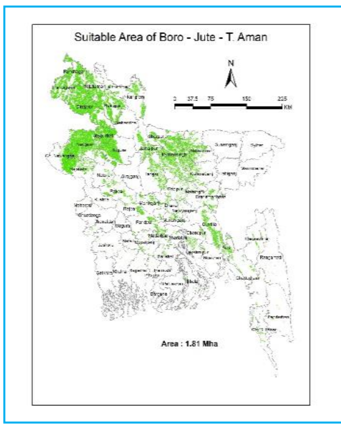
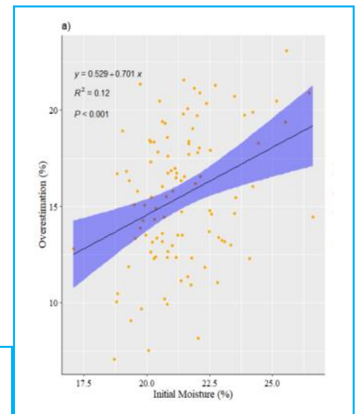
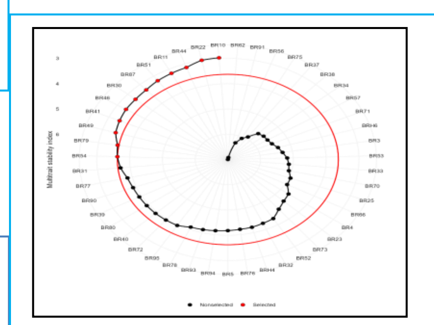
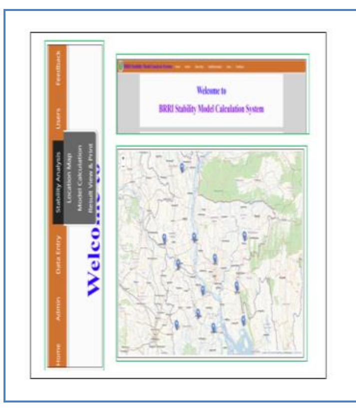
ANNUAL RESEARCH REVIEW WORKSHOP

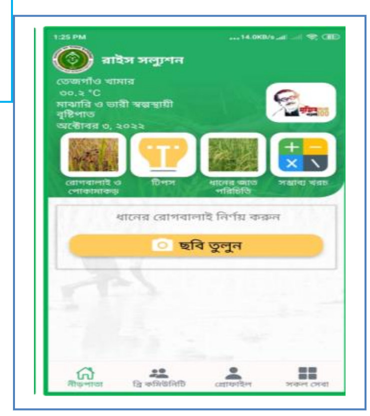
2022-23











XIV
AGRICULTURAL STATISTICS DIVISION

BANGLADESH RICE RESEARCH INSTITUTE

GAZIPUR 1701

CONTENTS

PERSONNEL

Agricultural Statistics Division

Research Personnel and Supporting Staff

Dr. Md. Ismail Hossain
Chief Scientific Officer and Head

Niaz Md. Farhat Rahman
Principle Scientific Officer

Md. Abdul Qayum
Senior Scientific Officer

Md. Abdullah Aziz
Senior Scientific Officer

Md. Abdullah Al Mamun
Scientific Officer

Md. Shahinur Alam
Scientific Assistant

ICT Cell Personnel and Supporting Staff

S. M. Mostafizur Rahman
System Analyst

Md. Mahfuz Bin Wahab
Programmer

Kabita
Assistant Programmer

Rokib Ahmed
Data Analyst

Nuraiya Kulsom
Senior Data Entry Control Operator

Md. Aminuzzaman
Computer Assistant

Md. Akhter Hossain
Computer Assistant

Summary

T. Aman varieties, BRRI dhan49 and BRRI dhan87 were found stable. None of the varieties were found to be unstable during T. Aman season. Among the aromatic rice BRRI dhan5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 were found as below average stable in T. Aman season. Boro varieties, BRRI dhan89, BRRI dhan92, BRRI dhan29 and BRRI hybrid dhan3 and BRRI hybrid dhan5 were found stable. None of the varieties were found to be unstable during Boro season. On the other hand, only aromatic rice varieties BRRI dhan50 appeared to below average stable.

Utilizing a multi-trait stability index, the case of FA1, factors like GY, TN, atnd PN identified BRRI dhan87, BRRI dhan79, and BRRI hybrid dhan4 as top performers, with FA1 contributing less than 0.25 to their performance. Out of the 47 varieties, BR10, BR22, BRRI dhan44, BR11, BRRI dhan51, BRRI dhan87, BRRI dhan30, BRRI dhan46, BRRI dhan41, BRRI dhan49, and BRRI dhan79 were selected at 30% selection intensity using MTSI.

During yield estimation from crop cut samples, most of the cases had found significant overestimation. The change of initial moisture, moisture reduction and dust significantly increase for overestimation with a rate of change 0.701, 0.859 and 0.818 percent, respectively. Most of the variety found a significant variation of the overestimation in crop cut sampled in sundry method. The highest and lowest overestimations observed were 7.08 and 23.08%, respectively for sundry methods. The average overestimation (%) for sundry sampled observed 15.52%.

The drought intensity shifted from the northern to central and southern zones of Bangladesh, which had an adverse impact on crop production and the livelihood of rural and urban households. So, this precise study has important implications for the understanding of drought prediction and how to best mitigate its impacts.

The highly significant genotype × environment interaction effects for grain yield confirmed that genotypes responded differently to the variation in environmental conditions for long, medium and short duration T.Aman varieties. Greater portion of total variation was explained by environmental main effect, indicating that the environments were diverse and a major part of variation in grain yield reflected from environmental changes. In Aman season, BR11 and BRRI dhan30 recorded the highest average grain yielder and ideal genotypes among long duration varieties. BRRI dhan49, BRRI dhan93 and BRRI dhan94 were the most stable genotype with above-average yield in medium duration where BRRI dhan71, BRRI dhan72, BRRI dhan87 and BRRI dhan95 were the most stable genotypes and above average yielder for short duration.

Rice area increased about one and half folds but the production increased about four folds during 1971-72 to 2021-22. Although the growth rate of rice area was 3.96 in year 1972-73 but in 2021-22 is -0.95. Similarly, growth rate of rice production was 1.30 in year 1972-73 but in 2021-22 is 8.91.

This novel approach can help rice growers in a better and more coordinated way in response to weather extremes or climate variability that exceeds their inherent coping capacity. This can significantly reduce the disaster risk of the rice farming communities, which is a major development challenge in Bangladesh.

In Boro season, BRRI dhan96 is suited all regions of Bangladesh. Whereas BRRI dhan97 and BRRI dhan99 are suitable for saline regions. In T. Aus seasons BRRI dhan98 is appropriate for western, region of Bangladesh.

More or less throughout the year eastern side of Bangladesh is high rainfall and low temperature area and western side is low rainfall and high temperature area. Spatial distribution of minimum temperature and total rainfall are more or less same but maximum temperature is vice-versa to minimum temperature and total rainfall.

During Aman 2022 about 5.82 Mha of rice was cultivated in Bangladesh and highest Aman production district was Dinajpur.

In all divisions of Bangladesh average total precipitation of July month in 2050 will be increased in comparison to average total precipitation during 2010-2018, only exception is Chattogram division, where precipitation will be decreased by about 69 mm. The precipitation of July month will rise the highest in Sylhet and Mymensingh divisions with an amount of about 59 mm and 53 mm, respectively.

Boro-Fallow-T.Aman cropping pattern is suitable in west and middle part of Bangladesh and total suitable area is 3.85 Mha. Boro-Aus-T.Aman corriping pattern cover total suitable area 1.09 Mha and these suitable area in north-west and central northern sides of Bangladesh. Boro-Jute-T.Aman is suitable in north-west and central northern sides of Bangladesh. Total suitable area is 1.81Mha

The rice cultivation areas in Babuganj Upazila over three years has manifested several significant transformations, shedding light on the dynamic nature of agricultural practices and land usage in the region. There was a remarkable growth in newer rice cultivation zones, predominantly originating from fallow lands.

In the reporting year, two types of training were conducted under "Capacity Building through Training" programme. A total of 60 participants were trained through the training programmes. The participants of these training were scientists and SA, FM and AFM of BRRI.

Seven activities have been done in the reporting year 2022-23 under the project Computer programming, Software Development and Digitization. A new web application has been developed to calculate the stability index for BRRI stability model. Also developed a new unique platform for BRRI developed all the Management Information System (MIS). Five web applications have been updated and continuously run in the whole reporting year named (1) Salary Management System for BRRI HQ (2) Labour Management System for BRRI HQ (3) Budget Management System (4) Quota Management System and (5) CL Application Management System for Agricultural Statistics Division of BRRI.

ICT cell of this division has developed Sensor-based rice pest management through Artificial Intelligence (AI) technology named 'Rice Solution' mobile App and Rice profiling App. Also, developed 'BRRI Rice doctor' mobile and web apps both English and Bengoli version with the help of different divisions of BRRI. Developed dynamic view connectivity, Bangla search and inner banner system for BRKB web apps. Besides, modified the RKB mobile apps and disseminate of modern rice technology and its management information at the farmer door step through RKB Mobile Apps. We developed Vehicle Requisition Management System (VRMS) of BRRI. So that, the requester informed through SMS on basis of demanding vehicle for official or personal purpose as well as driver get confirmation SMS for their upcoming duty. Also, we developed "BRRI Alapon" Telephone Directory Mobile App. We established video conferencing system (VCS) at BRRI to communicate with MoA and others government organization. We organized five day-long, two day-long, day-long 'Public Service Innovation' training workshops in the reporting year. A total of 400 participants were trained through the innovation, SPS trainings and e-Nothi in-house trainings. In addition, Cyber security system has been strengthened for BRRI.

Project 1: Statistical methodology in Rice Research

Experiment 1.1: Stability Analysis of BRRI varieties

(In collaboration with Plant Breeding Div., Plant Physiology Div., Agronomy Div., ARD and BRRI R/S's)

-Md. Ismail Hossain, Md. Shahjahan Kabir, Niaz Md. Farhat Rahman, Md. Abdul Qayum, Md. Abdullah Aziz, Md. Abdullah Al Mamun, Md. Sazzadur Rahman, Khandakar Md Iftekharuddaula, Md. Humyaun kabir and One Scientist from each Regional Station

Introduction

Stability models developed by Comstock and Robinson (1952), do not consider the response of environment on genotypic variation in identification of stability of the genotypes and thus, there is no information on how the genotypes will behave under rich, average or poor environment. On the other hand, Finlay and Wilkinson's (1963), also Eberhart and Russell (1966) used the concept of regression analysis in their stability models. The most serious and logical objection to the regression technique for stability analysis is that the site means or the environmental indices, which are employed as independent variables, are essentially not independent of the dependent variables, i.e., genotype means. Another serious limitation of the stability models those use regression technique is for the regression coefficients, use for measuring the stability of varieties which are unreliable due to poor to very poor fit of the regression model to the observed data in most of the cases. Thus, the models that use the regression technique to determine the varietal stability is not out of criticism. So, a new model was developed for stability analysis of genotypes in the year 2004-05 that avoids the jargons of regression analysis and uses a single index to identify the stability of a genotype across different environments and calibration and fine-tuning work on the model is doing since last year.

Objectives

1. To determine the stability index of BRRI released varieties
2. To maintain season, year and location-wise database on BRRI varieties.
3. To determine the interaction of BRRI varieties (genotypes) across all the environment

Materials and Method

Experiments are being conducted in T. Aman season and Boro with BRRI released rice varieties since 2001-22 at Gazipur and different regional stations. The collaborative regional stations in the T. Aman season are Rajshahi, Rangpur, Cumilla, Sonagazi, Barishal, Satkhira and Kushtia and in the Boro season Rajshahi, Rangpur, Cumilla, Habiganj, Barishal, Bhanga, Satkhira, Sonagazi and Kushtia. The numbers of varieties are 47 and 49 in T. Aman and Boro season respectively. The design was RCB with three replications and the effective plot size (harvest area) was 3.0-x-3.2 m^2 leaving the two-border row from each side. Recommended crop management practices were followed. Stability analysis of the experimental data was performed by using a newly developed model. The model deals with the performance of the genotypes across the geographical locations differing in land, soil and other biotic and abiotic factors over the years characterizing fluctuation of weather variable, floods, drought etc. Stability analyses of the experimental data were performed following the newly BRRI developed model, which is described below:

The stability model

The newly developed stability model takes into account the performance of the genotypes across the geographical locations differing in land, soil and other biotic and abiotic factors over the years characterizing fluctuation of weather variable, floods, drought, etc.

In the new model, the stability of a genotype is determined by three parameters. These are:

(1) Measure of yield fluctuation of i^{th} variety, $S_i = \frac{\sum_{j=1}^{s} S_{ij}}{s}$

S_{ij} is the coefficient of variation (CV) of the yield index of i^{th} variety in j^{th} location and is computed as,

$S_{ij} = \frac{V_{ij}}{\bar{z}_i} \times 100$, where

$V_{ij} = \sqrt{\frac{\sum_{k=1}^{t} (z_{ijk} - \bar{z}_{ij})^2}{t}}$ = yield index of i^{th} variety in j^{th} location,

where, $\bar{z}_{ij} = \sum_{k=1}^{t} \frac{z_{ijk}}{t}$

$z_{ijk} = \frac{\bar{y}_{ijk}}{\bar{y}_{jk}}$ = Yield index of ith variety in jth location and kth year with respect to average yield of all varieties in jth location and kth year

$\bar{y}_{ijk} = \frac{\sum y_{ijkl}}{r}$ = Average yield of ith variety in jth location and kth year $\bar{y}_{jk} = \frac{\sum \bar{y}_{ijk}}{v}$ = Average yield of all varieties in jth location and kth year

y_{ijkl} = ith variety yield of lth replication in jth location and kth year.

v = no. of variety, s = no. of location, t = no. of years and r = no. of replication.

(2) Measure of performance of ith variety, $D_i = \frac{\sum_{j=1}^{s} d_{ij}}{s}$

(3) Measure of superiority of ith variety in jth location, $d_{ij} = \frac{(\bar{z}_{ij} - \bar{z}_j)}{\bar{z}_j} \times 100$; where, $\bar{z}_j = \frac{\sum_{i=1}^{v}\sum_{k=1}^{t} z_{ijk}}{tv}$.

A variety for which S_i is the minimum, $d_{ij} \geq 0$ for all j and D_i is a positive maximum, is defined as the most stable variety among the alternatives: stable across the locations and over the years.

In other words, a variety to be stable

- Should have minimum variability than other varieties
- Should yield consistently higher than other varieties across the locations and
- Should have higher yield than other varieties over locations and years

Combining the three quantities S_i, D_i and d_{ij}, the stability index of ith genotype is defined as:

$$G_i = \left(F_i^I + P_i^I + S_i^I\right)$$

where, F_i^I = Fluctuation index of ith variety = $\frac{Min(S_i)}{S_i}, i = 1, 2, 3, ...v$

P_i^I = Performance index of ith variety = $\frac{D_i}{Max(|D_i|)}$, i = 1, 2, 3,.......v

S_i^I = Superiority index of ith variety = $\frac{P_i}{t\, x\, s}, i = 1, 2, 3, ...v$

P_i = No of times the ith variety exceeded $\bar{z}_{ij}$ in all locations and year.

The value of G_i ranges from –1 to +3 i.e., $-1 \leq G_i \leq 3$. The higher the value of G_i more is the stability of the genotype across the environments. Stability of a variety is characterized as follows:

Value of G_i	**Nature of stability**
≤ 0	Unstable
$0 < \mathbf{G}_i \leq 1$	Below average stable
$1 < G_i \leq 2$	Average stable
$2 < G_i \leq 3$	Stable

Results and Discussion

Among T. Aman varieties, BRRI dhan49 and BRRI dhan87 were found stable with stability index 2.101 and 2.015 respectively. while BR3, BRRI dhan33, BRRI dhan39, BRRI dhan56, BRRI dhan57, BRRI dhan62, BRRI dhan70, BRRI dhan90 and BRRI dhan91 appeared to be below average stable. BR4, BR10, BR11, BR22, BR23, BR 25, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan40, BRRI dhan41, BRRI dhan44, BRRI dhan46, BRRI dhan49, BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54, BRRI dhan66, BRRI dhan71, BRRI dhan72, BRRI dhan73, BRRI dhan75, BRRI dhan76, BRRI dhan77, BRRI dhan78, BRRI dhan79, BRRI dhan80, BRRI dhan93, BRRI dhan94, BRRI dhan95, BRRI hybrid dhan4 and BRRI hybrid dhan6 were found having average stability among T. Aman varieties. Among the aromatic rice BRRI dhan5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 were found as below average stable in T. Aman season (Table 1).

Among Boro varieties, BRRI dhan89, BRRI dhan92, BRRI dhan29 and BRRI hybrid dhan3 were found as stable with stability index 2.223, 2.194, 2.001 and 2.174 respectively. BR3, BR9, BR14, BR15, BR16, BRRI dhan28, BRRI dhan36, BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan63, BRRI dhan67, BRRI dhan68 BRRI dhan69, BRRI dhan74, BRRI dhan88, BRRI dhan96, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101, BRRI dhan102 and BRRI hybrid dhan2 varieties were found as average stable and rest of the 17 varieties appeared to be below average stable. Among the non-aromatic rice. On the other hand, only aromatic rice BRRI dhan50 were found as average stable in Boro season (Table 2). From the yield data 2001-2022 of BRRI varieties the average maximum yield was observed 6.60 t/ha in T. Aman varieties and average minimum yield was observed 1.55 t/ha. From the yield data 2001-02 to 2022-23 the average maximum yield was observed 8.51 t/ha in Boro varieties and average minimum yield was observed 2.75 t/ha (Table 3). The yield differences due to lodging, lack of management, disease and insect infestation, bird and rat damage etc.

Table 1. Stability parameters of grain yield for T. Aman.

Variety	Stability parameter 2001-2022			Stability index	Stability rank	Nature of stability
	Si	Di	Pi	Gi	Ri	
Non-aromatic rice						
BR 3	18.117	-9.321	95	0.833	37	BAS
BR 4	13.228	0.464	84	1.261	23	AS
BR 10	13.902	8.493	76	1.406	17	AS
BR 11	14.131	8.126	89	1.461	13	AS
BR 22	14.082	6.382	88	1.411	16	AS
BR 23	15.812	1.576	87	1.181	28	AS
BR 25	15.741	-0.714	89	1.142	30	AS
BRRI dhan30	12.967	6.887	91	1.516	10	AS
BRRI dhan31	13.756	2.392	92	1.319	21	AS
BRRI dhan32	15.931	7.127	95	1.395	18	AS
BRRI dhan33	21.051	-11.297	85	0.645	40	BAS
BRRI dhan39	17.533	-1.656	78	0.975	35	BAS
BRRI dhan40	14.252	5.914	90	1.413	15	AS
BRRI dhan41	16.423	3.743	92	1.247	24	AS
BRRI dhan44	14.363	7.064	61	1.356	19	AS
BRRI dhan46	15.744	1.195	62	1.159	29	AS
BRRI dhan49	10.889	12.27	57	2. 101	1	S
BRRI dhan51	16.364	4.939	48	1.234	25	AS
BRRI dhan52	11.269	9.571	53	1.713	5	AS
BRRI dhan53	14.355	2.467	44	1.271	22	AS
BRRI dhan54	18.226	5.502	46	1.233	26	AS
BRRI dhan56	17.048	-6.152	48	0.944	36	BAS
BRRI dhan57	20.737	-18.789	47	0.46	42	BAS
BRRI dhan62	27.497	-20.289	41	0.322	45	BAS
BRRI dhan66	13.156	4.925	35	1.428	14	AS
BRRI dhan70	18.464	-8.697	26	0.717	39	BAS
BRRI dhan71	13.553	8.798	32	1.521	9	AS
BRRI dhan72	11.515	14.328	27	1.736	4	AS
BRRI dhan73	16.139	4.452	35	1.322	20	AS
BRRI dhan75	17.027	1.393	29	1.102	32	AS
BRRI dhan76	16.363	-5.155	35	1.031	34	AS
BRRI dhan77	13.953	-5.529	31	1.063	33	AS
BRRI dhan78	13.044	7.117	23	1.504	12	AS
BRRI dhan79	10.229	10.645	21	1.778	3	AS
BRRI dhan80	12.369	5.711	23	1.505	11	AS
BRRI dhan87	12.941	19.709	24	2.015	2	S
BRRI dhan90	18.044	-8.215	13	0.826	38	BAS
BRRI dhan91	17.852	-34.166	15	0.129	47	BAS
BRRI dhan93	11.207	12.708	11	1.692	6	AS
BRRI dhan94	14.319	11.929	13	1.545	8	AS
BRRI dhan95	19.645	5.373	11	1.104	31	AS
BRRI Hybrid dhan4	17.356	4.951	36	1.211	27	AS
BRRI Hybrid dhan6	15.269	16.185	28	1.662	7	AS
Aromatic rice						
BR 5	19.674	-23.001	87	0.354	44	BAS
BRRI dhan34	20.805	-25.718	90	0.259	46	BAS
BRRI dhan37	18.244	-23.275	92	0.399	43	BAS
BRRI dhan38	17.008	-20.359	88	0.508	41	BAS

Note: AS=Average stable, BAS=Below average stable, Stable=S and Unstable=US

Table 2: Stability parameters of grain yield for Boro

Variety	Stability Parameter 2001-2023			Stability Index	Stability Rank	Nature of Stability
	Si	Di	Pi	Gi	Ri	
Non-Aromatic Rice						
BR 1	11.437	-5.749	93	0.939	36	BAS
BR 2	12.585	-9.609	99	0.724	46	BAS
BR 3	10.083	-0.894	102	1.315	19	AS
BR 6	12.993	-7.574	98	0.786	44	BAS
BR 7	12.422	-7.822	103	0.835	41	BAS
BR 8	13.007	-5.361	95	0.875	39	BAS
BR 9	10.707	1.463	102	1.376	15	AS
BR 12	11.297	-8.445	98	0.851	40	BAS
BR 14	9.645	-0.608	103	1.373	16	AS
BR 15	11.474	1.124	103	1.314	20	AS
BR 16	12.487	0.155	96	1.165	28	AS
BR 17	20.131	-11.924	93	0.315	48	BAS
BR 18	10.936	-8.197	100	0.891	38	BAS
BR 19	12.022	-4.458	92	0.962	35	BAS
BR 26	10.715	-6.759	105	0.998	32	BAS
BRRI dhan27	12.421	-7.501	93	0.798	43	BAS
BRRI dhan28	12.202	0.132	97	1.189	25	AS
BRRI dhan29	9.825	12.317	106	2.001	5	S
BRRI dhan35	11.741	-4.332	94	0.996	33	BAS
BRRI dhan36	11.611	-3.402	100	1.068	30	AS
BRRI dhan45	13.677	-6.682	79	0.806	42	BAS
BRRI dhan47	9.884	-1.374	65	1.292	21	AS
BRRI dhan55	10.331	1.454	59	1.464	14	AS
BRRI dhan58	10.475	7.051	57	1.696	6	AS
BRRI dhan59	11.999	-2.247	55	1.173	27	AS
BRRI dhan60	12.237	-0.964	50	1.174	26	AS
BRRI dhan61	10.126	-2.614	50	1.253	24	AS
BRRI dhan63	9.834	-4.537	37	1.124	29	AS
BRRI dhan64	12.876	-10.255	37	0.607	47	BAS
BRRI dhan67	10.501	-2.734	45	1.262	23	AS
BRRI dhan68	9.484	2.992	42	1.583	10	AS
BRRI dhan69	10.247	3.787	38	1.502	13	AS
BRRI dhan74	11.169	6.463	38	1.559	11	AS
BRRI dhan81	12.154	-10.644	28	0.769	45	BAS
BRRI dhan84	10.849	-7.592	23	0.910	37	BAS
BRRI dhan86	8.684	-9.527	22	0.987	34	BAS
BRRI dhan88	9.833	-1.524	25	1.316	18	AS
BRRI dhan89	10.094	17.335	24	2.223	2	S
BRRI dhan92	10.443	14.039	19	2.194	3	S
BRRI dhan96	9.293	-3.044	15	1.291	22	AS
BRRI dhan97	9.191	5.275	12	1.595	9	AS
BRRI dhan99	11.982	8.578	14	1.599	8	AS
Bangabandhu dhan100	9.779	3.526	10	1.556	12	AS
BRRI dhan101	-	6.916	10	1.329	17	AS
BRRI dhan102	-	14.427	10	1.685	7	AS
BRRI Hybrid dhan2	10.221	17.636	45	1.973	6	AS
BRRI Hybrid dhan3	10.477	18.179	48	2.174	4	S
BRRI Hybrid dhan5	9.631	21.051	33	2.381	1	S
Aromatic Rice						
BRRI dhan50	9.431	-7.524	63	1.039	31	AS

Note: S=Stable, AS=Average Stable, BAS=Below Average Stable

Table 3: Maximum and minimum yield of BRRI released rice variety (2001- 2023)

SL	T.Aman (2001 to 2022)			Boro (2001-02 to 2022-2023)		
	Varieties	Max.	Min.	Varieties	Max.	Min.
1	BR 3	6.45	1.04	BR 1	8.38	1.70
2	BR 4	6.54	0.96	BR 2	7.98	1.34
3	BR 5	6.17	0.63	BR 3	8.23	2.30
4	BR 10	7.37	1.03	BR 6	7.92	1.86
5	BR 11	8.73	0.65	BR 7	8.35	2.18
6	BR 22	6.38	1.17	BR 8	9.23	1.18
7	BR 23	6.64	0.95	BR 9	8.83	2.13
8	BR 25	6.86	1.27	BR 12	7.90	2.22
9	BRRI dhan30	6.91	1.18	BR 14	8.33	2.50
10	BRRI dhan31	7.00	1.21	BR 15	9.77	2.06
11	BRRI dhan32	7.31	1.97	BR 16	8.64	1.75
12	BRRI dhan33	6.72	0.94	BR 17	7.80	1.46
13	BRRI dhan34	5.91	0.68	BR 18	8.36	1.34
14	BRRI dhan37	6.18	0.66	BR 19	8.78	1.63
15	BRRI dhan38	6.42	0.67	BR 26	8.51	2.12
16	BRRI dhan39	6.77	0.85	BRRI dhan27	7.87	1.68
17	BRRI dhan40	6.79	1.15	BRRI dhan28	8.41	2.28
18	BRRI dhan41	6.98	1.06	BRRI dhan29	9.53	2.22
19	BRRI dhan44	6.75	1.49	BRRI dhan35	8.47	1.53
20	BRRI dhan46	6.84	1.45	BRRI dhan36	8.72	2.40
21	BRRI dhan49	7.60	2.15	BRRI dhan45	8.52	1.83
22	BRRI dhan51	7.25	1.01	BRRI dhan47	7.98	2.24
23	BRRI dhan52	8.07	2.13	BRRI dhan50	7.25	2.15
24	BRRI dhan53	6.63	1.98	BRRI dhan55	8.44	2.26
25	BRRI dhan54	7.00	1.66	BRRI dhan58	9.14	3.18
26	BRRI dhan56	6.46	1.23	BRRI dhan59	8.32	1.97
27	BRRI dhan57	5.59	1.02	BRRI dhan60	8.73	2.52
28	BRRI dhan62	5.54	0.78	BRRI dhan61	8.11	3.13
29	BRRI dhan66	6.69	2.11	BRRI dhan63	8.30	3.29
30	BRRI dhan70	6.31	1.72	BRRI dhan64	8.16	2.25
31	BRRI dhan71	7.07	1.41	BRRI dhan67	7.98	3.49
32	BRRI dhan72	6.84	2.91	BRRI dhan68	9.15	3.64
33	BRRI dhan73	6.93	2.52	BRRI dhan69	8.89	3.60
34	BRRI dhan75	6.61	1.41	BRRI dhan74	8.95	3.67
35	BRRI dhan76	6.22	1.18	BRRI dhan81	7.45	3.00
36	BRRI dhan77	6.39	1.88	BRRI dhan84	7.79	3.25
37	BRRI dhan78	6.36	2.31	BRRI dhan86	7.45	3.56
38	BRRI dhan79	6.34	2.74	BRRI dhan88	7.94	4.05
39	BRRI dhan80	5.83	2.36	BRRI dhan89	9.37	3.95
40	BRRI dhan87	7.14	1.91	BRRI dhan92	9.22	3.52
41	BRRI dhan90	4.99	1.97	BRRI dhan96	7.81	3.79
42	BRRI dhan91	4.39	1.11	BRRI dhan97	8.50	3.73
43	BRRI dhan93	6.53	3.71	BRRI dhan99	9.68	4.11
44	BRRI dhan94	6.65	3.08	Bangabandhu dhan100	8.75	4.08
45	BRRI dhan95	5.49	2.34	BRRI dhan101	7.37	5.49
46	BRRI Hybrid dhan4	6.58	1.16	BRRI dhan102	8.88	3.96
47	BRRI Hybrid dhan6	6.95	2.11	BRRI Hybrid dhan2	9.42	3.73
48	-	-	-	BRRI Hybrid dhan3	9.52	3.02
49	-	-	-	BRRI Hybrid dhan5	9.76	4.60
Average		6.60	1.55	**Average**	8.51	2.75

Conclusion

T. Aman varieties, BRRI dhan49 and BRRI dhan87 were found stable. None of the varieties were found to be unstable during T. Aman season. Among the aromatic rice BRRI dhan5, BRRI dhan34, BRRI dhan37 and BRRI dhan38 were found as below average stable in T. Aman season.

Boro varieties, BRRI dhan29, BRRI dhan89, BRRI dhan92 and BRRI hybrid dhan3 and BRRI hybrid dhan5 were found stable. BR3, BR9, BR14, BR15, BR16, BRRI dhan28, BRRI dhan36, BRRI dhan47, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan63, BRRI dhan67, BRRI dhan68 BRRI dhan69, BRRI dhan74, BRRI dhan88, BRRI dhan96, BRRI dhan97, BRRI dhan99, Bangabandhu dhan100, BRRI dhan101, BRRI dhan102 and BRRI hybrid dhan2 varieties were found as average stable and rest of the 17 varieties appeared to be below average stable. On the other hand, only aromatic rice varieties BRRI dhan50 appeared to average stable. In T. Aman varieties the average maximum and minimum yield was observed 6.60 t/ha and 1.55 t/ha respectively. The average maximum and minimum yield were observed 8.51 t/ha and 2.75 t/ha respectively in Boro varieties.

Study 1.1: Dynamics of Multi-trait stability index (MTSI) for identifying the most stable genotypes of three rice growing season in Bangladesh

Md. Abdullah Al Mamun, Md. Ismail Hossain, Md. Shahjahan Kabir, Niaz Md. Farhat Rahman, Md. Abdul Qayum, and Md. Abdullah Aziz

Introduction

Rice holds a paramount position as a vital crop and a dietary staple for a significant population across numerous Asian countries, with a particular emphasis on its significance in Bangladesh. The productivity of this essential crop is susceptible to various environmental challenges, including drought, cold, heat, and imbalances in nutrient levels. Hence, it becomes imperative to assess different rice genotypes in diverse environmental conditions to pinpoint those that exhibit both adaptability and consistency, catering to a wide spectrum of growing conditions or specific locations (Sharifi, 2020). Understanding the interplay between genotype and environment, often referred to as Genotype by Environment Interaction (GEI), plays a pivotal role as a decision-making tool, especially in the later stages of introducing new rice varieties. This aids in the screening of breeding lines and the endorsement of released varieties (Yan and Kang, 2003). Olivoto et al. (2019a) introduced a novel quantitative genotypic stability measure known as the Weighted Average of Absolute Scores based on Singular Value Decomposition (SVD) of Best Linear Unbiased Predictors (BLUPs) for GEI effects, aptly abbreviated as WAASB. This index combines information from SVD with BLUPs, derived from a Linear Mixed-Effect Model (LMM), offering a comprehensive perspective on stability. Additionally, they introduced WAASBY, a superiority index that balances mean performance with stability (MPE). These indices amalgamate the visual tools of AMMI with the predictive accuracy of BLUP, providing a robust approach for stability analysis. Santos and Marza (2020) effectively applied these indices in the selection of more productive and stable forage oat genotypes. Furthermore, Olivoto et al. (2019b) proposed a Multi-Trait Stability Index (MTSI), facilitating the simultaneous selection process with a focus on MPE for the analysis of multi-environment trials (METs). This approach incorporates both fixed and mixed-effect models for assessing several traits and capitalizes on the graphical interpretations offered by AMMI alongside the predictive accuracy of BLUP. Ultimately, these innovative methods contribute significantly to enhancing rice cultivation and breeding practices.

Objective

To evaluate the stability of rice genotypes by multi-trait stability index (MSTI) analysis under different environmental conditions. Also investigate the dynamics of multi-trait stability index (MTSI) for identifying stable genotypes.

Materials and Methods

Experimental design and plant materials

This experiment was carried out for the evaluation of 47 T. Aman rice genotypes in a randomized complete block design (RCBD), with three replications in 2021. To assess the performance and stability simultaneously, these rice genotypes were evaluated in four different locations of Bangladesh Barishal, Cumilla, Gazipur, and Rangpur. The data for GY: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle were used to perform the all analysis.

Statistical Analysis

Estimating the WAASB and WAASBY indices

All statistical analyses were performed using metan (multi-environment trial analysis) (Olivoto and Lúcio, 2020) and gge (genotype plus genotype-by-environment) (Wright and Laffont, 2018) R packages. WAASBi (weighted average of absolute scores based on SVD of BLUP-interaction effects of the i_{th} genotype or environment) (Olivoto *et al.*, 2019a) is calculated by equation 1.

$$WAASB_i = \frac{\sum_{k=1}^{p} |IPCA_{ik} \times EP_k|}{\sum_{k=1}^{p} EP_k} \quad (1)$$

Where, interaction principal component axis ($IPCA_{ik}$) is the score of the i^{th} genotype (or environment) in the k^{th} IPCA; and EP_K is the amount of the variance explained by the k^{th} IPCA.

WAASBY index for simultaneous selection based on grain yield (Y) and stability (WAASB) is obtained by equation 2 (Olivoto *et al.*, 2019a).

$$WAASBY_i = \frac{(rG_i \times \theta_Y) + (rW_i \times \theta_S)}{\theta_Y + \theta_S} \quad (2)$$

Where, $WAASBY_i$ is the superiority index for the i^{th} genotype, that weights between performance and stability, θ_Y and θ_S, are the weights for the response variable and the stability (WAASB) (Olivoto et al., 2019b) assumed to be 50 and 50 in our study, indicating equally weight of grain yield and stability. In addition, 21 scenarios varying θ_Y and θ_S (100/0, 95/5, 90/10,..., 0/100) were planned. Gi and Wi are the values of grain yield and WAASB for i^{th} genotype. rG_i and rW_i are the rescaled values (0–100) for the response variable and WAASB, respectively. Because the best values for grain yield and WAASB are the maximum and minimum values, the transformations were carried out according to the following equations (Olivoto et al., 2019b).

$$rG_i = \frac{100-0}{G_{max}-G_{min}} \times (G_i - G_{max}) + 100 \quad (3)$$

and

$$rW_i = \frac{100-0}{W_{max}-W_{min}} \times (W_i - W_{max}) + 0 \quad (4)$$

Multi-trait index based on factor analysis

The multi-trait stability index (MTSI) (Olivoto *et al.*, 2019b) was computed by equation 5.

$$MTSI_i = \left[\sum_{j=1}^{f} \left(F_{ij} - F_j\right)^2\right]^{0.5} \quad (5)$$

Where, the MTSI is the multi-trait stability index for the ith genotype, F^{ij} is the j^{th} score of the i^{th} genotype, and F^j is the j^{th} score of ideotype. The genotype with the lowest MTSI is then closer to the ideotype and therefore presents a high MPE for all analysed variables (Olivoto et al., 2019b).

