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FACTOR ANALYSIS OF CLIMATE-SMART PRACTICES USED FOR BORO RICE CULTIVATION IN SYLHET DISTRICT OF BANGLADESH

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ABSTRACT

Paul G, Talucder MSA, Uddin MS, Afroz T, Afrin R (2018) Factor analysis of climate-smart practices used for boro rice cultivation in Sylhet district of Bangladesh. *J. Innov. Dev. Strategy.* 12(1), 82-88.

Boro rice is leading crop in Sylhet region which have raised serious concerns due to its role in CH_4 and N_2O emission. Adoption of climate-smart practices (*CSP*) is crucial which increase productivity, reduce CH_4 and N_2O emission and increase system robustness to shocks. Factor analysis was done to document the status of *CSP* that were practiced by Boro rice farmers in Sylhet sadar upazila of Bangladesh. Data were collected through face-to-face interview from 102 randomly selected farmers from five unions of Sylhet sadar upazila *i.e.,* Hatkhola, Mogalgaon, Kandigaon, Tuker Bazar and Khadim Para during January to March 2018. Focus group discussions were done to validate the collected information. Most of the farmers were young having more than 20 years of farming experience but mostly were illiterate and had primary level of education. The farmers of the study area were aware of climate change, they observed the impact of climate change on rice farming and they want to adapt with this changing climate. Thirteen *CSP* were adopted by the farmers in the study area out of nineteen *CSP*. Thus, by using factor analysis on these thirteen existing *CSP*, three factors named as GHG mitigation and system resilience, sustainably increasing productivity, and nutrient management factor were extracted based on both index of eigen values and the percentage of variance. These three factors can explain 69.037% of the total variance from which 30.494% of the total variance explained by GHG mitigation and system resilience factor. Among these factors, high yielding rice varieties (*HYV*), perching, adjusting planting time, and alternative wetting and drying (*AWD*) were mostly being practiced by the farmers compared to others *CSP* in the study area. It implies that promoting *CSP* is necessary for sustainable boro rice production in the spell of *SDGs*.

Key words: *Climate-smart practices(CSP), factor analysis, boro rice, Sylhet*

INTRODUCTION

Rice is considered as a leading food crop in the world (Ricepedia, n.d.). About 11.4 million ha of land produces 51.64 million tons of rice in Bangladesh (BBS 2015). Among the three-growing season, boro or dry season rice (December/January to March/April) covers about 4.8 milion ha of land and produces majority of total production in Bangladesh (BBS 2015). With the increasing population growth rate, it is expected that the demand for rice will be 36.1 million tons by 2050 (Kabir *et al.* 2015). Hence, agricultural systems are a major anthropogenic source of *GHGs i.e.* CH_4 and N_2O which have raised serious concerns (*e.g.* Reiner and Milkha, 2000; Kritee *et al.* 2018; Montzka *et al.* 2011). It has impact on ecological footprint (Foley *et al.* 2011). It has a role to cross over the planetary boundaries, which is not supposed to be (*http://www.stockholmresilience.org*). Therefore, rice production systems in future will need to combine increased yields with decreased *GHG* emissions. In these circumstances, *FAO* proclaimed Climate Smart Agriculture (*CSA*) vision to avert world hunger through triple win challenges, *i.e*. increasing productivity and building resilience to climate change while reducing *GHG* emission. Under this vision, a good number of crop management strategies have been recognized as Climate-Smart Practices (*CSP*). *CSP* are playing substantial role on sustainably increasing production, reducing *GHG* emission and increase system resilience to climate change (*e.g.* Islam *et al.* 2018a; Islam *et al.* 2018b; Onyeneke *et al.* 2018; Afrin *et al.* 2017). It is very urgent to document degree of adoption of *CSP* in boro rice cultivation in Bangladesh.

