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ANALYSIS OF ENVIRONMENTAL VIABILITY OF CROP-CATTLE INTEGRATION UNDER CLIMATE CHANGE IN BANGLADESH

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Abstract

Low carbon farming (LCF) by crop cattle interactions has great impact on climate change. Given the increasing climate vulnerability of coastal Bangladesh, evaluating low carbon farming systems is essential to enhance soil carbon sequestration and sustain rice productivity under climate change shocks. This study presents the findings of environmental viability of LCF sets by crop - cattle integration under climate change shocks. Data were collected from 300 low carbon sample farms under three coastal districts of Bangladesh namely Khulna, Satkhira and Bagerhat. Data on soil carbon content in *Boro* and *Aman* rice fields recorded under three alternative options of control and treatment conditions. There were nine and five adaptation options in the *Boro* and *Aman* rice seasons. About 27% respondent farmers adopted soil and rice crop management technique with climate stress-tolerant varieties involving ideal fertilizer management and irrigation in *Boro* rice season. On the other hand, about 54% responded farmers chosen the adaptation option of soil and rice management involving balanced fertilizer use and irrigation. The estimated highest initiative feasibility of low carbon farm was found in Dumuria upazila of Khulna district, which observed in *Boro* and *Aman* production by 6240 kg and 4510 kg/ha yield with a technical feasibility indicator of 1.25% and 1.19% organic carbon sequestration in soil, respectively. It recommends that 50% of NPKSZn can be used with bio-solids treatment as low carbon farming technique. Finally, the study demonstrates that cattle integrated low carbon farming practices can simultaneously increase rice yield and soil organic carbon sequestration, improving environmental viability and climate resilience in coastal farming systems.

Keywords: Climate change, Coastal ecosystem, Crop-cattle integration, Environmental viability, Low carbon farming

1. Introduction

The coastal areas of Bangladesh experience several natural disasters which most vulnerable (Minar et al., 2013) and there agriculture facing various natural disaster and opponent during farming. The agriculture sector has a countless opportunity for a carbon sequestration and contribution to greenhouse gases (GHGs) reduction which contributed about 14% of global amount and Bangladesh agricultural activities contribute about 39% of national GHGs emissions (FAO, 2015). Low carbon farming adaptation practices may offer Bangladeshi farmers the opportunities capitalize on the global carbon market. It was claimed that LCF adaptation shift farming practices that are more feasible, involve less input cost and resulted in lower GHGs emission and soil carbon sequestration sinks (Hossain & Ali, 2024).

The several NGOs involve to disseminate LCF under climate smart agriculture in coastal areas of Bangladesh and introducing technologies of crop cultivation, fertilizer and water management which resulted to shift of traditional cultivation practices. This study analyzed environmental feasibility of these LCF techniques which was assessed by using tripartite framework environmental feasibility (Ali & Meisner, 2017; Anwar & Zahan, 2023; Majumder et al., 2024). The concept of environmental feasibility of LCF combines mainly three elements. The framework consists of identifying workable technique of LCF under technical potentiality (TP), initiative feasibility (IF) and behavioral plasticity (BP) (Nielsen et al., 2020) . The present study measured TP and IF of sample low carbon rice farming by using farm survey data and finding related policy options from GHGs mitigation potentialities data of secondary sources. Therefore, this study is taken to analysis the environmental viability of crop-cattle integrations.

The expected outcomes of the study include generating empirical evidence on the environmental viability of crop–cattle integrated LCF systems, identifying technically sound and practically feasible low carbon practices, and providing policy-relevant insights to support scaling up climate-resilient and environmentally sustainable rice-based farming systems in coastal Bangladesh.

2. Methodology

2.1 Farm survey

The study conducted on the basis of primary data on farm survey by using interview schedule, focus group discussion (FGD) and key informant interviews (KII) from south-western districts of Bangladesh. Secondary data and information were collected from published and unpublished sources. A survey is commonly used to primary data collection for research. Setting objectives, interviewing relevant respondents by structural questionnaire or survey schedule is a common feature of survey design (Dillon & Hardaker, 1980). The present study used farm survey approach to find out the information about crop and cattle at farmer's level. The survey was carried out by using structured questionnaire. The questionnaire was developed and field-tested for necessary modifications before starting data collection in the selected field. The direct interview has done by making personal visits to the farmers from 2017-2022. The sample farmers were interviewed through trained enumerator including researcher himself over the period of data collection. Details of farm input output data of respondent farmers are recorded in survey schedule for the period 2017-2022.

The input-output data of latest farming under innovations adoptions were collected over phone to correct discrepancies. Then compile it for final survey according to the data need for each objective. The questionnaire has three main sections; the first section related to farmer's identification and profile about farm size, family size, and land tenure systems, physical assets, social capital and access to basic facilities etc. The second section is related to cost and revenue patterns of crop and cattle operational activities. For collecting innovation adoption status, the third section was developed. Since 2010, the selected areas have been covered by the climate change adaptation programme of three non-government organizations (NGOs) viz., Shushilon Prodipon and Uttaran, and government organization viz., Department of Agricultural Extension (DAE).

2.2 Description of the study area

The field survey was conducted for the research from October 2017 to July 2022 in 03 districts namely Khulna, Satkhira and Bagherhat in coastal region of Bangladesh.