The steps to compute the MTSI are:

1. Firstly, define an ideotype a prior, i.e., which one is better to increase and which one is better to decrease (in terms of selection gains). The factor analysis of WAASBY is the first step to compute the MTSI index. Then, a Euclidean distance is used to compute the distance between the genotypes' scores to the ideotype's score.
2. Secondly, provide weights for mean performance and stability. Here should explicitly consider a greater weight for GY.
3. Compute the WAASBY index (which is compute with the waasb() function of metan package, and use this model in the mtsi() function.
4. Based on the ideotype defined, the function will try to find the better ones, close to the ideotype.

MTSI dynamics analysis

Rearranging attribute combinations resulted in different rankings of stability under various selection intensities, as represented by the MTSI index. The heatmap illustrated the dynamics of MTSI, aiding in the selection of target traits for varietal improvements through trait combinations. The following table represents the trait combination for developing the MTSI dynamics (Table 9).

Table 5: Trait combination of identifying the dynamics of multi-trait stability index (MTSI)

Dynamics	Trait combination	Dynamics	Trait combination
MTSI_1	GY, GD, TN, PN, PL, GPP	MTSI_14	GY, PN, PL
MTSI_2	GY, GD	MTSI_15	GY, PN, GPP
MTSI_3	GY, TN	MTSI_16	GY, PL, GPP
MTSI_4	GY, PN	MTSI_17	GY, GD, TN, PN
MTSI_5	GY, PL	MTSI_18	GY, GD, TN, PL
MTSI_6	GY, GPP	MTSI_19	GY, GD, TN, GPP
MTSI_7	GY, GD, TN	MTSI_20	GY, TN, PN, PL
MTSI_8	GY, GD, PN	MTSI_21	GY, TN, PN, GPP
MTSI_9	GY, GD, PL	MTSI_22	GY, PN, PL, GPP
MTSI_10	GY, GD, GPP	MTSI_23	GY, GD, TN, PN, PL
MTSI_11	GY, TN, PN	MTSI_24	GY, GD, TN, PN, GPP
MTSI_12	GY, TN, PL	MTSI_25	GY, TN, PN, PL, GPP
MTSI_13	GY, TN, GPP		

The statistical analyses were performed by using R software with the "metan" package (Olivoto and Dal'Col Lúcio, 2020).

Results and discussion

The overall grain yield of T. Aman rice varieties ranged from 1.49 ton ha^{-1} to 6.78 ton ha^{-1} while the environments mean yield was 4.49 ton ha^{-1}. Others statistical factors such as, mean, standard error of mean (SEM), standard deviation (St. dev.), coefficient of variation (CV %), confidence interval (CI) for characters in all environments are presented in Table 6. The Likelihood Ratio Test (LRT) demonstrated significant impacts of genotype and genotype-environment interactions (GEI) (Table 7).

Table 6. Basic descriptive statistic for various morphological and physiological traits of T. Aman rice varieties under studied evaluated in four environments.

Variable	CV (%)	Max	Mean	Median	Min	SD Mean	SE	CI
GD	9.99	161.00	130.38	132.00	95.00	13.02	0.55	1.08
GPP	26.12	250.00	113.20	113.00	32.00	29.57	1.25	2.45
GY	22.24	6.78	4.49	4.60	1.49	1.00	0.04	0.08
PL	8.41	31.00	26.40	26.92	18.90	2.22	0.09	0.18
PN	16.28	12.20	8.72	8.80	5.00	1.42	0.06	0.12
TN	12.71	14.60	10.02	10.00	6.00	1.27	0.05	0.11

Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle, CV: Coefficient of variation, SD: Standard deviation, SE: Standard error, CI: Confidence interval.

The genotypic variance was higher than residual for PL, GY, GPP and GD, whereas the GEI variance was higher than for all traits except TN and PN (Fig 8). We have found for PL, GY, GPP and GD is mostly dominated by genotype and environment effect. Growth duration is mostly regulated by both genotype and environment effects. The no. of panicle, no. of tiller mostly influence by residual factors then genotypes and environments interaction factor. High values of broad sense heritability were calculated for all traits under study, the highest broad sense heritability of genotypic mean was growth duration (95%) and lowest was no. panicle per hill (18%) (Table 8). The genotypic selection accuracy (Acc) values ranged from 0.43 (PN) to 0.97 (GD). The highest CVg was recorded for GY (11.33) and lowest was TN (2.46). The CV ratio was highest for growth duration (14.54) followed by panicle length (1.09), grain yield (1.05), grain per panicle (0.61), no. of tller per hill (0.22), and no. of panicle per hill (0.21) (Table 8).

Table 7: Likelihood ratio test (LRT) for different traits under studied of 47 T. Aman rice varieties evaluated in four environments.

VAR	model	logLik	AIC	LRT	Pr(>Chisq)
GY	GEN	-597.30	1222.60	36.28	0.000
GY	GEN: ENV	-649.78	1327.56	141.24	0.000
GD	GEN	-1304.34	2636.67	176.74	0.000
GD	GEN: ENV	-1805.04	3638.08	1178.14	0.000
TN	GEN	-928.32	1884.64	1.62	0.204
TN	GEN: ENV	-933.81	1895.61	12.59	0.000
PN	GEN	-964.87	1957.75	0.71	0.400
PN	GEN: ENV	-985.96	1999.92	42.88	0.000
PL	GEN	-1034.46	2096.91	39.84	0.000
PL	GEN: ENV	-1083.64	2195.28	138.21	0.000
GPP	GEN	-2398.28	4824.57	2.03	0.154
GPP	GEN: ENV	-2567.99	5163.97	341.44	0.000

Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle, UGP: no. of unfilled grain per panicle, TGW: thousand grain weight, GEN: Genotype, ENV: Environment, AIC: Akaike information criterion.

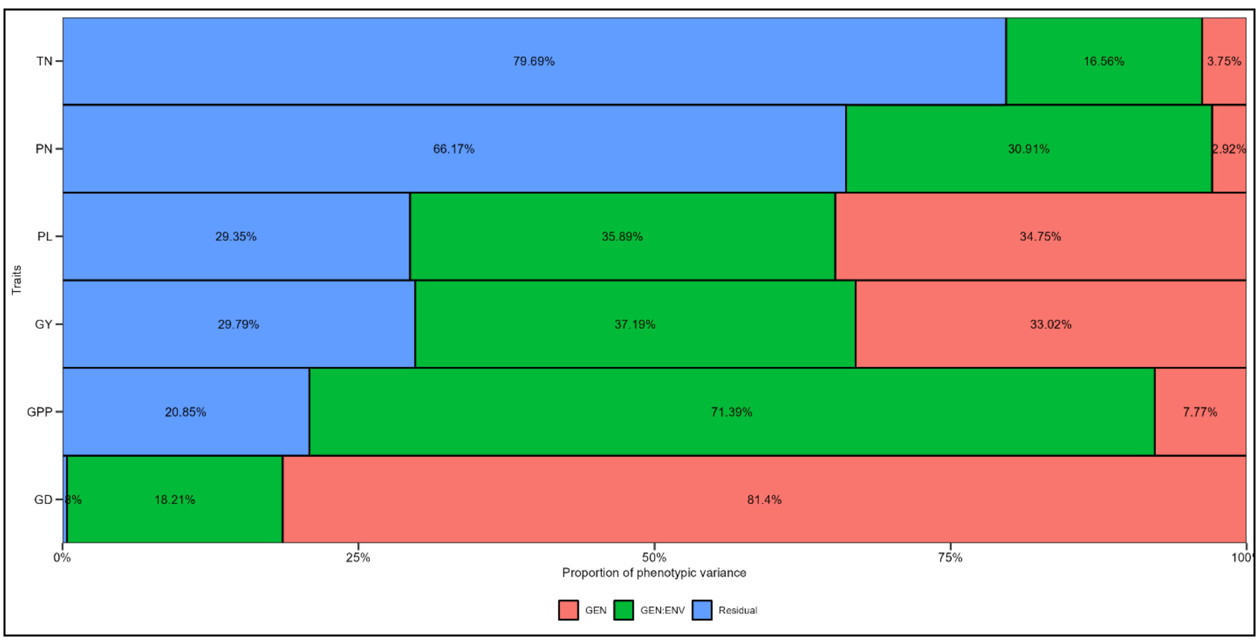


Fig. 8: Proportion of the phenotypic variance for 47 T. Aman rice traits assessed in four different environments. Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle.

Table 8. Deviance analysis, genetic parameters and variance components for nine morphological and physiological traits evaluated in 47 T. Aman rice varieties

Parameters	GY	GD	TN	PN	PL	GPP
Phenotypic variance	0.78	171.66	1.62	1.97	3.86	663.02
GEIr2	0.37	0.18	0.17	0.31	0.36	0.71
h2mg	**0.74**	**0.95**	**0.26**	**0.18**	**0.75**	**0.28**
Accuracy	0.86	0.97	0.51	0.43	0.87	0.53
rge	0.56	0.98	0.17	0.32	0.55	0.77
CVg	11.33	9.07	2.46	2.75	4.39	6.34
CVr	10.76	0.62	11.32	13.09	4.03	10.39
CV ratio	1.05	14.54	0.22	0.21	1.09	0.61

Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle, PV: phenotypic variance, GEI R2: GEI coefficient of determination, h2mg: heritability of genotypic mean, Acc: accuracy of genotype selection, rge, association among genotypic values across environments, CVg: genotypic coefficient of variation, CVr: residual coefficient of variation.

Association analysis

A significant association was noticed between grain yield and grain per panicle (GPP), no. of tiller per hill (TN) no. of panicle per hill (PN), panicle length (PL) and grain per panicle (GPP). Grain yield have found insignificant low positive correlations on growth duration (GD) (Fig 9).

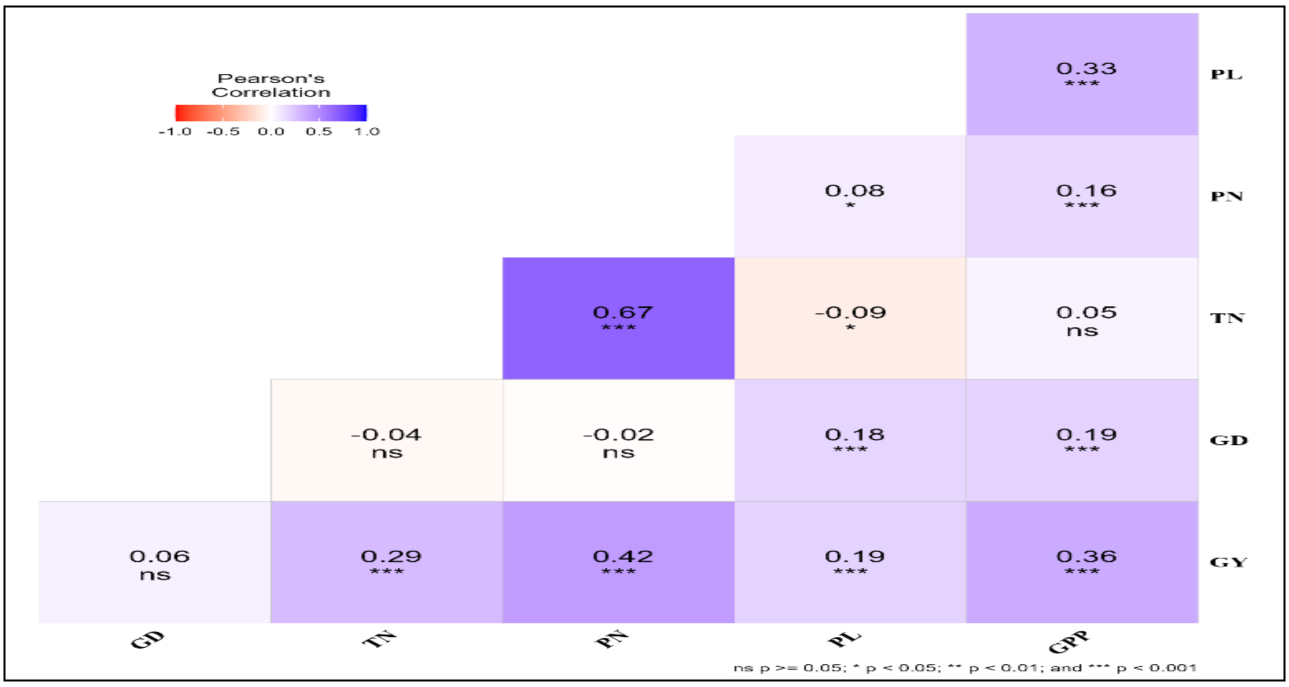


Fig. 9: Pearson's correlation matrix among 47 T. Aman rice traits evaluated in seven environments. Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle.

Genotype's selection based on MTSI and contribution of factors to the MTSI

Six principal components were maintained, and the variance in these first two factors accumulated was 59.58% (Table 5). The six attributes were clustered into the two different factors as: FA1: (Yield, TN, and PN); FA2: (GD Yield, GPP and PL) (Table 10).

The strengths and weaknesses plot for varieties based on different factor using multi-trait stability index reveal the factor presented the smallest contribution for variety indicating the most performer genotypes or vice versa. In the case of FA1, the factor elements GY, TN and PN; the BRRI dhan87, BRRI dhan79 and BRRI hybrid dhan4 are the most performer of those traits where FA1 contribute proportion less than 0.25 (Fig 10). The values of the MTSI presuming 30% selection intensity for selecting highly stable variety (Fig 11). Among 47 varieties BR10, BR22, BRRI dhan44, BR11, BRRI dhan51, BRRI dhan87, BRRI dhan30, BRRI dhan46, BRRI dhan41, BRRI dhan49, BRRI dhan79 are the selected variety using MTSI at 30% selection intensity.

Table 9. Explained variance, eigenvalues, factorial loadings after varimax rotation and communalities estimated in the factor analysis.

VAR	FA1	FA2	PC	Eigenvalues	Variance (%)	Cum. variance (%)
GY	0.82	-0.05	PC1	2.18	36.34	36.34
GD	0.18	-0.80	PC2	1.39	23.24	59.58
TN	0.76	0.08	PC3	0.96	15.92	75.50
PN	0.84	-0.29	PC4	0.60	10.04	85.54
PL	0.23	-0.28	PC5	0.55	9.12	94.66
GPP	-0.18	-0.83	PC6	0.32	5.34	100.00

Where Yield: grain yield (ton/ha), GD: growth duration (days), TN: no. of tiller per hill, PN: no. of panicle per hill, PL: panicle length, GPP: no. of grain per panicle, UGP: no. of unfilled grain per panicle, TGW: thousand grain weight, FA, the factor retained, Bold values show the traits cluster within each factor, Cum. Var. (%) Cumulative variance.

Table 10. Selection differential of the WAASBY index and Selection Gain (%) for different traits of 47 T.Aman rice varieties

VAR	Factor	Xo	Xs	SD	SDperc	h2	SG	SGperc	sense	goal
GY	FA1	4.49	5.00	0.51	11.30	0.74	0.37	8.33	increase	100
TN	FA1	10.02	10.50	0.47	4.71	0.26	0.12	1.22	increase	100
PN	FA1	8.72	9.30	0.58	6.61	0.18	0.10	1.20	increase	100
GD	FA2	130.40	138.80	8.43	6.46	0.95	7.98	6.12	increase	100
PL	FA2	26.40	26.82	0.42	1.58	0.75	0.31	1.19	increase	100
GPP	FA2	113.20	122.00	8.79	7.76	0.28	2.50	2.20	increase	100

Where GY: Grain yield (ton/ha), GD: Growth duration (days), TN: No. of tiller per hill, PN: No. of panicle per hill, GP: No. of grain per panicle, Xo: Mean for WAASBY index of the original population, Xs: Mean for WAASBY index of the selected genotypes, SD: Selection Differential, SG: Selection gain.

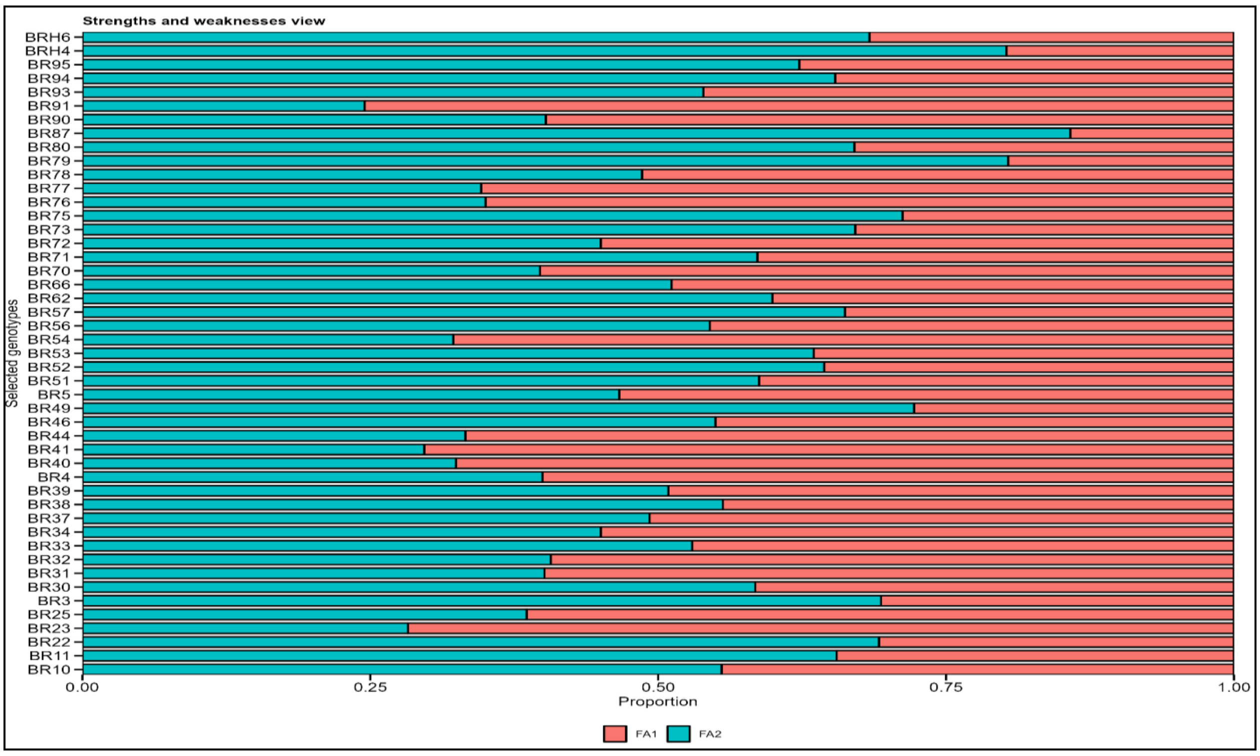


Fig. 10: The strengths and weaknesses view of genotypes selected. The y-axis presents the ratio of each factor on the calculated MTSI of the selected genotypes. The minimum the proportions explicated by a factor, the nearer the traits within that factor are to the ideotype. Where G stands for genotypes and FA stands for factor.

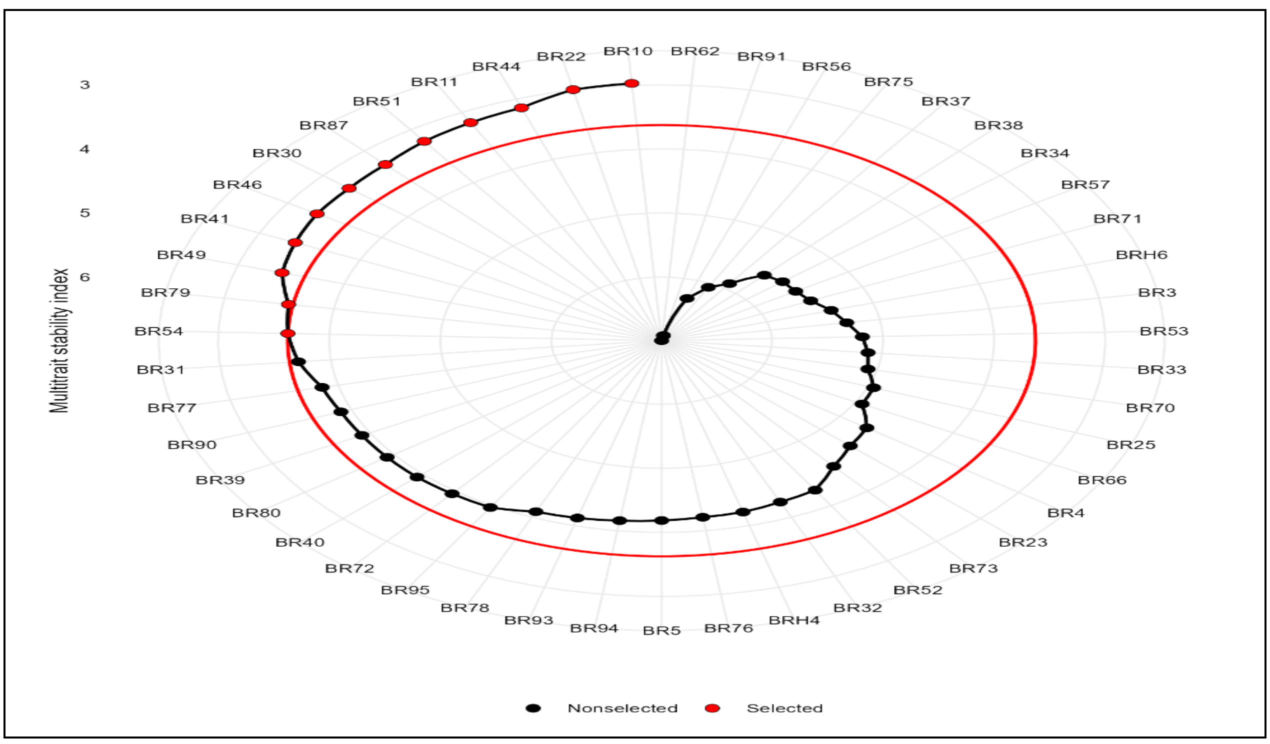


Fig. 11: Selection of highly stable variety on the basis of multi trait stability index considering 30% selection intensity.

Dynamics of MTSI

The dynamics of the multi-trait stability index (MTSI) provide valuable insights into the performance and adaptability of different traits within a set of varieties or genotypes. By analysing MTSI, researchers and breeders can assess how various combinations of traits contribute to overall stability and performance in different environments. This information is crucial for selecting and developing varieties that not only yield well but also exhibit resilience and consistency across diverse conditions. The MTSI allows for the identification of traits that have a substantial impact on variety performance and can guide breeding efforts to prioritize and enhance these traits, ultimately leading to more robust and adaptable crop varieties. Furthermore, MTSI analysis aids in tailoring varietal improvements to meet specific agricultural goals and environmental challenges, making it a valuable tool in modern crop breeding and selection processes. The results rearrange of the combination of different attributes and the following MTSI index represents the different ranking of stability under the respective selection intensity. Heatmap showed the dynamics of MTSI, will help to select the targeted traits in varietal impartments by applying traits combinations (Fig 12).

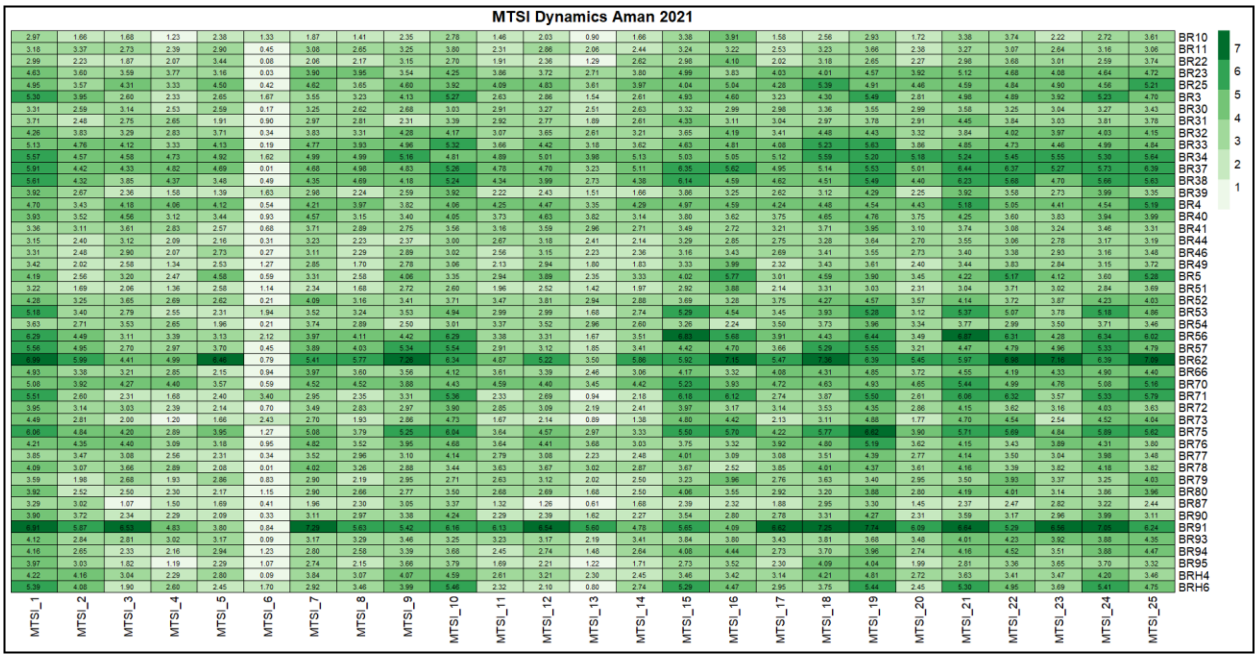


Fig. 12: Dynamics of multi trait stability index (MTSI) for Selection of highly desirable traits.

Conclusion

Utilizing a multi-trait stability index, we assessed the performance of rice varieties across different factors. For instance, in the case of FA1, factors like GY, TN, and PN identified BRRI dhan87, BRRI dhan79, and BRRI hybrid dhan4 as top performers, with FA1 contributing less than 0.25 to their performance. Out of the 47 varieties, BR10, BR22, BRRI dhan44, BR11, BRRI dhan51, BRRI dhan87, BRRI dhan30, BRRI dhan46, BRRI dhan41, BRRI dhan49, and BRRI dhan79 were selected using MTSI at 30% selection intensity.

Activity 1.2: Comparative study for rice yield estimation by adjusting moisture content

(In collaboration with Plant Physiology Div.)

-Md. Abdullah Al Mamun, Md. Ismail Hossain, Md. Shahjahan Kabir, Niaz Md. Farhat Rahman, Md. Abdul Qayum, Md. Abdullah Aziz, and Avijit Biswas

Introduction

The moisture content of paddy grain decreases from different moisture (%) to 14% for safe storage of grains, and seeds should be dried to below 12 %. Ideal moisture content for milling is between 12–14%. (IRRI Rice Knowledge Bank, 2009). According to standard procedure for determining yield components at harvest, for the measuring final grain dry the samples to reduce moisture content to 10–16% (IRRI Rice Knowledge Bank, 2009). Differences in grain moisture content can result in a significant variation in the processing characteristics of the grain as well as estimation. During rice yield estimation, it is very much important to adjust the moisture content after crop cut. Reduce the estimation error a comparative study is need for estimating the rice yield by adjusting moisture content. Hence, the objective of this study is to determine adjustment factors to estimate the paddy yield and develop a criterion for performing a reliable estimation. Which can help to reduce the estimation for rice production.

Objectives

- To determine the adjustment factors for rice yield estimation.
- To develop a criterion for performing a reliable estimation.

Methodology

The study was conducted in Boro season. For this study, BRRI released rice varieties were used. The samples were manually cleaned to remove all foreign materials such as dust, dirt, small broken and immature kernels. The initial moisture content of the samples was determined by oven drying method at 70ºC for 48 h (Sacilik et al., 2003). In order to obtain desired moisture levels below the initial moisture contents, the samples were kept for natural drying (sun dry) and artificial drying (oven dry), both until the desired moisture contents of the samples were obtained (Yang et al., 2003). The data were analyzed statistically using programming R software and data preparation and compilation will be completed using Microsoft Excel software.

Results and discussion

Results showed that, the sample initial moisture content was observed ranges 17.09 to 26.61% for the sundry methods where, the used sample average initial moisture content had 21.37%. In the sundry method the reduced compare moisture (%) was14±0.07. Also, in the sun dry method the average moisture reduction from different sample was 7.31%. There are three important things observed for overestimation one is the initial moisture content, high range of moisture reduction and another is dust removal (dust, dirt, small broken and immature kernels, no. of unfilled grain, a small portion of panicle, broken straw, etc.) (Fig. 13). There is a strong relationship between ranges of initial moisture, moisture reduction and dust. A significant positive correlation has been found between initial moisture, moisture reduction and dust with overestimation (Fig. 13a-c). The graphical representation of Linear Regression Coefficients showed the relationship of initial moisture content and overestimation (Fig. 13a). The initial moisture content coefficient in the regression equation is 0.701. This coefficient represents the mean increase of initial moisture content in percentage for every additional one percent change in initial moisture. If the initial moisture content increases by 1 percent, the average overestimation increases by 0.701 percent. The regression coefficient of moisture reduction and dust percentage were 0.859 and 0.818, respectively (Fig. 13a-b). Data points are plotted on three axes in a 3D scatter plot to show the relationship between three variables i.e., moisture reduction, dust and overestimation. The position of the marker that symbolizes each row in the data table is determined by the values of the columns set on the X, Y, and Z axes (Fig. 14). Results found that during yield estimation from crop cut samples, most of the cases had found significant overestimation (Fig. 15). The lowest and highest overestimations observed were 7.08 and 23.08%, respectively for sundry methods. The average overestimation (%) for sundry sampled observed was 15.52±0.34 (red line) and most of the variety found a significant variation of the overestimation (Fig. 15).

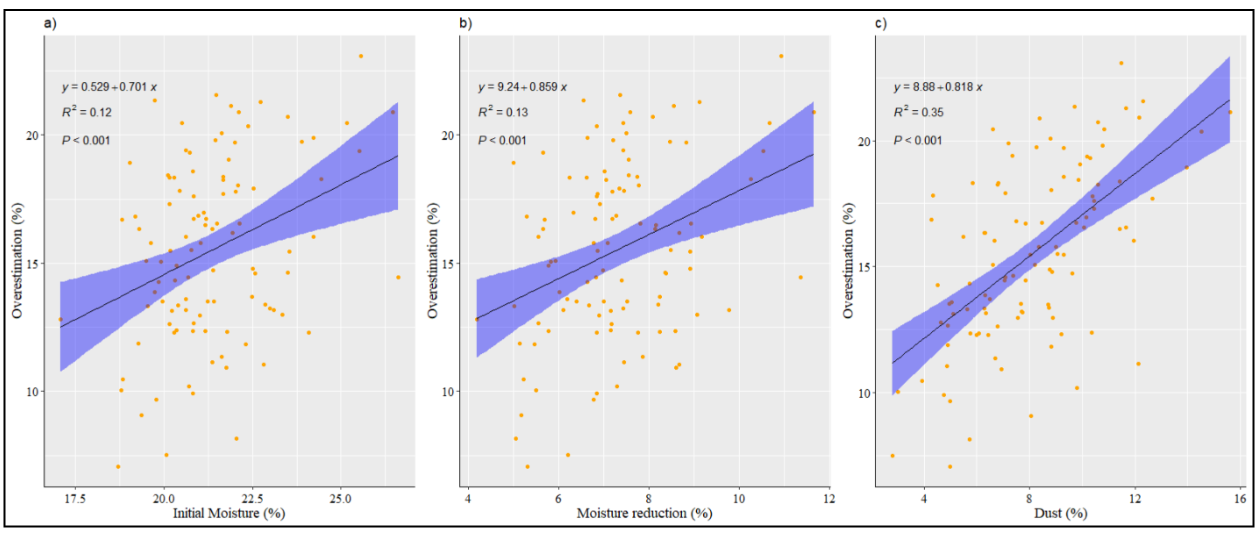


Fig.13: Relationship of initial moisture content (a), moisture reduction (b), and dust percent (c) on overestimation of different crop cut sample in sundry methods.

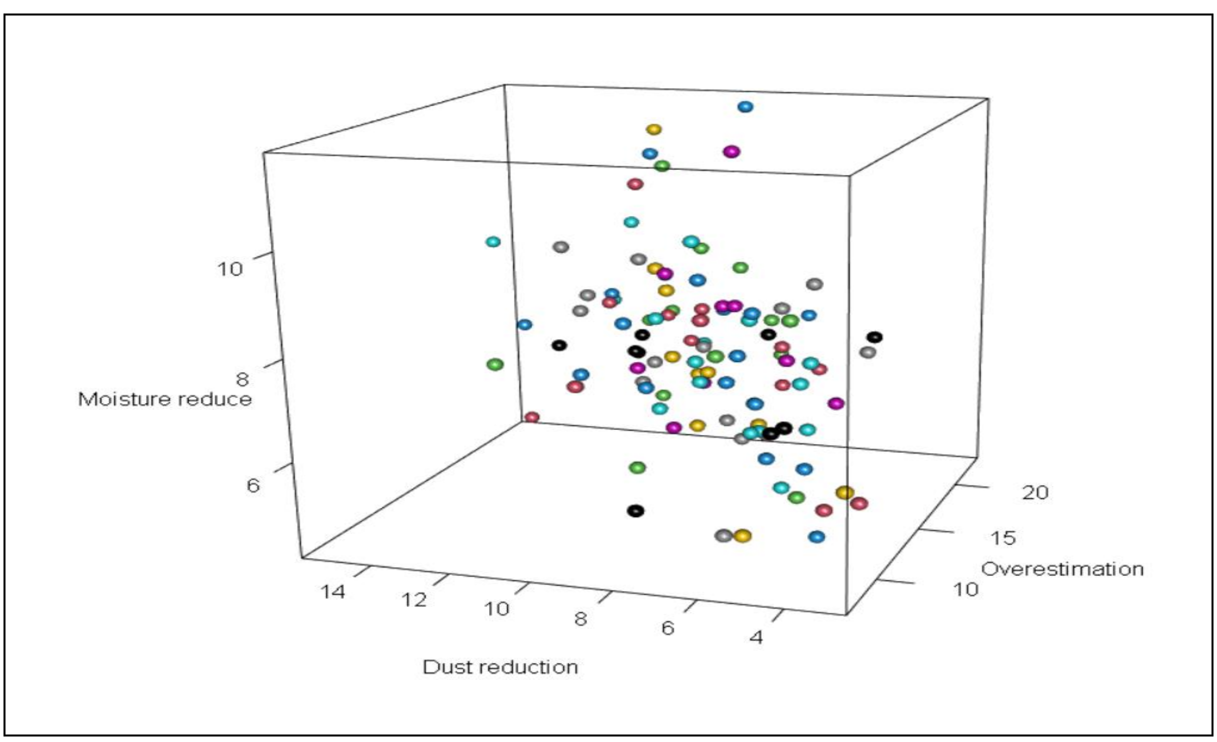


Fig. 14: 3D Relationship between moisture and dust reduction on overestimation in sundry methods.