In recent years, many studies have focused on *CSA* both in developed and developing countries (*e.g.* Lipper *et al.* 2014; Onyeneke *et al.* 2018). However, few studies have been reported regarding the extent of *CSP* in boro rice cultivation in Bangladesh (*e.g.* Afrin *et al.* 2017; Hasan *et al.* 2018; Billah and Hossain 2017; Mahashin and Roy 2017; CIAT 2017) and none of them use factor analysis approach for ranking existing *CSP*. With a view of this, this study was undertaken to analysis the mostly practiced *CSP* during boro rice cultivation in Sylhet Sadar upazila by using factor analysis approach.

MATERIALS AND METHODS

The study was conducted at Sylhet sadar upazila of Sylhet district. Among the eight unions in Sylhet sadar upazila, five unions, namely Hatkhola, Mogalgaon, Kandigaon, Tuker bazar, Khadim para union were selected randomly for the study were shown in Figure 1. Data for this study were collected by using simple random sampling method through face-to-face interview during January to March 2018. A pre-test survey was undertaken before the actual collection of data. Randomly selected 102 farmers of these five unions were asked about their socio-economic characteristics (age, education, family size, farm size, area under boro cultivation, rice farming experience, labour availability, soil type, irrigation sources), perceptions on experiencing climate change, impact of climate change on boro rice cropping and existing climate-smart practices (*CSP*). Respondents were also asked regarding nineteen *CSP* practices in their boro rice cultivation. *CSP* practices are alternate wetting and drying (*AWD*), crop rotation, fallowing, light trap, perching, rice-cum-duck farming, rice-cum-fish farming, high yielding varieties, adjusting planting time, ratoon crop, leaf color chart, green manuring, use of urea super granule (*USG*), vermicomposting, application of biochar, solar irrigation, water saving laser land levelling, Madagascar method and direct seeded (*e.g.* Onyeneke *et al.* 2018; Hasan *et al.* 2018; Afrin *et al.* 2017). Respondents were asked to indicate their extent of above eighteen *CSP* practices with a three-point scale: regularly, sometime, occasionally and not at all.

