (CRD) comprising of 18 treatments viz., T_1- 2 dS/m EC, T_2 - 4 dS/m EC, T_3 – 6 dS/m EC, T_4 – 8 dS/m EC, T_5 – 10 dS/m EC, T_6 - 12 dS/m EC of water. Each replication was three times repeated. Treatment was randomly arranged in every replications, that was divided into 18 pots. The results showed that the application of T_1- 2 dS/m EC of saline water gave the maximum plant height at 1st flowering (cm), length of green fruit (cm), diameter of green fruit (cm), weight of single green fruit (gm) and fruit yield/plant (gm). So, it may terminate that 2 dS/m EC of saline water for our soil health to cultivation, management of soil and cost effective for farmer level.

key word: salinity ; okra ; growth; yield ; kharif ; EC ; CRD

Introduction

Salinity reduces water availability for plant use. High salt levels hinder water absorption, inducing physiological drought in the plant. The soil may contain adequate water, but plant roots are unable to absorb the water due to unfavorable osmotic pressure. This is referred to as the osmotic or water deficit effect of salinity. Plants are generally most sensitive to salinity during germination and early growth. High concentration of salts in the root zone decreases soil water potential and the availability of water (Lloyd, et al., 1989). The second effect of salinity is shown when excessive amounts of salt enter the plant in the transpiration stream and injure leaf cells, which further reduces growth. This is called the salt specific or ion excess effect of salinity (Greenway and Munns, 1980). Symptoms may include restricted root growth, marginal or leaf tip burning/browning, inhibited flowering, reduced vigor and reduced crop yields. Human induced salinity, combined with the natural, limits food production in most semiarid regions of the world (Rengasamy, 2010). The majority of the world's water is salty containing 30 g of sodium chloride per liter. The availability of saline water is greater than fresh water (Flower, 2004). Salt sensitive crop showing sign of stress including wilting even when there is adequate soil moisture (Maas and Hoffman,1977). Seed germination and early seedling growth stages are more sensitive to salinity than later developmental stages (Tayyaba et al., 2010). Plant species respond to salinity stress either by exclusion or inclusion of toxic ions from their shoots or roots (Greenway, et al., 1980; Munns, 1993; Jacoby, 1999). The nutritional imbalance taking place as a result of high amount of sodium (Na^+) may lead to metabolic disorder such as reduction in protein synthesis and enzyme activities. Studies on physiological mechanisms of salt tolerance revealed that plants may reduce damaging effects of salts by controlling salt uptake (Munns and Tester, 2008), reducing damage under excessive ion uptake (Flowers and Yeo, 1995) as well as by osmotic adjustment (Patade, et al., 2008; et al., Singh et al., 2010). In saline environment, plant growth is affected by complex interaction of hormones, osmotic effects, specific ion effects and nutritional imbalances, probably all occur simultaneously (Arbona et al., 2005). Salt stress is one of the major environmental constraints limiting agricultural productivity (Wei et al., 2003). Salinity is the buildup of soluble salts by which saline water are formed (Levy and Syvertsen, 2004). It is a popular vegetable among both the consumers and farmers because it is rich in vitamins and minerals (Oyelade et al., 2003). Almost all parts of okra plant are consumed, like fresh okra fruits are used as vegetable, roots and stems are used for clearing the cane juice (Chauhan, 1972) and leaves and stems are used for making fiber and ropes (Jideani and Adetula, 1993). Salinity alters the metabolic and biochemical activities of plants, negatively affecting their production due to the decrease in stomatal conductance and photosynthesis rate, inhibition of protein synthesis and enzymatic activities, and intensification of chlorophyll degradation (Liang, et al., 2018). The experiment was carried out to find out the effect of different strength of saline water on growth and yield of okra.

Materials and Methods

The experiments were carried salinity management and research center, soil resource development institute, Batiaghata, Khulna to test the effect of different strength of saline water on emergence and growth of sweet gourd. Plastic pots were used in conducting the experiment. The plastic pots were firstly washed by washing powder and followed by rinsing with distilled water. Then these were dried in air. After drying the plastic pots were ready for the experiment. Finely prepared soil was used as a matrix for seed emergence. Up to 10 cm of the pot was filled up by soil. Necessary amount of salt treatment was given to create saline environment by saturating the soil before placing the okra seed.

