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Performance evaluation of climate resilient rice varieties for increasing productivity in flood prone area of Assam

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Abstract
An enormous amount of research has been conducted into the representation of climate change. Weather variability has emerged as a major challenge in the field of agriculture. The present climate change scenario requires sustainable agricultural practices. Northeast India has one of the most fragile ecosystems. The agricultural landscape of the region predominantly relies on rain-fed conditions. With the shifting patterns of rainfall, a rise in extreme weather events is anticipated, leading to a heightened frequency of both droughts and floods. Given its role as a basin in the mountainous northeastern region of India, the region is exceedingly susceptible to the profound impacts of climate change on agriculture. This study aims to assess the efficacy of site-specific technologies, such as stress-tolerant rice cultivars, in boosting farmers' resilience to flood-related challenges. The ability of agriculture to adapt to weather variations and climate change is crucial for ensuring the livelihood security of the numerous small-scale and marginalized farmers in the area. The research is centered on the traditional "Bao dhaan" variety, known for its capacity to thrive in submerged and deep-water conditions. Specifically, Bao dhaan exhibits resilience to submergence up to depths of 3 to 4 meters in low-lying regions with prolonged water stagnation exceeding 50 cm over a month. Local Bao dhaan strains demonstrate traits like stem elongation, submergence tolerance, and kneeing ability. The region grapples with recurring challenges posed by sudden floods, necessitating agricultural solutions that can withstand flash flooding and bolster climate-resilient farming practices. Introduction and demonstration of submergence tolerant rice varieties is one option to cope up with adverse climate variability. The paper elaborates on the varieties and the technological demonstrations of varieties which can sustain in flood prone areas.

Keywords: Sustainable, climate change, rice, varieties, flood and submerge

Introduction

The variability in weather patterns that contributes to climate change presents a significant challenge to the sustainable production of food grains to cater to the burgeoning population. Climate change projections for India up to the year 2100 suggest an overall temperature increase ranging from 2 to 4 degrees Celsius, with marginal changes in precipitation levels. However, distinct regions are anticipated to undergo varying alterations not only in the volume of rainfall but also in the distribution patterns in the ensuing decades (Kavikumar, 2010) [3]. In addition to the altered rainfall trends, it is projected that extreme weather events will escalate in frequency across the country, leading to heightened occurrences of droughts and floods. The climatic variability in Northeast India has already been recorded in terms of fluctuations in rainfall patterns, including a rise in the frequency of intense rainfall events resulting in localized flooding, diminished rainy days, and the emergence of mid-season or terminal dry spells (Deka *et al.*, 2013) [1]. Analysis of long-term rainfall data (1901-2010) indicates a notable downward trend in both annual and monsoonal (June to September) rainfall in the Brahmaputra and Barak basins of Assam (Deka *et al.* 2015) [2].

Indian agriculture, encompassing approximately 58% of its cultivated land as rainfed, is susceptible to recurring stresses arising from climatic variations and climate change (Kavikumar, 2010) [3]. Thus, the sector is expected to confront severe repercussions of climate change, with the North Eastern region of the country, particularly Assam, being highly vulnerable. Serving as a basin for the entire mountainous Northeast region and capturing 65 to 72 percent of the total monsoonal rainfall, Assam experiences recurrent flooding, with 45% of its territory identified as flood-prone (Department of Agriculture, Assam). Floods, water stagnation, flash floods, and subsequent sand sedimentation represent prevalent climatic vulnerabilities in most districts of Assam due to intense monsoonal rainfall coupled with irregular distribution. Enhancing the resilience of agriculture to effectively manage weather variability and climate change has become indispensable for ensuring the livelihood security of millions of small-scale and marginalized farmers in this region.