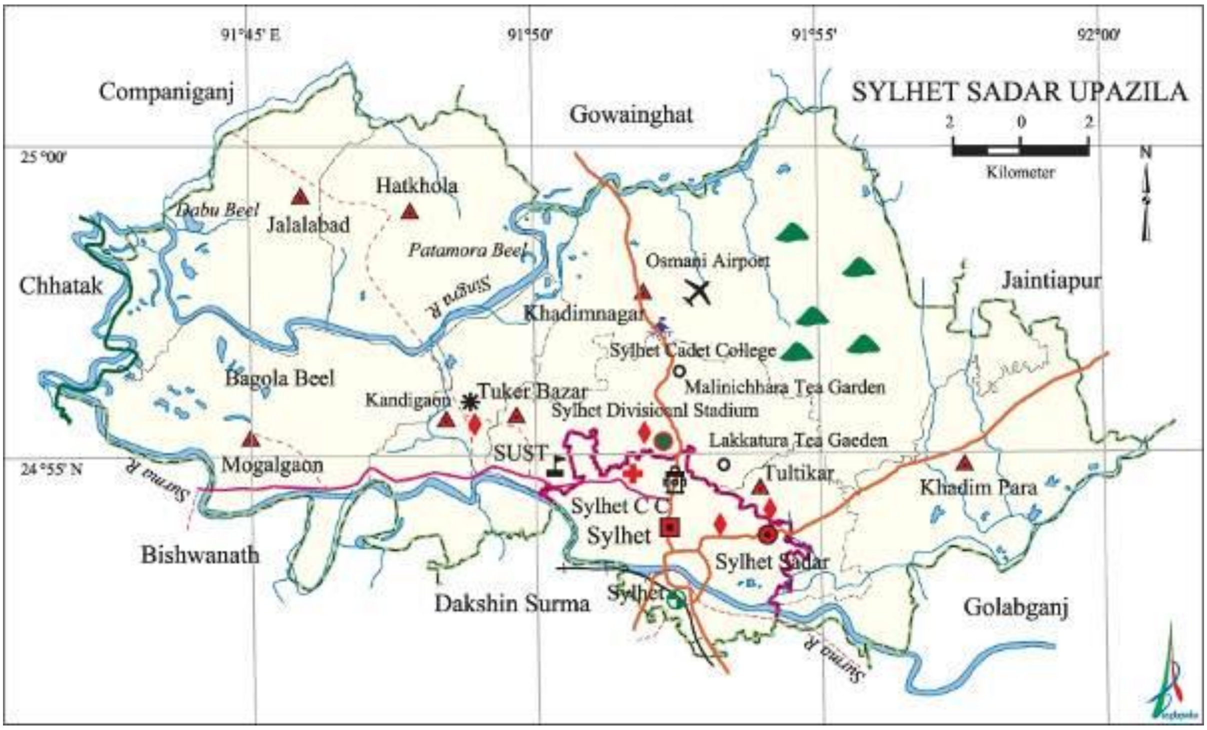

Fig. 1. Sylhet sadar upazila showing study unions

Collected data were analyzed in accordance with the objectives of the study. Various statistical measures such as frequency counts, percentage distribution, average, standard deviation and mean were used for describing data. Factor analysis (Olkin and Sampson, 2001) was used to know the status of which *CSP* were mostly practiced by farmers in boro rice farming in the study area.

RESULTS AND DISCUSSION

Socio-economic characteristics of the farmers: On the basis of National Youth policy, respondents were classified into three categories namely Young (<35 years), Middle Aged (36-50 years) and Old Aged (above 50 years). From Table 1 it was observed that about 42.15% farmers were young and the mean age of selected farmers was 41.33±13.27 (±SD). It was reported that maximum proportion of the respondents family were medium (5-8 members) sized and the percentage is about 44.12% (Table 1). On the contrary almost 33.33% and 22.55% farmers belong to large (>8) and small (<5) family. From Table 1 it can be noted that about more than half of the (54.90%) farmers having high farming experience of more than 20 years. The mean of rice farming experience is 25.52±13.45 years. About 47.05% of farmers have medium sized farm which was around 1.01 to 3.00 hectares and the portion of landless or marginal sized farmers was about 3.92%. About 47.05% of farmers have medium sized farm which was around 1.01 to 3.00 hectares and the portion of landless or marginal sized farmers was about 3.92%. It was observed from Table 1 that 69.61% farmers have small sized land for cultivating boro which is around 0.21 to 1.00 hectares. In compare to the farm size distribution, it was reported that the area under boro cultivation is less in Sylhet sadar upazila. Here the average land for cultivating boro rice was 0.73±0.93 hectares which also explains the situation. About 33% farmers in the study area were without education and 44% were primarily educated (Figure 2). It also observed that, every farmer from higher secondary and university graduate explains the labour situation as Crisis Level. But most of the farmer state the labour situation sufficient are from the people who have only primary or secondary education. The overall scenario in the study area was that the farmers were highly suffered from labour crisis.

Table 1. Farmers basic socio-demographic characteristics

Farmers' characteristics	Categories of characteristics	Number of respondent	Range		Mean	Std. dev.
			Min.	Max.		
Age (Years)	Young (<36) Middle Aged (36-50) Old Aged (>50)	43(42.15%) 36(35.29%) 23(22.55%)	15.2	79.63	41.33	13.27
Family Size (Number)	Small (<5) Medium (5-8) Large (>8)	23(22.55%) 45(44.12%) 34(33.33%)	3	18	7.49	3.172
Rice Farming Exp. (Years)	Low (<10) Medium (10-20) High (>20)	11(10.78%) 35(34.31%) 56(54.90%)	3	60	25.52	13.45
Farm Size (Hectare)	Landless & Marginal (<0.21) Small (0.21-1) Medium (1.01-3) Large (>3)	4(3.92%) 42(41.18%) 48(47.05%) 8(7.84%)	0.146	5.706	1.386	1.044
Area under Boro cultivation (Hectare)	Landless & Marginal (<0.21) Small (0.21-1) Medium (1.01-3) Large (>3)	7(6.86%) 71(69.61%) 21(20.59%) 3(2.94%)	0.121	5.706	0.735	0.9315