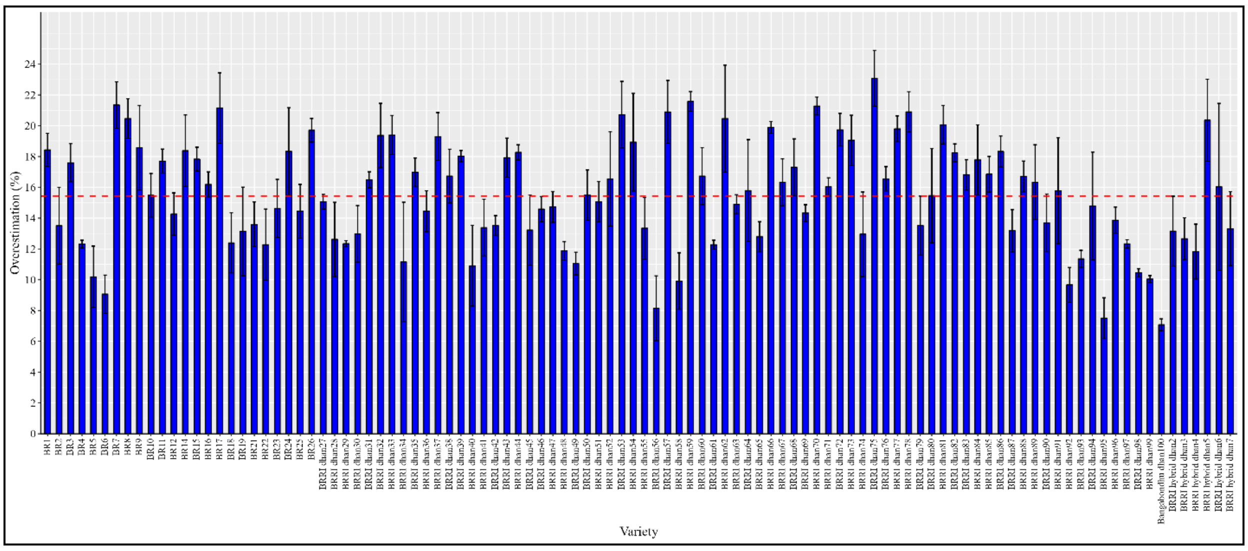


Fig. 15: Average overestimation of crop cut sample of different rice varieties in sundry dry method.

Conclusion

Results found that during yield estimation from crop cut samples, most of the cases had found significant overestimation. The change of initial moisture, moisture reduction and dust significantly increase for overestimation with a rate of change 0.701, 0.859 and 0.818 percent, respectively. Most of the variety found a significant variation of the overestimation in crop cut sampled in sundry method. The highest and lowest overestimations observed were 7.08 and 23.08%, respectively for sundry methods. The average overestimation (%) for sundry sampled observed 15.52%.

Activity: 1.3: Identification of influential climatic parameter and the best model for seasonal drought prediction in Bangladesh: Application of machine learning algorithm

(In collaboration with Agricultural Economics and Plat Pathology Div.)

-Md. Abdullah Al Mamun, Md. Ismail Hossain, Md. Shahjahan Kabir, Md Abdur Rouf Sarkar, Sheikh Arafat Islam

Introduction

Climate change has had and continues to have catastrophic effects on humanity. Severe weather occurrences, particularly heat waves, droughts, cyclones, and heavy rain, are becoming more frequent and intense, leading to displacement, famine, and poverty (Miyan 2015). Drought, the most frequent climate occurrence worldwide, is characterized by a shortage of precipitation which causes long-term water scarcities (Campos 2015; Hao and Singh 2015; Thomas and Prasannakumar 2016; Orimoloye et al. 2022). Droughts are one of the most expensive calamities, affecting millions of people annually and costing an estimated $6 to $8 billion annually (Mare et al. 2018). However, the slow-onset nature of drought makes it challenging to analyze and model its spatio-temporal consequences.

Climate change adaptation and coping strategies have remained a global concern for decades. One of the key reasons for the failure of disaster risk management in climate-vulnerable countries like Bangladesh is that the government always emphasizes response and recovery over monitoring, preparedness, and mitigation. In light of this, accurate drought projections are crucial for the sustainable management of agricultural resources. The erratic and spatial nature of drought, with varying intensity and frequency (Mortuza et al. 2019), necessitates identifying rapid, consistent, and precise prediction models to quantify drought-related risks.

In Bangladesh, very little research has been done using ML (Machine Learning) methods (Yaseen et al. 2021; Elbeltagi et al. 2022; Kafy et al. 2023). All research was one or two region-specific (Osmani et al. 2022), and the development of ML models for drought forecasting on a more disaggregate regional scale has yet to unfold. Besides, researchers did not identify the relative importance of climatic attributes for drought assessment. The novelty of this study is that it fills these gaps by developing the best ML models for Standardized Precipitation Evapotranspiration Index (SPEI) forecasting at multiple time scales and drought intensity mapping for Bangladesh. Specifically, the current study predicts SPEIs for 35 meteorological stations using 24 ML models. Then the deployed models' performance was evaluated to select the best drought forecasting features, and finally the spatio–temporal pattern of seasonal drought intensity and frequency was estimated for meteorological research stations across Bangladesh.

Objective

The objective of this study is to determine the most effective machine learning methods and categorize the key factors influencing drought prediction.

Materials and methods

Climate records at the daily timescale from 35 meteorological stations were collected by the Bangladesh Meteorological Department (BMD) over the past 40 years, from 1981 to 2020. The climate variables were daily rainfall amount (mm), maximum temperature (°C), minimum temperature (°C), mean temperature (°C), sunshine hours (h), wind speed (ms^{-1}), and relative humidity (%). In addition, potential evapotranspiration (PET) at the monthly timescale was calculated from the aforementioned climate variables. The Food and Agricultural Organization (FAO) recommends the Penman-Monteith (PM) equation (Chiew et al. 1995) as the single standard technique for calculating reference evapotranspiration (ET_0), and it has been effectively utilized in Bangladesh. It integrates physiological and meteorological attributes and has been widely used around the world because of its intrinsic rationality and reliability (Mokhtar et al. 2020). Hence, the PM equation based on the weather parameters was utilized to compute the monthly ET_0 over the research locations.

Model selection process for data analysis

In this study, twenty-four (24) machine learning models were constructed to predict the Standardized Precipitation Evapotranspiration Index (SPEI) in various timescales, including 1-, 3-, 6-, and 12-month periods. The methodology, as illustrated in Fig. a, encompassed the subsequent procedural phases:

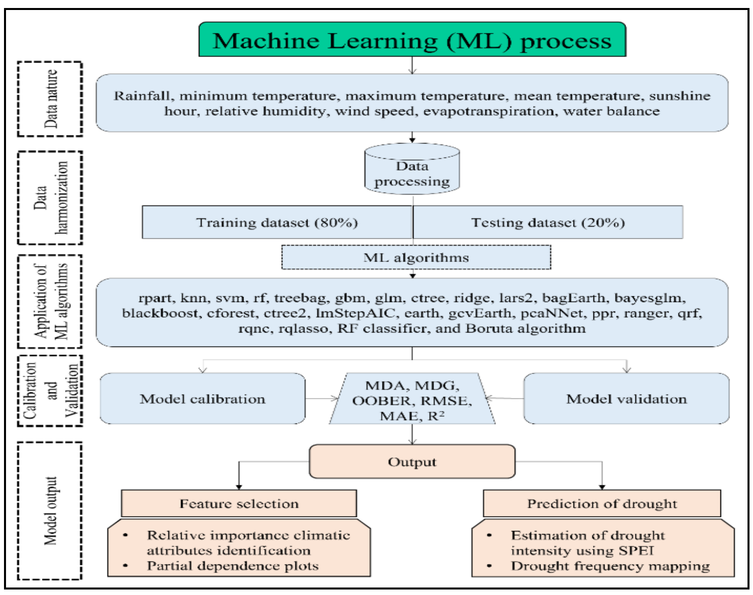


Fig. a. Conceptual framework of prediction of SPEI by ML algorithms for the study.

Standardized precipitation evapotranspiration index (SPEI)

In this study, we estimated SPEI at time scales of one month (SPEI1), three months (SPEI3), six months (SPEI6), and a year (SPEI12). These estimates were used to measure the impact of precipitation deficits in the short term on agricultural drought. According to the SPEI classification criteria, the value of SPEI ≥ 0 indicates no drought, −1.0 < SPEI < 0 indicates mild drought, −1.5 < SPEI ≤ −1.0 indicates moderate drought, −2.0 < SPEI ≤ −1.5 indicates severe drought and SPEI ≤ −2.0 indicates extreme drought (Banimahd and Khalili 2013). The greater the value of the SPEI in the negative, the more severe the drought. We also estimated the severity of drought. A drought event's duration (m) equals the number of months between its start (included) and end month (not included). The absolute value of the total of all SPEI values during a drought event is known as severity (S_e). A drought event's intensity (DI_e) is defined as severity divided by duration(Spinoni et al. 2014). The greater the DI_e number, the more severe the drought. The formulae are as follows:

$$S_e = \left|\sum_{j=1}^{m} Index_j\right|_e \quad (6)$$

$$DI_e = \frac{S_e}{m} \quad (7)$$

Where, e, j, $Index_j$, m, S_e, and DI_e are the drought event, month, SPEI value in month j, duration, severity, and intensity of a drought event e, respectively.

Machine learning algorithms

We have considered analysing 24 distinct machine learning algorithms (rpart, knn, svm, rf, treebag, gbm, glm, ctree, ridge, lars2, bagEarth, bayesglm,blackboost, cforest, ctree2, lmStepAIC, earth, gcvEarth, pcaNNet, ppr, ranger, qrf, rqnc, rqlasso) from various ML fields to determine the correlation between drought prediction and the weather attributes. The prediction of multiscale SPEI1, SPEI3, SPEI6, and SPEI12 considered tree-based algorithms, regression, and classification models. We used multiple predictive modelling techniques employing a variable selection algorithm. These methods included linear least squares models and penalized linear, additive, and recursive partitioning models, all implemented with R programming code for variable selection and prediction.

Model evaluation metrics

Model validation is a necessary step of ML modelling for evaluating the accuracy and reliability of models. Scholars employed various statistical metrics for this purpose(Nabavi-Pelesaraei et al. 2018; Garosi et al. 2019; Chen et al. 2021). We used RMSE, MAE, and R^2 to evaluate the performance of the constructed models.

Results and Discussion

Correlation analysis

In this study, meteorological indices (SPEI1, SPEI3, SPEI6, SPEI12) were used to assess drought conditions in Bangladesh. Associations with nine weather parameters were explored: precipitation (PRCP), minimum temperature (TMIN), maximum temperature (TMAX), average temperature (TMEAN), total sunshine (TSUN), relative humidity (RH), wind speed (WS), evapotranspiration (ET), and water balance (WB) (Fig. b). For SPEI1, significant positive correlations were found with rainfall (0.390), relative humidity (0.215), and water balance (0.422), while negative correlations were observed with maximum temperature (-0.168), mean temperature (-0.070), total sunshine hour (-0.265), wind speed (-0.129), and evapotranspiration (-0.258) ($p < 0.05$). Similar relationships were noted for SPEI3. For SPEI6 and SPEI12, positive associations were seen with rainfall, relative humidity, and water balance. Conversely, negative correlations were found with maximum temperature, total sunshine hour, wind speed, and evapotranspiration. These results imply that as SPEI6 and SPEI12 values decreased, certain meteorological parameters tended to increase significantly.

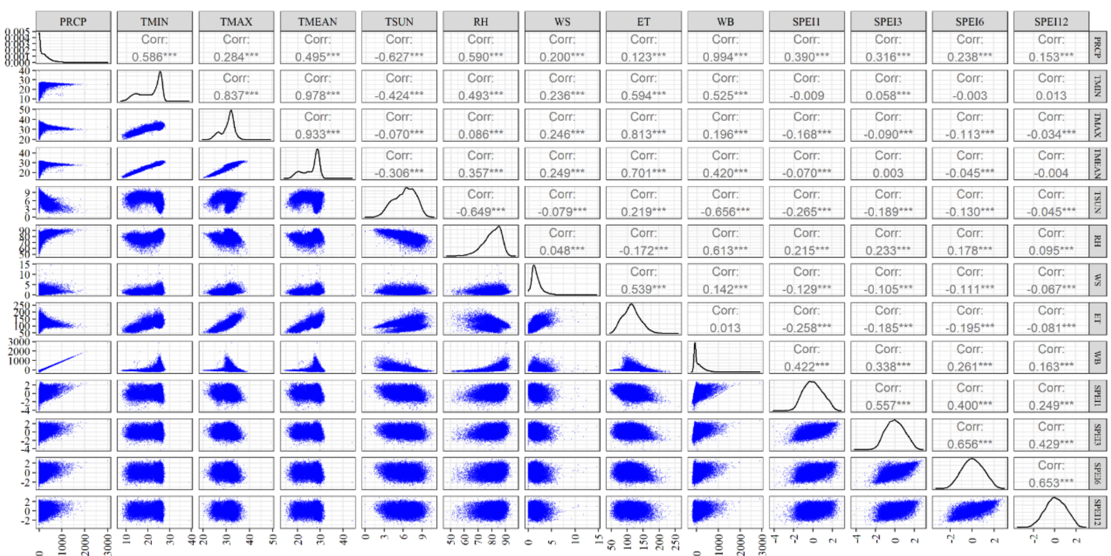


Fig. b. Correlation coefficients among the weather parameters and SPEI's values.

Identification of best climatic attributes for different SPEIs

Based on the results depicted in Fig. c, the critical variables for the SPEI1 time scale were identified as WB, PRCP, TMIN, and ET. For the SPEI3, SPEI6, and SPEI12 time scales, the most significant variables were WB, PRCP, TMAX, and TMIN. Consequently, WB, PRCP, TMAX, and TMIN emerged as the predominant factors influencing the construction of drought prediction models using machine learning. The random forest classifier algorithms tuned using cross-validation ten folds and five repeats were summarized, and the performance of the RF classifier was presented in Table a. The best three contributors for the SPEI1 model were WB, PRCP, and TMIN with the highest percentage values, and the overall OOB error rate for SPEI1 model was 17.77%. However, the worse contributor was identified as WS, RH, and TSUN, getting the lowest percentage among the variable for SPEI1. We found that the SPEI3 model had the same contributors as the SPEI1 model. The best predictor for SPEI6 was WB, followed by TMIN, PRCP, and TMAX. The worse contributor was WS, which had the lowest percentage value of MDA and MDG, but the OOB error rate was 23.05%. The annual time scale (SPEI12) also has a vital role in identifying and predicting drought. The best and most significant contributors for SPEI12 were WB, TMIN, and TMAX, and the OOB error rate was low at 6.59%. Thus, the findings indicated that WB, PRCP, TMAX, and TMIN were the most significant contributors to drought model prediction across different time scales of Bangladesh.

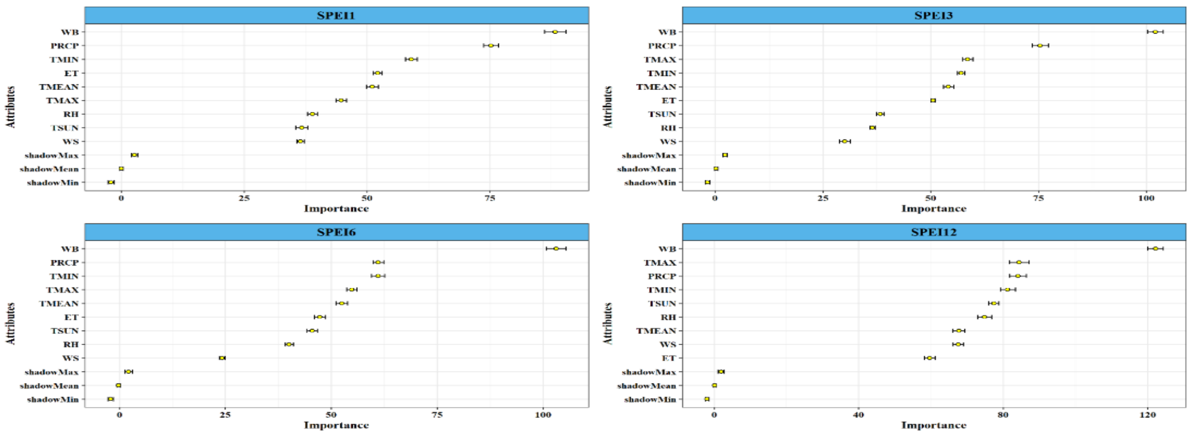


Fig. c. Best feature combination of predictor variables based on the Boruta algorithm.

Ranking the best predictive model for different regions at multiple timescales of SPEIs

Given the geographical positioning and climatic unpredictable changes across the country, a one-size-fits-all model would not be suitable for predicting drought in all locations. Here, we demonstrated a regional drought forecast for 35 meteorological stations using 24 ML models at various SPEI periods (Figs. d). The performance of each model was graded using higher R^2 and lower MAE and RMSE values, illustrated through a heatmap. The results revealed that the best model differed across geographical locations and timespan. In the northern region of Bangladesh, for instance, at Rajshahi station in SPEI1 and SPEI12, the ranger model performed the best (ranked first). Similarly, the bagEarth and svm models had the highest performance in SPEI3 and SPEI6, respectively. In the southern region of Khulna, the ranger, bagEarth, earth, and ppr models performed most well at SPEI1, SPEI3, SPEI6, and SPEI12, respectively. Regarding regional representation, the ranger model demonstrated superior performance in 79% and 63% of regions (out of 35 stations) for SPEI1 and SPEI3, respectively. Conversely, for SPEI6 and SPEI12, the bagEarth and ppr models excelled, leading in 63% and 58% of regions, respectively (Fig. d). However, the heatmaps of SPEI1 and SPEI3 were identical, and the usual R^2 values for SPEI12 were fairly high. Refer to Figs. d and e for detailed information on the best model for each region.

Evaluation of best predictive models for the specific region

We used scatter plots of fitted vs. observed values and R^2 values to evaluate the best model for use across all regions and different time periods of SPEIs (Fig. g). For SPEI1, the R^2 values ranged from 0.57 to 0.93, indicating a positive correlation between the ML model and the observed data, with the model explaining 57-93 percent of the variance in the fitted data. Similarly, for SPEI3 and SPEI6, the R^2 values ranged from 0.52 to 0.92 and 0.57 to 0.95 respectively, signifying a positive correlation between the ML models and the observed data, with the model's explaining 52-92 percent and 57-95 percent of the variance in the fitted data, respectively. Lastly, the high R^2 value for SPEI12 suggested a better fit for the model. Thus, confirming the validity of the models selected for drought prediction in Bangladesh across different time scales and regions.

Table a. Performance of RF classifier model with different SPEI time scales derived from different feature combinations.

Attributes	SPEI1			SPEI3			SPEI6			SPEI12		
	MDA (%)	MDG (%)	OOB error rate (%)	MDA (%)	MDG (%)	OOB error rate (%)	MDA (%)	MDG (%)	OOB error rate (%)	MDA (%)	MDG (%)	OOB error rate (%)
PRCP	13.65	15.24	17.77	13.76	15.63	19.19	10.84	14.44	23.05	9.90	17.02	6.59
TMIN	12.67	10.85		11.90	10.32		12.58	11.70		13.40	9.19	
TMAX	9.15	9.10		11.46	9.62		10.75	9.70		12.97	9.55	
TMEAN	10.03	9.64		10.72	9.43		10.39	10.13		9.33	6.91	
TSUN	7.53	7.35		7.38	7.80		10.00	8.80		10.61	8.42	
RH	8.86	6.88		7.57	8.09		8.75	9.43		10.07	10.45	
WS	9.01	6.29		7.13	6.57		5.98	7.39		9.44	7.56	
ET	11.04	9.58		10.28	8.50		9.76	8.71		7.36	8.72	
WB	18.06	25.07		19.81	24.03		20.94	19.70		16.91	22.18	

Note: MDA: Mean Decrease Accuracy; MDG: Mean Decrease Gini; OOB: Out-of-bag estimate of error rate.

To examine the accuracy in SPEI prediction, boxplots of 25%, 50%, and 75% quantile values for both observed and projected SPEI are shown in Fig. h. The figure illustrates that the identified best models adequately simulated the variability in SPEI1, SPEI3, SPEI6, and SPEI12 values across different regions. While many predicted SPEI values exhibited minimum fluctuation, except the observed values displayed a wide range when SPEI fell below -2 or exceeded 2 in a few cases. However, the identified best model showed better accuracy in simulating the variability and quantile of SPEIs compared to others. All prediction models exhibited enhanced performance in modelling SPEI quantiles across various SPEI scales, particularly at higher orders.

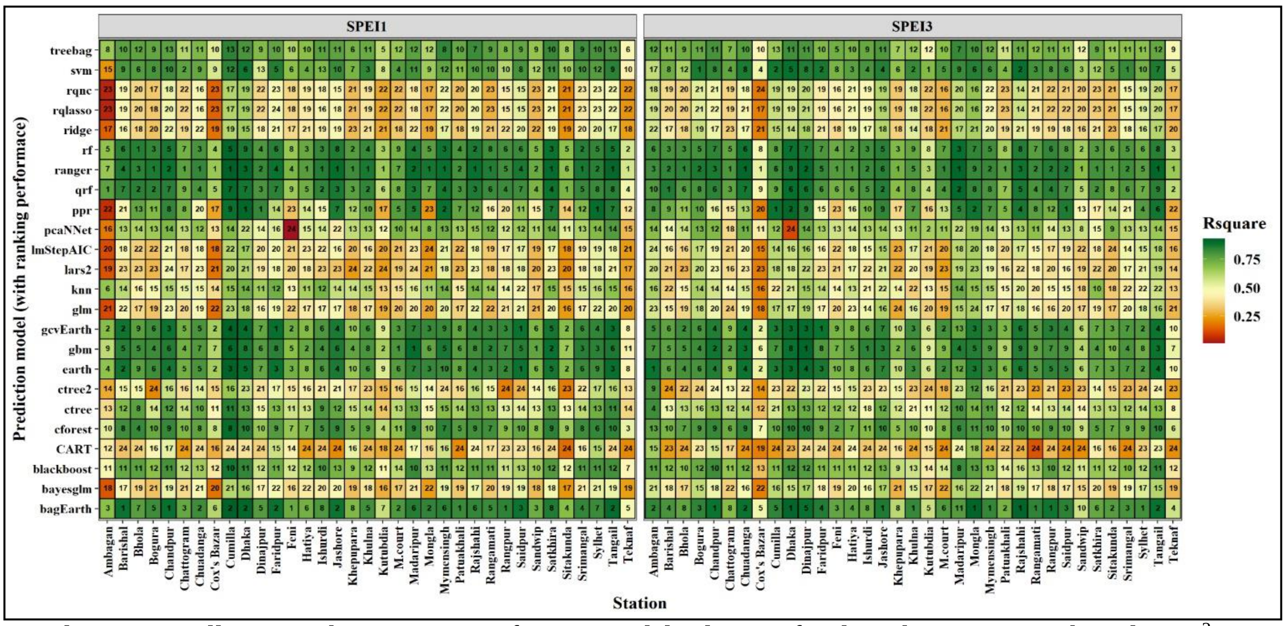


Fig. d. Heatmap illustrates the region-specific ML model selection for drought assessment based on R^2, MAE, and RMSE values. Various colors indicate the strength of the R^2 values. The region-specific ranking of ML models for predicting SPEI1 and SPEI3 was displayed by the added value label in the middle of the box. Greater R^2 and lower MAE and RMSE values defined the performance ranking scale of the model.

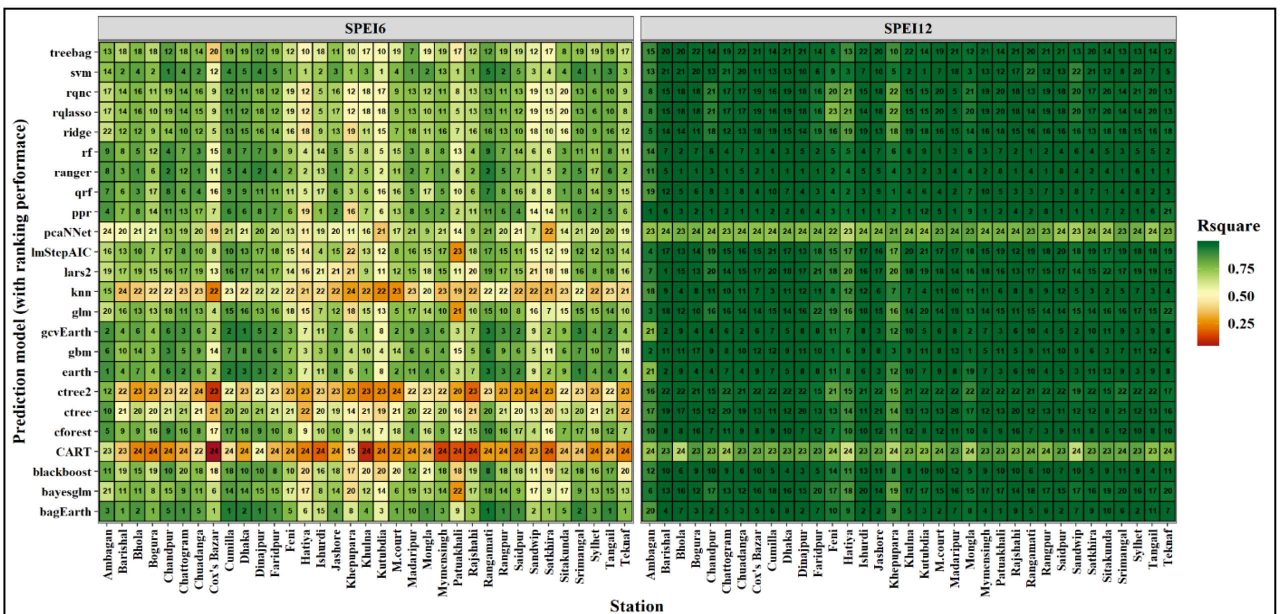


Fig. e. Heatmap illustrates the region-specific ML model selection for drought assessment based on R^2, MAE, and RMSE values. Various colors indicate the strength of the R^2 values. The region-specific ranking of ML models for predicting SPEI6 and SPEI12 was displayed by the added value label in the middle of the box. Greater R^2 and lower MAE and RMSE values defined the performance ranking scale of the model.

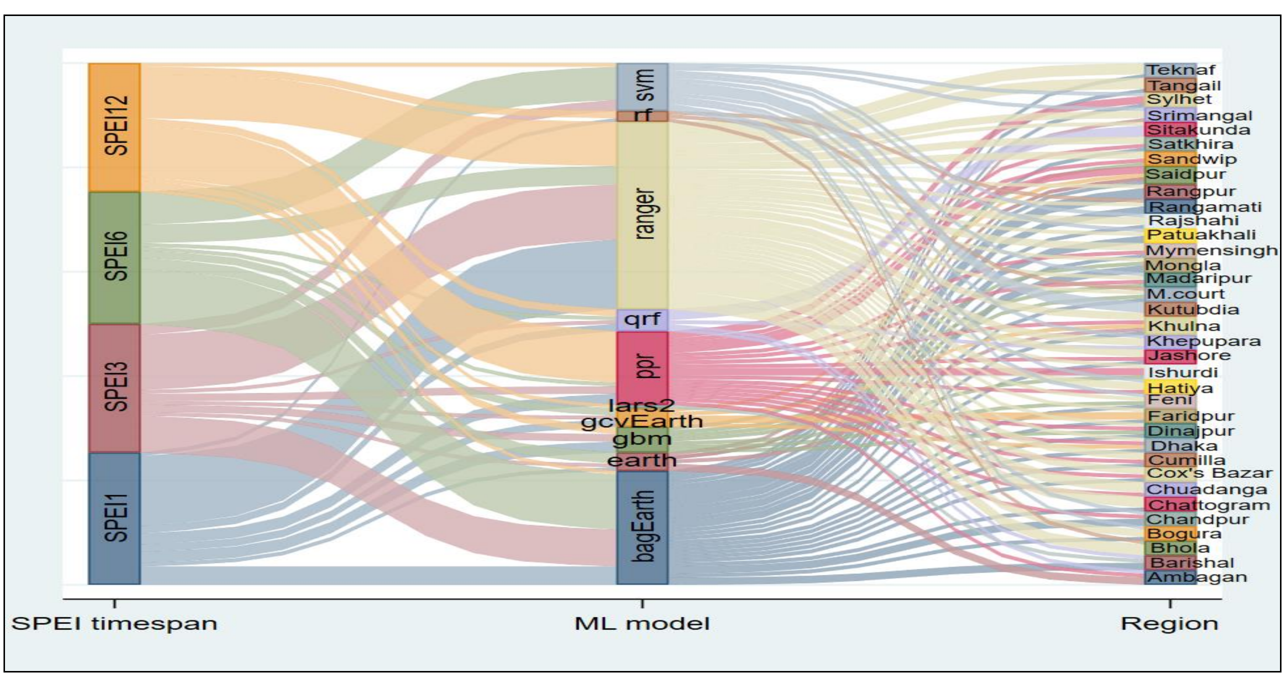


Fig. f. The Sankey graph illustrates a visualization of drought prediction models in Bangladesh across different timescales and regions.

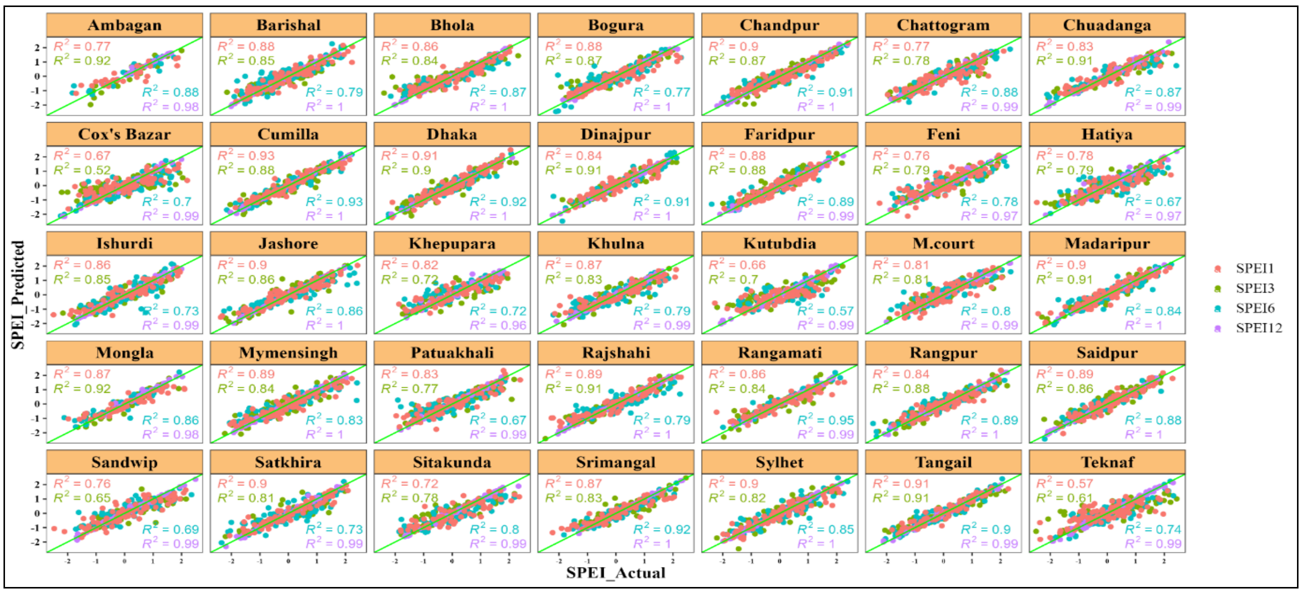


Fig. g. Region-specific best predictive ML models' performance.

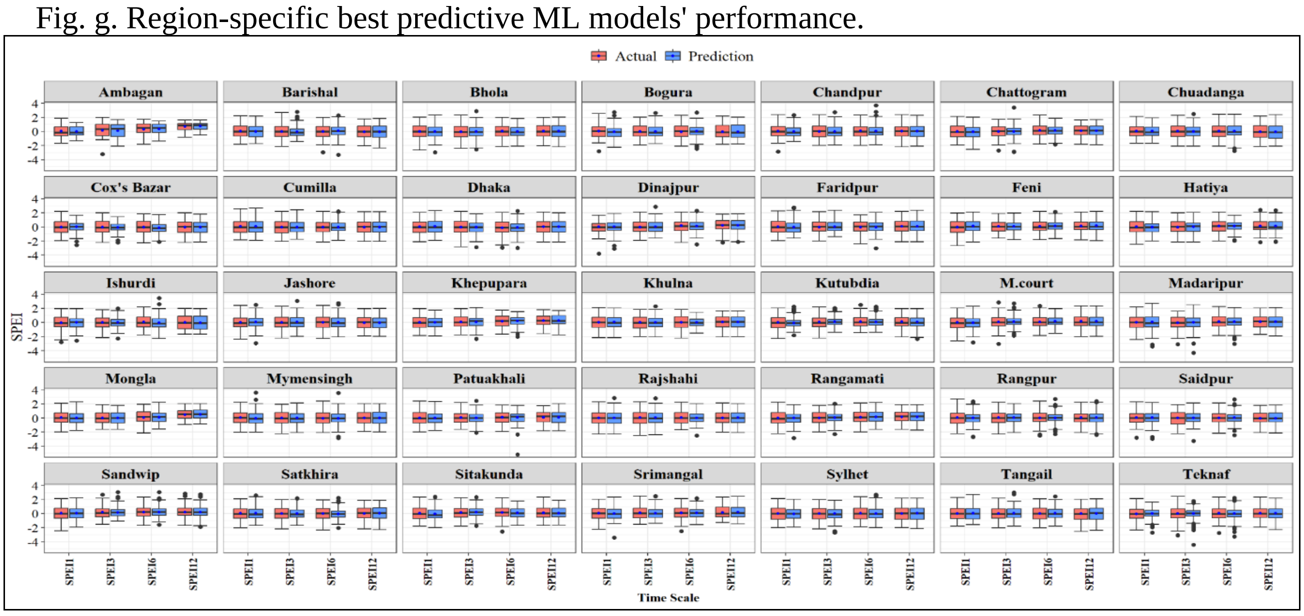


Fig. h. Box plot presentation of the best ML model performance of SPEI prediction for multiple time scales at the 35 investigated meteorological stations of Bangladesh.

Partial dependence plot for fitted projection

We employed a multivariate regression model to assess the significance of weather variables, and their relative effect on predicting SPEIs. In our analysis, ICE curves (depicted in black) and their mean (illustrated as the red line) were employed to visualize the relationships between individual weather attributes and the predicted SPEIs. This approach allowed us to identify critical climatic threshold values (Fig. i). The findings revealed that Bangladesh experienced a range of drought moderate to severity levels, with a deficit of 92, 95, 115, and 143 mm of average rainfall over one, three, six, and twelve months, respectively. Temperature played a crucial role, with minimum, maximum, and mean temperatures exceeding 20.7±1.1, 30.9±0.7, and 25.9±0.8℃, respectively, resulting in severe drought conditions across these time scales. Similarly, we observed that extended periods of sunshine hours and relative humidity surpassing 6.3±0.6 hours and 77.3±1.3 percent, respectively, contributed to drought conditions. Low wind speeds below 1.9±0.2 m/s and high evapotranspiration exceeding 123±10 mm at all four-time scales also played a significant role in inducing drought in the country. Furthermore, the water balance was identified as a substantial factor affecting SPEI prediction. Below-average water balance levels, specifically 116, 143, 148, and 190 mm for one, three, six, and twelve months, respectively, were associated with drought occurrences in Bangladesh. These findings provide critical insights into the complex interplay of weather variables and their impact on drought patterns in the study region.

Spatio–temporal pattern of seasonal drought intensity and frequency

Using the region-specific best selected model based on SPEI influential meteorological parameters, we predicted the seasonal intensity and frequency of drought over time in Bangladesh (Fig. j). We divided the forty years into four periods, i.e., Period I: 1981-1990, Period II: 1991-2000, Period III: 2001-2010, and Period IV: 2011-2020. Results showed that while drought intensity has decreased over time, but the return period has become more frequent. Spatially, the drought intensity shifted from the northern to central and southern zones of the country. In periodic assessment, the period with the most severe drought intensity was Period II. Notably, the frequency of drought has increased in Periods III and IV, indicating an increase in the number of droughts that occurred twice a decade in the past.