Rice is the staple food of Assam with an area of 2434000 ha

(Statistical Handbook Assam, 2018) and winter rice is the major crop cultivated during *kharif* season contributing about 73 percent of total rice production. The occurrence of multiple waves of floods during the *kharif* season affects *kharif* rice production in about 4.75 lakh hectares of land annually. The predominant rice mono-cropping by most of the farmers with small farm holding results in damage from monsoon floods. Flash floods not only result in significant damage to the standing rice crops but also adversely affect the soil by causing substantial silt accumulation in the fields, leading to permanent loss of fertile agricultural land. Assam has a long-standing tradition of cultivating a diverse range of rice varieties in various agro-ecological settings as a means of adapting to unfavorable climatic conditions. One such traditional farming practice involves cultivating deep-water or floating rice landraces, commonly referred to as Bao dhaan, which exhibit the ability to endure submergence at depths ranging from 3 to 4 meters in low-lying areas with water stagnation exceeding 50 cm for over a month during the season. Local Bao dhaan strains demonstrate traits like stem elongation, submergence tolerance (Sarma *et al*., 2009) [5], and kneeing ability. The *Bao* rice varieties are known to rich in mineral contents, but they are low yielder (1628 to 3000 kg /ha). However, the innate problem in most of the rice areas of Assam is occurrence of intermittent flash floods for 3 to 5 times in monsoon season, each of 7 - 15 days duration. In such situation farmers depend on early *Ahu* or summer rice to compensate loss of *kharif* rice crop, which is also submerged by flash flood water due to pre-monsoon rains at the time of harvesting leading to yield loss. Agriculture in most of the district, therefore, has become not only non-remunerative but also has become risky in recent times. Enhancing agricultural productivity in these areas requires demonstrating technologies that can withstand flash floods and help support climate resilient agriculture. Introduction and demonstration of submergence tolerant rice varieties is one option to cope up with adverse climate variability. Keeping in view of these constraints, Krishi Vigyan Kendras under Assam Agricultural University has been demonstrating site specific technology like stress tolerance rice varieties for enhancing the adaptive capacity of farmers to flood hazards under NICRA since 2012 and APART project.

Materials and Methods

Assam occupies tropical latitudes ranging from 24°08'N to 27°59'N and eastern longitudes from 89°42'E to 96°01'E. The presence of the Brahmaputra in the north and the Barak in the south, along with their numerous tributaries, establishes a dynamic and robust hydrological system in Northeast India, contributing to the occurrence of floods. Recognizing the significant issue of seasonal flooding, various climate-resilient rice cultivars such as submergence-tolerant Ranjit Sub 1, Bahadur Sub 1, Swarna Sub 1, staggered planted Gitesh, short-duration Luit, and Disand during the kharif season, as well as the rice variety 'Joymati' during the rabi season, have been trialed in farmers' fields across 17 districts of Assam under the NICRA initiative since 2012 and the APART projects since 2018. The performance of these cultivars and their adoption by farmers were closely monitored. Weather parameters were documented using secondary data and analyzed following standard methodologies.

Results and Discussion

Assam features a warm and humid climate characterized by an average annual rainfall of 2297.4 mm. The monsoon season in the region typically commences in the first week of June and extends through September. Throughout the year, the state receives approximately 2% of its rainfall in the winter season (January-February), 25% in the summer season (March-May), 65% during the monsoon season (June-September), and 7% in the post-monsoon period (October-December) (Economic Survey 2017-18). Notably, a significant proportion of rainfall occurs in the pre-monsoon period, resulting in a relatively dry winter (Rabi) season. The prevailing weather conditions have been observed to significantly influence the occurrence and severity of floods. Flooding events tend to recur two to seven times annually from mid-May to September. The duration and depth of inundation in rice fields vary across different locations within the study area.

Enhancing resilience of agriculture through situation specific rice varieties

Submergence tolerant rice varieties in flash flood affected area for sustainable production during flood

Due to the prevalent issue of flooding significantly hampering crop production during the kharif season in the project area, timely cultivation of winter rice (Sali) was impeded by floodwaters. Consequently, local late Sali varieties were predominantly adopted for cultivation. In a semi-deep rainfed lowland environment prone to flash floods, the introduction of a submergence-tolerant rice variety was deemed essential (Sarkar *et al*., 2009) [4]. The study focused on the introduction of rice varieties Swarna Sub 1, Ranjit Sub 1, and Bahadur Sub 1 to mitigate the impact of such weather-related hazards during the years 2018-19 and 2019-20.

Analysis presented in Table 2 revealed that the submergence-tolerant rice variety 'Swarna Sub 1' exhibited resilience to submergence conditions lasting up to 13 days, yielding an average of 44.42 quintals per hectare, representing an increase of up to 27.93% compared to local varieties. This variety was trialed across 387.89 hectares involving 1012 farmers in 11 districts of Assam, with 43.72% of farmers adopting the technology.

Data from the demonstration of the rice variety Ranjit Sub 1, spanning 16 districts and involving 2640 farmers across 1090.71 hectares, showed an average yield of 47.09 quintals per hectare, marking a 29.31% increase over local varieties. Adoption rate for this variety stood at 46.50% (Table 3).

Furthermore, the submergence-tolerant rice variety Bahadur Sub 1 was showcased across 528.81 hectares by 1452 farmers in 13 districts of Assam. This variety demonstrated a 26.30% increase in yield compared to local varieties, achieving an average yield of 46.77 quintals per hectare. Farmers cultivating this variety could earn a net return of Rs. 34,264.42 per hectare with a Benefit to Cost ratio of 1.89.