Preparation of different strength of saline water

Application of saline water for the experiment of expected water salinity strength was 2 to 12 dS/m EC. Saline water was collected from different saline sources and then it was mixed with another sample of saline water for achieving the expected sample. Then different saline water sample was made for pot experiment. Different concentrations (2, 4, 6, 8, 10 and 12 ds/m EC) of saline water was applied to pot for the strong transplanting and plant growth. The salinity level was maintained by calculating the salt level, using EC meter. The experiment was laid out in the Completely Randomized Design (CRD) with three replications. The following treatments were 2, 4, 6, 8, 10 and 12 dS/m EC of saline water. The seedlings were transplanted to the planting medium. Disinfected and healthy seedlings were placed in plastic pots. Each Plastic pot was treated by 2, 4, 6, 8, 10 and 12 dS/m EC saline water.

Plant growth observation

Internal growth activity was monitored from the days of seed sowing till yield collection carefully. The Plant height at 1st flowering (cm), Length of green fruit (cm), Diameter of green fruit (cm), Weight of single green fruit (gm), Fruit yield/plant (gm) were recording very carefully. Proper management about the pot and growth of plants were observed. Time to time weeding, fertilizer application, pot checking and special care to plant proper growth were following up to yield harvesting. Early prepared saline water was applied in every three days later, pest controlling chemical and abiotic affect was observed. The data was collected at 45 days after okra was fully matured. Then yield contributing data was collected and then analyzed.

Initial Chemical properties of soil of pot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g			
7.4	1.95	0.22	0.11	17.52	57.25	1.03	1.22
Slightly Acidic	M	M	L	M	VH	M	VH

Statistical analysis

The data obtained for different characters were statistically analyzed. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' test by using statistix software, version 10.

Results and Discussions

Soil salinity (EC: dS/m) of Experimental pot

Initial Soil Salinity of pot soil was 1.74 dS/m. After applying different strength of saline water soil salinity of different pot was increased.

Table 1: Soil salinity of different pot after applying different strength of saline water.

Treatment	Soil Salinity (EC*: dS/m) of pot			
	10 DAS**	20 DAS	30 DAS	40 DAS

T_1 (2dS/m)	1.76	1.81	1.92	2.21
T_2 (4dS/m)	1.88	1.93	2.91	3.99
T_3 (6dS/m)	1.92	2.15	3.46	5.23
T_4 (8dS/m)	2.05	2.79	4.25	6.52
T_5 (10dS/m)	2.56	3.20	5.32	7.46
T_6 (12dS/m)	3.45	4.15	6.46	8.99

*EC determined by 1: 1 extraction Method

** DAS- Days after sowing

Okra is a good nutritious and edible vegetable. The characters of okra of promoting vegetative growth and yield performance parameters at different days after sowing (DAS) have been shown (table 1). The growing attributes and other results on main and combined effect of different strength of saline water and other management practices and their interactions have been presented and discussed here. The influence of different level of saline water salinity caused a considerable variation in plant growth, production of yield and economic benefits of plants which was statistically significant at different DAS. After applying different strength of water salinity in different pot, the expected parameters were changed and noticed that saline water created a vulnerable environment for yield.

Table 2: Okra plant growth of different stages at different strength of water salinity

Treatment	Plant height at 45 DAS(cm)	Length of green fruit (cm)	Diameter of green fruit (cm)	Weight of single green fruit (gm)	Fruit yield/plant (gm)
T_1 (2 dS/m)	**51.60a**	**12.20a**	**1.35a**	**12.36a**	**231a**
T_2 (4 dS/m)	**44.70b**	**11.90a**	**1.24a**	**11.02a**	**196b**
T_3 (6 dS/m)	**36.20c**	**10.40a**	**1.12a**	**10.53a**	**110c**
T_4 (8 dS/m)	**0d**	**0b**	**0b**	**0b**	**0d**
T_5 (10 dS/m)	**0d**	**0b**	**0b**	**0b**	**0d**
T_6 (12 dS/m)	**0d**	**0b**	**0b**	**0b**	**0d**
LSD	**2.76**	**1.87**	**0.27**	**2.37**	**18.40**
CV (%)	**7.05**	**8.14**	**12.22**	**10.52**	**11.56**

*EC determined by 1: 1 extraction Method

Plant height at 1st flowering

The variation of okra plant height due to different strength of water salinity was statistically significant at 45 days after sowing (DAS) (Table 2). Plant height depends on several factors like genetic makeup, nutrient availability, climate, soil salinity and up taking environment etc. The maximum plant height at was (51.60 cm) found at the treatment T_1 (2 dS/m EC of saline water) but the plant height 45 Days after seed sowing was (44.70 cm) found in the treatment T_2 (4 dS/m EC of saline water) and the minimum plant height at 45 days after seed sowing was (36.20 cm) found in the treatment T_3 (6 dS/m EC of saline water).