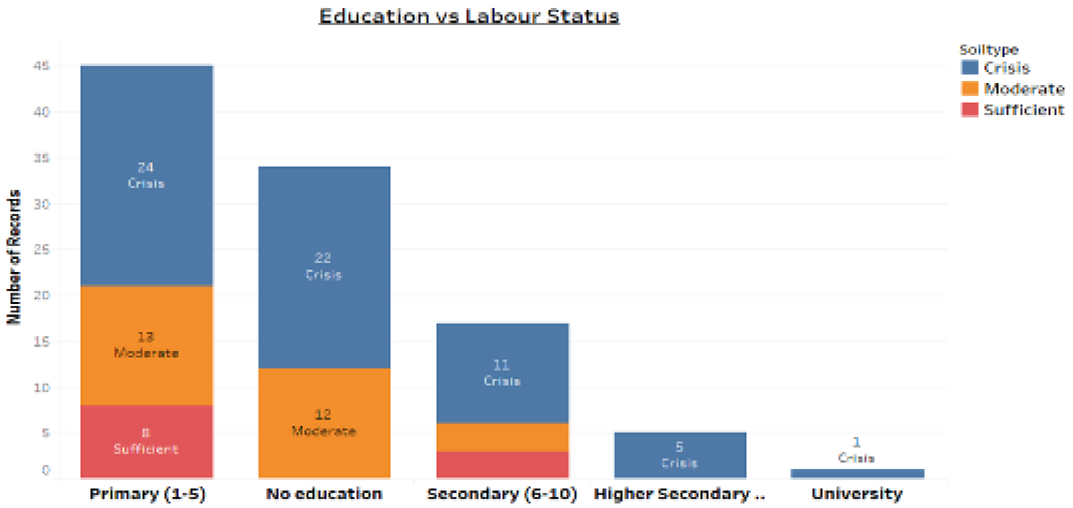

Fig. 2. Education and labour status of farmers

Climate Change: Figure 3 shows that about 97% (99 out of 102) farmers observed climate change in past 10 years. The farmers of the study area were aware of climate change and they want to adapt with this changing climate. From their perspective of climate change they found significant changes in temperature and rainfall.

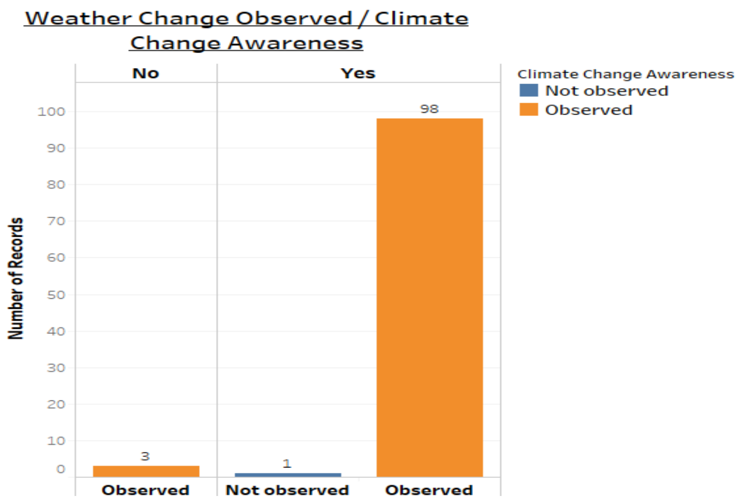

Fig. 3. Farmers perception regarding Climate Change

Soil Type: Five types of soil were reported in the study area as loamy soil (79%), sandy loam soil (9%), clay soil (8%), sandy soil (6%) and clay loam soil (2%) (Figure 4). It was observed that most of the farming land in Sylhet sadar upazila were loamy textured soil.

Irrigation Sources: It was found from the Figure 5 that, most of the farmers used river (29 out of 102 farmers), canal (22), khal (19) and chara (18) as their main sources of irrigation for Boro rice cultivation in Sylhet sadar upazila. There was lack of modern irrigation sources such as deep tube wells, shallow tube wells and low lift pumps (LLPs) in the study area.