Table 1. Major features of the selected upazilas of the study areas

District	Khulna	Satkhira		Bagerhat
Upazila	Dumuria	Koyra	Shamnagar	Mongla
Area (sq.km)	454.23	1775.41	1968.24	461.22
Population (000)	279862 M-144334 F-135528	192534 M-95993 F-96541	313781 M-160294 F-153487	149030 M-80819 F-68211
Density per sq. km	616	108	159	102
Literacy rate%	48.66%	32.4%	39.69%	56.1%
Average size of family	5.64	6.02	5.70	5.90
Agricultural income	65.3%	66.64%	64.98%	36.31%
Means of transport	Van, Easy bike, Motor bike	Van, Easy bike, Motor bike	Van, Easy bike, Motor bike	Van, Easy bike, Motor bike
Sanitation	50.61%	30.97%	44.84%	22.23%
NGO activities	BRAC, GB, ASA, Uttaran, Sushilon, Samadhan, Solidaridad, CSS, Prodipan	BRAC, GB, ASA, Uttaran, Sushilon, Samadhan, Solidaridad, CSS, Prodipan	BRAC, GB, ASA, Uttaran, Sushilon, Samadhan, Solidaridad, CSS, Prodipan	BRAC, GB, ASA, Uttaran, Sushilon, Samadhan, Solidaridad, CSS, Prodipan

Source: District Statistics 2011, Bangladesh Bureau of Statistics 2021

BRAC- Bangladesh Rural Advancement Committee, GB- Grameen Bank, ASA- Association of Social Advancement, CSS- Christian Service Social.

2.3 Sampling design and sample size

A multi-stage sampling technique was applied in selecting the sample households. In the first stage, 04 upazilas of 03 districts of Bangladesh were selected and used purposive sampling technique. The purposive sampling technique was used for this study based on three considerations. Firstly, this study area was selected based on the accessibility and proximity to conduct the survey properly. Secondly, in those areas were selected where crop-cattle combination for low carbon farming technique comparatively high. Thirdly, Khulna, Satkhira and Bagherhat districts were selected to represent southwestern region of Bangladesh. Three villages from each upazila were randomly selected. From each village, 25 adapted farm households were randomly chosen for better representation of the population. In total, 300 adapted farm households were selected for the benchmark study those who was considered for core trainee of the technology transfer. The similarities in the socio-economic, agro-ecological zones, and production environment, the sample size was considered a valid representation of the whole population.

Table 2. Selection of sample under multi-stage sampling technique

District/ Upazila	No. of villages	No. of farms per village	Total no. of sample farms
Khulna			
Dumuria	3	25	75
Koyra	3	25	75
Satkhira			
Shamnager	3	25	75
Bagherhat			
Mongla	3	25	75
Total	12	-	300

2.4 Other data sources

Primary and secondary both data used in the study. The rainfall, humidity and temperatures of 2017-2022 were collected from the nearest weather stations (Khulna, Satkhira and Mongla) and the Bangladesh Agricultural Research Council (BARC). The study used published and unpublished statistics and information of different research papers and institutions and internet sources. The notable sources are the Bangladesh Ministry of Agriculture, DAE, Upazila Agricultural Office (UAO), Bangladesh Metrological Department (BMD), Bangladesh Rice Research Institute (BRRI), Bangladesh Bureau of Statistics (BBS), Inter-governmental Panel of Climate Change (IPCC) and Food and Agricultural Organization (FAO). Expert opinion and field-level experience of officials and academics also provided information that helped to check the consistency of the collected data.

2.5 Data coding, entry, cleaning and analyzing

The collected data was coded for data entry into the Microsoft Excel spreadsheet before being converted to Stata program for analysis. The entry was first made according to regions and then pooled according to the analysis framework. The data was cleaned by producing frequency distributions and examined for outliers. When data found consistent, it was then prepared for further analysis. Collected data were arranged and analyzed into three categories. Most of the instruments are quantitative; some are analyzed tabular form using descriptive statistics and farm management analytical tools. The statistical and econometric modeling instruments used various test statistics techniques for validating the calculates. Different statistical tools like mean, standard deviations, maximum or minimum, frequencies and percentages were used. Various expert opinion, internet sources and published papers about LCF technique used the qualitative assessment of adaptations.

3. Results and Discussion

3.1 GHG emissions reduction potentialities by practicing LCF of sample rice farms

The farming is responsible for GHGs emission under four ways and the most common emitted GHGs from rice field is methane, nitrous oxide is formed by the microbial cavities in the soil. The carbon storage in the soil is affected by the direct and indirect emissions of CO2, associated with on and off farm energy production. Low carbon rice farming offers cultivation of rice that reduces, minimize or remove GHGs emission from production activities. The most common LCF practice affects under three management domains namely, soil and crop management, fertilizer management and irrigation water management. The low carbon farming was performed through minimum tillage, anaerobic fermentation, applying organic fertilizer, mulching, crop rotation, intercropping, rational use of water and a set of techniques in production lifecycle specially designed for specific climatic zones.