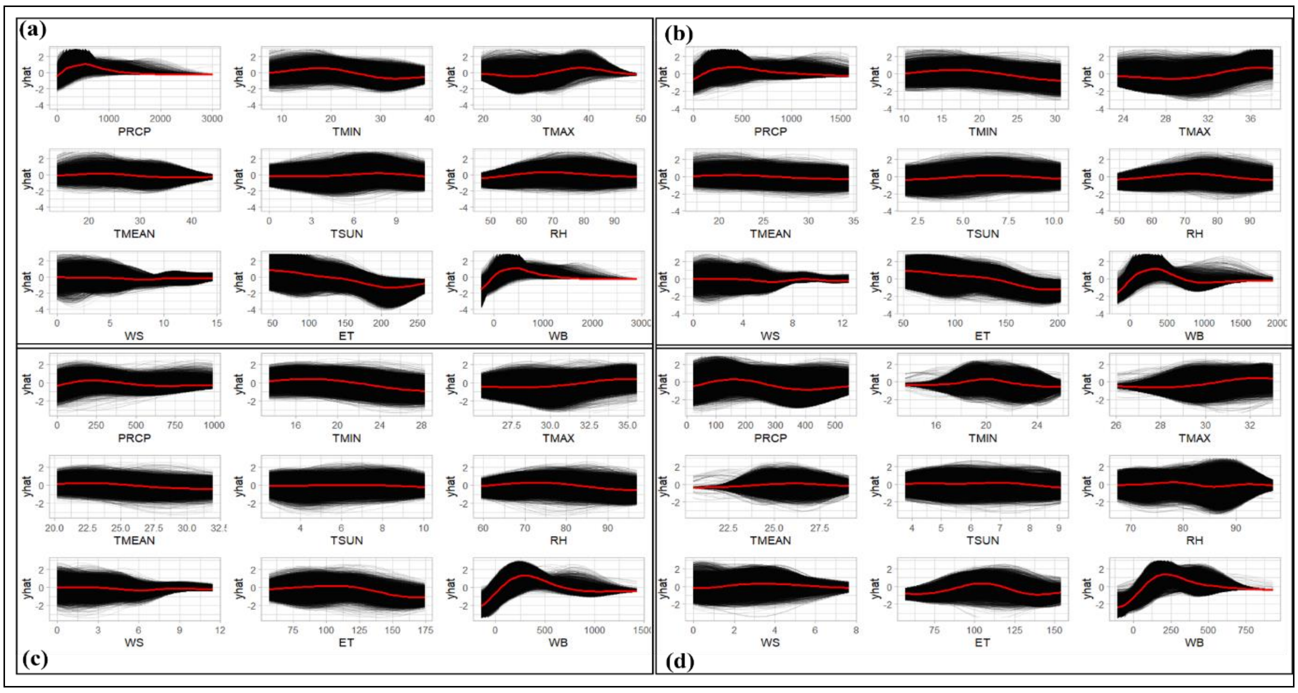


Fig. i. Fitted a partial dependence plot using the ICE curve method for each climatic feature against SPEI (yhat) for different time scales (a) SPEI1, (b) SPEI3, (c) SPEI6, and (d) SPEI12. Black and red curves denote ICE curves and their average value.

Season-wise, pre-kharif was the most common season for drought compared to other seasons. During the Period I of the Pre-kharif season, the northern, eastern, and a few southern regions of the country were primarily affected by severe drought. During Period II, the northern and the majority of the central regions were most affected by drought, while the severity of drought in the north and center regions gradually relieved in Period III. In Period IV, the drought severity has been more prevalent in the Rangpur, Bogura, Sylhet, Mymensingh, Cumilla, Jashore, Sitakundu, Kutubdia and parts of southern regions in Bangladesh. Except for Rajshahi, the drought intensity of the Barind tract (located mainly in the northwestern part) was so unpredictable and has decreased significantly in recent decades. Noticeably, we found that the intensity of drought (>1.0) in Chattogram division has been affected continuously over the last forty years. The highest frequency of drought was observed during Period III (2001-2010). Among all periods, the spatial patterns of drought frequency had changed, and high crop-intensive areas had become more vulnerable in the pre-kharif season.

During the Kharif season (June-October), the incidence of drought was lower than in the pre-Kharif season, but the pattern was comparable. In Period I of the Kharif season, the northern region of the country was hit by a severe drought, and the central half of the region was affected by a moderate drought. The intensity of the drought shifted from the north to the central region during the succeeding decade. During Period III, the majority of the northwest region again witnessed a severe drought, while the rest of the county was affected by a mild drought. In Period IV, the frequency of drought increased relative to previous periods, and its intensity rose in the north-eastern, central, and southern regions of Bangladesh.

During the Rabi season in Period I, the southwest and a portion of the northern region experienced drought intensity larger than one, and drought frequency greater than three times the average. However, nearly the entire country faced drought conditions in the succeeding decade. Throughout the country, the drought intensity has reduced, but frequency increased in Period III. Again, during Period IV, the divisions of Barishal, Chattogram, and Sylhet, as well as parts of the central regions, had droughts with intensities more than one. This suggests that drought conditions were similarly erratic throughout the Rabi season.

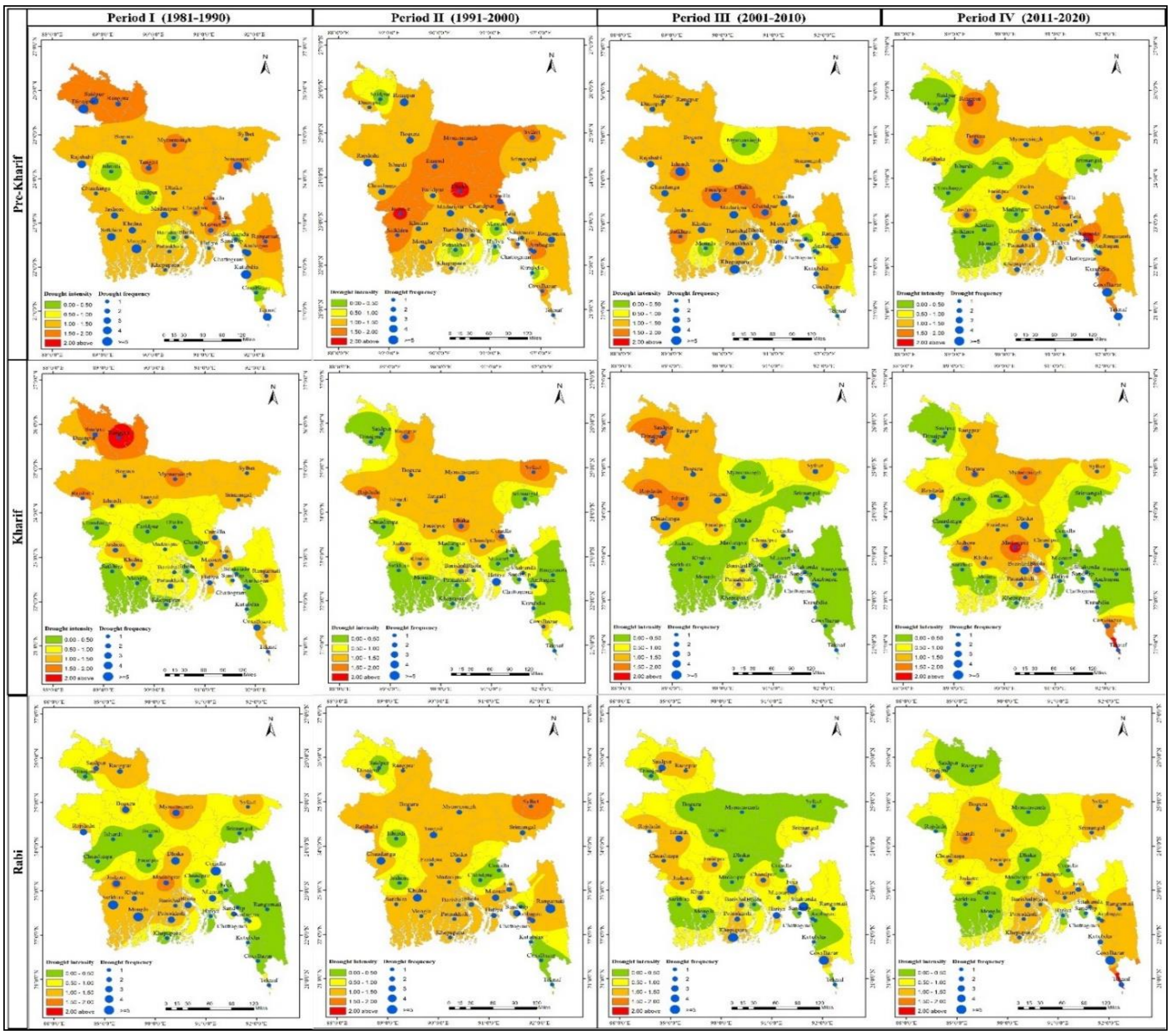


Fig. j. Spatio–temporal pattern of drought intensity and frequency based on the best predicted model for Pre-kharif, Kharif, and Rabi seasons over four decades (1981-1990, 1991-2000, 2001-2010, and 2011-2020) of Bangladesh.

Overall, the intensity and frequency of drought in Bangladesh have exhibited erratic patterns over the past forty years, with certain periods witnessing more severe droughts than others. Factors such as average rainfall, temperature, sunshine hours, relative humidity, wind speed, and evapotranspiration have collectively influenced drought intensity, along with water balance deficits. These factors have significantly influenced SPEI predictions, rendering regions with high crop intensity more susceptible. This underscores the crucial importance of comprehending the impacts of drought on food production and livelihoods in the region.

Conclusions

Droughts pose a severe environmental risk in countries that rely heavily on agriculture, resulting in heightened levels of concern regarding food security and livelihood enhancement. Bangladesh is highly susceptible to environmental hazards, with droughts further exacerbating the precarious situation for its 170 million inhabitants. Therefore, we are endeavouring to highlight the identification of the relative importance of climatic attributes and the estimation of the seasonal intensity and frequency of droughts in Bangladesh. With a period of forty years (1981-2020) of weather data, sophisticated machine learning (ML) methods were employed to classify 35 agroclimatic regions into dry or wet conditions using nine weather parameters, as determined by the Standardized Precipitation Evapotranspiration Index (SPEI). Out of 24 ML algorithms, the four best ML methods, ranger, bag Earth, support vector machine, and random forest (RF) have been identified for the prediction of multi-scale drought indices. The RF classifier and the Boruta algorithms shows that water balance, precipitation, maximum and minimum temperature have a higher influence on drought intensity and occurrence across Bangladesh. The trend of spatio-temporal analysis indicates, drought intensity has decreased over time, but return time has increased. There was significant variation in changing the spatial nature of drought intensity. Spatially, the drought intensity shifted from the northern to central and southern zones of Bangladesh, which had an adverse impact on crop production and the livelihood of rural and urban households. So, this precise study has important implications for the understanding of drought prediction and how to best mitigate its impacts. Additionally, the study emphasizes the need for better collaboration between relevant stakeholders, such as policymakers, researchers, communities, and local actors, to develop effective adaptation strategies and increase monitoring of weather conditions for the meticulous management of droughts in Bangladesh.

Project 2: Multivariate analysis of BRRI varieties

Activity 2.1: Genotype X Environment Interaction of BRRI Varieties

(In collaboration with Pl. Breeding Div., ARD Regional Stations)

-Md. Abdullah Al Mamun, Md. Ismail Hossain, Md. Shahjahan Kabir, Niaz Md. Farhat Rahman, Md. Abdul Qayum, Md. Abdullah Aziz, Rokib Ahmed and One Scientist from each Regional Station

Introduction

Rice is the main staple food in Bangladesh, occupies nearly 80% of the total net cropped area (Hossain *et.al*, 2015). Development and adaption of high yielding cultivars under wide range of diversified environments is one of the major goals for the plant breeders in crop improvement programme (Boseet.al, 2015). The development of rice varieties is affected by the environment, genotype and their interaction. Yield performance of different varieties varies across testing environments and its grain yield performance is a function of genotype (G), environment (E) and genotype × environment interaction (GEI). The structure of GEI is very important in plant breeding programs because a significant GEI can seriously impair efforts in selection of superior genotypes in relation to new crop introductions and cultivar development programs leads to successful evaluation of stable genotype, which could be used for general cultivation (Yan and Racjan, 2002; Vasgas et al. 2001; Reza et al.2007).

Objective

The major objective of the study was to identify BRRI released rice genotypes that have both high mean yield and stable yield performance across different environments for different ecosystem of Bangladesh.

Materials and Methods

The experiment was conducted in multi-environment trials for T. Aman 2022. Forty-seven (47) BRRI released T. Aman rice varieties were evaluated in nine environmental conditions of Bangladesh, such as Barishal, Bhanga, Cumilla, Gazipur, Kushtia, Rajshahi, Rangpur, Satkhira, and Sonagazi. The experimental sites covered all ecosystems of Bangladesh. The experiments were carried out in randomized complete block design (RCBD) with three replications and evaluated for rice grain yield. Each experimental plot comprised of 3m × 2m. Standard agronomic practices were followed and plant protection measures were taken according to Adhunik dhaner chash, BRRI (2022). AMMI model was used to quantify the effect of different factors (genotype, location) of the experiment. The model further provides graphical representation of the numerical results (GGE biplot analysis) with a straight-forward interpretation of the underlying causes of G × E.

Results and discussion

ANOVA of combined analysis

The combined analysis revealed that the yield of rice genotypes was significantly influenced by environment and contributed 48.59, 39.20 and 36.14% of the total variation for short, medium, and long duration respectively in the Aman season. Additionally, the relative contribution of genotype sum of squares was found 23.48, 10.97 and 13.93% for long, short, and medium duration respectively. Genotype by environment (G × E) contributed the most 33.59% to the total variation for medium duration followed by 27.14% and 26.78% for long and short duration (Table 4).

Greater portion of total variation was explained by environmental main effect indicating that the environments were diverse and a major part of variation in grain yield reflected from environmental changes. The highly significant genotype × environment interaction effects for grain yield confirmed that genotypes responded differently to the variation in environmental conditions. The yield variations could be attributed to the different environmental (climatic) conditions and to different edaphic conditions at different locations. In this case application of stability analysis for identifying widely and/or specifically adaptation of rice genotypes is essential.

Table 4. ANOVA of individual category (long, medium and short duration) Aman 2022.

SV	Long duration			Medium duration			Short duration		
	DF	MS	SS (%)	DF	MS	SS (%)	DF	MS	SS (%)
ENV	8	25.94**	36.14	8	17.50**	39.20	8	36.75**	48.59
REP(ENV)	18	0.41**	1.29	18	0.39**	1.94	18	0.42**	1.26
GEN	17	7.93**	23.48	12	3.27**	10.97	15	5.62**	13.93
ENV:GEN	136	1.15**	27.14	96	1.25**	33.59	120	1.35**	26.78
Residuals	306	0.22	11.96	216	0.24	14.29	270	0.21	9.43
CV (%)	13.17			11.47			11.49		
$LSD_{0.05}$	0.76			0.78			0.74		

Note: ENV=environment, GEN= genotype, DF = degrees of freedom; MS = mean sum square; SS (%) = explain % sum of squares; ** = significant at 1% level.

Performance and stability of rice genotypes across tested environments
Aman season:
The GGE biplot explained 73.43%, 68.47%, and 55.45% of the total variation of the environments for long, medium and short duration respectively (Fig. 16-19). Within a single mega-environment, genotypes should be evaluated on both mean performance and stability across environments. Figures 16a, 17a and 18a shows average-environment coordination (AEC) views of the GGE biplot for grain yield of long, medium, and short duration. Fig. 16-19 shows the yield performances and summary of ideal genotypes and genotypes with stable and high mean yields in different categories (long, medium and short duration). BR11 recorded the highest average grain yield (4.49 t/ha) in long duration (Fig. 16a). BR10, BR22, BRRI dhan30, BRRI dhan40, were the above-average yields (3.59 t/ha). Thus, the BR11 and BRRI dhan30 were the most ideal genotype with the highest mean yield and stability among the tested genotypes (Fig. 16a). The genotype BRRI dhan78 (4.63 t/ha), BRRI dhan94 (4.60 t/ha), BRRI dhan79 (4.58 t/ha), BRRI dhan93 (4.56 t/ha), BRRI dhan49 (4.52 t/ha) were the most stable genotype with above-average yield (4.24 t/ha) in medium duration (Fig. 17a). BRRI dhan72 (4.88 t/ha), BRRI dhan87 (4.62 t/ha) BRRI dhan71 (4.58 t/ha), BRRI dhan95 (4.33 t/ha), and BRRI Hybrid dhan6 (4.31 t/ha) recorded the above-average yields among short duration variety. Among high yielded variety the BRRI dhan71, BRRI dhan72, BRRI dhan87 and BRRI dhan95 showed the closest position from the axis line, and designated as most stable and ideal genotype in short duration (Fig. 18a). Also, BRRI Hybrid dhan6, BRRI dhan66 were the moderately stable genotypes and above average yielder (Fig. 19).

Identification of which-won-where and mega-environment
One of the most attractive features of a GGE biplot is its ability to show the which-won-where pattern of a genotype by environment dataset. This plot consists of a polygon with perpendicular lines, called equality lines, drawn onto its sides. These lines divide the polygon into various sectors. Genotypes located on the vertices of the polygon are the best performers in one or more environments falling within a particular sector.

The biplot showed three sectors containing all the test environments in long duration and accordingly three mega-environments were identified (Fig. 16b): One mega-environment had five locations, Gazipur, Bhanga, Cumilla, Rajshahi and Sonagazi; the second consisting of three locations- Barishal, Satkhira, and Kushtia; and rest mega-environment contains only Rangpur location. Hence, the winning genotype in those environments was BR11 for first; BR10 is the second location where BRRI dhan41 only suitable for Kushtia and Satkhira. BR3 closed to third mega environment and the location was Rangpur (Fig. 16b).

In medium duration, the biplot grouped the test locations into four mega-environments (Fig. 17b). The first mega-environment had three locations, Sonagazi, Rajshai, and Gazipur. The second had two locations those were Cumilla and Barishal. The third contained three locations Bhanga, Satkhira and Rangpur. The fourth mega environment had only one location i.e., Kushtia. BRRI dhan49 and BRRI dhan80 were the winning genotype in the first mega-environment while BRRI dhan94 was the winner in the second and BRRI dhan78 and BRRI dhan79 was the winner in the third and BR25 in the last mega-environment.

The biplot was divided into two mega-environments in short duration (Fig. 18b). The first mega-environment had six locations-Bhanga, Cumilla, Gazipur, Kushtia, Rajshahi and Rangpur with BRRI dhan72 being the winning genotypes. The second mega-environment had three locations-Barishal, Satkhira and Sonagazi where BRRI dhan87 and BRRI hybrid dhan6 were the winner in this mega-environment. BRRI dhan62, BRRI dhan56, BRRI dhan57 and BRRI dhan90 were the low yielder of short duration genotypes.

Evaluation of test environments
In long duration (Fig. 16), there were three clusters of environments, one contains Barishal, Satkhira, and Kushtia; another contains Gazipur, Bhanga, Cumilla, Sonagazi, and Rajshahi; the other cluster contains only, Rangpur. Among them Cumilla and Sonagazi were closely associated (Fig.16c). Kushtia, Rajshahi and Rangpur had the longest vector and hence was highly discriminating. Overall, the locations Sonagazi was highly representative and can be considered ideal environments for evaluating long duration genotypes (Fig.16c). GGE biplot showed three distinct clusters in medium duration: one contains Cumilla, Sonagazi and Gazipur; another cluster contains Barishal and Rajshahi; and Bhanga, Satkhira, Kushtia and Rangpur remain same cluster (Fig. 17c). The closest association were observed between the environments Gazipur and Sonagazi; and Barishal and Rajshahi. The location Rangpur position in the longest vector and showed week correlation with

Cumilla and Sonagazi. The ideal environment was found Rajshahi and Kushtia (Fig. 17c). for testing medium duration genotypes with its appreciable discriminating ability and representativeness and position nearest to the circle point of AEA (average-environment axis).

In short duration GGE biplot showed three distinct clusters (Fig. 17c). Barishal, Rajshahi, Gazipur and Kushtia considered one cluster and the second cluster contains Rangpur, Cumilla and Bhanga and the rest cluster contain only two locations Sonagazi and Satkhira. Bhanga showed the longest vector, making it more discriminating than the other environments. Considering the criteria of ideal environment, Kushtia, Gazipur and Rajshahi showed a smaller angle with the AEA and hence highly representative environment (Fig. 17c) for testing short duration genotypes.

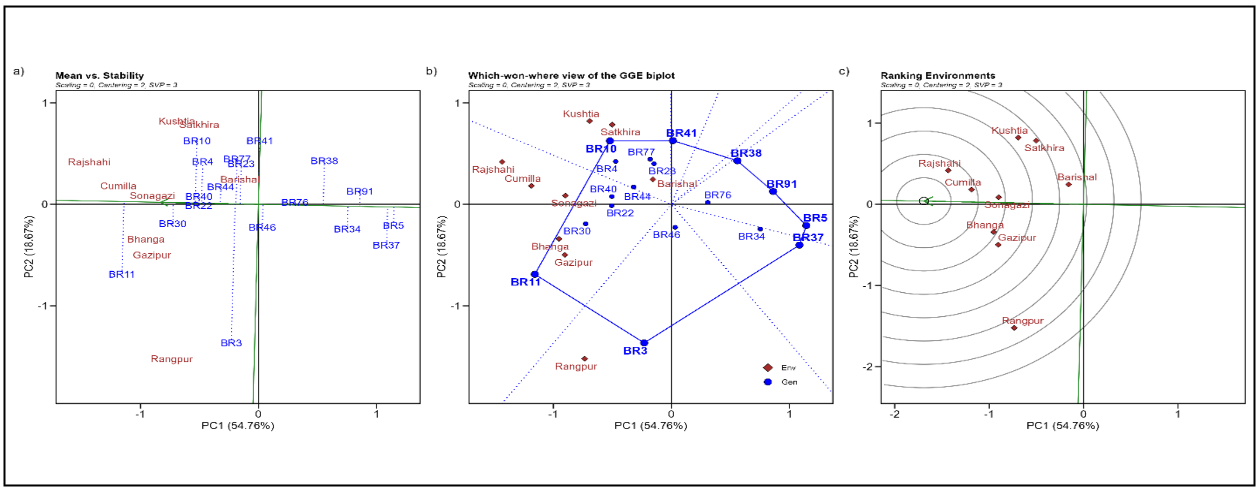


Fig. 16: GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-environments (b) and association among the test environments (c) of long duration rice genotypes for yield and specific genotype × environment interactions in T. Aman 2022.

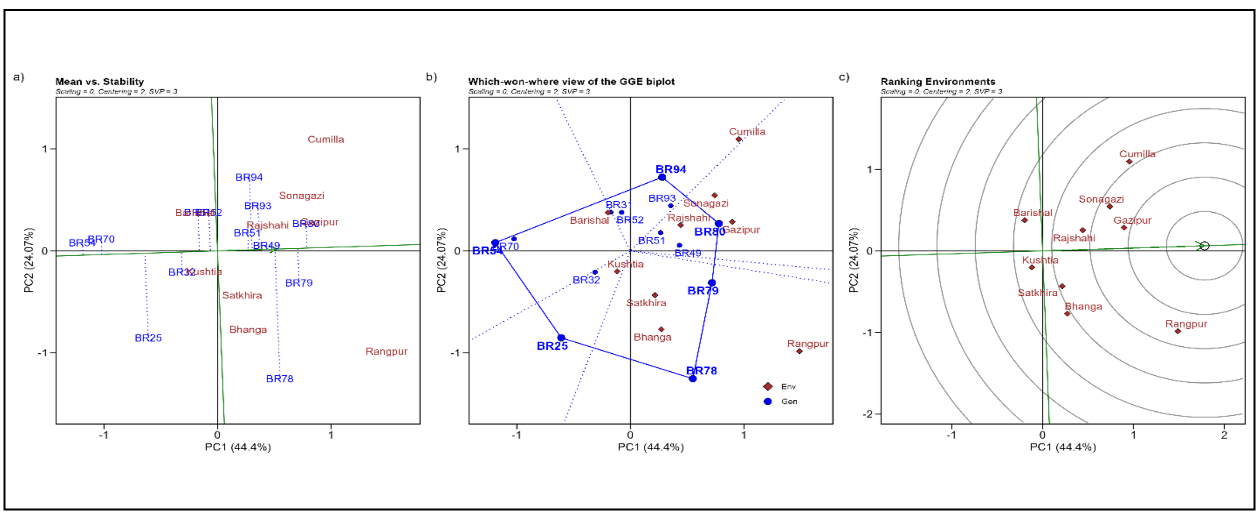


Fig. 17: GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-environments (b) and association among the test environments (c) of medium duration rice genotypes for yield and specific genotype × environment interactions in T. Aman 2022.

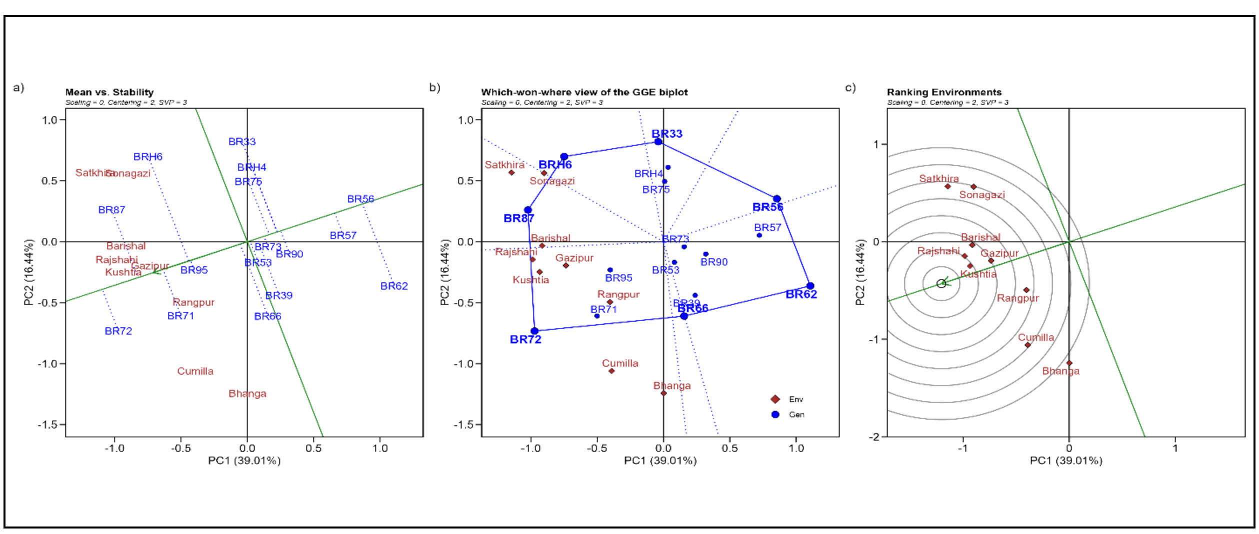


Fig. 18: GGE biplot of mean and stability (a), GGE biplot identification of winning genotypes and their related mega-environments (b) and association among the test environments (c) of short duration rice genotypes for yield and specific genotype × environment interactions in T. Aman 2022.

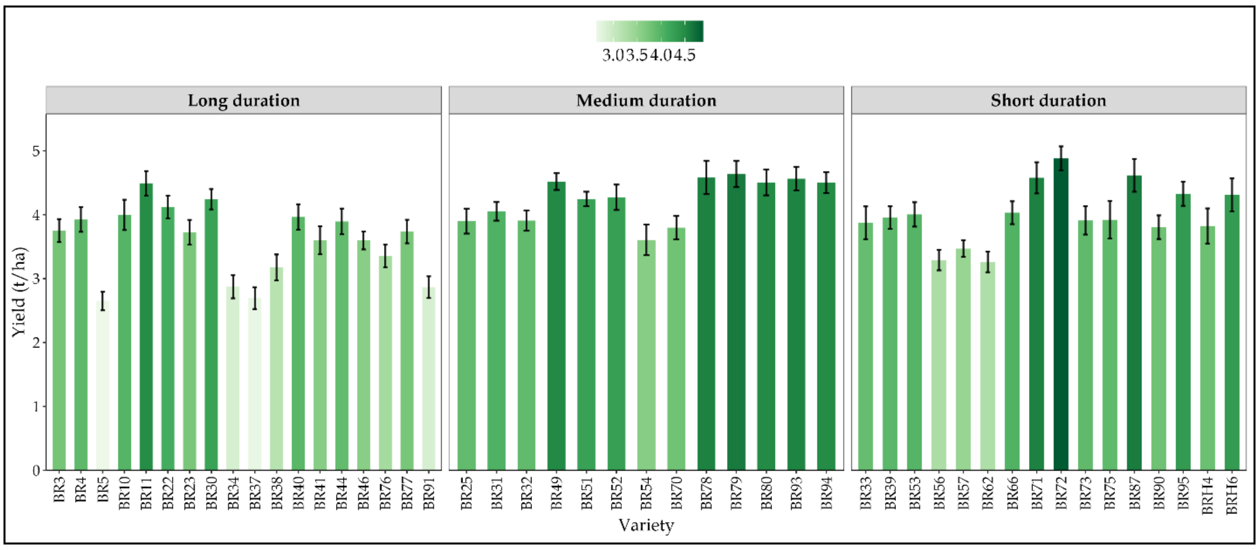


Fig. 19: Grain yield performance of BRRI released T. Aman rice varieties during 2022.

Conclusion

The highly significant genotype × environment interaction effects for grain yield confirmed that genotypes responded differently to the variation in environmental conditions for long, medium and short duration Aman varieties. Greater portion of total variation was explained by environmental main effect indicating that the environments were diverse and a major part of variation in grain yield reflected from environmental changes. In Aman season, BR11 and BRRI dhan30 recorded the highest average grain yielder and ideal genotypes among long duration varieties. BRRI dhan78, BRRI dhan94, BRRI dhan79, BRRI dhan93 and BRRI dhan49 were the most stable genotype with above-average yield in medium duration where BRRI dhan71, BRRI dhan72, BRRI dhan87 and BRRI dhan95 were the most stable genotypes and above average yielder for short duration.

Project 3: Rice and Rice Related Database

Activity 3.1: Maintenance of rice and related database

- Md. Ismail Hossain, Md. Shahjahan Kabir, Niaz Md. Farhat Rahman, Md. Abdul Qayum, Md. Abdullah Aziz, Md. Abdullah Al Mamun and Rokib Ahmed

Objectives

1. To maintain up-to-date computerized information on rice and related crops
2. To provide rice and related information to other research divisions and interested persons.

Methodology

Secondary data on rice and other important crops were collected periodically from Bangladesh Bureau of Statistics (BBS), Agricultural Marketing Directorate, Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB), Bangladesh Agricultural Development Corporation (BADC) and other sources periodically and computerized. We have initiated a database system where we used updated software and database program. To make this database, we were used **SQL Server** 2005 express edition/2008/2010/2012 version and **Oracal** 9i/10g/11i version.

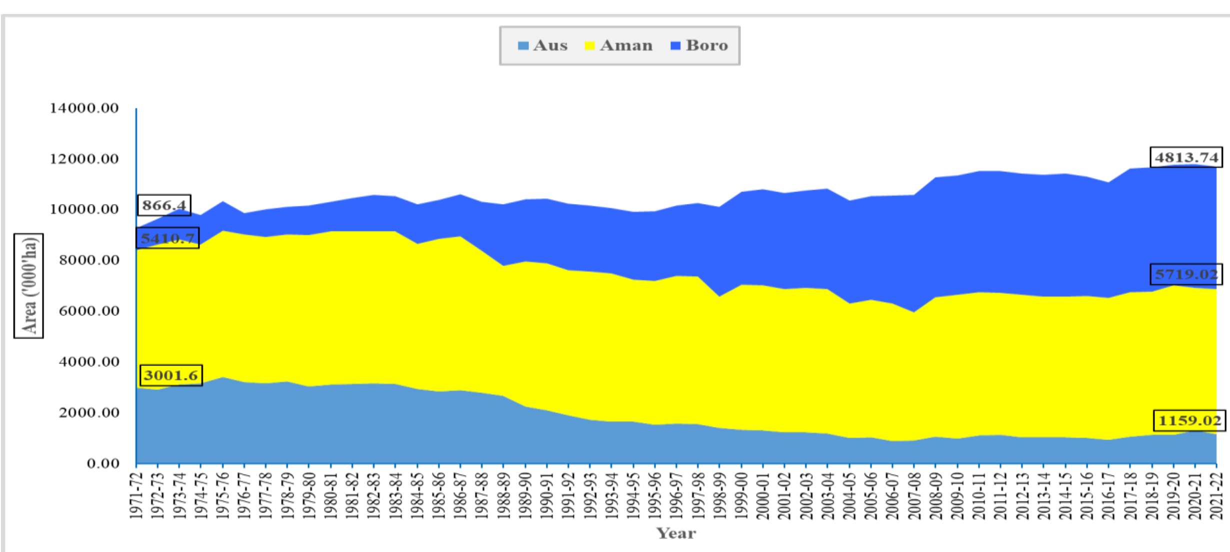
Results

Existing databases have been updated. After necessary correction the data were analysed and the output were available in BRRI website in different form under different scenarios. Using the time series data (area and production data from 1971-72 to 2021-22) we produced rice cultivated area and production graph of Bangladesh (Graph 1 & Graph 2). Rice area increased about one and half folds but the production increased about four folds during 1971-72 to 2021-22. Rice area growth rate was 3.96 in year 1972-73 but in 2021-22 is -0.95 (Table 11). Similarly, Rice production growth rate was 1.30 in year 1972-73 but in 2021-22 is 8.91 (Table 12). Besides using the rice and related database, created a Data Leadership Dashboard System. Which is uploaded in internal e-service menu of BRRI website. From which one can see and know at a glance the region and variety wise performance of BRRIs developed rice varieties.