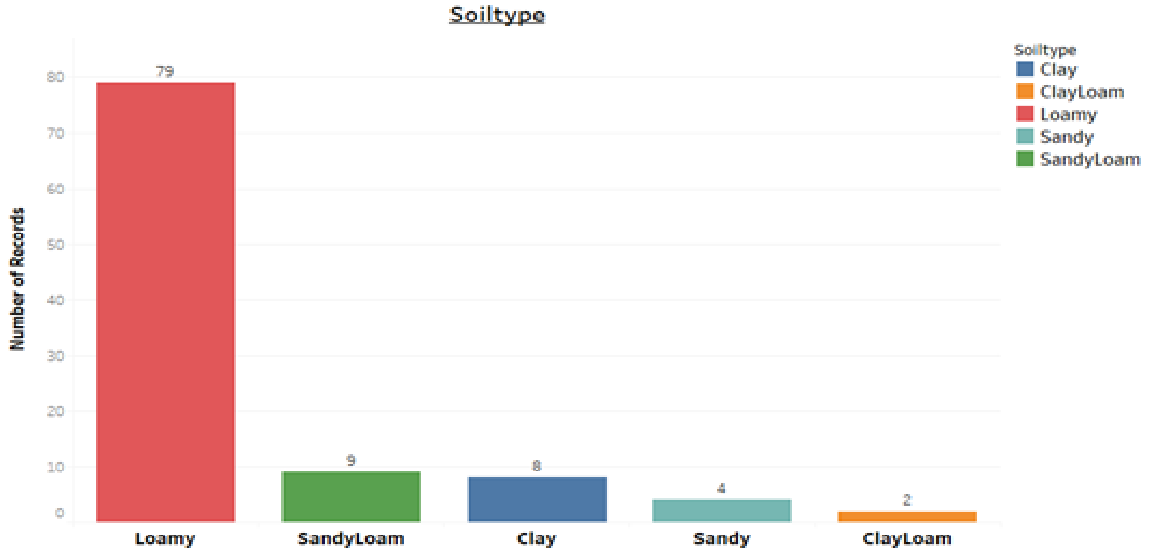

Fig. 4. Types of soil used by farmers

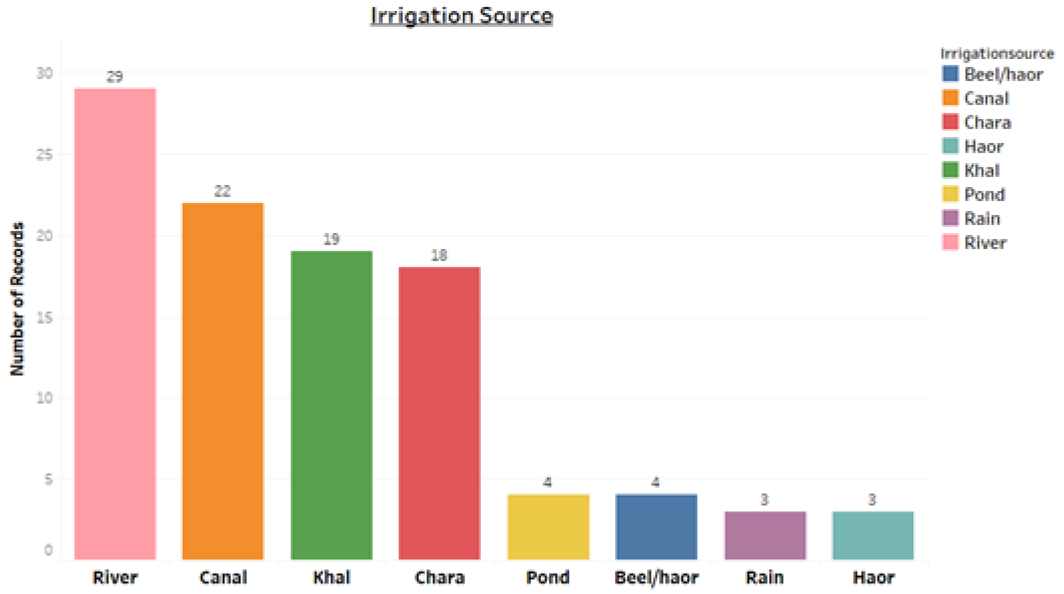

Fig. 5. Irrigation sources of farmers

Factor Analysis of CSA practices in boro rice cultivation

In the study area, nineteen *CSP viz.* alternate wetting and drying (*AWD*), crop rotation, fallowing, light trap, perching, rice-cum-duck farming, rice-cum-fish farming, high yielding varieties, adjusting planting time, ratoon crop, leaf color chart, green manuring, use of urea super granule (*USG*), vermicomposting, application of biochar, solar irrigation, water saving laser land levelling, Madagascar method and direct seeded were reported. It was found that amongst the 19 *CSP*, farmers were totally unfamiliar with 6 *CSP*, such as vermicomposting, application of biochar, solar irrigation, water saving laser land levelling, Madagascar method and direct seeded. Thus, factor analysis was performed using 13 existing *CSP* to find out the most adopted *CSP* by the farmers.

To ensure suitability for conducting factor analysis, this study used the Kaiser-Meyer-Olkin (*KMO*) test and Bartlett's test of sphericity. The *KMO* value ranges from 0 to 1, the acceptable values should be greater than 0.5. *KMO* values closer to 1 are better for factor analysis. Bartlett's test of sphericity determines if the correlation matrix is an identity matrix. If there exists an identity matrix, factor analysis is meaningless (Field 2000; Ghosh and Jintanapakanont 2004). From Table 2 the result of the *KMO* test was 0.806 and Bartlett's test of sphericity was high at 670.64 (associated with probability value of 0.000). Both tests indicated the suitability of the variables for factor analysis.

Table 2. Kaiser-Meyer-Olkin (*KMO*) and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.806
Bartlett's Test of Sphericity	Approx. Chi-Square	670.64
	d.f.	78
	Sig.	0.000

The aim of the data extraction is to reduce a large number of items into factors. Many extraction rules and approaches exist including: Kaisers criteria (eigen value >1), the Scree test, cumulative percent of variance extracted and parallel analysis. In this study, to determine the no of factors, both eigen values approach and the percentage of