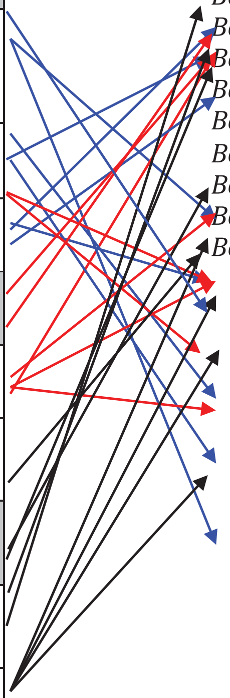
The study area sample farmers were practice LCF under soil and crop management domain by combination of minimum tillage and IPM (Integrated Pest management), crop rotation with legumes and use of salinity tolerant variety. Crop rotation on the same land support biodiversity. Right crop mixes, based on science and demonstrated effect, develop resilience by bringing about a balance in the farm ecology and remove the risk of crop failures due to insecticide attack. New cultivation also removes the risk exposure for farm household against erratic and spatial rainfall, temperature shocks and salinity intrusion. The fertilizer management includes use of balance fertilizer dose and organic fertilization with vermicompost and bio-solids. Reduction of excess nutrient application and balanced fertilizer use are the main mitigation options in farming. Organic fertilizer can improve soil methane production potentials and the abundances of methane (Zhou G. et al., 2020).

Irrigation management includes effective irrigation and rain water harvesting by building water reservoir and diversion ditches. It is also minimize the methane emission while alternate wetting and drying is maintained properly which depends on the efficiency of water regulation, soil type and cultivation management practices (Sriphirom et al., 2019). Intermittent aeration makes the soil environment toxic which results in the oxidation of methane, methanotrophs, causing a drop in methane emission. It is reported that up to 80% of the methane produced during the rice-growing season is oxidized by the methanotrophs (Singh et al., 2010). In contrast, LCF rice cultivation makes the soil environment anaerobic, resulting in decreasing redox potential (-150 mV), which leads to the anaerobic decomposition of complex organic substrates by methanogens that finally drive methane production (Minamikawa et al., 2006; Wang et al., 2009).

3.2 Adaptation options of Boro season in coastal region of Bangladesh

Boro is main rice growing season considering to the total cultivated area and production which starts from mid-December and harvests in mid-April. Good quality seed of high yielding varieties (HYV), organic and inorganic fertilizer, and underground water used in Boro production technology. Saline water and seasonal drought creates the problem for Boro cultivation in coastal region of Bangladesh. So, farmers choose saline free water to irrigate the crop land, temperature, drought and salt tolerant varieties of Boro seeds. There are nine types of adaptations found in the study area. Greenhouse gas emissions associated with pesticide applications against invasive species constitute an environmental cost of species invasions that has remained largely unrecognized. For ranking, one or more sub-components from each adaptation option rank as one, at least one chosen sub-component from two adaptation obtain was ranked as two and three main adaptation option sat least one sub- component chosen from each will rank 3. The detailed discussion is presented in following sub-sections.

Soil and rice management technique with climate stress-tolerant varieties involving ideal fertilizer management and as well as watering: This adaptation was including three basic elements of alternative management such as salt tolerant seed, ideal fertilizer management and watering from deep tube well. This adaptation system consists two basic components balance fertilizer dose and organic fertilizer increased soil porosity, soil pH, exchangeable K and Ca, available P and S, soil carbon storage and essential nutrients availability to the rice plant and sustaining rice yield, while improving salinity level by decreasing electro-conductivity values in saline soils in coastal region. The sample Farmers take a plan for irrigation in the cultivated land. Nowadays deep tube well of 300 meters in depth could ensure saline free irrigation water. Seasonal drought hampers the Boro cultivation. So, the farmers took those techniques which confirm saline-free water to irrigate crop field and choose temperature tolerant varieties of rice. The respondent farmer cultivated HYVs with salt tolerant, apply ideal fertilizer dose and watering in Boro season. The Fig. 1 reveals the performance score was 3 but 27% sample farmers adopted it.



Coping factors by LCF	Option choice	Performance score (0-3)	Percentage of adopt
1. Soil and crop management			
Integrated crop management Minimum tillage and IPM			
Crop rotation with legumes			
Use of saline tolerant variety			
2. Best fertilizer management			
Use of balance fertilizer dose			
Organic fertilization with vermie compost/ bio-solids			
3. Irrigation water management			
Irrigation and rain water harvesting			
Water reservoir and diversion ditches			
	Boro-1	3	27
	Boro-2	3	16
	Boro-3	3	19
	Boro-4	1	5
	Boro-5	2	10
	Boro-6	1	6
	Boro-7	2	5
	Boro-8	2	9
	Boro-9	1	3