Table 11. Rice area ('000'ha) growth rate in Bangladesh from 1971-72 to 2021-22

Year	Season			Total Area (ha.)	GR (%)
	Aus	Aman	Boro		
1971-72	3001.6	5410.7	866.4	9278.7	-
1972-73	2930	5713.8	1002.6	9646.4	3.96
1973-74	3107.9	5718.7	1222.7	10049.3	4.18
1974-75	3179.1	5449.9	1161.2	9790.2	-2.58
1975-76	3419.9	5759.9	1147.9	10327.7	5.49
1976-77	3217.1	5806.4	854.2	9877.7	-4.36
1977-78	3161.7	5771.2	1093.7	10026.6	1.51
1978-79	3234.6	5805.1	1071.8	10111.5	0.85
1979-80	3036.3	5972.7	1148.4	10157.4	0.45
1980-81	3111.2	6035.8	1160	10307	1.47
1981-82	3145.6	6010.3	1301.7	10457.6	1.46
1982-83	3158.1	5993	1432.8	10583.9	1.21
1983-84	3138.7	6006.7	1401.2	10546.6	-0.35
1984-85	2937.6	5710.2	1574.4	10222.2	-3.08
1985-86	2844.9	6018.9	1533.2	10397	1.71
1986-87	2903.6	6052.4	1651.7	10607.7	2.03
1987-88	2788.3	5590.4	1942.6	10321.3	-2.70
1988-89	2683.46	5100.8	2438.3	10222.56	-0.96
1989-90	2255	5702.5	2453.6	10411.1	1.84
1990-91	2107.3	5775.3	2547.9	10430.5	0.19
1991-92	1915.9	5692.3	2634.9	10243.1	-1.80
1992-93	1735.1	5843.7	2598.9	10177.7	-0.64
1993-94	1649.4	5843.3	2580.8	10073.5	-1.02
1994-95	1663.75	5594.17	2663.54	9921.46	-1.51
1995-96	1541.85	5646.4	2753.57	9941.82	0.21
1996-97	1592.29	5802.49	2782.59	10177.37	2.37
1997-98	1565.88	5808.45	2888.56	10262.89	0.84
1998-99	1424.26	5165.5	3526.67	10116.43	-1.43
1999-00	1351.32	5704.87	3651.89	10708.08	5.85
2000-01	1325.23	5709.96	3761.84	10797.03	0.83
2001-02	1242.18	5647.22	3771.34	10660.74	-1.26
2002-03	1243.72	5682.11	3844.84	10770.67	1.03
2003-04	1202.58	5677.61	3943.5	10823.69	0.49
2004-05	1024.68	5279.92	4063.79	10368.39	-4.21
2005-06	1034.27	5429.01	4065.81	10529.09	1.55
2006-07	905.71	5415.62	4250.1	10571.43	0.40
2007-08	918.66	5048.16	4607.85	10574.67	0.03
2008-09	1065.56	5497.77	4716.31	11279.64	6.67
2009-10	984.22	5662.89	4706.6	11353.71	0.66
2010-11	1112.87	5645.64	4770	11528.51	1.54
2011-12	1138	5580	4810	11528	0.00
2012-13	1053	5610	4760	11423	-0.91
2013-14	1051	5530.2	4790	11371.2	-0.45
2014-15	1045	5530	4846	11421	0.44
2015-16	1025	5590.4	4685.1	11300.5	-1.06
2016-17	941.7	5583.3	4547.3	11072.3	-2.02
2017-18	1075.1	5679.5	4859.4	11614	4.89
2018-19	1145.13	5621.9	4909.85	11676.88	0.54
2019-20	1134	5883.8	4754.4	11772.2	0.82
2020-21	1304.99	5625.9	4872.6	11803.49	0.27
2021-22	1159.02	5719.02	4813.74	11691.78	-0.95

Sources: BBS and DAE

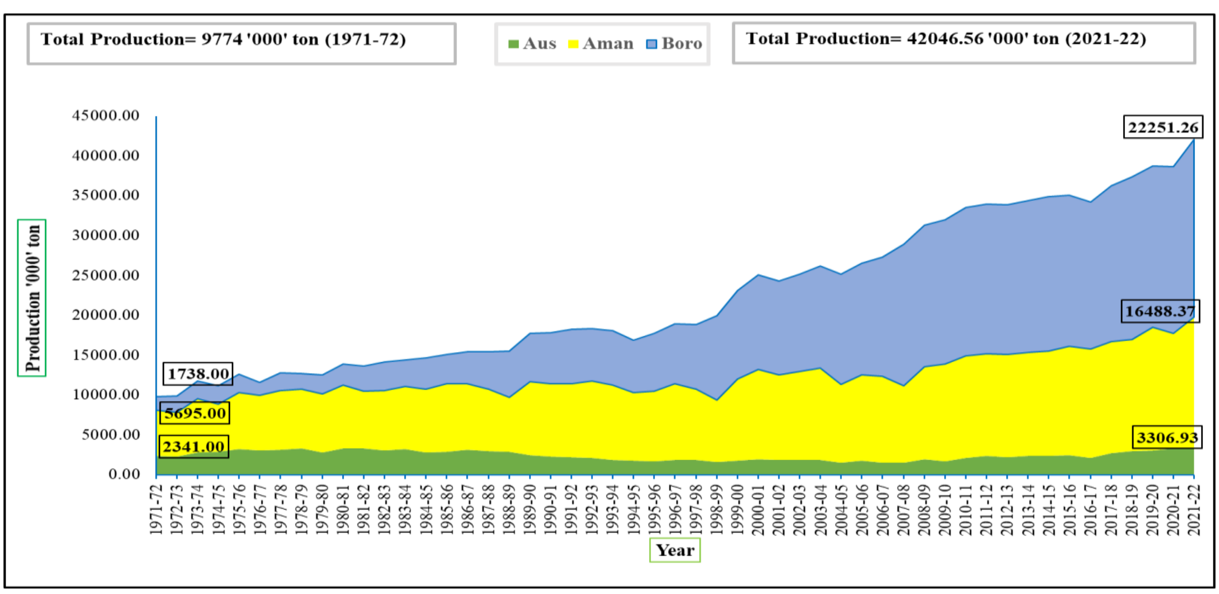


Graph 1: Cultivated area of Rice (Aus, Aman and Boro) in Bangladesh from 1971-72 to 2021-22

Table 12. Rice production (000'm.ton) growth rate in Bangladesh from 1971-72 to 2021-22

Year	Season				
	Aus	Aman	Boro	Total Production (MT)	GR(%)
1971-72	2341.00	5695.00	1738.00	9774.00	-
1972-73	2243.00	5587.00	2071.00	9901.00	1.30
1973-74	2801.00	6699.00	2220.00	11720.00	18.37
1974-75	2859.00	6000.00	2250.00	11109.00	-5.21
1975-76	3229.00	7045.00	2286.00	12560.00	13.06
1976-77	3014.00	6905.00	1650.00	11569.00	-7.89
1977-78	3103.00	7422.00	2239.00	12764.00	10.33
1978-79	3287.00	7429.00	1929.00	12645.00	-0.93
1979-80	2809.00	7303.00	2427.00	12539.00	-0.84
1980-81	3289.00	7964.00	2630.00	13883.00	10.72
1981-82	3270.00	7209.00	3152.00	13631.00	-1.82
1982-83	3065.00	7516.00	3548.00	14129.00	3.65
1983-84	3222.00	7843.00	3350.00	14415.00	2.02
1984-85	2783.00	7930.00	3909.00	14622.00	1.44
1985-86	2828.00	8542.00	3671.00	15041.00	2.87
1986-87	3130.00	8267.00	4010.00	15407.00	2.43
1987-88	2993.00	7690.00	4731.00	15414.00	0.05
1988-89	2856.00	6857.00	5831.00	15544.00	0.84
1989-90	2475.00	9202.00	6033.00	17710.00	13.93
1990-91	2261.00	9167.00	6357.00	17785.00	0.42
1991-92	2179.00	9269.00	6807.00	18255.00	2.64
1992-93	2075.00	9680.00	6586.00	18341.00	0.47
1993-94	1850.20	9419.20	6772.20	18041.60	-1.63
1994-95	1790.70	8504.00	6538.70	16833.40	-6.70
1995-96	1676.00	8790.00	7220.60	17686.60	5.07
1996-97	1870.00	9551.00	7460.00	18881.00	6.75
1997-98	1874.60	8849.80	8137.30	18861.70	-0.10
1998-99	1616.90	7735.80	10551.90	19904.60	5.53
1999-00	1734.00	10306.00	11027.00	23067.00	15.89
2000-01	1916.00	11249.00	11920.50	25085.50	8.75
2001-02	1808.00	10726.00	11766.00	24300.00	-3.13
2002-03	1850.70	11118.40	12222.20	25191.30	3.67
2003-04	1831.80	11520.50	12837.10	26189.40	3.96
2004-05	1500.00	9819.00	13837.10	25156.10	-3.95
2005-06	1745.00	10810.00	13975.30	26530.30	5.46
2006-07	1512.00	10841.00	14965.00	27318.00	2.97
2007-08	1507.00	9662.00	17762.00	28931.00	5.90
2008-09	1895.00	11613.00	17809.00	31317.00	8.25
2009-10	1709.00	12207.00	18059.00	31975.00	2.10
2010-11	2132.82	12791.00	18616.00	33539.82	4.89
2011-12	2333.00	12798.00	18783.00	33914.00	1.12
2012-13	2158.00	12897.00	18778.00	33833.00	-0.24
2013-14	2326.00	13023.30	19007.00	34356.30	1.55
2014-15	2328.00	13190.20	19343.00	34861.20	1.47
2015-16	2468.00	13591.40	19001.10	35060.50	0.57
2016-17	2133.60	13656.00	18411.80	34201.40	-2.45
2017-18	2709.70	13993.80	19575.80	36279.30	6.08
2018-19	2920.20	14054.90	20388.50	37363.60	2.99
2019-20	3012.00	15502.00	20181.40	38695.40	3.56
2020-21	3284.70	14437.80	20885.30	38607.80	1.23
2021-22	3306.93	16488.37	22251.26	42046.56	8.91

Sources: BBS and DAE



Graph 2: Rice Production (Aus, Aman and Boro) in Bangladesh from 1971-72 to 2021-22

Conclusion

Rice area increased about one and half folds but the production increased about four folds during 1971-72 to 2021-22. Although the growth rate of rice area was 3.96 in year 1972-73 but in 2021-22 is -0.95. Similarly, growth rate of rice production was 1.30 in year 1972-73 but in 2021-22 is 8.91. Moreover, rice and related data have been updating regularly and the collected data are being available in BRRI website. Also, being producing different types of graphs, trend and climatic map of Bangladesh by using the database as per requirement of BRRI authority and BRRI scientists.

Project 4: Agro-meteorology and crop modelling

Study 4.1: Minimizing agro micro climatological risk factors for maximizing sustainable rice production in Bangladesh

(In collaboration with Agronomy Div., Entomology Div., Plant Physiology Div., Soil Science Div., IWM Div., Plant Pathology Div., and Agril.Econ. Div.)

-Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun, Rokib Ahmed, Mohammad Chhiddikur Rahman, Md. Mofazzel Hossain, ABM Zahid Hossain, Mohammad Ashik Iqbal Khan, Md Khairul Alam Bhuiyan, Md. Mozammel Haque, Tuhin Halder, Md. Ismail Hossain and Md. Shahjahan Kabir

Introduction

Ensuring food security is a major challenge of a country with an increasing population and reducing agricultural land as well as regular short- and long-term climate hazards. Of all cereal crops in Bangladesh, rice plays the leading role by contributing 90% of total food grain production (Agriculture Diary, 2018). The national agricultural policy of Bangladesh emphasizes strengthening the early warning system to forecast extreme weather events and provide action-oriented advisories to the farmers as a part of climate-resilient agricultural practices. The weather forecast and advisory service focused on food security and responsiveness to climate change in Bangladesh. Whereas weather forecasts-based rice advisory system has potential for reducing poverty by increasing the rice yield, avoiding insect and disease outbreaks, efficient water management, labour and energy utilization, reduce losses and risks, reduce pollution with judicious use of agricultural chemicals through proper management in time and also provide guidelines for selection of the best-suited rice varieties according to the anticipated climatic conditions. This is how the system reduces the overall costs of production and increases the income of the farmers.

Objective

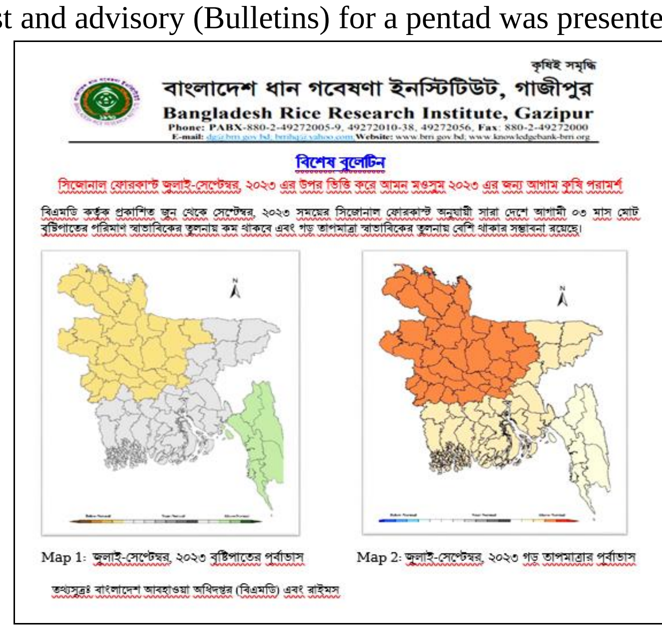
The objective of this study is to perform weather forecasts at season basis and validate forecast based rice crop management system through integrated rice advisory system (IRAS) in Aus, Aman and Boro for sustainable rice production in Bangladesh.

Materials and Methods

The seasonal weather forecast and rice advisory were generated in Aman season (July to September, 2023) for BRRI HQ and different R/S's. A team comprising of multidisciplinary researchers (agronomist, plant pathologist, entomologist, soil scientist, plant physiologist, irrigation specialist, agricultural statistician, and agricultural economist) were participated to generate location-specific weather forecast for five parameters, viz rainfall, relative humidity, wind speed, minimum and maximum temperature and prepared advisories using local language called Bengali at different growth stages of Boro rice based on weather forecasts. Weather research and forecasting (WRF) model for forecasting, which is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs will be used for the seasonal weather forecast. Maps 1 and 2 shows as a sample how the weather forecast and rice advisory looks like.

Results

Seasonal weather forecast and rice advisory (Bulletins) were generated in three seasons. The seasonal weather forecast and advisory (Bulletins) for a pentad was presented here:



কৃষি পরামর্শ

আমন ধান চাষে করণীয় হিসেবে নিম্নলিখিত আগাম পরামর্শ প্রদান করা হলোঃ

- বৃষ্টির জন্য অপেক্ষা না করে সঠিক সময়ে বীজতলায় বীজ বপন এবং জমিতে চারা রোপনের জন্য প্রয়োজনীয় সেচ প্রদানের ব্যবস্থা গ্রহণ করে রাখতে হবে।
- বৃষ্টির পানি বিভিন্ন প্রচলিত পদ্ধতি ব্যবহার করে সংরক্ষণ করার প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে। যেমন জমির তুলনামূলক নিচুঁ অংশে অথবা সুবিধাজনক অন্য কোন স্থানে বৃষ্টির পানি সংরক্ষণের ব্যবস্থা করা যেতে পারে। সেচের পানি অপচয় রোধে ফিতা পাইপ বা প্লাষ্টিক পাইপ ব্যবহার করা যেতে পারে এবং জমির চারপাশে আইল উঁচু করে পানি ধরে রাখতে হবে।
- বীজতলা এবং জমিতে সার বিশেষ করে ইউরিয়া প্রয়োগে সতর্কতা অবলম্বন করতে হবে।
- বীজতলা এবং জমিতে সবুজ পাতা ফড়িং এবং টুংরো রোগের আক্রমণ বাড়তে পারে। সে ক্ষেত্রে বীজতলায় হাতজাল, অলোক ফাঁদ এবং দুইবার কীটনাশক প্রয়োগ করতে হবে। তাছাড়া জমিতে এ রোগের আক্রমন দেখা দিলে সাথে সাথে আক্রান্ত গাছ তুলে মাটিতে পুতে দিয়ে বীজতলার ন্যায় একই পদ্ধতি অবলম্বন করতে হবে।
- জমিতে মাজরা পোকা, পাতা মোড়ানো পোকা, পাতা মাছি পোকার আক্রমণ হতে পারে বিধায় প্রয়োজনীয় সতর্কতা অবলম্বন করতে হবে।

বিশেষ বুলেটিন তৈরিতে
এগ্রোমেট ল্যাব, ব্রি

Conclusion

For reducing micro climatological risk factors weather-based rice advisory system consider and manage the full spectrum of risks from weather extremes or climate variability. This novel approach can help rice growers in a better and more coordinated way in response to weather extremes or climate variability that exceeds their inherent coping capacity. This can significantly reduce the disaster risk of the rice farming communities, which is a major development challenge in Bangladesh.

Project 5: Utilization of geographical information system (GIS) in rice research

Activity 5.1: Suitability (Edaphic) Mapping of BRRI dhan96-99

(In collaboration with Plant Breeding Div., Soil Science Div. and ARD)

- Rokib Ahmed, Md. Abdullah Aziz, Dr. Biswajit Karmaker, Md. Ismail Hossain, Niaz Md. Farhat Rahman, Md. Abdul Qayum and Md. Abdullah Al Mamun

Introduction

Bangladesh agriculture involves food production for 163.65 million people from merely 8.75 million hectares of agricultural land (Salam *et al.*, 2014). More food will be required in future because of increasing population as well as decreasing resources (e.g. land, labour, soil health and water) and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as the great challenges to keep the pace of food production in the background of increasing population. Sufficient rice production is the key to ensure food security in Bangladesh. In fact, Rice security is synonymous to "Food security‟ in Bangladesh as in many other rice growing countries (Brolley, 2015). We have very limited amount of land resource, moreover 0.4% rice land is reducing every year (The daily Prothom-Alo, 2015). Thus, we need to best use of limited land resource. Our land is not homogenous all over the Bangladesh. Various physical and chemical properties of soil vary spatially, on the other hand various rice varieties are suitable for some specific physical and chemical properties. As we need to high production with limited land, so it will be very helpful if we have variety wise suitability map based on soil properties. BRRI dhan93 to BRRI dhan95 varieties are prospective varieties. So, these varieties land suitability maps are very important.

Objectives

1. To construct edaphic suitability maps for newly released BRRI varieties.
2. To find out variety wise suitable area for production.

Methodology

Soil physical properties namely, land type, top soil texture, relief, soil consistency, soil moisture, soil permeability, soil reaction soil salinity, drainage and slope were considered to determine area suitable for growing respective rice varieties.

The suitability scale 1 to 3 was assigned to each soil characteristic in relation to respective rice varieties cultivation.

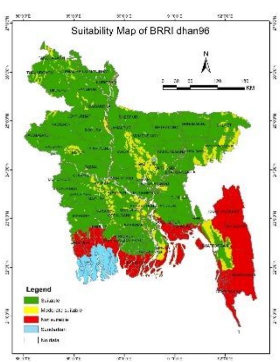
- 1- for the suitable,
- 2- for moderately
- 3- for not suitable.

Suitable areas for respective rice varieties cultivation in Bangladesh were determined by two steps: step 1, Input vector themes of land type and other soil physical properties were converted into grid themes for analysis in the Model Builder environment using Arc GIS 10.3 Spatial Analyst Module. Step 2, Then each input grid was weighted by the relative influence for suitability assessment. The relative influences were the relative weights in precent assigned to grid themes of soil parameters. These weights were the values of "Precent Influence Field" in the weighted overlay table of the Model Builder.

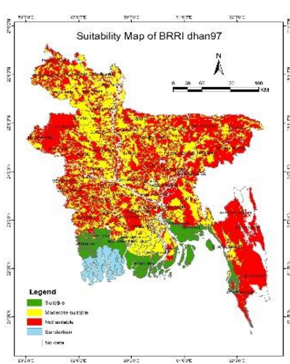
Results and Discussion

Boro Season: BRRI dhan96 is suited all regions of Bangladesh except southern and hill tracks regions (Map 3) and BRRI dhan97 is suitable for southern part especially saline area of Bangladesh (Map 4). Also, BRRI dhan98 is suitable for western region (Map 5) and BRRI dhan99 is suitable for saline area of Bangladesh (Map 6).

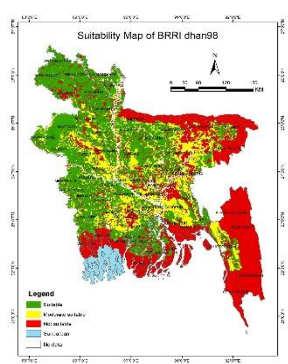
Aus Season: BRRI dhan98 is appropriate for all over the Bangladesh, especially, western regions of Bangladesh, but not for areas that are hilly or saline area. Map 3 shows the suitability map of BRRI dhan98.



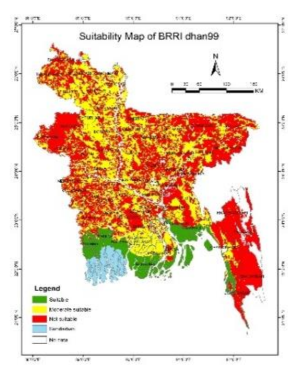
Map 3: Suitability map of BRRI dhan96



Map 4: Suitability map of BRRI dhan97



Map 5: Suitability map of BRRI dhan98



Map 6: Suitability map of BRRI dhan99

Conclusion

In Boro season, BRRI dhan96 is suited all regions of Bangladesh. Whereas BRRI dhan97 and BRRI dhan99 are suitable for saline regions. In Aus season, BRRI dhan98 is appropriate for western region of Bangladesh.

Activity 5.2: Climatic Mapping of Temperature (Maximum & Minimum) and Rainfall

- Rokib Ahmed, Md. Abdullah Aziz, ,Md. Ismail Hossain Niaz Md. Farhat Rahman,
Md. Abdul Qayum and Md. Abdullah Al Mamun.

Introduction

Bangladesh is an agro-based country. Agriculture of Bangladesh still depends on mercy on climate**.** Climatic factors such as temperature, rainfall, atmospheric carbon dioxide and solar radiation etc. are closely linked with agriculture production. Therefore, rice production would be major concern in recent years due to changing climatic conditions. Because there is a significant amount of rice yield may hamper for only fluctuations of those climatic parameters (Basak, 2010). Thus, climatic factors mapping would be great tool for climatic factors analysis and assist to increase crop production.

Objectives

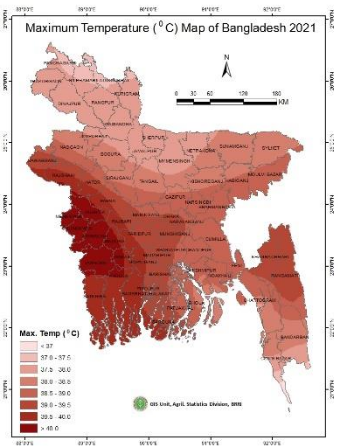
1. To determine expected maximum and minimum temperature and rainfall in different region in Bangladesh.
2. To determine areas of critical maximum and minimum temperature and rainfall map of Bangladesh during the period and
3. Year wise comparison of various climatic factors maps and determines their change directions.

Methodology

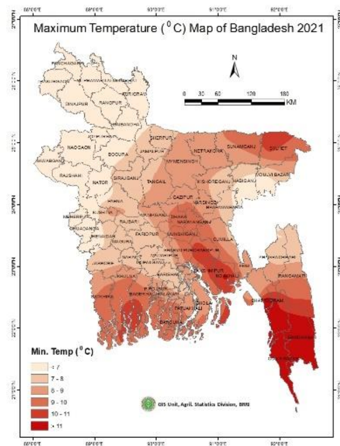
Data on daily maximum and minimum temperature and rainfall of 42 weather stations of BMD for the year of 2021 was used for the study. Year and stations wise maximum value of maximum temperature and minimum value of minimum temperature and total rainfall were determined. Then by using Geo-statistical tools of Arc GIS10.8 software maps were prepared. From the maps scenario of climatic factors were described.

Results and Discussion

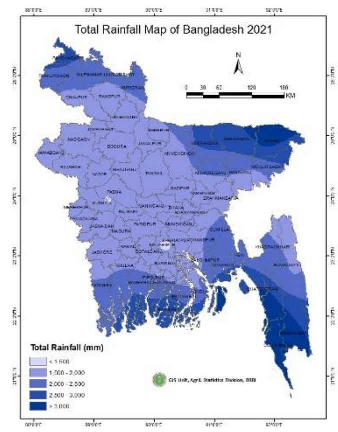
In 2021, maximum temperature was high in central western part of Bangladesh and lower in south-eastern and north-western regions. Map 7 shows the maximum temperature map of Bangladesh for 2021. Minimum temperature were lower in north-western and high was in south eastern region. Map 8 shows the minimum temperature map of Bangladesh for 2021. Total rainfall were the highest in north-east corner and south-east, lowest was central part of Bangladesh. Map 9 shows the total rainfall map of Bangladesh for 2021.



Map 7: Max.temp. of Bangladesh in 2021



Map 8: Min.temp. of Bangladesh in 2021



Map 9: Total rainfall of Bangladesh in 2021

Conclusion

More or less throughout the year eastern side of Bangladesh is high rainfall and low temperature area and western side is low rainfall and high temperature area. Spatial distribution of minimum temperature and total rainfall are more or less same but maximum temperature is vice-versa to minimum temperature and total rainfall.

Activity 5.3: Season wise rice area mapping of Bangladesh

(In collaboration with IWM and all R/S)

-Md. Abdullah Aziz, Setara Yesmin, Md. Ismail Hossain, Niaz Md. Farhat Rahman, Md. Abdul Qayum and Md. Abdullah Al Mamun.

Introduction

Bangladesh is an agro-based country and rice is the main agricultural product. Rice contributes more than 80 percent to the total food supply (Bhuiyan et al, 2002). Now a days, remote sensing and GIS are considering as powerful tools for crop mapping, monitoring and yield forecasting. These tools are very much reliable, moreover, it is time, labor and cost effective. Identification of crop types and mapping are the first steps of satellite remote sensing-based crop monitoring and yield forecasting system (Shewalka et al., 2014). So far in Bangladesh limited research has been done for satellite remote sensing-based rice crop identification and mapping. Thus in Bangladesh context rice mapping using Satellite remote sensing is very important.For a good planning for rice pricing, export- import decision etc. we need season wise rice crop area estimate through mapping, monitoring and yield forecasting.

Objectives

- To construct season wise rice area map of Bangladesh.
- To estimate season wise rice area of Bangladesh

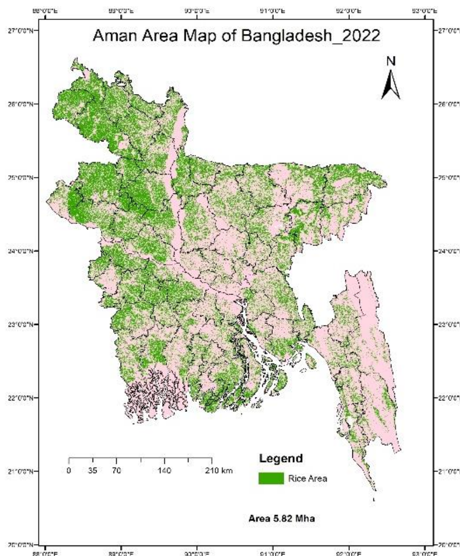
Methodology

Remote sensing and GIS are considering as powerful tools for crop mapping. Satellite Images were collected from MODIS data portal of NASA. Time series and level 03 product image of Normalized Difference of Vegetation Index (NDVI), Effective vegetation index (EVI) and Land Surface Water Index (LSWI) were collected according to the respective rice growing season. Whenever rice crop is initial stage i.e., transplanting time its vegetation index is very low and peak vegetative stage i.e., PI or booting stage its vegetation index is very high and in ripening or harvest time its vegetation index become again low. This algorithm was applied in agriculture area of Bangladesh and threshold value developed by ground truth data collected through GPS reading of various rice field all over the Bangladesh. Then season wise rice maps were prepared.
Then district wise rice cultivated area were calculated.

Results and Discussion:

Aman area 2022

The total area of rice grown in Aman in 2022 was about 5.82 Mha. The districts with the highest of land under cultivation were Dinajpur (approximately 285600ha) and Naogaon (about 275625ha), whereas the districts with the lowest of land under cultivation were Narayangaj and Munshiganj, respectively, with areas of about 15212.5 ha and 13056.25ha (Map 10 and Table 13).



Map 10: Aman 2022 Area Map of Bangladesh

Table 13: District wise Aman 2021 Area Bangladesh

DISTNAME	Area_ha	DISTNAME	Area_ha	DISTNAME	Area_ha	DISTNAME	Area_ha
Barishal	69800	Kushtia	98587.5	Gazipur	31606.25	Sirajganj	114062.5
Jhalokati	25006.25	Magura	77681.25	Gopalganj	54525	Dinajpur	285600
Pirojpur	49737.5	Meherpur	44850	Kishoreganj	89287.5	Gaibandha	101712.5
Bandarban	73675	Narail	41456.25	Madaripur	30193.75	Kurigram	86575
Brahamanbaria	84475	Satkhira	94006.25	Manikganj	22231.25	Lalmonirhat	77931.25
Chandpur	48706.25	Jamalpur	121843.75	Munshiganj	13056.25	Nilphamari	114087.5
Chattogram	117318.75	Mymensingh	169850	Narayanganj	15212.5	Panchagarh	103843.75
Cumilla	109593.75	Netrakona	116131.25	Narsingdi	37412.5	Rangpur	145400
Cox'S Bazar	53887.5	Sherpur	78793.75	Rajbari	46293.75	Thakurgaon	150750
Feni	42093.75	Bogura	202981.25	Shariatpur	17856.25	Habiganj	119306.25
Khagrachhari	60981.25	Joypurhat	76412.5	Tangail	111418.75	Maulvibazar	75793.75
Lakshmipur	37543.75	Naogaon	275625	Bagerhat	65437.5	Sunamganj	140068.75
Noakhali	104456.25	Natore	119775	Chuadanga	29706.25	Sylhet	178450
Rangamati	48287.5	Ch. Nawabgan	90837.5	Jashore	134706.25	Barguna	58918.75
Dhaka	31325	Pabna	119218.75	Jhenaidah	111500	Patuakhali	146875
Faridpur	105581.25	Rajshahi	149700	Khulna	104300	Bhola	65343.75
Total							**5819681**

Conclusion

About 5.82 Mha of rice were farmed overall in 2022 during Aman season and highest Aman production district was Dinajpur. In 2021 total Aman area was 5.87 Mha. Thus, total Aman area has been decreased a little bit in the year 2022.

Activity 5.4: Projected Climatic Factors (2050) Maps of Bangladesh

- Md. Abdullah Aziz, Niaz Md. Farhat Rahman, Rokib Ahmed, Md. Ismail Hossain, Md. Abdul Qayum and Md. Abdullah Al Mamun.

Introduction

Bangladesh is still significantly reliant on agriculture, and agriculture has a significant relation with climate. Bangladesh's food production is threatened by climate change. Predicting future climate changes is extremely crucial for smart agricultural planning and adapting to climate change. As the climate is changing, we need to predict future climatic conditions to cope with climate change and keep the food security of Bangladesh. This is the goal of the government of Bangladesh as well as set in the sustainable development goals (SDGs) by the United Nations to ensure food security by establishing climate resilient crop production (Rahman et al., 2021). The future prediction of precipitation would help to take necessary policies for the development of future climate resilient agricultural technologies.

Objectives

1. To construct projected climatic factors maps of Bangladesh for 2050
2. To determined projected climatic factors value district/division wise of Bangladesh for 2050.
3. To deliver an idea about future climate to researchers and planners

Methodology

Step-1: Data Collection

In this study, we used the most recurrently used source of freely available, high resolution, downscaled, bias-corrected, and long-term climate raster dataset with global coverage, WORLDCLIM 1.4, for past (1970-2000) and future (2040-2060 or 2050), its updated version 2.1 (Fick and Hijmans 2017) present (2010-2018) for precipitation. All the data are in raster with a high spatial resolution of 2.5 arc minutes.

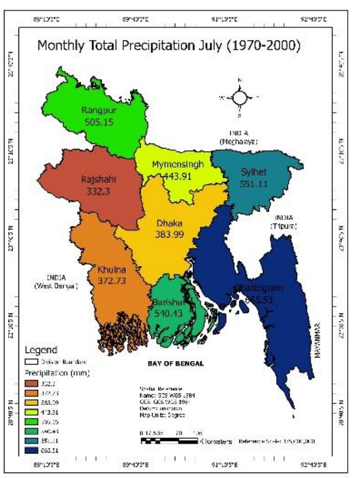
Step-2: Compilation and Processing of Climate Data

Cell statistics function from the GIS software (ArcGIS 10.3 version)

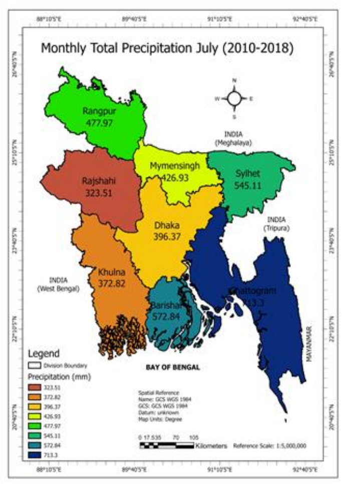
Step-3: Preparation of Precipitation Projection Map

Whole country and division-wise precipitation map for the past (1970-2000), present (2000-2018) and future (2040-2060 or 2050) prepare using Arc GIS software.

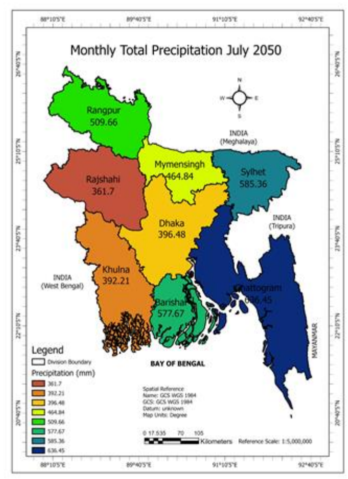
Results and Discussion:



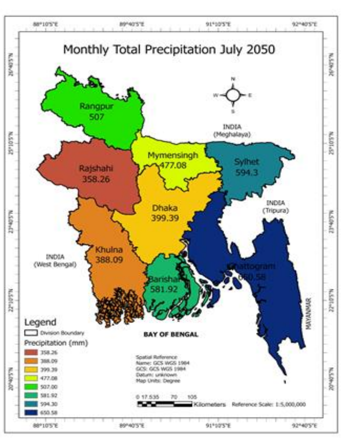
Map 11: July month average of total precipitation from 1970-2000



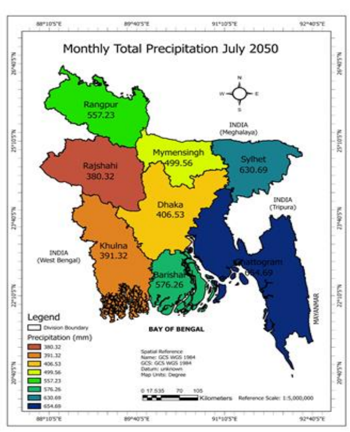
Map 12: July month average of total precipitation from 2010-2018



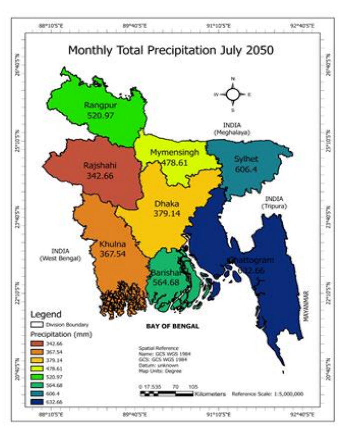
Map 13: July month average of total precipitation for the year 2050 according to RCP 2.6



Map 14: July month average of total precipitation for the year 2050 according to RCP 4.5



Map 15: July month average of total precipitation for the year 2050 according to RCP 6.0



Map 16: July month average of total precipitation for the year 2050 according to RCP 8.5

Map 11: A division-wise analysis showed that Chattogram division was found to have the highest precipitated division viz. 665.51 mm followed by Sylhet division (551.11 mm), and Barishal division (540.43 mm). The lowest precipitation was observed in Rajshahi division (332.3 mm), which is known as the drought prone region of the country.

Map12: The division-wise analyses show that Chattogram is the highest precipitation division (713.3 mm) followed by Barishal (572.84 mm). This analysis is slightly differing with the 1970-2000 periods, where the second highest precipitation showed in Sylhet division.

Map13: The division specific analyses deliver that Chattogram and Sylhet will be the highest precipitate division i.e., 636.45 and 585.36 mm respectively, where Rajshahi will be the lowest precipitated division with 361.7 mm in July month average.

Map14: The highest precipitation division will be Chittagong (650.58 mm) followed by Sylhet division (594.3 mm) and lowest precipitation division will in Rajshahi division with an average of 358.26 mm in July month.