Length of green fruit of okra

Different organic ingredients helps to produce plant leaves which influenced by water salinity in soil. Production of okra depends on the nutrients that exists in soil and given by other application. Different length of green fruits okra per plant at 45 DAS have been shown in Table 2. Due to the application of different water salinity strength to plants, a significant difference in fruits length of green okra per plant was observed that was statistically significant at 45 DAS. Fruits length of green okra with T_1 (2dS/m EC of saline water) irrigation was 12.20 cm and with T_2 (4dS/m EC) the length of green fruits was 11.90 cm. The lowest length of green fruits of okra per plant (10.40 cm) was found at T_3 (6 dS/m EC of saline water).

Diameter of green fruit

The strength of water salinity has a profound effect on plant canopy, intra cellular nutrients communication and yield production. It shows variation in characters and management of okra plants. Saline water had a significant effect on growing of diameter of green okra (Table 2). The plants with the largest diameter of green fruits (1.35 cm) was grown with T_1 treatment (2 dS/m EC of saline water) while the plants with the T_2 treatment (4 dS/m EC of saline water), the diameter of green fruit was 1.24 cm. The smallest diameter of green fruit of okra (1.12 cm) was grown with the treatment of T_3 (6 dS/m EC of saline water).

Weight of single green fruit

Different intensity of water salinity had a great significant effect on fresh weight of single green fruit per plant (Table 2). The plants with the highest weight of single green fruit (12.36 gm) was grown with T_1 treatment (2 dS/m EC of saline water) while the plants with the T_2 treatment (4 dS/m EC of saline water), the weight of single green fruit was 11.02 gm. The smallest weight of single green fruit of okra (10.53 gm) was grown with the treatment of T_3 (6 dS/m EC of saline water). The maximum weight of single green fruit might be due to water salinity effect and plant growth resistant. Interaction effect of different strength of water salinity treatment was significant on fresh weight of single green fruit.

Fruit yield/plant

Okra crops growth with different saline water treatment that approach on economic fruit yield per plant. It revealed that the variation among different water salinity strength were statistically significant. The plants with the largest fruit yield/plant (231 gm) was grown with T_1 treatment (2 dS/m EC of saline water) while the plants with the T_2 treatment (4 dS/m EC of saline water), the fruit yield/plant was 196 gm. The smallest fruit yield/plant of okra (110 gm) was grown with the treatment of T_3 (6 dS/m EC of saline water). Saline water application to okra plants and production process on total economic yield per plant revealed that variation among different water salinity strength were statistically significant.

Conclusion

From the experiment it is clear that, higher Plant height at 1st flowering (51.60 cm), length of green fruit (12.20 cm), diameter of green fruit (1.35 cm), weight of single green fruit (12.36 gm), fruit yield/plant (231 gm) and higher potential yield could be obtained by cultivating the okra crop at T_1 (2dS/m EC of saline water) treatment early in different saline prone area under saline region of Bangladesh. Further experiment may be carried out in different area of saline zone of Bangladesh before giving final recommendation.

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Effect of ground water table & salt concentration on top soil salinity

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Abstract

The process of soil and water salinization that occurs in different geological, hydro-geomorphological, agricultural, and climatic environment is very complex reaction by various mechanisms. Specifically, the objective is to characterize and find out the groundwater conditions contributing to existing salinity problems. Salinization of land and water is brought about by physical and chemical processes that increase salt concentrations in soil ground water. The process responsible for the development of salinity in soil and water is intimately related to the transport of dissolved salt ion mass in groundwater flow systems. According to the experiment, when ground water level starts to down and the same time salinity in soil and water starts increase. In February, the ground water level was 5 feet 3 inch, the salinity in water was 2.1 dS/m, at single layer mulching, the salinity in soil was 2.2 dS/m and the highest soil salinity was 3.2 dS/m in open soil and the lowest salinity was in double mulching soil (1.8 dS/m). In June, the ground water level was in down at 9 feet 3 inch, salinity at water was 8.8 dS/m, in single layer mulching, the salinity was 11.2 dS/m and the lowest salinity was in double mulching covered top soil (8.3 dS/m), the salinity level was very high in open top soil (16.5 dS/m). This experiment shows that soil water level starts to decrease from February month to June (early dry season to early rainy season). It is very much significant that salinity increase relation has simultaneously co-relation with the decreasing of ground water level in soil.