Source: Own Farm Survey- 2017-2022

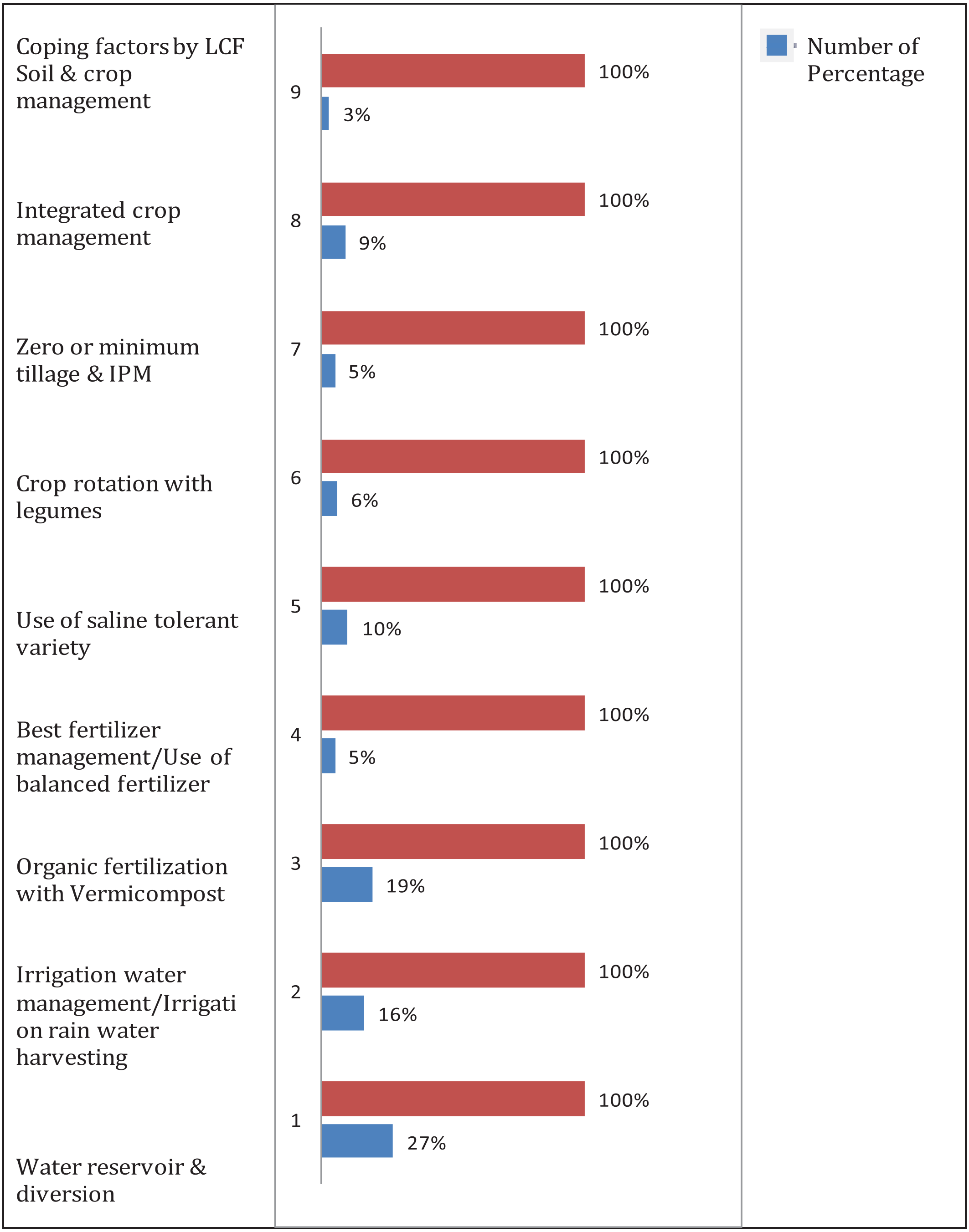
Fig.1 Low carbon farming performance in *Boro season*

Soil and rice management through salt-tolerant varieties and best fertilizer use by nitrogen deep placement with water harvesting: Under this adaptation practice three alternative cultivation practices applies to reduce impact of climate shocks. The initial inspiration is soil and rice management by keeping soil health. The second components are balanced fertilizer use which means proper application of all necessary macro and micronutrients in a balanced proportion at different stages of crop growth (Zewide & Sherefu, 2021). The farmers of the study area watering in the rice field by shallow tube wells. They use water reservoirs and diversion ditches to drain for additional water. Farmers keep the reservoir or small pond at the middle enclosed by the rice lands. Harvest rain water was applied 2/3 times for irrigation in rice field. The lands were also enclosed by earthen embankment to protect entry of saline water. The practice rank was 3% and 16% of the respondent farmer took it.

Rice management by salt-tolerant varieties, best fertilizer uses with urea deep placement as well as irrigation by water reservoir and diversion ditches: Three primary adaptations are processes that involving soil rice management, balance fertilizer uses and watering. Best fertilizer management exercise by nitrogen deep placement in the roots of plants. The system helps to apply fertilizer on irrigated rice fields efficiently and at the same period to protect methane emission. Balance doses fertilizer use as well as mitigation technique that protect nitrogen losses and methane emission from the crop land and also improves nitrogen use efficiency, delay the nitrogen release (Huda, 2015). The integrated rice and soil management applies salt tolerant varieties, urea is widely applied in the study area and deposit rain water is applied two or three times for watering. Its rank 3 and 19% sample farmer adopt it.

Zero or minimum tillage-based integrated rice management with saline-tolerant varieties: Tillage encourages methane emission, soil erosion and soil nutrition loss from the rice field. Zero or minimum tillage reduce production cost and an effective way of protecting soil nutrition in crop land which is a tool of mitigation technique. The farmers of the coastal region cultivated HYV salt tolerant seed varieties invented by BINA dhan-8, BINA dhan-10, BRRI dhan36, BRRI dhan47 and BRRI dhan55. The figure 1 and 2 represents that adaptation option score is 1 and only 5% of farmer applied it and this adaptation option is not popular in coastal region of Bangladesh.

Crop management, balance fertilizer management exercise by urea deep placement involving water reservoir: Three basic components present in this adaptation options. Farmers of the study area use new salt tolerant varieties, minimum fertilizer and saline free irrigation water. This adaptation option rank was 2% and 10% respondent farmer practiced it. Water management (Irrigation) with water reservoir and diversion ditches: The respondent farmer applied only one adaptation option and salt-free water management. The practice has mitigation effective because it decreases the water and the carbon foot prints in the cultivation system. This adaptation option rank is 1 and only 6 percent respondents farmer adopt this option. Soil and rice management exercise with saline tolerant varieties linked with watering with water reservoir and diversion ditches: Soil and rice management used here that have to protect salinity for seed and soil. Watering is managed by applying a rain –water reservoir. This adaptation option rank is 2 and only 6 percent sample farmers received this choice.