Map15: The division specific analyses generate the same results as before. The highest precipitation in the July month will be in Chattogram (654.69 mm) followed by Sylhet division (630.69 mm) and the lowest precipitation will be in Rajshahi division as 380.32 mm.

Map16: Showing the highest precipitation division will be again Chattogram (632.66 mm) followed by Sylhet division (606.4 mm) and the lowest precipitation division will be the same as all others RCP model i.e., Rajshahi division (342.66 mm).

Table 10: Summary of July month average total precipitation of 1970 to 2000, 2010 to 2018 and forecasted 2050 (By RCP model 2.6, 4.5, 6.0 and 8.5)

Division	Average Precipitation (mm) 1970 to 2000	Average Precipitation (mm) 2010 to 2018	Precipitation(mm) 2050 (RCP 2.6)	Precipitation(mm) 2050 (RCP 4.5)	Precipitation (mm) 2050 (RCP 6.0)	Precipitation (mm) 2050 (RCP 8.5)	Average of Precipitation (mm) 2050 (RCP 2.6, 4.5, 6.0 and 8.5)	Average of Precipitation (mm) 2050 to 2010-2018
Rangpur	505.15	477.97	509.66	507	557.23	520.97	523.715	45.745
Rajshahi	332.3	323.51	361.7	385.26	380.32	342.66	367.485	43.975
Khulna	372.73	372.82	392.21	388.09	391.32	367.54	384.79	11.97
Mymensing	443.91	426.93	464.84	477.08	499.56	478.61	480.0225	53.0925
Sylhet	551.11	545.11	585.36	594.3	630.69	606.4	604.1875	59.0775
Dhaka	383.99	396.37	396.48	399.39	406.53	397.14	399.885	3.515
Barishal	450.43	572.84	577.67	581.92	576.26	564.68	575.1325	2.2925
Chattogram	665.51	713.3	636.45	650.58	654.69	632.66	643.595	-69.705

From the Map 11 to 16 and Table 10, it is found that in all divisions of Bangladesh average total precipitation (average by RCP 2.6, 4.5, 6.0, and 8.5 models) of July month in 2050 will be increased in comparison to average total precipitation during 2010-2018, only exception is Chattogram division, where precipitation will be decreased by about 69 mm. The precipitation of July month will rise the highest in Sylhet and Mymensingh divisions with an amount of about 59 mm and 53 mm, respectively.

Conclusion

July month in 2050 will be increased in comparison to average total precipitation during 2010-2018, only exception is Chattogram division, where precipitation will be decreased by about 69 mm. The precipitation of July month will rise the highest in Sylhet and Mymensingh divisions with an amount of about 59 mm and 53 mm, respectively.

Activity 5.5: Suitability Mapping of Various Cropping Pattern

Md. Abdullah Aziz, Rokib Ahmed, Md. Ismail Hossain, Md. Abdul Qayum and Md. Abdullah Al Mamun.

Introduction:

Cropping pattern is important in agricultural system. Various physical and chemical properties of soil vary spatially, on the other hand various cropping pattern are suitable for some specific physical condition. As we need to high production with limited land, so it will be very helpful if we have cropping pattern wise suitability map based on soil properties.

Objectives:

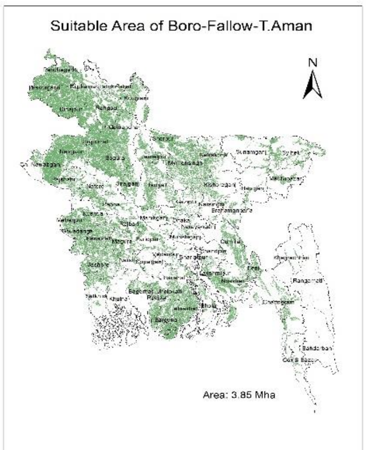
1. To construct suitability maps for major cropping pattern of Bangladesh.
2. To find out cropping pattern wise suitable area for production.

Methodology

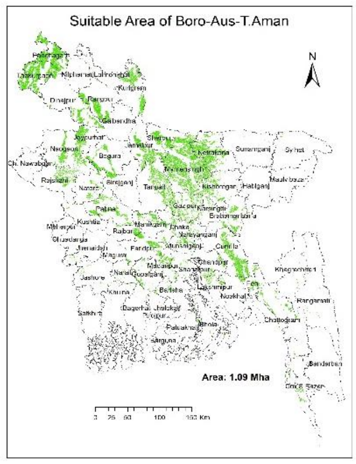
Four (04) soil properties digital maps were collected from Bangladesh Agricultural Research Council (BARC). Like, 1. Land type 2. Soil Texture 3. Soil salinity 4. Slope. Suitable classes for four (04) soil properties of respective cropping patterns were selected. All selected area were then intersected to extract out suitable area for cultivation of respected cropping pattern. Suitable area of all cropping patterns was calculated in hectors. The whole process was carried out by Arc GIS environment.

Results and Discussion:

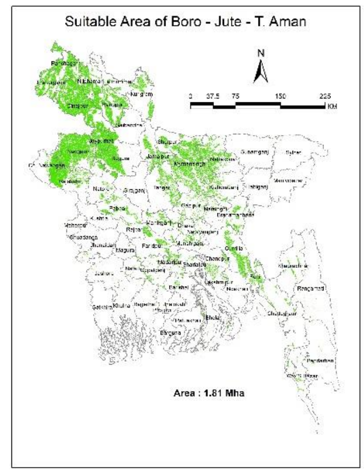
Boro-Fallow-T.Aman cropping pattern is suitable in west and middle part of Bangladesh (Map 17) and total suitable area is 3.85 Mha. Boro-Aus-T.Aman corriping pattern cover total suitable area 1.09 Mha and these suitable area in north-west and central northern sides of Bangladesh (Map 18). Boro-Jute-T.Aman is suitable in north-west and central northern sides of Bangladesh (Map 19) and total suitable area is 1.81 Mha.



Map 17: Suitability Map of Boro-Fallow-T.Aman



Map 18: Suitability Map of Boro-Aus-T.Aman



Map 19: Suitability Map of Boro-Jute-T.Aman

Conclusion

Production will be increased if we cultivate the specific cropping pattern in their specific suitable area**.** These suitability maps are very much useful for technology dissemination and adaptation.

Activity 5.6: Delineation of Rice Area changes in Costal Area of Bangladesh Using Remote Sensing Data and Machine Learning Approach

(In collaboration research with BRRI R/S Barishal)

- Md. Abdullah Aziz, Rokib Ahmed, Md. Ismail Hossain, Mir Md. Moniruzzaman Kabir, Aishik Debnath, Md. Abdul Qayum and Md. Abdullah Al Mamun.

Introduction

The Rice Area of Bangladesh is not the same over time. Various environmental and socio-economic causes of the rice area vary over time. Moreover, recently governments have many interventions to increase the rice area, especially in coastal regions like the Barishal and Khulna divisions. Thus, it is important to know the effect of their program through delineating the rice area changes over time.

Objectives

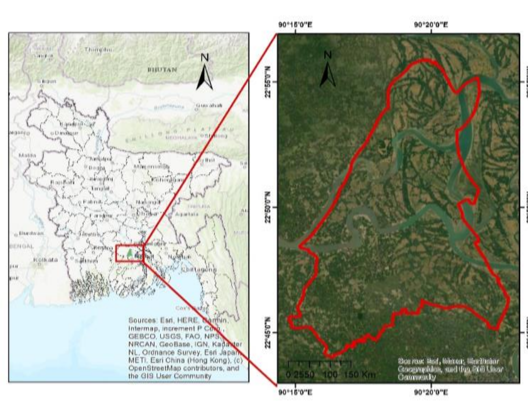
- Delineate the rice area changes over time
- To quantify the types of land cover that migrated into and out of the rice-growing region.
- To delineate the prospect of Boro rice expansion.

Methodology

Study Area

Babuganj Upazila is an administrative unit located in southern Bangladesh, specifically within the Barisal District. Geographically, it is situated at approximately 22.8319°N latitude and 90.3222°E longitude (Map 20). The upazila spans an area of approximately 164.88 km^2, providing a diverse landscape for various land use and land cover analyses.

Babuganj is bordered by several neighbouring administrative units, shaping its socio-economic and agricultural dynamics. To the north lies Gaurnadi Upazila, while to the south are Barisal Sadar and Jhalokati Sadar Upazilas. The eastern boundaries are shared with Muladi and Barisal Sadar Upazilas, and to the west is Wazirpur Upazila.



Map 20: Study Area

Data:

For this study, Sentinel 2A, 10m spatial resolution satellite imagery data was utilized to assess the land use land cover (LULC) changes during the Boro season in Babuganj upazila of the Barishal district.

In Bangladesh boro rice is cultivated from December to May (Rahman et al., 2013; Gumma et al., 2014; Faisal et al., 2019; Mainuddin et al., 2021). In March boro rice comes in peak vegetative stages i.e., maximum tillering/booting stages (Faisal et al., 2019, Gumma et al., 2014; Singha et al., 2019).

Image Pre-processing and Classification

The collected images were stacked together to form an RGB image, which was then used to produce a preliminary land use land cover map (LULC) for each year (2019 and 2022). To achieve more accurate and detailed classification, the images were analyzed and training data were produced based on colour, texture, tone, and structure, which allowed for the identification of different land cover types (Bianconi et al., 2021; Navarro et al 2019; Hiremath and Bhusnurmath 2014). Then Maximum Likelihood supervised image classification was used to prepare final land use land cover maps.

Methodological framework

Collect NIR, Red, Green band images for March 2019 and 2022 of the study area

↓

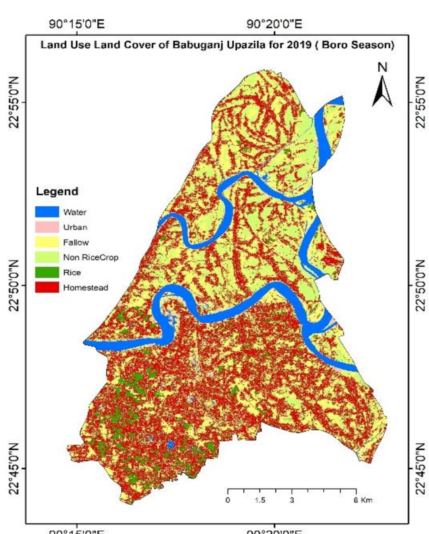
Produce LULC maps for 2019 and 2022

↓

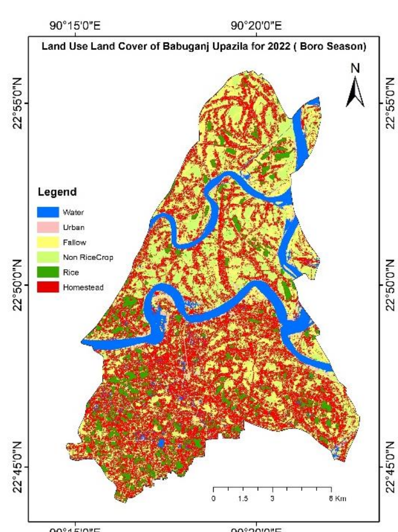
Perform Change Detection Analysis

Results:

From land use land cover map of 2019 and 2022 (Map 21 & 22) the land cover changes can be detected precisely. The Rice area has increased sufficiently in 2022**.**



Map 21: Land Use Land Cover of Babuganj Upazila 2019



Map 22: Land Use Land Cover of Babuganj Upazila 2022

In Table 14 and Figure 20 land cover changes have been recorded more precisely. From the table it is also evident that rice area increased dominantly in the four years (from 1013.41 ha to 1499.99) and the change percentage is more than 48% which is the highest among all other classes. After that the change percentage is 21% for water class. Almost every area class in Babuganj district experienced an increasing trend except for fallow lands. It experienced a declining trend exceptionally.

Perhaps, to understand the change percentage more specifically a bar diagram has been created to point out which class has been changed more dominantly over the years. Furthermore, from Figure 13, it can be pointed out clearly that rice area changed dominantly over the years having the highest percentage (48%), after that water area (21%) is showing the second highest position in the diagram and urban, non-rice crop area and homestead area come respectively. However, fallow land area showed negative percentage as it experienced declining trend over the years. Thus, we can say new rice area mainly comes from fallow land.

Table 14: Land Use Land Cover Change of Babuganj Upazila over 2019 to 2022

SL No	Class	Area (ha)_2019	Area(ha)_2022	Change	Change(%)
1	Water	1628.84	1975.78	346.94	21.29982
2	Urban	332.42	367.03	34.61	10.41153
3	Fallow	3985.04	2609.21	-1375.83	-34.5249
4	Non-Rice Crop	4156.34	4490.54	334.2	8.040728
5	Rice	1013.41	1499.99	486.58	48.01413
6	Homestead	6476.85	6650.35	173.5	2.678771
Total		17592.9	17592.9		

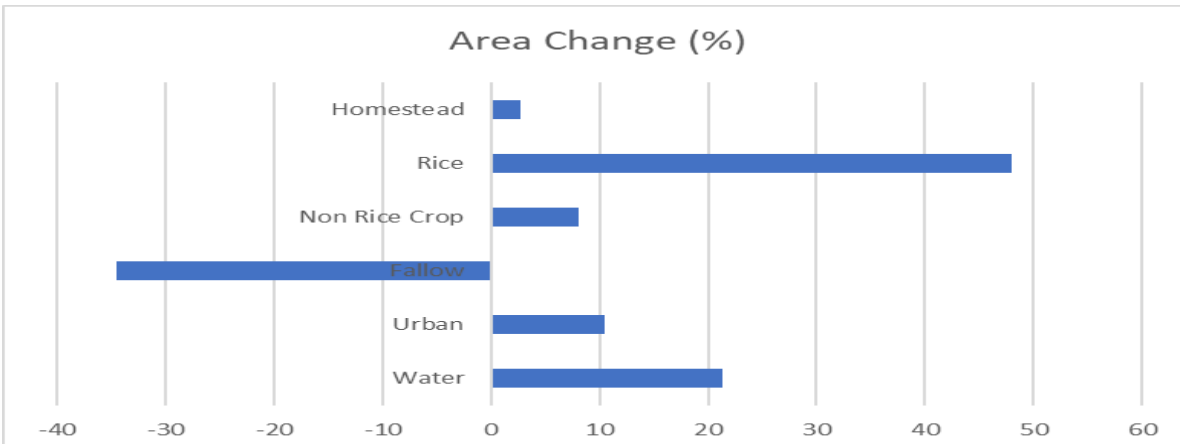
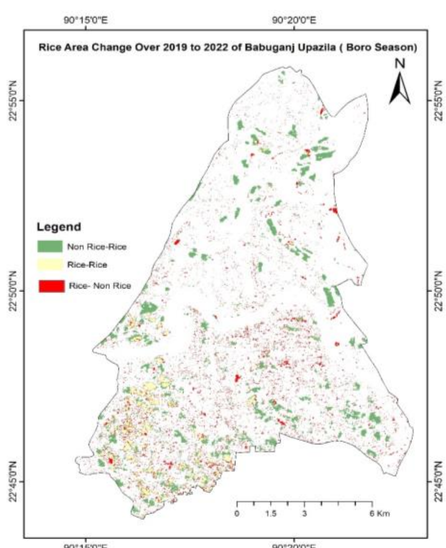


Fig. 20: Land Use Land Cover Change of Babuganj Upazila over 2019 to 2022

The rice transformation area has been classified in three ways in rice transformation map (Map 20) i.e., stable rice area (Rice-Rice area), transformed rice area where rice cultivation has been started (Non-Rice-Rice) and cultivated rice area turned in to non-cultivation area (Rice-Non-Rice).

Examining the shift in rice cultivation area from 2019 to 2022 in Babuganj Upazila, Table 15 provides insight into remarkable changes. The stable rice area (Rice-Rice) spanning 410.35 hectares is contrasted by the significant expansion of transformed non-rice areas into rice cultivation (Non-Rice-Rice), covering 1089.64 hectares. Additionally, the transition of rice areas to non-rice usage (Rice-Non-Rice) occupies 603.06 hectares.



Map 23: Rice Area Transformation of Babuganj, Upazila over 2019 to 2022

Table.15: Rice Area Transformation of Babuganj, Upazila over 2019 to 2022

Transformation	Area(ha)
Rice-Rice	410.35
Non-Rice-Rice	1089.64
Rice- Non-Rice	603.06

Table 16: Land cover shifted to Rice Area over 2019 to 2022

Non Rice-Rice	
Land cover	**Area_ha**
Water	1.45
Urban	5.29
Fallow	423.34
Non-Rice Crop	350.81
Homestead	308.75
Total	**1089.64**

Table 17: Land cover shifted from Rice Area over 2019 to 2022

Rice-Non Rice	
Land cover	**Area_ha**
Water	17.61
Urban	6.46
Fallow	67.49
Non-Rice Crop	113.38
Homestead	398.12
Total	**603.06**

Tables 16 and 17 elaborate on the alteration of land cover within the rice-growing region over the same period. The transformation from non-rice to rice areas highlights the conversion of formerly uncultivated lands (Fallow, 423.34 hectares), plots under other crops (Non-Rice Crops, 350.81 hectares), and homesteads (308.75 hectares) into rice cultivation zones. Conversely, rice areas shifted to non-rice uses primarily reverted to homesteads (398.12 hectares), other crops (113.38 hectares), and fallow lands (67.49 hectares).

Conclusion

The evolution of rice cultivation areas in Babuganj Upazila over three years has manifested several significant transformations, shedding light on the dynamic nature of agricultural practices and land usage in the region. There was a remarkable growth in newer rice cultivation zones, predominantly originating from fallow lands, non-rice crops, and homesteads. This remarkable growth signifies that the region has witnessed an increased inclination towards rice farming, notwithstanding socioeconomic or environmental pressures.

Project 6: Capacity Building through Training

Activity 6.1: Training Program on Experimental Data Analysis

(In collaboration with Training Division)

- Md. Ismail Hossain, Md. Abdullah Al Mamun, Md. Abdullah Aziz, Md. Abdul Qayum Niaz Md. Farhat Rahman, Md. Sahadat Hossain and Shanaj Parveen

Introduction

Training is an important and only the method for developing skills on research. To set up the experiment, collecting, compiling, reporting, analyzing and presenting of data training helps to increase the accuracy of the finding.

Objectives

1. To train up BRRI personnel on experimental data analysis using different statistical software.
2. To make BRRI personnel self-dependent on experimental data analysis.
3. To developed skills on research planning, program and report writing.

Methodology

Enhanced lectures and discussion, group discussion, review and feedback were the training method. Different statistical software was used for experimental data analysis. The course of schedule by two parts one for advanced MS Excel data management and analysis including data entry, coding and naming; Basic operations: Use of functional keys Date function ‘Text function”, “IF ELSE” function Lookup function (‘VLOOKUP’ and ‘HLOOKUP’; Data validation); Conditional formatting; Pivot table in MS Excel for 2 days. Another very interactive session for advance statistical analysis and data management using Programming R (R Studio) was also shared in this training program for 4 days. The application of different packages of R included those sessions like introduction and basic of R and R Studio; Programming R Data frame; Indexing from a vector set; Indexing of data frame; Logical Operators; Arithmetic operators and experimental data analysis including CRD, RCBD single and multiple factors, Split plot design, multiple comparisons of the test (LSD, DMRT, HSD) etc.

Results and discussion

Training program on experimental data analysis has been conducted with the collaboration of Training Division for 5 batches including 16 participants for each batch. A total of approximately 80 BRRI scientists were trained about advanced experimental data analysis. The participants of this training were SO and SSO of BRRI HQ and regional stations.

Conclusion

All the participants enabled to handle experimental data and analysis the data accurately by using R programming. Also, increased their capacity on experimental data analysis and data interpretation. Besides, developed their capacity on research planning, program and report writing. So, Skills of BRRI personal on experimental data analysis have been enriched.

Activity 6.2: Training Program on Multivariate Data Analysis

(In collaboration with Training Division)

- Md. Ismail Hossain, Md. Abdullah Al Mamun, Md. Abdullah Aziz, Md. Abdul Qayum
Niaz Md. Farhat Rahman, Md. Sahadat Hossain and Shanaj Parveen

Introduction

Multivariate data analysis is a type of statistical analysis that involves more than two dependent variables, resulting in a single outcome. This training gives us the clear and straightforward guideline to conduct experimental design for MVA and data analysis. Also helps us to increase the accuracy of the finding.

Objectives

1. To train up BRRI scientists on multivariate data analysis using different statistical software.
2. To give clear and straightforward guideline of how to conduct experimental design for MVA.
3. To make BRRI scientists self-dependent on multivariate data analysis.
4. To developed skills on research planning, program and report writing.

Methodology

Enhanced lectures and discussion, group discussion, review and feedback were the training method. Different statistical software was used for the multivariate data analysis. Dot plot, Bar plot, Graphical view of Heat map, Graphical view of the Correlation matrix and correlation plot, GGE Biplot Analysis, Principal component analysis; Cluster analysis, multi-location trail analysis were discussed, path analysis, Genetic variability and divergence analysis were the topics of this training program. Also used some widely used R packages such as “ggplot2”, “metan” “cluster”, “factoextra”, “FactoMineR” “doebioresearch” “readxl”, “readr” etc were used to perform advanced multivariate data analysis PCA, cluster, CVA, D^2 and path analysis etc.

Results and discussion

With the collaboration of Training Division, the training program on multivariate data analysis has been conducted for 5 batches including 16 participants for each batch. A total of approximately 80 BRRI scientists were trained about advanced multivariate data analysis. The participants of this training were SO and SSO of BRRI HQ and regional stations.

Conclusion

The participants enabled to handle experimental design for MVA and analysis the multivariate data independently by using R programming. Then, developed their capacity on multivariate data analysis and data interpretation. Also, developed their capacity on research planning, program and report writing. So, knowledge and skills of BRRI scientists on multivariate data analysis have been enriched.

Project 7: Computer Programming, Software Development and Digitization

Activity 7.1: Develop a web application to calculate the Stability Index for BRRI Stability Model

- Md. Abdul Qayum, Md. Ismail Hossain, S. M. Mostafizur Rahman, Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun and Rokib Ahmed

Introduction

In the Genotype (Variety) development and release process Stability Analysis one of the most important characteristics for the genotypes. Assuming this importance Agricultural Statistics Division of BRRI developed a Stability model that was a great achievement of the division. But the analysis procedure to find out the stability index of genotypes is very laborious and time consuming by the develop model. We already developed a computer program using R software to calculate the stability index for BRRI stability model. But for this R programming every users need an R environment setup in their machine (PC/Laptop). To overcome this complexity we want to develop a web application software so that one can easily calculate the stability index of variety/genotype using BRRI developed stability model under this study.

Objectives

- To develop a web application to calculate the stability index for BRRI stability model.

Methodology

Develop a web application integrating R and Batch Script (background software) with XAMPP, HTML, PHP, JQuery and JavaScript. For using this web application, user needs the arrangement of the data in the specific format to calculate the stability index for BRRI stability model. At least three location, genotypes and years average data needs to perform this model and the data format is shown in the following table 18.

Table 18: Sample data format table

Locations ↓	Genotypes ↓	Average Yield of Genotype				
		1st Year	2nd Year	3rd Year	....	Last Year

Software Development Progress

The Home page, Menu bar with some view is shown in the following figure 21. Location map preparation, Stability model view, Model Calculation and Stability result view and print option developed complete. This software not hosted yet.

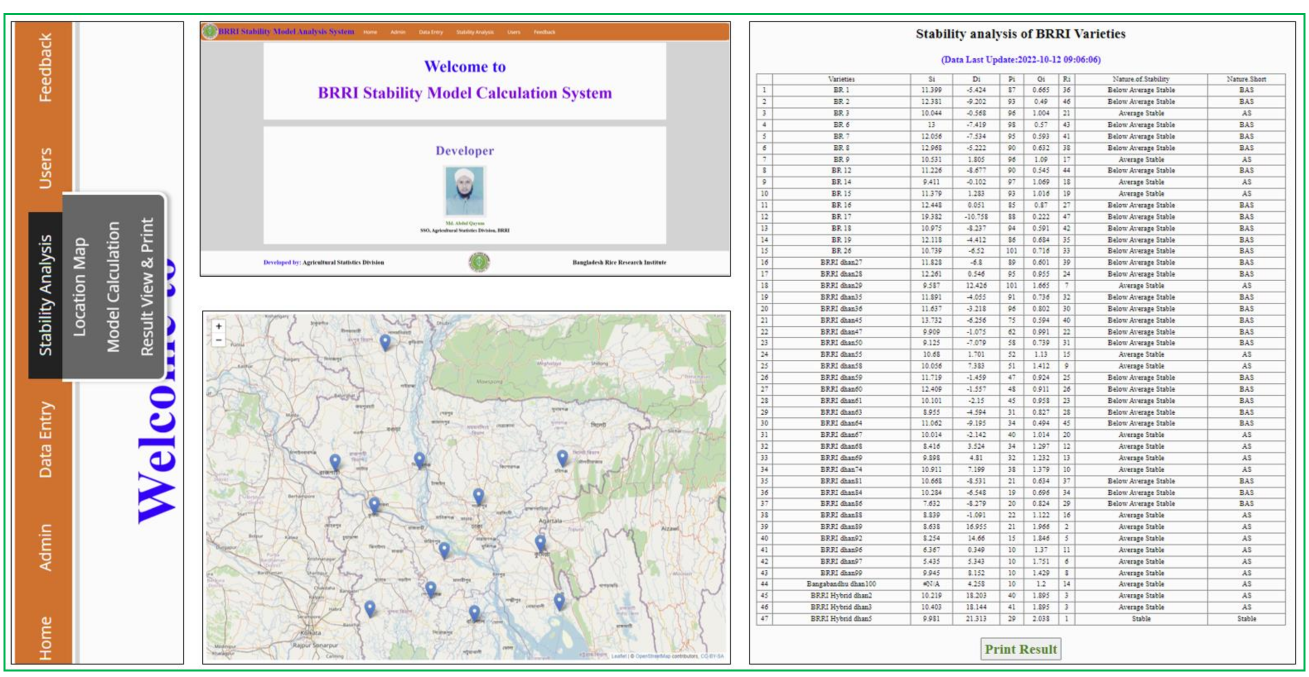


Fig. 21: Pictorial view of the Stability Analysis Web Application Software

Conclusion

Developed a web application to calculate the stability index for BRRI developed stability model. By this web application software, we can easily and quickly calculate the stability index if the data available in the require format. This software saves resources to calculate the stability of genotypes. This software not hosted yet.

Activity 7.2: Develop a Platform for BBRI Developed Management Information System (MIS)

- Md. Abdul Qayum, Md. Ismail Hossain, S. M. Mostafizur Rahman, Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun and Rokib Ahmed

Introduction

Already BRRI developed many web applications. (1) Salary Management System 2 Version (2) Labour Management System 2 Version (3) Budget Management Software (4) Quota Management Software (5) CL Application Management Software (6) Stability Analysis for BRRI Model Calculation Software, Also, try to develop (7) Rice Disease Monitoring System Software and (7) Tour Distance Calculation System Software. All the above developed software hosted in different Server with different address. So sometime user face difficulty to find them. Also need more link to include in the BRRI website. So, the time demand to develop a unique platform for all the BRRI developed MIS Software. Under this activity we developed a unique platform for all the developed software so that one can easily find out and used their needed software.

Objectives

- To develop a unique platform for BRRI developed MIS

Methodology and Development Progress

This unique platform developed by using XAMPP, HTML, PHP, Javascript (JS) and JQuery. The platform is ready and host in the BRRI LAN (172.16.101.17/MIS_BRRI/). A screenshot of the unique platform shown by the figure 22.

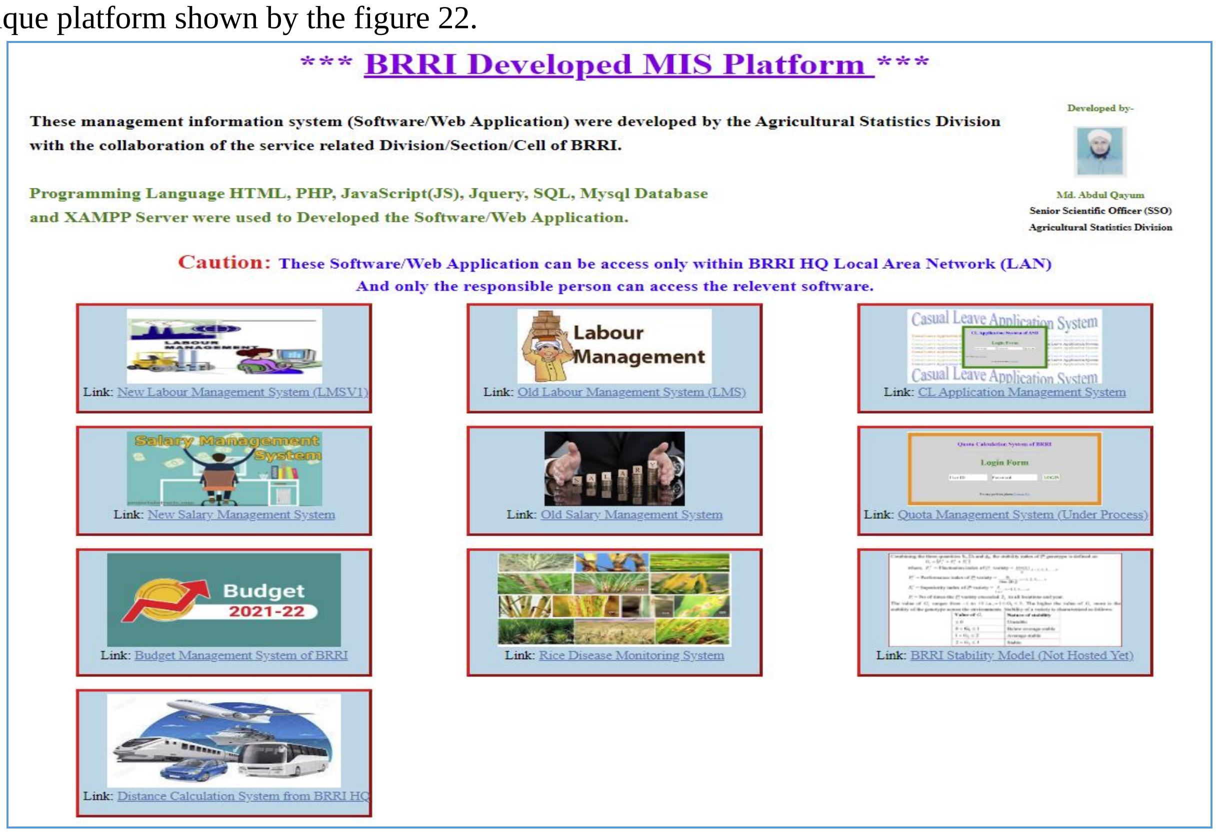


Fig. 22: Pictorial view of the unique platform for BRRI developed all MIS Software

Conclusion

By this unique platform for all the BRRI developed MIS software, users can easily and quickly find out and used their needed software. This platform saves time of the users.

Activity 7.3: Digitalized budget management system of BRRI

- Md. Abdul Qayum, Md. Ismail Hossain, S. M. Mostafizur Rahman, Rokib Ahmed and Md. Fahad Hasan

Introduction

Budget management one of the important parts of an organization. Proper management of budget can take the organization in the top one. Most of the time policy makers need the current situation of budget of the organization. Finance and Accounts (F&A) Division of BRRI HQ is to manage the yearly budget of BRRI. For this, they collect budget from the ministry and distribute to the employees of BRRI according to the demand and preserve in a register book. After that they prepared budget related report from the register book manually but the procedure is quite difficult and time and labour consuming. In this circumstance, Agricultural Statistics Division developed "Digitalized Budget Management System" for BRRI under this activity.

Objective

- To update the developed digital budget management system for BRRI

Methodology

Develop a web application using XAMPP, HTML, PHP, JavaScript (JS) and JQuery. Now the system is live in the BRRI LAN (172.16.100.168/budget) and the home page is shown in figure 23 below.

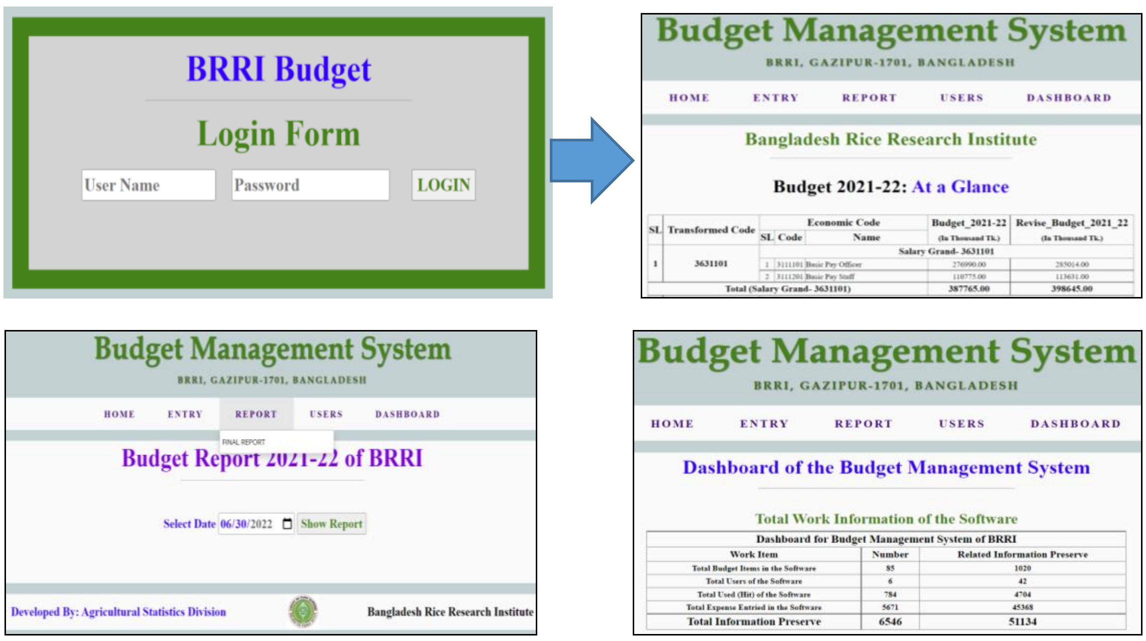


Fig. 23: Pictorial view of the Budget Management System of BRRI

Conclusion

This is an excellent digital system to manage and report generate of the budget of BRRI. The respected users can input the budget related information and can see all the report with printable format after login in the system. The total 51,134 information already preserve in the software database and the users using this service 784 times from start to till date.

Activity 7.4: Digitalized quota management system of BRRI

- Md. Abdul Qayum, Md. Ismail Hossain, S. M. Mostafizur Rahman, Rokib Ahmed, Nuraiya Kulsom and one from administration section

Introduction

Employee recruitment is a continuous process of an organisation. Quota management is one of the crucial events for recruit manpower of an institute. To recruit the new employee for the vacant post of the organization, Administration and Common Service division continuously put their hard work for this management. It is great pleasure to us that this quota calculation work has been done by the Agricultural Statistics Division. The calculation system was very sensitive and manually it is a very laborious and time consuming. So, the time demand is that a digital system must developed for maintaining, updating and calculating the quota system. In this circumstance, Agricultural Statistics Division developed "Digitalized Quota Management System" for BRRI under this activity to manage the quota calculation system for BRRI.

Objective

1. To develop a digital quota management system for BRRI

Methodology

This is a web application and developed by using XAMPP, HTML, PHP, JavaScript (JS) and JQuery. The system already launched to use. Now the system is in live in the BRRI LAN (172.16.100.168/quota) and the home page is shown in figure 24.