Introduction

Crop production in saline area is highly limited because of salinity in ground water. During kharif-1 season, salinity starts to increase from the January and it ranges to November. Saline water from the river water and seawater moves vertically and horizontally to other cropping area. This saline particle and mineral co-exist with other yield beneficial uptaking nutrient and those create a bilateral saline solution. This saline solution directly moves to ground water and turns the soil micro water into saline. Salinity increases very rapidly when evaporation of water from the top soil get started by sun rays. It influences the vertical upward of saline water at the root zone of plant. The main obstacle to intensification of crop production in the coastal areas is seasonally high content of salts at the root zone of the soil. The salts enter inland through rivers and channels, especially during the early part of the dry (winter) season, when the downstream flow of fresh water becomes very low. During this period, the salinity of the river water increases. The salts enter into the soil by flooding with saline river water or by seepage from the rivers, and the salts become concentrated in the surface water layers through evaporation and evapotranspiration. The saline water may also cause an increase in salinity of the ground water and make it unsuitable for irrigation. The increase in water salinity in ground water of these areas has created a limitation for cultivation. Utilization of low quality ground water for crop irrigation because of prolonged dry spells in conjunction with heavy salt minerals is the principal source bringing about soil salinization. Scarcity of quality irrigation water during dry season limits cultivation of rabi (winter) crops and kharif-1 (March-July) season. Variability of rainfall, uncertain dates of onset and recession of seasonal floodS and risk of drought restrict cultivation. Uncertain rainfall delays sowing/transplanting and flood damages of crops. The texture of most of the saline soils varies silt clay to clay. Land preparation becomes very difficult as the soil dries out. Deep and wide cracks develop and surface soil becomes very hard. These also necessitate deep and rapid tillage operations. Presence of saline ground water table throughout the year within top soil depth is another factor affecting crop production in the saline belt. Sea level rise and reduction of fresh ground water reservoirs due to changes in rainfall patterns are the two major climate change induced hydrological variables that can severely affect saltwater intrusion in coastal water bank. Tidal flooding occurs during wet season (June to October), direct inundation by saline water and upward on lateral movement of saline ground water during the dry season (February to May). In addition, cyclone and tidal surge is accelerating this problem. In the coastal areas of Bangladesh, salinization is one of the most serious types of land degradation as well as a major obstacle to the optimal utilization of ground water resources. Salinization is the process where the concentration of dissolved salts in water and soil is increased due to natural or human induced processes. Fresh water is lost through evapotranspiration and hydrolysis. Arid and semiarid climates are associated with water logging and ground water access. In all represented cases, ground water is the main geological agent for transmitting, accumulating, and discharging salt. Salinization in land and water is brought by physical and chemical processes that increase concentrations of salt in soil and water. The processes that responsible for the development of saline land and water is very complex and intimately related to the transport of dissolved salt mass in groundwater flow systems. The redistribution of soluble salts accumulated in a soil micro pore is evident mainly in topographically lower areas by terminal salt water in river, dry area and sea water. Evaporation, evapotranspiration, hydrolysis, and leakage leadS salt accumulation in water. When mineralized groundwater near the ground surface continually evaporates and causes minerals to precipitate, it increases the salt concentration in root zone. This process involve the mineralization of the groundwater, the physical transport of dissolved salts, the discharge of saline base flow into streams and river and the precipitation of salts within the soil cropping zone. Most of the salt in the groundwater system comes from micro pore, which includes parent materials structures, salt dissolved in the water recharging system and salt contributed from mineral dissolution within the groundwater flow system. The most important process that addS salt to groundwater is mineral dissolution reactions in the subsoil and to a lesser extent along the entire bilateral movement of saline water flow system. The land geography is low lying land, down ward movement of fresh water and inland along the sea coastal part of Bangladesh. According to salinity survey findings and salinity monitoring information about 1.02 million ha (about 70%) of the cultivated lands are affected by varying degrees of soil salinity. Million hectares of lands is affected by very slight, slight, moderate, strong and very strong salinity respectively. Cropping intensity may be increased from very slight to slightly in saline areas by adopting proper soil and water management practices with introduction of salt tolerant varieties of different crops. To mitigate the salt water for fill up the demand of fresh water for irrigation, especial emphasis may be given to adopt ground water reservoir technology.

Materials and Method

This experiment was conducted at the Salinity Management and Research Centre (SMRC), Soil Resource Development Institute, Batiaghata, Khulna, Bangladesh during the Kharif-1 season of 2023. Ground water depletion is a serious problem for irrigation in crop production. A deep pipe was installed directly into the soil vertically in the field at 01-02-2023. It was used for checking the ground water level measurement. Three beds were made for salinity level correction. One bed was open soil condition where no mulch was used, another one was made by single layer mulching bed where mulch was spread under the top soil and third one was double layer mulching bed where two layers of mulch was used. In double layer mulching bed, two layers of mulch was spread out, one was under the soil and another one was upper the top soil. Those three beds were made for measurement of soil salinity in every 15 days later.