Source: Own Farm Survey- 2017-2022

Fig. 2 Selected LCF of *Boro* rice farming practices in study areas

Zero tillage-based integrated rice management with saline tolerant varieties with water reservoir and diversion ditches: In the study area farmers transplant Boro rice without tillage or minimum tillage. The farmers use salt tolerant varieties because the risk of salinity and they deposit rain water in the rice field by surrounding canals. The adaptation option rank was 2 and 8 percent farmer adopt it. Balanced fertilizer management exercise used by best fertilizer: Boro rice yield depends on proper utilization of inputs like as irrigation and fertilizer. The best fertilizer management exercise by balanced fertilizer refers to a blanket dose of fertilizer for a certain area based on crop requirements and soil fertility status (Miah et al., 2005). This adaptation option score 1 out of 3 and only 3% farmer adopt it.

3.3 Adaptation of Aman season in coastal region of Bangladesh

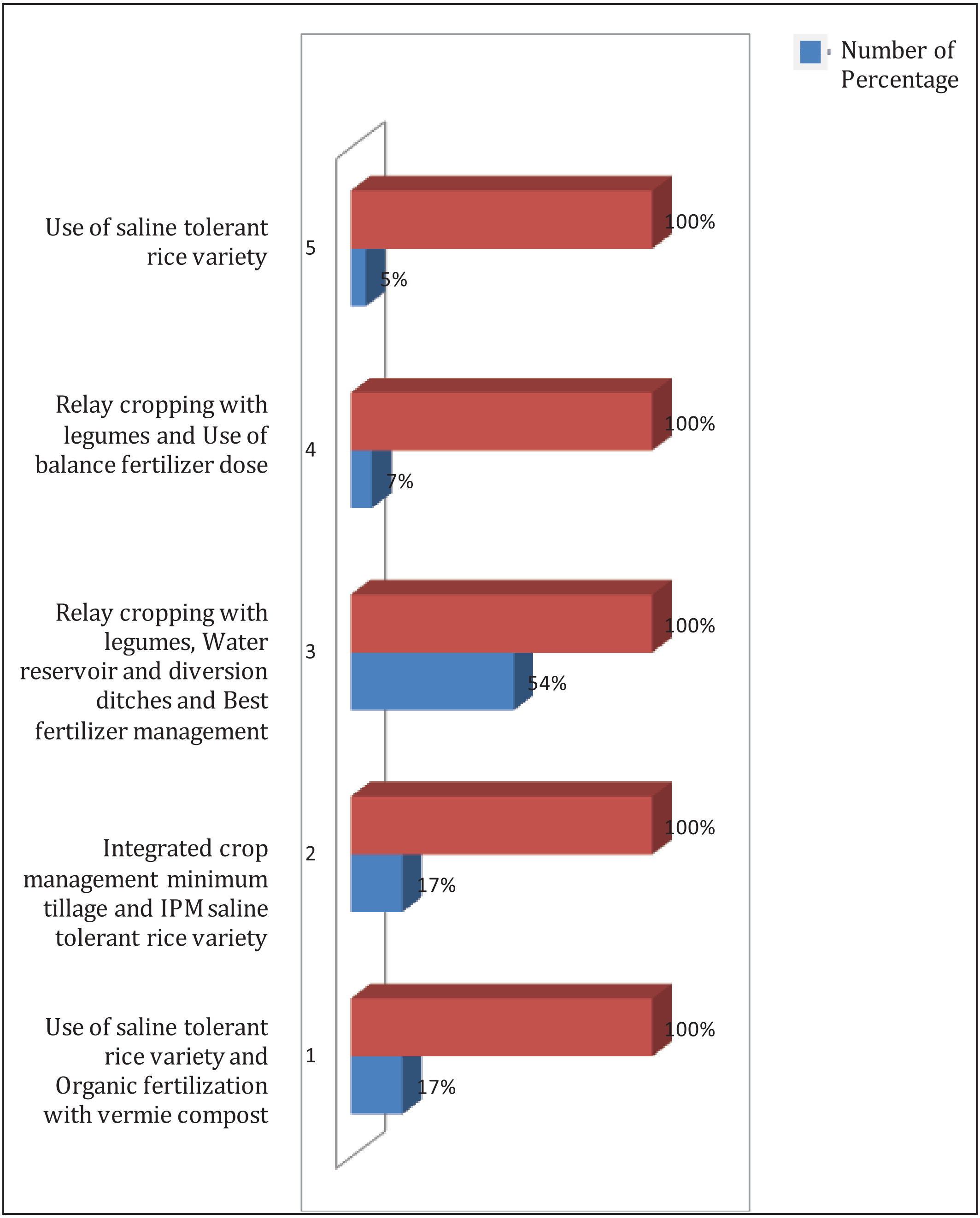
Aman rice season is a rain-fed rice growing season in coastal region. The Aman rice farmers wait for heavy rainfall to decrease the soil salinity. High temperatures, less precipitation and salinity shocks hamper to Aman rice growth. To reduce climate variability shocks, the coastal farmers adopting alternative production technique. Five adaptation option` saw in Aman season. Each option consists of several sub- components. Three sub-components in the coping factor for soil and crop management: zero or minimum tillage and IPM based integrated crop management, crop rotation with legumes and use of saline tolerant variety. The option of best fertilizer management makes by two sub-components: use of balance fertilizer dose and organic fertilization and irrigation water management consists of irrigation and rain water harvesting. Soil and rice management with saline tress seed varieties Zero or minimum tillage decrease production cost and emission of greenhouse gases from the cultivated land. It helps to restore soil nutrition in the cultivation land. Farmers of this area are interested in salt tolerant seed varieties such as BRRI dhan40, BRRI dhan41, BRRI dhan53 and BRRI dhan54. Crop rotation helps to gain three benefits: maintaining soil nutrition, increase rice and legume production and mitigating greenhouse gases emission from the cultivated land. Khesari is the most common legume crop in the coastal region of Bangladesh. This adaptation score was 1 and 17% respondent farmer of the study area adopt this option.