Progress

- Quota management system software already been Developed and hosted in BRRI LAN
- Quota calculation and report preparation already start by this software

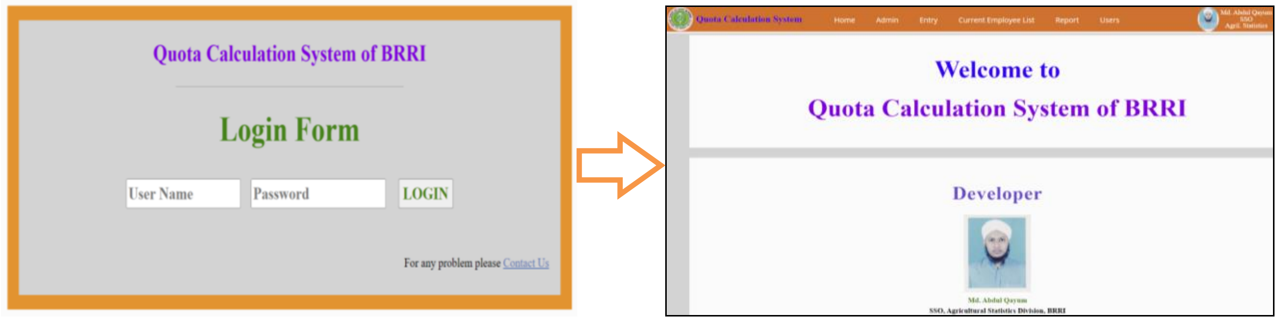


Fig. 24: Pictorial view of the Login and Home Page of the Quota Management System of BRRI

Conclusion

The respected user can input the employee related information and can see all the report with printable format after login in the system. This will be easy to access, accurate, consistent and most flexible quota management system in comparison to the existing system.

Activity 7.5: Digitalized salary management system of BRRI

- Md. Abdul Qayum, Md. Ismail Hossain, Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain, Tariq Salah Uddin and Sammi Akter

Introduction

One of the most important works of Finance and Accounts (F&A) Division of BRRI HQ is to prepare the monthly salary of the HQ employees. For this, they collect employee's salary related information and preserve in the salary register books. After that they prepared salary related report. Some of the report prepared manually and some of the report prepared using software. Unfortunately, the software failed to execute. So that, these existing practices and procedures took long time to prepare the salary related report in every month. In this circumstance, Agricultural Statistics Division developed "Digitalized Salary Management System" for BRRI HQ employee.

Objective

1. To digitalized "New Salary Management System" for BRRI HQ Employee

Methodology

The Salary Management System is a web application developed using XAMPP, HTML, PHP and JavaScript (JS). Now the system is in live in the BRRI LAN (172.16.100.168/salary) and the home page is shown in figure 25. The system included BRRI HQ employee information, salary preparation with report generating system, wages report and other reports with printable format.

Progress

- Salary management system software already been Developed and hosted in BRRI LAN
- Salary report preparation already start by this software and the Summary information Are given in table 19.
- A new menu "Personal" were introduced which included the following features-
  - Personal Information
  - Pay Slip
  - Salary Register Book
  - Salary Tracking (Upcoming...)
  - Income Tax payment document (Upcoming...)
  - Income Tax Calculation System
  - Yearly Salary Statement (Upcoming...)
- The Salary Management System Link: **172.16.100.168/salary**

Fig. 25: Pictorial view of the New Salary Management System of BRRI HQ Employee

Table 19: Summary information preserve of the software

Dashboard for Salary Management System of BRRI		
Work Item	**Number**	**Related Information Preserve**
Total Employee are in the Software	575	28175
Total Users of the Software	19	285
Total Used (Hit) of the Software	3945	31560
Total Salary Entried in the Software	11450	435100
Total Festival Allowances Entried in the Software	3197	31970
Total Pay Scale Entried in the Software	3197	15985
Total Elec. and Gas Bill Entried in the Software	6871	68710
Total Information Preserve	**29254**	**611785**

Conclusion

Already salary prepared by this software up to June/2023 date. All the salary related report stored in the database. The total 611785 information preserved in the database. Total users of the software were 19 and they were used 3945 times of the software.

Activity 7.6: **Digitalized labour management system of BRRI**

- Md. Abdul Qayum, Md. Ismail Hossain, Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun, Md. Mamunur Rashid, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman and Md. Akhter Hossain

Introduction

Farm Management Division of BRRI works for labour management. The division collect labour attendance data and prepared labour wages according to that collected attendance. The personnel of the division work hard for entry, updates, monitoring and reporting of the attendance as well as preparing the wages report manually. So that, many of these existing practices and procedures take many times to prepare wages report related many sheets per month. In this circumstance, Agricultural Statistics Division developed an update version (LMSV1) of the digitalized labour management system (LMS) for BRRI HQ under this program.

Main Objective

1. To update “Labour Management System (LMS)” of BRRI as user need.

Specific Objectives

1. Update “digitalized Attendance system of BRRI Labour” as user need.
2. Update “Digitalized and Automated Labour Wages System” as user need.
3. Update “Digital Labour Data Centre”
4. Modify the Web Application as user need.

Methodology

The New Labour Management System (lmsV1) is a web application developed using XAMPP, HTML, PHP, JavaScript (JS) and JQuery. In this digital system all the division/section/cell entry, update and approve the labour attendance. After approved the labour attendance by the head of the division/section/cell, the software system automatically prepared the attendance report and all the report related to labour wages (Top Sheet, Overtime Summary Sheet, Deduction Report, Final Bill Report, Bank Sheet Report, etc.) in printable format after entry the electricity-gas bill by Building & Construction Division and other deduction by Finance and Accounts Section.

Progress

Web Application software already been developed and hosted in a server (BRRI LAN). Now the system is in live in the (172.16.101.17/lmsV1) and the home page is shown in figure 26.

- The application is already running and the Summary information of the software is shown in table 20.
- An update version of labour management system (lmsV1) was developed

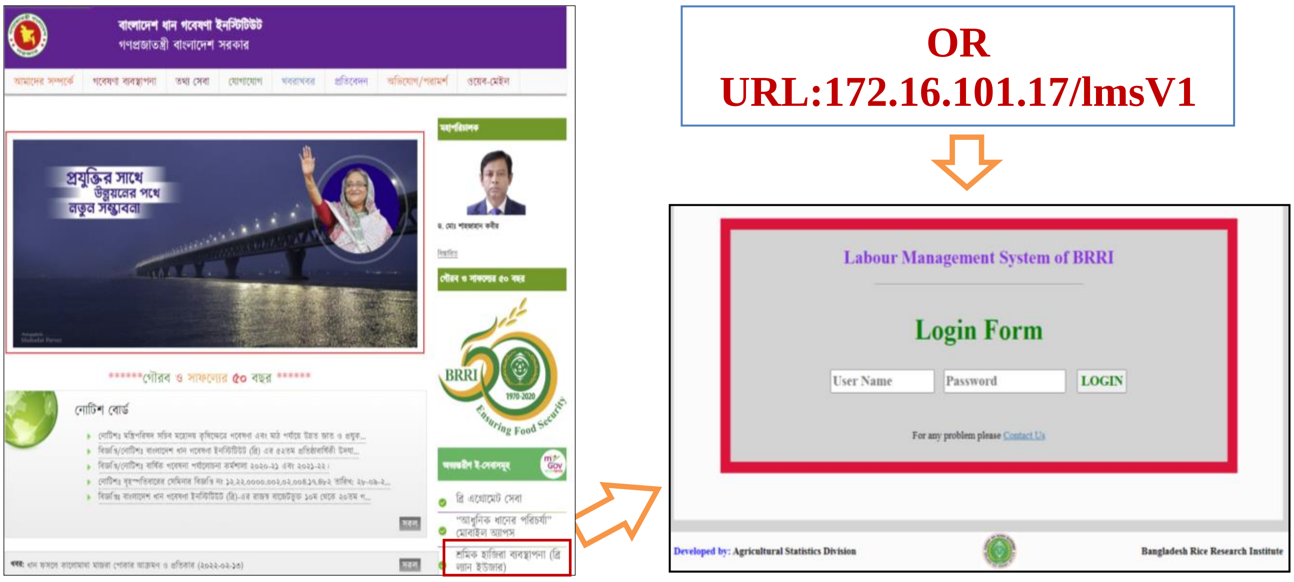


Fig. 26: Pictorial view of the New LMS (lmsV1) of BRRI HQ

Table 20: Summary information of the software up to till now

Dashboard for Labour Management System of BRRI (Up to the date and Time: 2023-08-08, 03:05:37pm)		
Work Item	**Number**	**Related Information Preserve**
Total Labours are in the Software	479	8622
Total Users of the Software	135	2025
Total Used (Hit) of the Software	23750	190000
Total Attendance Entried in the Software	470890	5179790
Total Deduction Entried in the Software	17980	270194
Total Information Preserve	**513234**	**5650631**

Conclusion

Total 135 users were used 23750 times of the software and 470890 attendances were entries about 479 labours. Also, attendance related 5179790 information were preserved. A new feature 'user's information' was including in the user account menu of the software.

Activity 7.7: Digitalized casual leave application system

- Md. Abdul Qayum, Md. Ismail Hossain, Niaz Md. Farhat Rahman, Md. Abdullah Aziz, Md. Abdullah Al Mamun, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman and Md. Akhter Hossain

Introduction

All the employee of the Agricultural Statistics Division of BRRI applies their casual leave application manually. The existing practices and the manual procedures take many times to apply for the leave. Under this program, Agricultural Statistics Division developed a digitalized Casual Leave (CL) Application Management System for Agricultural Statistics Division of BRRI.

Objective

- To digitalized casual leave application system for Agricultural Statistics Division

Methodology

The casual leave application system is a web application developed using XAMPP, HTML, PHP and JavaScript (JS). In this digital system all the employee applies their leave application through online. After approved the application by the head of the division/section system automatically prepared the leave application report.

Progress

- Web Application software already been developed only for Agricultural Statistics Division
- Need training for the users to run the application for another Division/Section/Cell.
- This Software hosted in BRRI LAN and the home page is shown in figure 27.

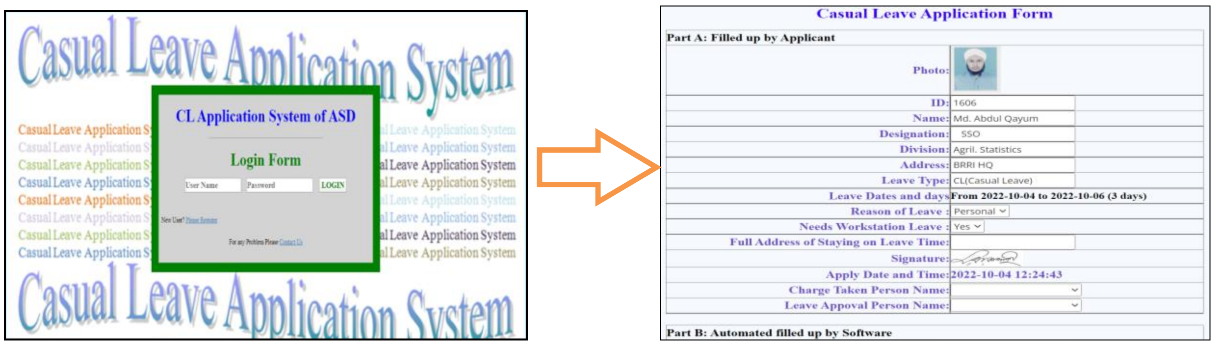


Fig. 27: Pictorial view of some page of the Casual Leave Application Management System of ASD

Conclusion

This application is currently running in the Agricultural Statistics Division. This software can be used in other divisions/sections/regional stations to the provision of necessary training. All kinds of reports related to casual leave can be generated by this web application automatically whenever the authority needs.

Project 8: Information and Communication Technology (ICT)

Activity 8.1: Smart profiling of rice varieties in Bangladesh

(in collaboration with Plant Breeding, Hybrid Rice, Biotechnology, Agronomy, Plant Physiology, Plant Pathology, Entomology, GQN and rice farming system div. of BRRI)

Objectives

1. To explore mechanism for profiling rice varieties with respect to environmental suitability, physical and physiological characteristics, yield potential and tolerance to abiotic and biotic stresses;
2. To electronically present and disseminate the newly developed smart profiled varieties information through a dynamic web application and mobile app to stakeholders;
3. To manage, maintain and host mobile and web app at server.

Introduction

The yield of rice is predominantly driven by variety. High yielding varieties (HYVs) ensure increased yield for the farmers. The BRRI, predominantly, and the BINA, partly, together with few private companies have been playing the gigantic role for releasing suitable rice varieties for the farmers of Bangladesh. The number of such varieties currently stands over 108. These varieties should be used in specific environments to ensure their yield potentials. Besides, the varieties have various life cycle (duration between sowing and harvesting) to fit into desired cropping system especially in adverse environments, such as the disaster-prone zones. Furthermore, some varieties may be good in yield, but prone to pest and diseases. In fact, the choice of a variety to sow has a significant impact on the sustainability and profitability of rice. Therefore, farmers require comparison between the varieties to choose the right one for their specific circumstances.
Currently, information on the rice varieties is available from BRRI and BINA in the form of booklets and/or leaflets. With a hard copy, it is very difficult for the farmers to compare one variety with the other. Besides, the ability to quickly update such information on newly-released varieties has been limited. Therefore, a mechanism needs to be explored for smart delivery-access of variety information.

According to work plan 8.4.3 activity of National ICT Policy-2018 has stated that it will develop a single and complete agricultural input and cropping plan with integrated advisory service through real-time data feeding system. 5G will be introduced by 2021-23. Introduction of upcoming technologies like-artificial intelligence, robotics, big data, block chain and IoT will be expedited (election manifesto 2018). Many activities are ongoing based on technology such as digital agriculture platform generating base data for crop field condition, crop stage mapping using satellite image processing and vertical agriculture for prediction mapping (National Strategy for AI Bangladesh 2019-2024). So BRRI has taken initiative to develop a mobile app named ‘Rice Profile’ for smart profiling of rice varieties in disaster-prone zones of Bangladesh.

Methodology

Information of 108 BRRI released varieties were collected from published and unpublished literature, and through personal contact with the relevant scientists of the institute. The information included potential yield, physical characteristics, disease tolerance, insect-pest tolerance and abiotic stress tolerance. The varieties were grouped under 17 rice types (Hisham et al., 2020): (i) Favourable Boro (short duration), (ii) Favourable Boro (Long duration), (iii) Saline Boro, (iv) Cold tolerant (Haor); (v) Cold tolerant (Northern and Western regions); (vi) Healthier rice (Boro); (vii) Favourable Aman; (viii) Saline Aman; (ix) Flash flood; (x) Drought; (xi) Tidal submergence; (xii) Deepwater; (xiii) Healthier rice (Aman); (xiv) Upland rice; (xv) T. Aus; (xvi) Healthier rice (Aus); (xvii) Premium quality rice. The information will consolidate in MS-Excel spreadsheet. The system is based on approved Software Requirement Specification (SRS) and System Designing Documents (SDD). At the development stage, it will follow the standard code convention, code level documentations, header of each file, algorithms, interfaces, code compression. Application Programming Interface (API) is made sharable to with another platform.

Fig. 28: 'Rice Profile' mobile app

Progress

- Already included 08 (Eight) rice type out of 17 rice type information in mobile app with varietal information through this profiler (Fig. 28).
- An easy comparison system of the varieties has been developed for a specific environment and quickly picking up the preferred one(s).

Activity 8.2: **New version of rice knowledge bank (RKB) mobile App**

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A mobile application (also called a mobile app) is a type of application designed to run on a mobile device, which can be a smartphone or tablet computer. Even if apps are usually small software units with limited function, they still manage to provide users with quality services and experiences.

Objectives

1. To develop the new version of RKB mobile apps.
2. To develop a push notification system.
3. To manage and maintain RKB Mobile apps.

Methodology

The mobile application of RKB (Rice Knowledge Bank) is a type of application software designed to run on a mobile device, such as a smartphone or tablet computer. RKB is a dynamic mobile application and also mobile base knowledge bank. RKB application has been developed with the information of BRRI released rice varieties, modern rice cultivation and agricultural machinery technologies, pest and disease management, soil and fertilizer management, irrigation and water management, quality rice seed production management, training and publications. RKB is an interactive tool for farmers, extension workers, scientists/researchers, teachers, students and other users who want to learn and control insects & diseases and other problems that can occur in rice, and how to manage them.

Progress

- Feedback meeting has been held between BRRI and MCC Ltd.
- Tender documents have been prepared.

Activity 8.3: **Sensor-based rice pest management through Artificial Intelligence (AI) technology of BRRI**

(In collaboration with Plant Pathology, Plant Physiology, Entomology, Soil Science and Agronomy div.)

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Objectives

4. To develop AI based mobile and web App for BRRI.
5. To identify AI scopes in rice research engaging scientists, extension worker and farmers.
6. To manage, maintain and host AI based mobile and web app at server.

Introduction

Bangladesh is embracing Artificial intelligence (AI) for the digitalization of the nation. AI is the simulation of human intelligence processes by machines, especially computer systems. The high-yielding varieties and agronomic good practice play a vital role through modern technologies like IoT (internet of things), machine learning method (MLM), artificial intelligence (AI) and big data which can create a dynamic shift towards modernizing agriculture. The crop and soil monitoring system will be developed through AI application. Particular applications of AI include expert systems, speech recognition & machine vision. According to work plan 8.4.3 activity of National ICT Policy-2018 has stated that it will develop a single and complete agricultural input and cropping plan with integrated advisory service through IoT, Sensor, AI, Big Data analytics and real-time data feeding system. 5G will be introduced by 2021-23. Introduction of upcoming technologies like-artificial intelligence, robotics, big data, block chain and IOT will be expedited (election manifesto 2018). Many activities are ongoing based on technology such as digital agriculture platform generating base data for AI, IoT for crop field condition, crop stage mapping using satellite image processing and vertical agriculture for prediction mapping (National Strategy for AI Bangladesh 2019-2024). So, BRRI has taken initiative to develop a sensor-based rice pest management through artificial intelligence (AI) technology.

Methodology

BRRI Rice doctor mobile and web application already developed (Fig. 29) where BRRI released rice varieties, modern rice cultivation, insect & pest, disease and agricultural machinery technologies information has included. But it is an interactive tool for farmers, extension workers, scientists/researches, teachers, students and other users when the hi-tech initiated. It has introduced hi-tech solution through Artificial Intelligence (AI) for controlling disease & insect by image analysis. The dynamic mobile and web application automatically provide the required problem-solving solution of rice disease and pest related with proper management within one to one and a half minutes. So, image data collection process is continuing from at least three districts of different region (Gazipur sadar, Rajshahi, Rangpur and Cumilla) for accurate result.

Progress

1. Mobile app has been developed and uploaded into Google Play Store and Apple App Store as ‘Rice Solution’.
2. Developed image analysis sensor through Artificial Intelligence (AI) and Machine Learning Method (MLM) under 4IR (4^{th} Industrial Revolution) technology;
3. Already stored and trained approximately 5000 images of several disease and insect through AI and MLM technology.

Fig. 29: 'Rice Solution' mobile app

Activity 8.4: Develop a new website for BRRI

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A website is a collection of web pages and related content that is identified by a common domain name and published on at least one web server. Such as google.com, yahoo.com, facebook.com and amazon.com. All publicly accessible websites collectively constitute the World Wide Web (www). There are also private websites that can only be accessed on a private network, such as an internal website for its users. Websites are typically dedicated to a particular topic or purpose, such as news, education, commerce, entertainment, or social networking. Hyperlinking between web pages guides the navigation of the site, which often starts with a home page. Users can access websites on a range of devices, including desktops, laptops, tablets, and smartphones. The software application used on these devices is called a web browser. Some websites require user registration or subscription to access the content. Examples of subscription websites include many business sites, news websites, academic journal websites, gaming websites, file-sharing websites, message boards, web-based email, social networking websites, websites providing real-time data, as well as sites providing various other services.

Objectives

1. To develop a new website for national and international seminars and symposiums.
2. To manage domain or sub-domain for the new website.
3. To host the new website at server.
4. To manage and maintain the new website.

Methodology

A new website was developed by the ICT cell, Agricultural statistics division (Fig.30). The website is an interactive platform for scientists, researchers, DAE personnel, teachers, students and others who want to get information and also submit their papers, abstracts and posters for attaining the international and national seminars & symposiums. The software is visible 24/7/365.

Progress

Bangladesh Rice Research Institute arranges national and international seminars and symposiums. Having a website makes it very easy for people to find information and also submit their papers, abstracts and posters for attaining national and international seminars and symposiums. Read up about BRRI, discover what BRRI does, and answer a bunch of questions they have. By having a website people will be able to get information about BRRI when they search on a search engine like Google, Yahoo or Bing. The website has been used to get information and submit their papers, abstracts, posters and others.

Fig. 30: New website for BRRI

Activity 8.5: Strengthening Cyber Security System for BRRI

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Cyber security system is the technique of protecting a server, computer network, software, application, files, source code and database from unauthorized access, hacked or attacked. Virtual Private Network (VPN) provides safe and encrypted connections over private and public networks that transport data securely. A virtual private network (VPN) protects data and identity over public networks by creating a private network from a public internet connection. VPNs mask internet protocol (IP) addresses. So, it is impossible to link it to online activity via IP detection. A VPN tunnel is an encrypted connection between a VPN client (local computer) and the server. Since the connection is encrypted, nobody is able to intercept, monitor, or alter the communications.

Objectives

1. To develop Virtual Private Network (VPN) for BRRI.
2. To develop VPN tunnel for BRRI.
3. To develop secure remote connectivity for BRRI.
4. To manage and maintain cyber security system.

Methodology

For strengthening the Cyber security system, developed design and architecture using AutoCAD and graphics software's. Shell program has been used for Virtual Private Network and configuration of the outer and inner tunnels. This Tunnel was used for encrypted communication between client and server. Remote connectivity between BRRI and national data centre was developed through Windows platform.

Progress

- We have already designed the architecture of cyber security system of BRRI.
- Configuration of Virtual Private Network (VPN) is completed successfully.
- Configuration of outer and inner tunnels are completed successfully.

Conclusion

After develop cyber security system nobody can trace the server (back-end server) of any location in the world. When client point and server point are connected through VPN, only that time server (back end or admin panel or c panel) will be visible for only the client computer. So, it will be possible to protect completely the BRRI's server such as mail server, webserver, website, FTP server, application and other web-related servers and all servers as well as all data will be safe and secured.

Activity 8.6: BRRI Alapon Telephone Directory Mobile App of BRRI

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman,
Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Alapon is a secured inter communication platform. Through a controlled network, a Govt. officer with Alapon App can find any other Govt. officers based on hierarchy using the directory service instantly, communicate with him over both voice & video call and share official files securely. It can download on any device and register using their National Identification (NID) Number which will synchronize all the details from the database accordingly. Moreover, a user can plug in the service using data network, communication cost becomes relatively low while ensuring strong user association within service network. So BRRI took the initiative to develop 'BRRI Alapon' mobile and web application for proper communication.

Objectives

1. To develop telephone directory mobile app for BRRI.
2. To communicate through mobile app via voice call, video call, email or SMS.
3. To provide location sharing through mobile app.
4. To provide all types of meeting, seminar etc notice via SMS through mobile app.

Methodology

The BRRI telephone directory mobile app named *"BRRI Alapon"* is developing for BRRI official. They are able to communicate with each other through this app like imo, Viber, Whatsup, WeChat etc. The app has features like chat, online calls, group messaging and location sharing. *"BRRI Alapon"* is available for free download in App Store (*iStore*) and Google play store for *Android* phone user. BRRI officials are able to download it with their valid and active mobile numbers on devices which they provided for the official database. The data has been collected from all division, section and regional station of BRRI. The data has included with name, designation, mobile number, email address, present posting, date of birth and blood group. The data was compiled into MS Excel format.

Progress

- Already database has been developed (Table 21).
- All types of data have been collected from divisions, sections and regional stations of BRRI for developing the telephone directory mobile app.
- Project proposal has already sent via Ministry of Agriculture to ICT division for developing an e-platform for this system. The process is going on.

			Director General			
ড. মোঃ শাহজাহান কবীর	মহাপরিচালক	০১৭১২-২৮০০৮৩	kabir.stat@gmail.com dg@brri.gov.bd	3.32301E+12	O+	১১/১১/১৯৯৪
খুরশীদ সিহাব	ব্যক্তিগত সহকারী	১৭১৮১১৭৭৯৯	bd.sihab@gmail.com	3276772682	B+	11-11-12
Md. Rabiul Islam	অফিস সহায়ক	১৯৮২৮৫৭৯৫৮	rabiulbrri@gmail.com	7350214784	AB+	২৬/০৭/২০১৫
Md. Rafiqul Islam	গাড়ী চালক	১৭২৩৬০৫০৮৬	mri849094@gmail.com	7794274949	A+	08-01-17
			Director Research			
ড. তমাল লতা আদিত্য	পরিচালক (গবেষণা)	১৭১৫৩৮২০১৯	directorresearchbrri@yahoo.com tamaladitya@yahoo.com	৭৩১০০৩১৫৫৯	O+ve	১১/১১/১৯৯৪
ড. মুন্নুজান খানম	উচ্চ শিক্ষা ও গবেষণা সমন্বয়কারী	১৯২৬২৫৫০৯১	munnujan_khanam@yahoo.com	২৩৬০০২৯২৩১	O+ve	১১/১১/১৯৯৪
ড. এবিএম জাহিদ হোসেন	এসএসও	১৭১২৭৬৩৩৫৯	abmz_hossain@yahoo.com	১০১৫৭৯১৭৬৫	B+ve	১১/০৮/২০০১
মোছাঃ আসমা খাতুন	প্রশাসনিক কর্মকর্তা	১৭১২৬৭৫৬৯২	asma.brri@gmail.com	৫৫০৯৫১৮২৮০	B+ve	০৫-০৫-২০১১
মোঃ নুর এ আলম শাহীন	অফিস সহকারী কাম কম্পিউটার মুদ্রাক্ষরিক	১৯১১৮৮৮৭০৫	shahinalambdg@gmail.com	৭৩১০০৮৪৩৫০	AB+ve	০৬-০১-২০১৩
মোঃ সোহেল রানা	অফিস সহকারী কাম কম্পিউটার মুদ্রাক্ষরিক	১৮১৫৮৮৩৭৩৬	amisohel123@gmail.com	৫৯৬২৯৫১২৮১	AB+ve	০৫-০৫-২০১১
			Dircetor Admin			
ড. কৃষ্ণ পদ হালদার	পরিচালক (প্রশাসন ও সাধারণ পরিচর্যা)	01827-172724	Official: da@brri.gov.bd Personal: kphalderr@gmail.com kphalder62@yahoo.com	4609751633	বি (বি পজিটিভ)	28-06-1987
মোঃ মোশাররফ হোসাইন	মহাপরিচালকের একান্ত সচিব	01715-257349	Personal mahfujahmed71@gmail.com	4624066835	O (O Negative)	08-01-17

Table 21: BRRI Alapon database

Conclusion

After developing the app is secure enough for conversations and optimized to minimize cost for the BRRI officials. Anybody call and exchange messages more securely using this app. App to app call, email and SMS is completely free for user.

Activity 8.7: **Vehicle Requisition Management System of BRRI**

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman,
Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

VRMS is an automated scripted transportation management system (TMS). The transportation pool management activities of BRRI are complex and updating the allottee individually in time which is tedious work. The designated official of Transport division is needed to work after office to manage the official vehicle requests and to convey the confirmation to the requester and driver over the phone. VRMS will ease the allotment work using a simple requisition management system that doesn’t require any advanced computing skills and the confirmation will be sent using SMS and email.

Objectives

1. To develop vehicle requisition management system (VRMS) for BRRI.
2. To inform through SMS, on the basis of demand vehicle at BRRI.
3. To provide SMS for drivers for confirming their upcoming duty.
4. To host VRMS at server.

Methodology

Vehicle Requisition Management System **(**VRMS) is a transportation pool management activity of BRRI are complex and updating the allottee individually in time which is tedious work. The designated official of Transport division is needed to work after office to manage the official vehicle requests and to convey the confirmation to the requester and driver over the phone. VRMS doesn’t require any advanced computing skills and the confirmation sent using SMS and email. So that, the requester informed through SMS on basis of demanding vehicle for official or personal purpose as well as driver get confirmation SMS for their upcoming duty. The database has already developed and architecture design has been finalized. The information of all vehicle of BRRI (driver’s name, mobile number and vehicle reg. number etc.) has been collected from transport section

Progress

- The database has already developed and architecture design has been finalized.
- The information of all vehicle of BRRI (driver’s name, mobile no, vehicle reg. no etc.) has been collected from transport section.
- A project proposal has already sent via Ministry of Agriculture to ICT division for developing an e-platform for this system. The process is going on.

Activity 8.8: **Training on Innovation, Service Process Simplification (SPS) and e-Nothi management for enhancing capacity of BRRI employee**

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman, Mrs. Kabita,
Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Innovation can be defined simply as a "new idea, device or method". Whereas Service Process Simplification (SPS) is a tool to simplify access to public services thereby reducing the time, cost and number of visits (TCV) required for citizens to access them. It is essential to introduce the culture of innovative practices that would accelerate and simplify the BRRI research activities and service delivery process. BRRI has implemented all innovation activities and conducted various training on PSI, SPS and e-Nothi management under Innovation Action Plan Guideline 2015 and several annual innovation work plan of BRRI.

Objectives

1. To provide various training on public service innovation (PSI), SPS and e-Nothi management to BRRI scientists and officers for developing capacity.
2. To bring qualitative changes in the internal research work process and service delivery in BRRI HQ and respective regional stations.
3. To compile various innovative idea through PSI and SPS training for piloting and replication activities.

Methodology

Innovation and Service Process Simplification (SPS) tool is essential to introduce the culture of innovative practices that would accelerate and simplify the BRRI research activities and service delivery process. Agricultural Statistics Division has implemented all innovation activities and conducted various training on Public Service Innovation (PSI), Service Process Simplification (SPS), Simple implementation Project (SIP) and e-Nothi management and several annual innovation work plan of BRRI. Day-long 'Innovation and SPS' workshop has already completed on 11 October' 2020 and two day-long 'Public Service Innovation' training has completed on 12-13 October' 2020 (Fig. 31) in spite of Covid-19 situation following social distance and health rules. 'e-Nothi System' in-house training has conducted from 31st May to 15th June' 2021 for all division and sections of BRRI HQ.

Progress

- Two day-long 'Public Service Innovation' training has completed on 3-4 June, 2023 at BRRI premises;
- Two day-long 'Public Service Innovation' training has completed on 27-28 May' 2023 at BRRI premises;

Fig. 31: Training on 'Public Service Innovation'

Activity 8.9: **BRRI Rice Doctor mobile and web app**

(In collaboration with Plant Pathology, Plant Physiology, Entomology, Soil Science and Agronomy div.)

- Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

The mobile application and web application named 'BRRI Rice Doctor' is being readied to help identify and manage rice crop problems in Bangladesh rice farms. The mobile and web app is now available in both English and Bangla at Google play store. The interactive Rice Doctor app use text and images to help extension workers, farmers, researchers and students diagnose diseases and other disorders affecting rice. It has brief descriptions of the signs, symptoms and management options. So BRRI took the initiative to develop Rice Doctor mobile app, web application and diagnosis tool for proper management of rice production.

Objectives

1. To develop rice doctor Apps for BRRI.
2. To manage and maintain BRRI rice doctor apps.
3. To host BRRI rice doctor Apps at server.

Methodology

Rice Doctor mobile and web application identify disease, insects and other criteria as a diagnostic tool through asking question, off-line content based on insect/diseases list, insect and disease list with image and content, ask question option about rice disease or insect type including voice, image, video and text, question wise push notification/SMS to give feedback about specific problem for user, global push notification and Bangla content reader (Text to speech). Anybody can download from *Google Play Store* of any android mobile phone and then install this app. The app can share through *SHAREit* app from one smart phone to another phone through offline. BRRI has developed Rice doctor mobile app and web application and diagnosis tool (Fig. 32 & 33) with help of Multimedia Content and Communications (MCC) Ltd.

Progress

- Developed final version of BRRI rice doctor mobile app and web application;
- Included diagnosis tool technique on BRRI Rice doctor mobile and web application;
- Included ‘Feedback’ option to provide necessary advice for improving the quality of app.
- A total number of 1,800 users have been downloaded from the Google play store.

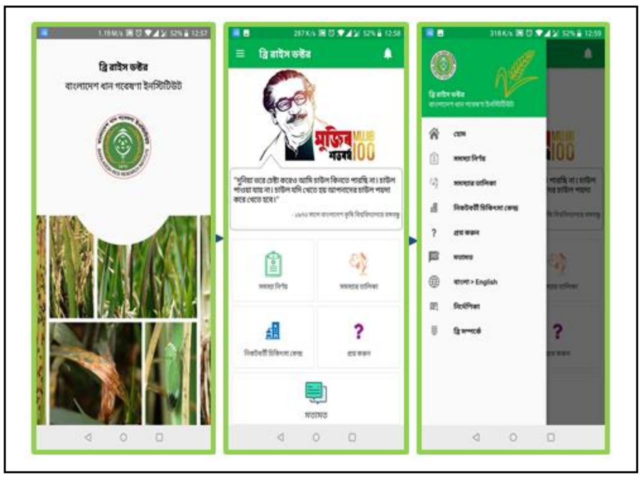


Fig. 32: BRRI Rice Doctor Mobile App

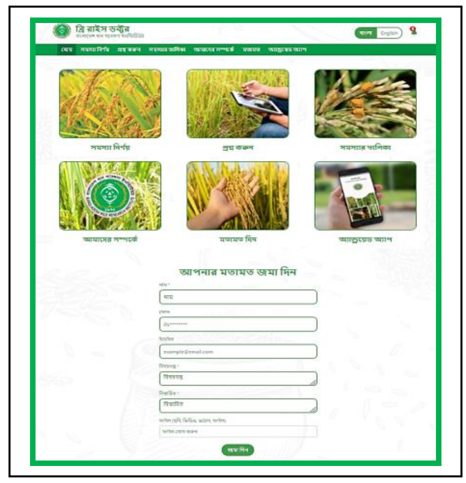


Fig. 33: BRRI Rice Doctor Web App

Activity 8.10: BRKB Website Management of BRRI

(In collaboration with training, breeding and others research divisions)

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Bangladesh Rice Research Institute (BRRI) developed the Bangladesh Rice Knowledge Bank (BRKB) web application. BRKB is a digital extension service that provides practical knowledge solutions, specialized for small-scale farmers in the country. BRKB is a treasure of rice knowledge. This is a dynamic source of knowledge that has been updated regularly to keep consistency with the latest innovations and users' feedback. BRKB showcases rice production techniques, agricultural technologies and best farming practices based on research findings in the country. The BRKB contains rice knowledge to address the regional as well as national issues associated with rice production and training.

Objectives

1. Provide more benefit to all users specially farmers, extension workers, researchers etc.
2. Include more information about rice production and related publications.

Methodology

BRKB Website has managed, maintained and modified by ICT Cell, Agricultural statistics division in collaboration with training, breeding and others research divisions. BRKB is updated regularly with the latest information of rice varieties, modern rice cultivation, pest management, soil and fertilizer management, irrigation and water management, quality rice seed production management, training and publications. Most of the materials i.e., fact sheets, training manuals, booklets, leaflets, brochures, posters have been prepared in Bangla, which are easily understandable to farmers and extension workers. The main sections of BRKB are rice cultivation methods, Boro rice varieties and production methods, Aman rice varieties and production methods, soil and fertilizer management, rice insects and their management, irrigation and water management, photo gallery etc (Fig. 34). “BRKB” web application has been developed by WordPress, JAVASCRIPT, HTML, CSS, InDesign, fireworks and MYSQL database.