variance approach were used. In the eigen values approach, factors with relatively large eigen values are extracted and those with relatively small eigen values are ignored. From table 3, it was observed that only three factors were extracted each having eigen values greater than 1.0 (3.964, 3.294 and 1.716). For the percentage of variance approach, the cumulative percentage of three factors was 69.037%, which means that these three factors explained 69.037% of the total variance. It is pretty good extraction because we are able to economize the number of choice factors. (i.e., from 13 statements to three underlying factor).

The percentage of variation explained by factor I is 30.494% and that of II and III are 25.341% and 13.203%, respectively (Table 3). Since there were many factors, the idea of rotation is to reduce the number factors on which the variables under investigation have high loadings. For orthogonal rotations, such as Varimax and Quartimax, the factors are not permitted to be correlated and the factor pattern and factor structure matrices are the same (Kline 1996; Field 2000).

Table 3. Factor analysis for existing Climate Smart practices(*CSP*)

Factor no.	**Factor name**	**Eigen Value**			***CSP***	**Items loading**
		Total	**% of variance**	**Cumulative %**		
I	*GHG* mitigation and system resilience factor	3.964	30.494	30.494	*AWD*	**0.831**
					Crop rotation	0.789
					Fallowing	0.790
					Light trap	0.823
					Perching	**0.845**
II	Sustainably increasing productivity factor	3.294	25.341	55.834	Rice-cum-Duck farming	0.781
					Rice-cum-Fish farming	0.829
					High yielding varieties	**0.866**
					Adjusting planting time	**0.834**
					Raton crop	0.830
III	Nutrient management factor	1.716	13.203	69.037	Leaf color chart	0.747
					Green manuring	0.817
					USG	0.778

* Rotation converged in 5 iterations

In this study principal component analysis using orthogonal (Varimax) rotation was applied. The factor analysis results in three factors for existing *CSP* among farmers in Sylhet sadar upazila and the factors were named according to common nature of statements. The detail about the factor included the factor number, factor name, their eigen value and their item loading as given in Table 3.