Nowadays farmer interested to cultivate climate stress and salt tolerant rice varieties such as BRRI dhan40, BRRI dhan41, BRRI dhan53 and BRRI dhan54. Department of Agricultural Extension and NGOs disseminated those varieties which maintain grain yield under climate shocks. Soil and rice management through relay cropping with legume and best fertilizer use. Farmers use three types of inorganic fertilizer like as urea, triple super phosphate (TSP) and mutate of potash (MoP) in rice field. The doses recommended by the DAE. The management system ensures cautious apply of urea for climate variability adaptation and mitigation. Bangladeshi farmers are not aware of balanced fertilizer use according to the needs of their land (Basak, 2010). Urea is cheaper and available than other inorganic fertilizers such as TSP and MoP. Crop rotation helps to gain three benefits: maintaining soil nutrition, increase rice and legume production and mitigating greenhouse gases emission from the cultivated land.

Khesari is the most common legume crop in the coastal region of Bangladesh. This adaptation option rank was 2 and 17 percent sample adopt it. Soil and rice management involving balanced fertilizer use and watering. Soil amendments with organic fertilizer increased soil porosity, soil. Organic carbon content, soil pH, exchangeable K and Ca content in coastal region. But a few farmers use organic fertilizer in Aman season. There are two sub-components for irrigation water management such as irrigation and rain water harvesting. The coastal area is saline-prone and watering by shallow tube wells severely so. Irrigation by deep tube wells and rain to ensure saline-free water. About 54 percent respondent farmer chose the adaptation option and the adaptation rank was 3.

Coping factors	Option choice	Performance score (0 to 3 scale)	Percentage of adopt
Soil & crop management	***Aman-1***	1	17
Integrated crop management Zero or minimum tillage & IPM	***Aman-3*** ***Aman-2***	3	54
Relay cropping with legumes	***Aman-4***	2	17
Use of saline tolerant rice variety	***Aman-5***		
Best fertilizer management		1	7
Use of balance fertilizer dose			
Organic fertilization with vermie compost		2	5
Irrigation water management			
Irrigation & rain water harvesting			
Water reservoir & diversion ditches			

Fig. 3 Low carbon farming performance in *Aman* season



Source: Field Survey

Fig. 4 Selected LCF of *Aman* rice farming practices in study areas

3.4 Integrated pest management with saline stress seed varieties

Integrated pest management is one of the best practices prescribed from last three decades for rice farmers in Bangladesh. It is more popular adaption option to manage climate shocks. The main objectives are behind IPM to minimize agro-chemicals and commercial pesticide. Because pesticide manufacture, transport and application of insecticides causes of greenhouse gases emission. In the study area farmers used various salt tolerant varieties. The adaptation option score was 1 and 7% sample farmer took it. Zero or minimum tillage based integrated rice management with saline stress varieties and balanced fertilizer management technique by urea deep placement: Tillage creates soil erosion and nutrition loss in the field. Minimum or zero tillage decline production cost. Farmers used salt–tolerant seed varieties and balance fertilizer management technique by nitrogen deep placement. The practice helps to use nitrogen on flooded rice fields. This adaptation option rank was 2 and only 5% farmer adopts this model.

3.5 Insight of low carbon emitting farming technique under Boro and Aman seasons

Soil amendments with bio-solids increased soil porosity, soil organic carbon content, soil pH, exchangeable K and Ca content in Khulna, Satkhira and Bagherhat, although exchangeable Na decreased significantly. Mixed application of inorganic fertilizer and bio-solids maximized Boro and Aman season which may be due to the higher availability of soil nutrients such as exchangeable K, exchangeable Ca, available P and available S to Boro and Aman season. Mixed application of inorganic and organic fertilizer could be a feasible option for increasing soil storage, nutrients availability to Boro and Aman and sustaining rice yield, while improving salinity level by decreasing Ec (Electrical conductivity) values in saline soils.

The increased soil organic C stock under mixed organic and inorganic amendments indicates the lower C emissions from Boro and Aman land to the atmosphere compared to sole organic and inorganic sources. (Busari et al., 2015) reported that maintenance of SOM/SOC in crop field is important, not only for improvement of agricultural productivity but also for reduction in C emission and mixed application of gypsum with cyanobacterial inoculums additions in soils would be a good practice for reducing methane emissions, improving soil nutrients availability to rice plant and also increasing rice yield attributes even under saline stress condition.