Progress

- In this reporting year, we have developed twenty-four web and mobile-based fact sheets. And all fact sheets have been uploaded to the BRKB website.
- Updated with the latest information of Aman, Aus and Boro rice varieties included the latest variety of BRRI dhan106, BRRI dhan105, BRRI dhan104 and BRRI Hybride dhan8.
- All types of information i.e., soil and fertilizer management, insects and rice diseases management etc. also updated regularly. It is routine work.

- A total number of 4,50,985 users have been visited the website.

Fig. 34: BRKB Website and mobile based fact sheet

Activity 8.11: Dynamic view connectivity system, Bangla searching system and inner banner system for BRKB Website

(In collaboration with training, breeding and others research divisions)

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab,
Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Dynamic view Connectivity is a way of viewing and understanding the information that considers all aspects to each other in a relationship and is interconnected. This means that change in one aspect can have an impact on other aspects. Thus, connectivity helps us teach about the repercussions of our actions, by sharing and telling stories of cause and effects, events and outcomes.

Objectives

1. To construct dynamic view connectivity system.
2. To create Bangla searching system.
3. To develop inner banner system.
4. To manage and maintain BRKB Website through regular updating of the information and documents

Methodology

ICT cell developed the connectivity between the BRKB website and Facebook page (Fig. 35). Bangla searching system is a web searching system on the BRKB website. It has the ability to search both in Bengali and English language. It searches and automatically characterizes Bangla and English content of the BRKB website. The inner banner system is a part of a dynamic website and is typically used for aesthetic reasons. The inner banner system is represented by large photos, graphics or videos that are placed in the prominent sections of a website.

Progress

- We have developed a dynamic view connectivity system and inner banner system also integrated into the BRKB website. That helps us about our present activities and actions.
- About 1020 research-related posts have been published in the dynamic view connectivity system and 35,589 uses have been got the service.
- We also developed the Bangla Searching system in BRKB. Now anyone can search using both Bangla and English content.

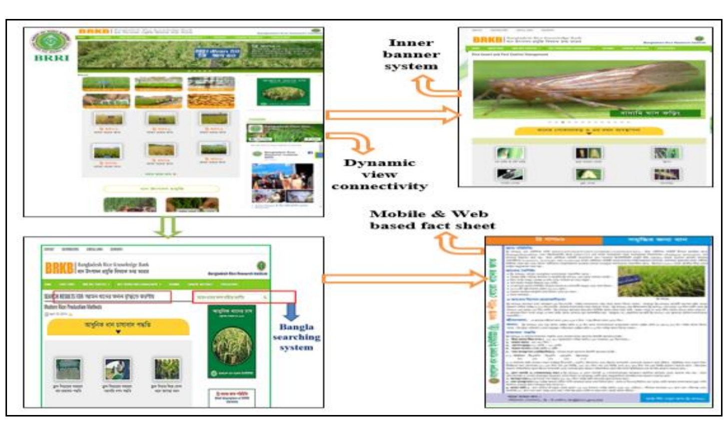


Fig. 35: Inner Banner System, Bangla searching System and Dynamic view connectivity

Activity 8.12: BRRI Web mail and Group mail

- Mrs. Kabita, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Webmail is a web-based email service that is any email client implemented as a web application running on a web server. Webmail software are Round cube, Squirrel Mail, Zimbra etc. Practically, every webmail provider offers email access using a webmail client, and many of them also offer email access by a desktop email client using standard email protocols, while many internet service providers provide a webmail client as part of the email service included in their internet service package. There exist also other software tools to integrate parts of the webmail functionality into the operating system. ICT cell of Agricultural Statistics division provides ICT-related support services to other divisions such as create webmail account, reset passwords, remove the block, lockout problems and other activities.

Objectives

1. To create Web mail and Group mail id with password for all scientists and officers of BRRI.
2. To manage, maintain and update regularly as routine work web mail and group mail of BRRI.

Methodology

BRRI web mail server sends, receives and stores email for all users. Almost every Internet Service Provider (ISP) includes at least one mailbox on their mail server as part of their basic service. When a client connects to a server, both computers must communicate the same protocol. The most widely used protocol is POP3 (Post Office Protocol version 3). It is almost always used in conjunction with SMTP (Simple Mail Transfer Protocol). POP3 is used to retrieve mail from the server (incoming) while SMTP is used to send mail through the server (outgoing). We have created individual email accounts into the BRRI domain for all scientists and all officers as per the requirement of the Ministry of Agriculture (MoA). BRRI Webmail & Group mail has been hosted on BCC (Bangladesh Computer Council) server.

Progress

- We have updated the BRRI mail server from 8.8.15_GA_4372 FOSS version to 8.8.15_GA_4545 version (Fig. 36). Now our mail server is more secure than the previous one.
- We provided 110 webmail related solutions in this reporting year.
- We have created individual e-mail id into BRRI domain for all scientists and all officers as per requirement of the Ministry of Agriculture (MoA).
- We have created group mail for all scientists, officers and regional stations as per requirement of BRRI scientists.

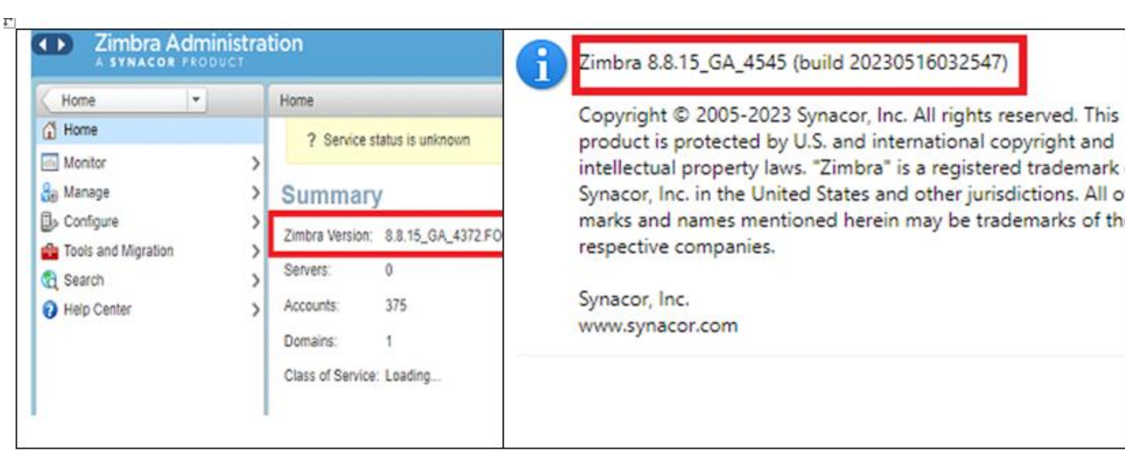


Fig. 36: Previous version VS new version

Activity 8.13: Developing secure system for BRRI Web Mail and Group Mail

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A Spamming Filtering System (SFS) is a program that is used to detect unsolicited and unwanted email and prevent those messages from getting to a user's inbox. Like other types of filtering programs, a spam filter looks for certain criteria on which it bases judgments. More sophisticated programs, such as Bayesian filters or other heuristic filters, attempt to identify spam through suspicious word patterns or word frequency. Secure Sockets Layer (SSL) Certificates provide secure, encrypted communications between a web mail user and an internet browser.

Objectives

1. To develop Spamming Filtering System (SFS) at BRRI web mail server.
2. To create Automatic Active & Close System (AACS) at BRRI web mail server.
3. To develop Secure Sockets Layer (SSL) system.

Methodology

Secure Sockets Layer (SSL) Certificates provide secure, encrypted communications between a webmail user and an internet browser. SSL stands for Secure Sockets Layer, the protocol that provides encryption. SSL Certificates are typically installed on pages that require end-users to submit sensitive information over the internet. Spamming Filtering System (SFS) will scan all users of webmail every other hour and find out the user who occurs spamming. When a webmail user creates some or heavy spamming, Automatic Active & Close System (AACS) will automatically detect the user and also block the user. As a result, the whole system (BRRI webmail) will be protected from the block of Gmail, yahoo, webmail or others e-mail server.

Progress

- We have developed Automatic Active and Close System (AACS) and spamming filtering system (SFS) in the BRRI webmail (Fig. 37).
- About 102 webmail users have created heavy spamming, AACS has detected those users and also blocked them so, the whole system has been saved from the block of Gmail, yahoo, webmail or others e-mail server.
- SFS has scanned about 102 webmail accounts and solved all problems.

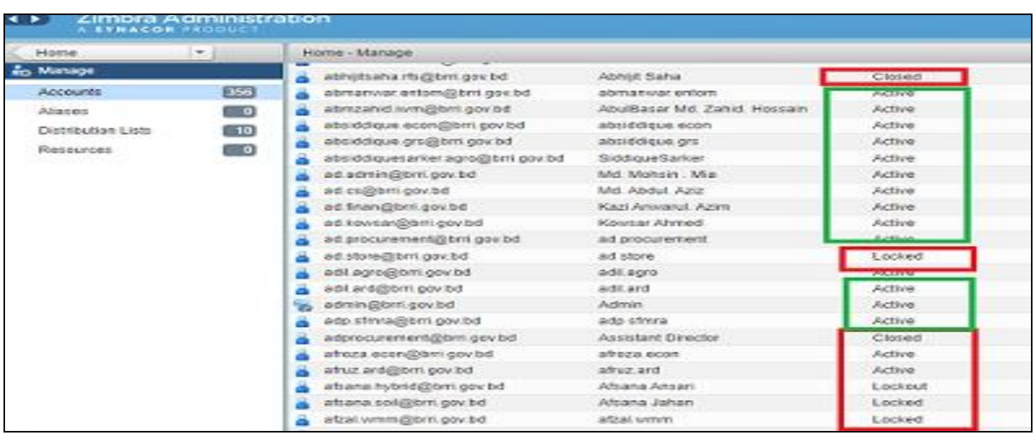


Fig. 37: Spamming Filtering System, Automatic Active & Close System and Secure Sockets Layer

Activity 8.14: **Online Application System of BRRI**

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman,
Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

The online application system for recruitment is an ideal portal for Government organizations to manage their recruitment related activities through online. Sometime it has an option to check applicant's identity is verified with national citizen database. Its activities covered includes from job posting to short listing of candidates based on result of evaluation examination. It reduces time of result processing drastically. It also increases quality of evaluation test management. So BRRI has introduced this online system to decrease hassles of applicants/students for Job Application. It also reduces time of Job applications processing for employer.

Objectives

1. To develop online application system of BRRI.
2. To host online application system at data centre.
3. To manage and maintain online application system through regular updating of the information and documents.

Methodology

Online application system was developed (Fig. 38) by Teletalk Mobile Company Limited with the help of ICT Cell, Agricultural Statistics division and Administration of BRRI. The Architecture of this software is client-server and data were managed by MY SQL Server. It has a primary server and a backup server. If one server is down, automatically another server is up. As a result, problem not be faced to user this software. Hence, total server was secured and protected.

Progress

- Started first time online application system from 23rd May to 12th June'2019. Already completed another online application process from 20.6.2022 to 03.07.2022. Applicants completed their application through this system and got admit card, written test date notification, result and all kinds of information through this online system and SMS based application.
- Completed agreement between BRRI and Teletalk Bangladesh Limited, a public limited company on 8 March' 2017 for Web and SMS based application.

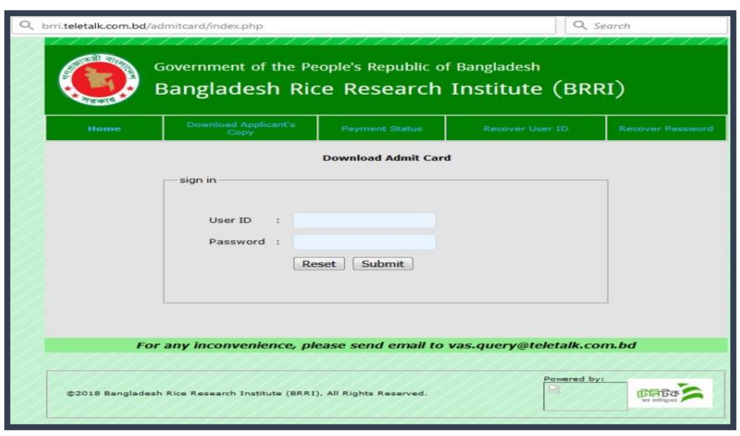


Fig. 38: Online Application System of BRRI

Activity 8.15: **e-Nothi System of BRRI**

- Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

In traditional filing system, decision making process used to take 5-7 days to take a decision on a file and or deliver the service but with new e-Filing system "nothi" this duration has come down to only 1-2 days depending on the nature of the case. It saves time, cost and visit of the citizen. The implementation of e- Filing system to ensuring faster movement of files through the different layers in government offices, increased transparency throughout the organization and increased accountability in governance. Hence, BRRI has taken initiative to ensure a paperless office management system through e-Nothi system.

Objectives

1. To setup "e-File Management Software" for administration, Accounts and Finance division of BRRI for establishing e-Governance.
2. To setup "e-File Management Software" for maintaining and reporting the results of financial transaction.

Methodology

"e-Nothi Management Software" is used by administration and all division of BRRI. This software is active in 24/7/365. It has a database server and a backup server. If one server is down, another server is up. As a result, any kinds of problem will not be faced to user this software. "Nothi" saves a huge amount of money and time required previously to obtain a service from government offices. But after the inception of this new generation e-Nothi system citizens have become empowered and got the privilege of electronic/virtual communication with the government offices sitting at home. It allows them to lodge their demand/requirement and track them real time online which was literally impossible in traditional Filing system. Citizens can now utilize their valuable time/money elsewhere to make their lives more fulfilling.

Progress

BRRI has taken initiative to ensure a paperless office management system through e-Nothi system (Fig. 39) on 24 September 2016. At present, BRRI obtained 1st position among all govt. organizations and departments for using e-Nothi System. BRRI has issued total 11410 letter to Ministry of Agriculture (MoA) and different organization as well as completed 28605 note from July/2022 to June/2023. Now e-Nothi system 100% is being used in all divisions and sections of BRRI as well as regional stations.

Fig. 39: e-Nothi System of BRRI

Activity 8.16: **LAN and internet connectivity of BRRI regional station (R/S)**

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A local area network (LAN) is a group of computers and peripheral devices that share a common communications line or wireless link to a server. A local area network may serve several users in an office. Administrators set up LANs so that network nodes can share resources such as printers or network storage. LAN networking requires cables, switches, routers and other components that let users connect to internal servers, websites and other LANs that belong to the same wide area network (WAN). Ethernet and Wi-Fi are the two primary ways to enable LAN connections. Ethernet is a specification that enables computers to communicate with each other. Wi-Fi uses radio waves to connect computers to the LAN.

Objectives

1. To setup Local Area Network (LAN) for all regional station of BRRI.
2. To setup Internet connectivity for all regional station of BRRI.
3. To manage and maintain LAN & Internet connectivity of BRRI regional station.

Methodology

Local area network and internet connectivity of BRRI regional station have been managed and maintained by ICT Cell, Agricultural Statistics Division with the help of the Network developer company and our ICT trained manpower.

Progress

- Established Local Area Network (LAN) connectivity at five regional stations i.e. Sonagazi, Cumilla, Rangpur, Barishal and Habigonj (Fig. 40).
- Increased 2 Mbps full duplex, dedicated and 3.5G (3.5 Generation) internet bandwidth at four regional stations. At present, we have increased the internet speed of sonagazi from 2 Mbps to 7 Mbps.
- Established WiFi connection at five regional stations i.e., Rangpur, Barishal, Sonagazi, Cumilla and Habigonj.

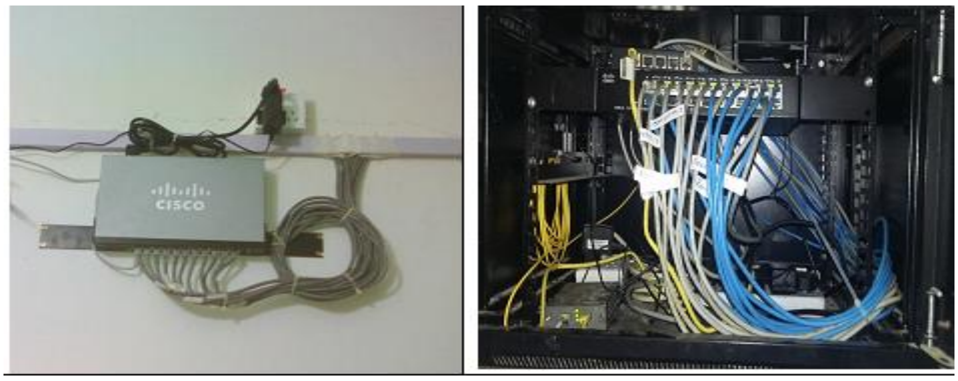


Fig. 40: LAN and internet connectivity of BRRI regional stations (R/S)

Activity 8.17: **BRRI Web Portal Management**

- Nuraiya Kulsom, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Mrs. Kabita, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

The National Portal Framework (NPF) is the single platform for accessing all public information from any government organization to ensure easy accessibility for citizens. Counting all ministries, departments, semi-government and autonomous organizations and all government offices at the division, district, upazila and union levels there are about 27,000 government offices.

Objectives

1. To develop and modify the design of BRRI Web Portal.
2. To manage and maintain BRRI Web Portal through regular updating of the information and documents.

Methodology

BRRI web portal (www.brri.gov.bd) has been developed by ICT cell, Agricultural statistics division with help of Access to Information (a2i) Programme. BRRI has been incorporated with it as a first organization among the NARS institute. It is a citizen-oriented web portal so the large majority of the population including farmers, researchers, extension officers, students, and teachers are benefited from BRRI Web Portal.

Progress

- In this reporting year, updated more than 1365 (one thousand three hundred and sixty-five) pages and uploaded more than 6643 (six thousand six hundred and forty-three) documents like PDF, JPG, report, Word and other files on the BRRI website (Fig. 41).
- In the reporting year, sent sixteen website reports to the ministry of agriculture (MoA).
- BRRI has made the web portal in both Bengali and English languages. It is the largest web portal (*www.portal.gov.bd*) in the world and BRRI is incorporated with it as the first organization among the NARS institute.
- Developed BRRI writer's pool, Rice pest corner and many more.
- Included the rice database, climate database, etc. on BRRI dynamic website and updated it regularly.
- To make it more updated and informative, we developed individual web page including picture of Headquarter and all regional stations of BRRI.

Fig. 41: BRRI Web Portal

Activity 8.18: Management of BRRI Local Area Network and internet Connectivity

-S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Ful Mia, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A local area network (LAN) is a group of computers and peripheral devices that share a common communications line or wireless link to a server. A local area network may serve several users in an office. Administrators set up LANs so that network nodes can share resources such as printers or network storage. LAN networking requires cables, switches, routers and other components that let users connect to internal servers, websites and other LANs that belong to the same wide area network (WAN). Ethernet and Wi-Fi are the two primary ways to enable LAN connections. Ethernet is a specification that enables computers to communicate with each other. Wi-Fi uses radio waves to connect computers to the LAN.

Objectives

1. To manage and maintain ICT network of BRRI.
2. To manage and maintain BRRI internet connectivity.
3. To manage and maintain BRRI and regional station Local Area Network (LAN).
4. To initiate e-Governance.

Methodology

ICT network and internet connectivity of BRRI have been managed and maintained by ICT Cell, Agricultural Statistics Division with the help of the network developer company and our ICT trained manpower.

Progress

- Agricultural Statistics Division have increased our Digital Data Network (DDN) bandwidth connectivity from 157 Mbps to 177 Mbps. Now our internet speed is faster than previous once (Fig. 42).
- Established a redundant internet line from Bangladesh Research and Education Network (BdREN). And also increased the bandwidth from 100 Mbps to 120 Mbps.
- Already given internet connection to 360 computers. But want to increase more internet connection. So, started to increase our bandwidth connectivity as per requirement of BRRI scientists and officers. Hopefully, within a short time all the BRRI scientists and officers will get more speed for internet access with smooth communication and they will be benefited to pass information internally as well as globally.

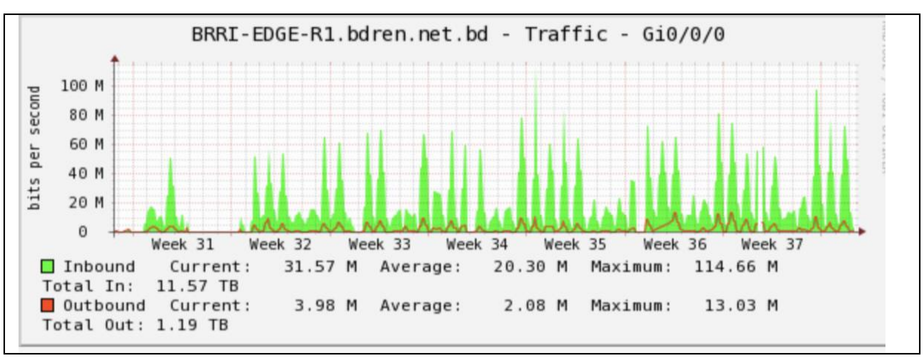


Fig. 42: BRRI LAN, internet connectivity

Activity 8.19: BRRI networks update, maintenance and extension

-Md. Mahfuz Bin Wahab, Md. Ismail Hossain, S. M. Mostafizur Rahman, Mrs. Kabita, Rokib Ahmed, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Facebook group is a page created for an organization or business to promote activities. Users can join the group and post their thoughts on a wall and interact through discussion threads. Mainly, fan pages have the advantage of being able to display information directly into their fans news feeds, while groups cannot. Groups, however, have the ability to message their members, as well as restrict who can and cannot join. *BRRI Networks* is a Facebook group, where only official interactions, various problems and their solutions can be post. It's a big forum for all kinds of scientists, officers and staffs of BRRI. ICT Cell created this Facebook to post anything for noble work of rice and rice related activity of this forum.

Objectives

- To create a group for BRRI to promote all activities of BRRI.
- To make a Facebook group, where only official interactions, various problems and their solutions can be post.
- To create a big forum for scientists, officers and staffs of BRRI. Where can post anything for noble work of rice and rice related activity of this forum.

Methodology

Basically, Facebook Groups are pages that you create within the Facebook social networking site that are based around a real-life interest or group or to declare an affiliation or association with people and things. The Facebook group of *BRRI Networks* link is (*https://www.facebook.com/groups/1409267722690061/*). Otherwise, *BRRI Networks* already linked with 'Krishi Bhabna' group (https://www.facebook.com/groups/1531163080439314/) maintained by Ministry of Agriculture (MoA). Thus, the *BRRI Networks* is continuing with regular updating by posted everybody of this group. BRRI has also a facebook page (*https://www.facebook.com/brribd*) which is very much interactive and responsive.

Progress

- To build a linkage among all scientists, officers and staffs, where *BRRI Networks* (Fig. 43) play an important role.
- At present, more than 33k user like the facebook page (Fig. 44) of BRRI and 4000 members are joined the 'BRRI Networks' facebook group. It's gradually increasing.
- *BRRI Networks* group is regular updated by skilled ICT cell employee and to protect all types of unwanted post, photo and other's spam through online filtering.

Fig. 43: BRRI Networks Facebook Group

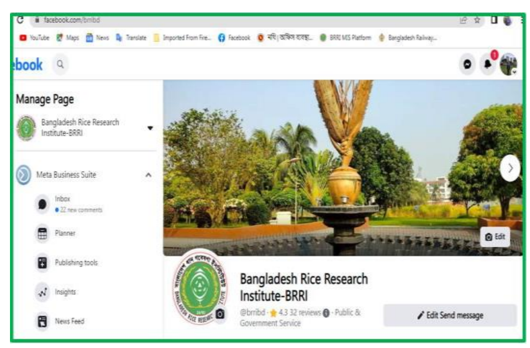


Fig. 44: BRRI Facebook page

Activity 8.20: Personal Data Sheet database of BRRI

-Mrs. Kabita, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Personal Data Sheet (PDS) is a document used by someone with a visual impairment or other impairment that inhibits his or her ability to read or write using a standard print format. The PDS contains all of the information that you would typically be asked to supply to complete an application. It includes name, address, telephone number, details about your academic and work history, supervisor's names, reference names and contact information etc. On the PDS, it can include everything; try to anticipate any question that might pop up on an application. ICT cell of Agricultural Statistics division provides ICT related support services to other divisions such as data entry, updating PDS database etc.

Objectives

1. To develop PDS database for all scientists, officers, clerks of BRRI.
2. To develop PDS database using user name & password.
3. To get BACKUP of PDS database regularly.

Methodology

PDS is a convenient way of organizing all the information that will be required to complete an application form. Instead of trying to keep track of a number of documents (record of work history, references, address book, etc.), it is helpful to keep this important information all together on a few stapled pages. Everyone needs a personal data sheet. Each document is used for a different purpose.

Progress

- Version 4 of PDS has been developed (Fig. 45).
- All data of Version 1 has been transferred to Version 4.
- PDS database is updated regularly with latest information. It is a routine work.

Fig. 45: PDS Database of BRRI

Activity 8.21: Video Conference system of BRRI

-Mrs. Kabita, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Video conferencing is the conduct of a videoconference (also known as a video conference or video teleconference) by a set of telecommunication technologies that allow two or more locations to communicate by simultaneous two-way video and audio transmissions. It has also been called 'visual collaboration' and is a type of groupware. Video conferencing differs from videophone calls in that it's designed to serve a conference or multiple locations rather than individuals. It has also been called visual collaboration and is a type of groupware. Video conferencing technology provides a video link between two or more people, which allows them to see and hear each other at the same time Video conferencing has made significant inroads in business, education, medicine and media. Like all long-distance communications technologies (such as phone and internet), to bring people together the technology also contributes to reductions in carbon emissions, thereby helping to reduce global warming. ICT cell of Agricultural Statistics division will provide Video conference system-related support services such as setup Skype software, installation webcam and headphone etc.

Objectives

1. To develop “Video conference system of BRRI” for administration, all divisional head and regional station head of BRRI.
2. To develop “Video conference system of BRRI” for research and administration works.

Methodology

A video conference is a live connection among people in separate locations for the purpose of communication, usually involving audio and often text as well as video. It digitally reproduces image using IP (Internet Protocols) technology, a standard set of rules to enable data transfer, and Local Area Network (LAN) connection. Video conferencing system is two-way communications with live video and audio system so it is needed brands of videophones, webcams, headphones (it can be Bluetooth headphone also) and video conferencing hardware and systems.

Progress

- Established video conferencing system at BRRI to communicate with MoA and others government organization.
- The communications between BRRI headquarter and other's regional station have been conducted by Video Conference System in every monthly co-ordination meeting, ADP meeting, Thursday Seminar and other types of meeting (Fig. 46).
- Bangladesh Research and Education Network (BDREN) funded by University Grant Commission (UGC) has established video conferencing system at BRRI.
- Already we have created Skype account for all divisional heads and regional stations head.

Fig. 46: Video Conference system of BRRI

Activity 8.22: **New version of management Information System (MIS) of BRRI**

- S. M. Mostafizur Rahman, Md. Ismail Hossain, Md. Mahfuz Bin Wahab, Mrs. Kabita, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

A management information system (MIS) is a computer system consisting of hardware and software that serves as the backbone of an organization's operations. An MIS gathers data from multiple online systems, analysis the data and generate reports to aid in management decision-making. The MIS system may also include software that supports decision-making. The software keeps a complete record of the past and current data in the required format and presents it for analysis whenever it is needed. Besides database maintenance and decision making, the software comes in handy in keeping a complete record of the financial management, project management, employee management, and decision support systems. On the whole, it serves as the backbone of an organization guaranteeing smooth and efficient functioning.

Objectives

1. To develop new version of management Information System (MIS) Software for BRRI.
2. To manage and maintain MIS of BRRI
3. To host MIS software at Bangladesh computer council (BCC).

Methodology

A management information system (MIS) is a computerized database of information organized and programmed in such a way that it produces regular reports on operations for every level of management in an organization. It is usually also possible to obtain special reports from the system easily. The MIS software of BRRI has 10 modules (HRMIS, FMIS, PMIS, RMIS, LMIS, VMIS, TMIS, IMIS, SMIS, Data Bank). The MIS Software will be developed under NATP-2 using PHP, JAVA, HTML, CSS, JAVASCRIPT and data will manage by ORACLE/MY SQL database.

Progress

- Ten workshops have been completed at Bangladesh agricultural research council (BARC).
- Feedback workshop has been completed.
- Tender documents have been prepared.

Activity 8.23: Rice Pest Corner

(In collaboration with Plant Pathology division & Entomology Division)

- Nuraiya Kulsom, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Mrs. Kabita, Rokib Ahmed, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Rice is the main staple food in Bangladesh, occupies nearly 80% of the total net cropped area of the country. Three major rice crops namely (Aus, Aman and Boro) constitute 100% of total rice production and grow in three different seasons. Bangladesh agriculture involves food production for 163.65 million people from merely 8.75 million hectares of agricultural land (Salam *et al.*, 2014). Since independence, there has been a three-fold increase in rice production in Bangladesh, which jumped from nearly 11 MT in 1971-72 to about 38.70 MT in 2019-20 (BBS, 2020). This has transformed the country from so called “Bottomless Basket” to a “Full of Food Basket”. Combined efforts of farmers, rice scientists, extension personnel and Government of Bangladesh have enabled the country with a surplus of about 2 MT of rice in 2019-20. In the last few years (2015-16 to 2019-20), rice production has increased by 0.36 MT per year (DAE, 2020). The main threat of rice cultivation in our country as well as in the world is pest problem. Insects affect human rice beings in a number of ways. So, BRRI has to been initiative to develop Rice Pest Corner for BRRI website for providing services to farmers, government agencies and concerned Institutions by identifying disease problems in rice and timely control to manage them.

Methodology

The Rice Pest Corner is an application that will be developed for insect and disease (pest) management of Rice. Most of the materials for application such as rice insects, disease and their preventive measures will be collected from Entomology and Plant Pathology Division and other different sources and all information will be prepared in both Bengal and English language. It will be easy to understand and an interactive tool for farmers, extension workers, scientists/researchers, teachers, students and other users who want to learn and control insect & disease-related problems on rice.

Objectives

1. To develop Rice Pest Corner for BRRI Website.
2. To develop a Web Application for Rice Pest Corner.
3. To manage and maintain Rice Pest Corner.

Progress

Developed ‘Rice pest corner’ with the information of insect and pest and disease management (Fig. 47). It has been developed for farmers, extension workers, scientists, researchers, teachers, students and other users who want to learn and control insect and disease and other problems that can occur in rice.

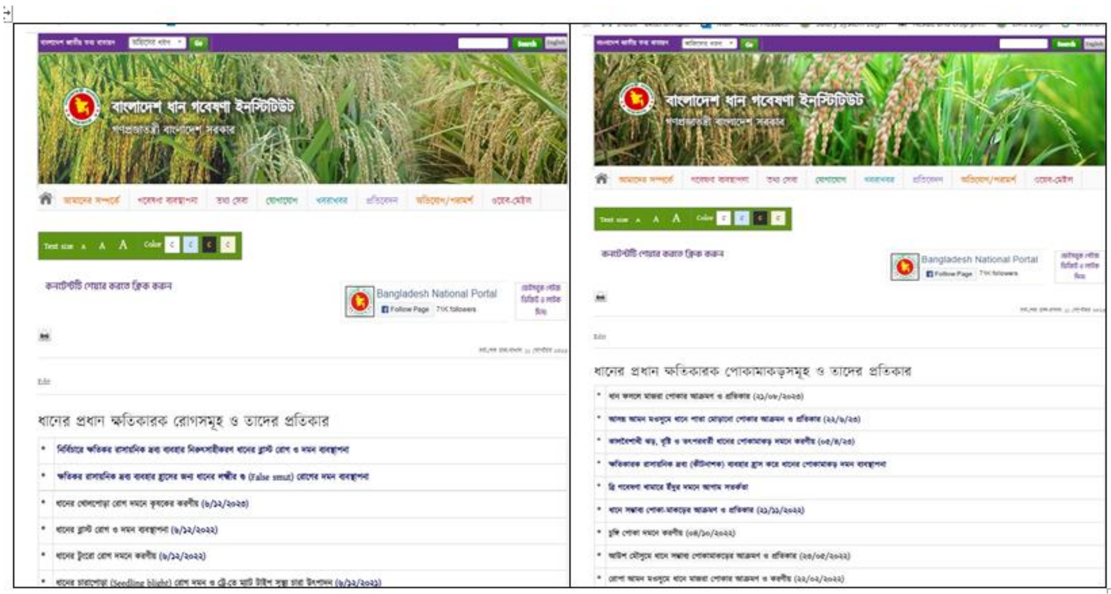


Fig. 47: Rice Pest Corner

Activity 8.24: Heritage of BRRI

- Mrs. Kabita, Md. Ismail Hossain, S. M. Mostafizur Rahman, Md. Mahfuz Bin Wahab, Nuraiya Kulsom, Md. Aminuzzaman, Md. Akhter Hossain

Introduction

Heritage is an essential part of the present we live in and of the future we will build. It is the full range of our inherited traditions, monuments, objects, and culture. So, ICT Cell of Agricultural Statistics Division included a menu named *Heritage* at BRRI web portal to remember all ex. scientists and officers' past activity and their memory by a short history. It includes, but is much more than preserving, excavating, displaying, or restoring a collection of old things. It is collection of almost retired scientists and officer's short biography and their past activity. Hence it is named *Heritage: History Archives of BRRI*.

Objectives

1. To develop "Heritage" for retired scientists, officers and staffs of BRRI.
2. To develop "Heritage "for research and administration works.
3. Create and stimulate awareness amongst the present employees of BRRI about ex. Scientists and officer's great activity so that they can follow their instruction and inform about their noble work.
4. Importance of preserving their all-past document as a digital document in the central web portal of BRRI.

Methodology

Basically, Heritage refers to something inherited from the past. So, ICT cell of Agricultural Statistics Division developed a menu named Heritage. Here, it has made individual pages (*http://www.brri.gov.bd/site/page/cdf8a394-1652-4607-a1d1-b87de15b20f8*) like retired DG and directors, retired CSO, PSO, Officers and retired staffs etc. It has included almost retired sscientists personal photo, short description and as well as a link where anybody can find about their detail information. Thus, it has made the "*Heritage*" because it is the broadest sense that which is inherited.

Progress

- Developed Heritage for all scientists, officers, staffs, and workers of BRRI as per requirement of the BRRI authority (Fig. 41).
- Developed individual webpage including picture of all scientists, officers, staffs and workers of BRRI
- Heritage is updated regularly. It is a routine work.

Fig. 41: Heritage at BRRI web portal

Support Services and ICT related fair

The scientists of this division are also engaged in helping scientists of other disciplines in planning experiments, statistical data analysis and interpretation of results. Sixty different types of analyses were performed during the reporting period. A number of maps were prepared using GIS and supplied to the scientists of other divisions whenever required.

Overall, ICT Cell of Agricultural Statistics division is providing e-Nothi system related support services to all research division, administration and procurement section. It is also providing BRRI heritage related support services such as updating data and uploading information to other divisions. Though it is an initiative in government perspectives but *BRRI Networks* Facebook group and Facebook page is a first introduced amongst all National Agricultural Research System (NARS) and also first among all research institute. It is regularly monitoring and updating with new information from any national and international newspaper or other sources. It is continuous process.

Otherwise, ICT Cell of Agricultural Statistics division is providing hardware, network and internet related support services to other divisions such as setup antivirus software, clean virus, update antivirus database and various troubleshooting related problem etc.

ICT Cell of Agricultural Statistics Division has been participated in several ICT and related fairs such as Digital World Fair, Development Fair, Tatha Mela and World Food Fair etc.