GHG mitigation and system resilience factor: The factor I was *GHG* mitigation and system resilience factor, the most important determinants of this study that accounted for 30.494% of the total variance (Table 3). Five practices represented the significant loadings of this factor. It is comprised of *AWD* (0.831), crop rotation (0.789), fallowing (0.79), light trap (0.823) and percing (0.845). Among all the practices within this factor, the highest factor loadings (0.845) were given to perching. From this output it was observed that, the farmers of the study area have mostly introduced perching and *AWD* techniques in the boro rice cropping as a climate-smart practice which also supported by the study Afrin *et al.* (2017), Billah and Hossain (2017) and Hasan *et al.* (2018).

Sustainably increasing productivity factor: The factor II was sustainably increasing productivity factor. This factor has emerged as the important determinants of research with 25.341% of total variance (Table 3). The sustainably increasing productivity factor included the practices: rice-cum-duck farming (0.781), rice-cum-fish farming (0.829), high yielding varieties (0.866), adjusting planting time (0.834) and ratoon crop (0.830). Amongst these practices farmers most widely practiced high yield shorter duration rice varieties as *CSP* that eventually improve the farmers income and which also related with *SDG2* (zero hunger) and *SDG1* (no poverty) (Billah and Hossain, 2017).

Nutrient management factor: The factor III, proposed as "nutrient management factor", accounted for 13.203% of the total variance. Practices included in the factors are leaf colour chart (0.747), green manuring (0.817) and *USG* (0.778). The highest load factor related to the practice "green manuring" (0.817) is the design (Table 3).

The empirical results were summarized the socio-economic characteristics of the farmers, their perceptions on climate change and existing climate smart practices in boro rice cropping in Sylhet sadar upazila. It was observed that maximum farmers were young (age less than 36 years) and most of them were medium (5-8 members) sized family. It also noted that the farmers in the study area were highly experienced of more than 20 years in rice farming (54.9%) farmers having high farming experience of more than 20 years. About 47.05% of farmers have medium sized farm around 1.01 to 3.00 hectares and 69.61% farmers used a small portion around 0.21 to 1.00 hectares land in boro rice cultivation which was really alarming. Most of the farmers in the study area were primarily educated (44%) whereas about 34% farmers were uneducated and a very small proportion of the farmers were educated. In the study area it was also found that the farmers were highly suffered from labour crisis. The farmers of the study area were aware of climate change. They observed climate change in past 10 years and they want to adapt with this changing climate. From their perspective of climate change they found significant changes in temperature and rainfall. It was observed that most of the farming land in Sylhet sadar upazila were loamy textured soil and farmers usually used rivers, canals, khals and jhoras water as their main sources of irrigation.

CONCLUSION

In the study area, thirteen climate-smart practices (*CSP*) were practiced. By using factor analysis, three factors such as *GHG* mitigation & system resilience, sustainably increasing productivity, and nutrient management factor were extracted based on both eigen values and the percentage of variance approach. These three factors explained 69.037% of the total variance. Among the factors, 30.494% of the total variance explained by *GHG* mitigation & system resilience factor. Compared to different practices, perching, high yielding varieties, adjusting planting time, and *AWD* practices were being mostly practiced by the farmers in the study area. The findings of our study were similar to the findings of the study Hasan *et al.* (2018), Afrin *et al.* (2017) and Billah and Hossain (2017). They identified sorjan method, urea deep placement, organic fertilizer, mulching, rain water harvesting, HYV, crop rotation, perching, agroforestry, *AWD* method as existing *CSP* practiced by the farmers of coastal areas and Kalapara upazila in Patuakhali district of Bangladesh. This practices have become very popular to the farmers as it increases the productivity, reduces the emission of CH_4 and N_2O and increasing system resilience as they were aware regarding climate change. Policies should be taken to promote *CSP* through research and extension.

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REFERENCES

Afrin R, Talucder MSA, Paul G, Uddin MS (2017) Status of climate-smart agricultural practices in Jointapur upazila of Sylhet district. *J. Sylhet Agril. Univ., 4*(2), 251-260.