Soil redox potential (Eh), pH, Ec, TDS and iron (Fe) were measured at every fortnight interval during rice cultivation in coastal region of Bangladesh. Soil organic carbon (Begum et al., 2018; Walkley & Black, 1934)), %Total N (Micro-Kjeldahi method, (Keeney & Nelson., 1982)), available P (Colorimetric method, (Watanabe & Olsen, 1965) available S (by the Calcium chloride extraction method (Williams & Steinbergs, 1959) were determined following standard methods. Exchangeable calcium (Ca), sodium (Na) and potassium (K) were extracted from soil using 1M CH3COONH4 solution. At the harvesting stage, soil bulk density was analyzed using cores (volume 100 cm3, inner diameter 5 cm), filled with fresh moisture soils. The collected soil core samples were oven dried at 1058ºC for 24 h and then weight of dried core samples, soil porosity were calculated using the bulk density and particle density according to the equation, Soil Porosity (%)= (1-BD/PD) x100 (Hao et al., 2008).

Mixed practice of inorganic fertilizer (50% of recommended NPKSZn) and bio-solids produced maximum rice grain yield, which may be due to the higher presence of soil nutrients like as exchangeable K, presence Ca, P and S to rice plant. In addition, soil Ec (electro-conductivity) and exchangeable Na content decline with bio-solids materials. Therefore, mixed practice of inorganic and organic fertilizers could be an effective option for increasing soil carbon storage, nutrients presence to rice plant and sustaining rice yield, while progress salinity level by decrease Ec values in saline soils. The increased soil organic C stock under mixed organic and inorganic materials indicates the lower C emission from rice fields to the atmosphere compared to sole organic or inorganic sources.

3.6 The mitigation potentialities of sample rice farm by LCF

The mitigation possibilities of LCF are main indicators of feasibility that recognize whether a certain initiative improve for adaptation. The idea of environmental probability readily addresses like a question which methods would be scaled to gain certain mitigation objectives? Which initiative would be performed at a cost that makes them catching technically? The sample LCF performed carbon capture and storage for greenhouse gases emission to adopt climate mitigation. The technical and initiative chance were evaluated by using Tripartite Framework, so carbon dealing policies within a nation would be justified to climate footprint from farmhouse level.

Table 3. Comparative assessment of wise yield and soil properties after amendment in Khulna

Locations	Treatments for LCF	*Boro*						*Aman*					
		IF		TP				IF		TP			
		Grain yield (kg/ha)	Soil porosity (%)	Ec (dS/m)	Soil pH	%Org C	%TN	Grain yield (kg/ha)	Soil porosity (%)	Ec (dS/m)	Soil pH	%Org C	%TN
Khulna, Dumuria	V_1	6120	45	4.8	7.1	1.10	0.20	4470	47	4.7	7.2	1.08	0.18
	V_2	6240	48	4.6	7.4	1.25	0.17	4510	50	4.5	7.6	1.19	0.16
	V_3	4690	50	4.3	7.6	1.23	0.10	4230	51	4.1	7.8	1.17	0.09

In Dumuria of Khulna district, *Boro* rice yield were 6120 kg, 6240 kg and 4690 kg/ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (no NPKSZn, 100% Bio-solid amendment). Here soil porosity was 45, 48 and 50%, salinity was 4.8, 4.6 and 4.3 dS/m, soil pH was 7.1, 7.4 and 7.6, %Organic C were 1.10, 1.25 and 1.23 and %TN were 0.20, 0.17 and 0.10 gradually for treatment V_1, V_2 and V_3. In Aman rice yield were 4470 kg, 4510 kg and 4230 kg/ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (No NPKSZn, 100% Bio-solid amendment). Here soil porosity were 47, 50 and 51%, salinity were 4.7, 4.5 and 4.1 dS/m, soil pH were 7.2, 7.6 and 7.8, %Organic C were 1.08, 1.19 and 1.17 and %TN were 0.18, 0.16 and 0.09 gradually for treatment V_1, V_2 and V_3.

Table 4. Comparative assessment of yield and soil properties after amendment in Khulna

Locations	Treatments for LCF	*Boro*						*Aman*					
		IF		TP				IF		TP			
		Grain yield (kg/ha)	Soil porosity (%)	Ec (dS/m)	Soil pH	%Org C	%TN	Grain yield (kg/ha)	Soil porosity %	Ec (dS/m)	Soil pH	%Org C	%TN
Khulna, Koyra	V_1	5530	43	4.6	7.2	1.04	0.19	4110	44	4.5	7.1	1.03	0.20
	V_2	5820	46	4.4	7.4	1.15	0.16	4350	46	4.2	7.3	1.18	0.17
	V_3	4490	47	4.1	7.5	1.19	0.08	3870	48	4.1	7.5	1.21	0.10

In Koyra upazila under Khulna district, Boro rice yield were 5530 kg, 5820 kg and 4490 kg / ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (no NPKSZn, 100% Bio-solid amendment). Here soil porosity were 43, 46 and 47%, salinity were 4.6, 4.4 and 4.1 dS/m, soil pH were 7.2, 7.4 and 7.5, %Organic C were 1.04, 1.15 and 1.19 and %TN were 0.19, 0.16 and 0.80 gradually for treatment V_1, V_2 and V_3. In Aman rice yield were 4110 kg, 4350 kg and 3870 kg/ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (No NPKSZn, 100% bio-solid amendment). Here soil porosity was 44, 46 and 48%, salinity were 4.5, 4.2 and 4.1 dS/m, soil pH were 7.1 7.3 and 7.5, %Organic C were 1.03, 1.18 and 1.21 and %TN were 0.20, 0.17 and 0.10 gradually for treatment V_1, V_2 and V_3.