Results and Discussion

Every 15 days later, the ground water layer depletion was measured through the deep pipe. This collected water and soil salinity were measured and salinity level was recorded (table 1). In 15-02-2023, the ground water depth was 5 feet 3 inch, water salinity was 2.1 dS/m, at open soil layer, the highest soil salinity was 3.2 dS/m, at single mulching layer the salinity was 2.2 dS/m and at double mulching layer, the lowest soil salinity was 1.8 dS/m.

Table 1 : Different Salinity level at different dates of water and soil salinity

Parameter	15-02-2023	01-03-23	16-03-23	01-04-23	16-04-23	01-05-23	16-05-23	01-06-23
Water depth	5′3″	5′8″	6′4″	6′9″	7′4″	7′8″	8′5″	9′3″
Ground Water salinity (dS/m)	2.1	2.8	3.4	5.3	6.1	7.2	8.1	8.8
Soil salinity dS/m (open)	3.2	4.3	5.4	7.3	9.4	10.1	12.4	16.5
Soil salinity dS/m (SLM)	2.2	3.6	4.8	5.2	6.5	7.8	9.3	11.2
Soil salinity dS/m (DLM)	1.8	3.2	4.1	4.9	5.8	6.1	7.2	8.3

SLM- Single Layer Mulching
DLM - Double Layer Mulching

In 01-03-2023, the ground water depth was 5 feet 8 inch, water salinity was increased to 2.8 dS/m, at open soil layer soil, the highest soil salinity was 4.3 dS/m, at single mulching layer, the soil salinity was 3.6 dS/m but at double mulching layer, it was the lowest soil salinity was 3.2 dS/m. After 15 days later in 16-03-2023, the ground water depth was down to 6 feet 4 inch, water salinity was rised to 3.4 dS/m, at open soil layer soil, the highest soil salinity was 5.4 dS/m, at single mulching layer, the soil salinity was 4.8 dS/m and at double mulching layer, the lowest soil salinity down to 4.1 dS/m. Again 15 days later, in 01-04-2023, the ground water depth was measured at 6 feet 9 inch, water salinity was 5.3 dS/m, at open soil layer soil, the highest soil salinity ranged at 7.3 dS/m, at single mulching layer, the soil salinity was 5.2 dS/m and at double mulching layer, the lowest soil salinity was gained 4.9 dS/m. In 16-04-2023, the ground water depth was recorded at 7 feet 4 inch, water salinity was 6.1 dS/m, at open soil layer soil, the highest soil salinity was 9.4 dS/m, at single mulching layer, the soil salinity was 6.5 dS/m but at double mulching layer, the lowest soil salinity was found 5.8 dS/m. About 15 days later, in 01-05-2023, the ground water depth was measured at 7 feet 8 inch, water salinity was 7.2 dS/m, at open soil layer soil, the highest soil salinity was 10.1 dS/m, at single mulching layer, the soil salinity was 7.8 dS/m but at double mulching layer, the lowest soil salinity was 6.1 dS/m. In 16-05-2023, the ground water depth was decreased to 8 feet 5 inch, water salinity was 8.1 dS/m, at open soil layer soil, the highest soil salinity was calculated at 12.4 dS/m, at single mulching layer, the soil salinity was 9.3 dS/m and at double mulching layer, the lowest soil salinity was gone down at 7.2 dS/m. At the date of 01-06-2023, the ground water depth was reached at 9 feet 3-inch, water salinity was touched at 8.8 dS/m, at open soil layer soil, the highest soil salinity was 16.5 dS/m, at single mulching layer, the soil salinity was 11.2 dS/m and at double mulching layer, the lowest soil salinity was recorded at 8.3 dS/m. In seepage areas dry spell and waterlogging induces clay eluviation near the surface and salinization at water depth in present day that reducing environments. When the water table rises to the surface, seepage areas are flushed by fresh water and salinization takes place. The resulting dis-equilbrium develops severe salinity environment land and degradation problems as a result of rising saline groundwater tables particularly when they act together in down surface positions of the land.

Conclusion

Groundwater plays a major role in the mobilization, accumulation, and discharge of salts into the root zone plant. Salinity increases during these periods of low recharge where only deep-water resources are present and the groundwater flows are insufficient. Saline groundwater flows along the vertical and horizontal streams and is accumulated in the soil system acts as a salt depository. This grounds water store directly influence the upper soil surface layer salinity range and water uptake by plants. However, ground water is the critical geological agent in the development of salinization.

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