BBS (2015) Year book of agricultural statistics 2015, 27th edition. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, www.bbs.gov.bd

Billah MM, Hossain MA (2017) Role of Climate Smart Agriculture Technologies in Sustainable Crop Production by the Coastal Farmers of Bangladesh. *Imp. J. Interdiscip. Res.,* 3(10), 398-403.

CIAT and World Bank (2017) Climate-Smart Agriculture in Bangladesh. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture (CIAT); World Bank. Washington, DC. 28.

Field AP (2000) Discovering statistics using SPSS for windows: advance techniques for the beginner. Great Britain: Sage Publication.

Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, Mueller ND, O'Connell C, Ray DK, West PC, Balzer C, Bennett EM, Carpenter SR, Hill J, Monfreda C, Polasky S, Rockstrom J, Sheehan J, Siebert S, Tilman D, Zaks DPM (2011) Solutions for a cultivated planet. *Nature,* 478, 337-342.

Ghosh S, Jintanapakanont J (2004) Identifying and assessing the critical risk factors in an underground rail project in Thailand: a factor analysis approach. *Int. J. Proj. Manag.,* 22, 633-643.

Hasan MK, Desiere S, D'Haese M, Kumar L (2018) Impact of climate-smart agriculture adoption on the food security of coastal farmers in Bangladesh. *Food Secur.*, 10, 1073-1088.

Islam SF, van Groenigen JW, Jensen LS, Sander BO, de Neergaard A (2018a) The effective mitigation of greenhouse gas emissions from rice paddies without compromising yield by early-season drainage. *Sci. Total Environ.*, 612, 1329-1339. doi:10.1016/j.scitotenv.2017.09.022

Islam SMM, Gaihre YK, Biswas JC, Singh U, Ahmed MN, Sanabria J, Saleque MA (2018b) Nitrous oxide and nitric oxide emissions from lowland rice cultivation with urea deep placement and alternate wetting and drying irrigation. *Sci Rep.*, 8(1), 17623. doi:10.1038/s41598-018-35939-7

Kabir MS, Salam MU, Chowdhury A, Rahman NMF, Iftekharuddaula KM, Rahman MS, Rashid MH, Dipti SS, Islam A, Latif MA, Islam AKMS, Hossain MM, Nessa B, Ansari TH, Ali MA, Biswas JK (2015) Rice vision for Bangladesh: 2050 and beyond. *Bangladesh Rice J*. 19, 1-18.

Kline P (1996) An easy guide to factor analysis. Great Britain: Routledge.

Kritee K, Drishya N, Daniel ZA, Jeremy P, Joseph R, Adhya TK, Proville J, Rudek J, Adhya TK, Loecke TD, Esteves T, Balireddygari S, Dava O, Ram K, Abhilash SR, Madasamy M, Dokka RV, Anandaraj D, Athiyaman D, Reddy M, Ahuja R, Hamburg SP (2018) High nitrous oxide fluxes from rice indicate the need to manage water for both long- and short-term climate impacts. *PNAS USA*., 115, 9720-9725.

Lipper L, Thornton P, Campbell B (2014) Climate-smart agriculture for food security. *Nat. Clim. Change*., 4, 1068-1072.

Mahashin M, Roy R (2017) Mapping Practices and Technologies of Climate-Smart Agriculture in Bangladesh. *J. Environ. Sci. & Natural Resources*., 10(2), 29-37.

Montzka SA, Dlugokencky EJ, Butler JH (2011) Non-CO_2 greenhouse gases and climate change. *Nature*., 476, 43-50.

Olkin I, Sampson AR (2001) Multivariate Analysis: Overview. International Encyclopedia of the Social & Behavioral Sciences., 10240-10247. doi:10.1016/b0-08-043076-7/00472-1

Onyeneke RU, Igberi CO, Uwadoka CO, Aligbe JO (2018) Status of climate-smart agriculture in southeast Nigeria. *GeoJournal.,* 83, 333-346.

Reiner W, Milkha SA (2000) The role of rice plants in regulating mechanisms of methane missions. *Biol. Fertil. Soils.,* 31, 20-29.

Ricepedia. Retrieved 08 October 2018, from http://ricepedia.org/rice-as-a-crop