Table 5. Comparative assessment of yield and soil properties after amendment in Satkhira

Locations	Treatments for LCF	*Boro (Robi Season)*						*Aman (Kherif 2 Season)*					
		IF		TP				IF		TP			
		Grain yield (kg/ha)	Soil porosity %	EC (dS/m)	Soil pH	Org C%	T-N%	Grain yield (kg/ha)	Soil porosity %	EC (dS/m)	Soil pH	Org C%	T-N%
Satkhira, Shamnogor	V_1	4650	44	5.7	7.1	1.18	1.07	3990	47	5.4	7.2	1.05	0.16
	V_2	4830	49	5.1	7.3	1.15	1.18	4270	50	5.2	7.4	1.13	0.13
	V_3	4570	51	4.8	7.7	1.07	1.25	4010	51	4.9	7.7	1.19	0.06

In Shamnagar upazila under Satkhira district, Boro rice yield were 4650 kg, 4830 kg and 4570 kg per ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (no NPKSZn, 100% Bio-solid amendment). Here soil porosity was 44, 49 and 51%, salinity was 5.7, 5.1 and 4.8 dS/m, soil pH was 7.1, 7.3 and 7.7, % organic C were 1.18, 1.15 and 1.07 and %TN were 1.07, 1.18 and 1.25 gradually for treatment V_1, V_2 and V_3. In Aman rice yield were 3990 kg, 4270 kg and 4010 kg/ha respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (No NPKSZn, 100% Bio-solid amendment). Here, the soil porosity were 47, 50 and 51%, salinity were 5.4, 5.2 and 4.9 dS/m, soil pH were 7.2, 7.4 and 7.7, %Organic C were 1.05, 1.13 and 1.19 and %TN were 0.16, 0.13 and 0.06 gradually for treatment V_1, V_2 and V_3.

In Mongla upazila under Bagherhat district, Boro rice produced were 4750 kg, 5060 kg and 4470 kg/ha, respectively for treatment V_1 (business-as-usual), V_2 (50% recommended NPKSZn with bio-solids amendment) and V_3 (no NPKSZn, 100% Bio-solid amendment). Soil porosity were 43, 44 and 49%, salinity was 6.7, 6.3 and 5.9 dS/m, pH was gradually 7.3, 7.5 and 7.8, % Organic C were 1.05, 1.05 and 1.20 and %TN were 0.15, 0.13 and 0.09 for gradually treatment V_1, V_2 and V_3.

Table 6. Assessment of yield and soil properties after amendment in Bagerhat

Locations	Treatments for LCF	*Boro*						*Aman*					
		IF		TP				IF		TP			
		Grain yield (kg/ha)	Soil porosity %	Ec (dS/m)	Soil pH	Org C%	T-N%	Grain yield (kg/ha)	Soil porosity %	Ec (dS/m)	Soil pH	Org C%	T-N%
Bagerha	V_1	4750	43	6.7	7.3	1.05	0.15	4340	45	5.5	7.2	0.89	0.13
Mongla	V_2	5060	44	6.3	7.5	105	0.13	4410	46	5.9	7.4	1.12	0.12
	V_3	4470	49	5.9	7.8	1.20	0.09	4070	47	6.1	7.5	1.10	0.09

On the other hand, Aman rice production were 4340 kg, 4410 kg and 4070 kg/ha respectively for treatment V_1, V_2 and V_3. Soil porosity were 45, 46 and 47%, salinity was 5.5, 5.9 and 6.1, pH was 7.2, 7.4 and 7.5, %Organic C were 0.89, 1.12 and 1.10 and %TN were 0.13, 0.12 and 0.09 for the treatment V_1, V_2 and V_3, respectively.

3.7 Storing carbon in the soil by LCF

As the climate changes, farmers are facing many challenges such as, heavy raining, sudden drought and high temperature, storm, soil degradation by salinity intrusions and new or different insect and diseases infestations. The low carbon agriculture would help to farmers to adapt on climate changes because high soil organic matter content and soil cover have various advantages against nutrient and water damage which capable soils to be more resilient to floods, droughts and soil degradation processes through salinity intrusions. The farmers are adopting in LCF systems by applying cattle residues that have some extra advantages to increase crop resistance against insects and diseases. Moreover, it helps to develop soil fertility status and encourage farmers to introduce new cropping systems to adapt to climatic changes. Besides, organic fertilization enables farmers to minimize risk and resulted a stable agro-ecosystems and economic yields, and lowers production costs.

4. Conclusions

The climatic variability shocks of temperature, heavy rainfall, drought and salinity intrusion hampers Boro and Aman seasons. The farmers are more fascinated in production profit associated with reviving production up to the threshold level. Among the 14 adaptation options found for Boro and Aman season in study area in which about 27% respondent farmer choice Boro-1 adaption option in Boro season and 54% respondent farmer choice Aman-3 adaptation options in Aman season. All the adaptation option has manifold advantages as sound agricultural systems and the extension worker can explore adaptation options to the farmhouse in coastal region. The V2 treatment (50% recommended NPKSZn with bio-solids amendment) treatment was found better than other treatments (V1 and V3) and Boro and Aman yield. Organic fertilization creates capable to farmers to minimize various probable risks, as a result of stable agro-ecosystems and yields may possible, and decline costs of production.

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Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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