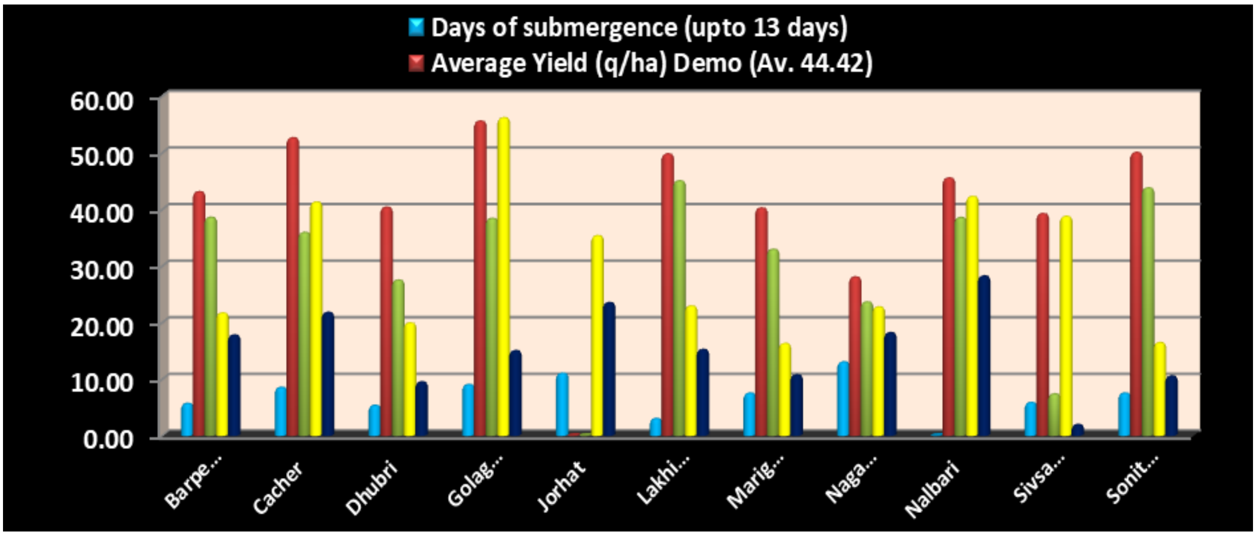


Fig 1: Performance of Swarna Sub 1 under the submergence condition.

The graphical demonstrations illustrate that the variety adopted in districts resulted in high yields. The variety was demonstrated in 16 districts by 2640 farmers covering an area of 1090.71 ha. The Golaghat district of Assam has shown maximum yield with the use of submergence technique.

Performance of Rice Variety: Ranjit Sub-1

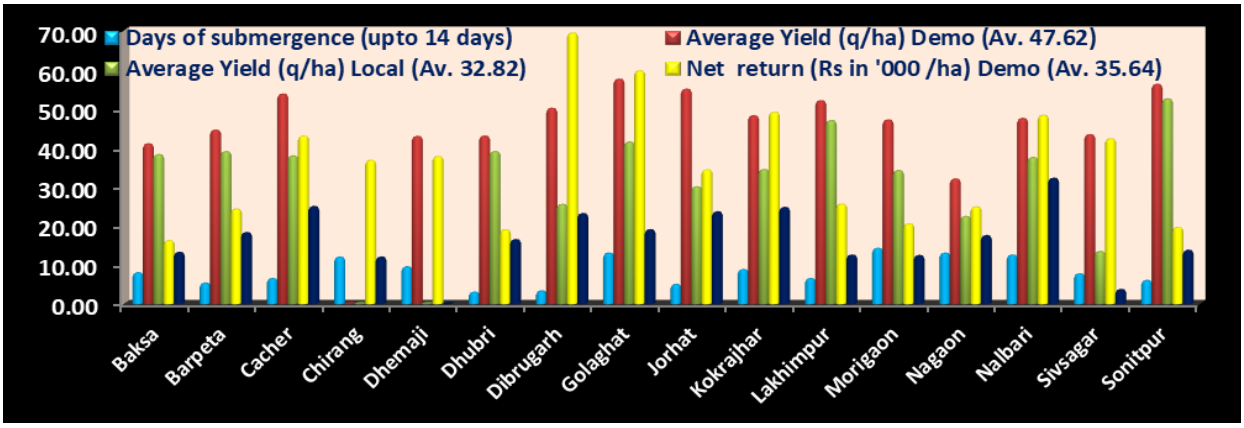


Fig 2: Performance of Ranjit Sub 1 under the submergence condition

The graphical demonstrations illustrate that the variety adopted in districts resulted in high yields. The variety was demonstrated in 16 districts by 2640 farmers covering an area of 1090.71 ha. The Sonitpur district of Assam has shown maximum yield but the net returns are low, whereas the Dibrugarh district has the maximum returns.

Performance of Rice Variety: Bahadur Sub 1

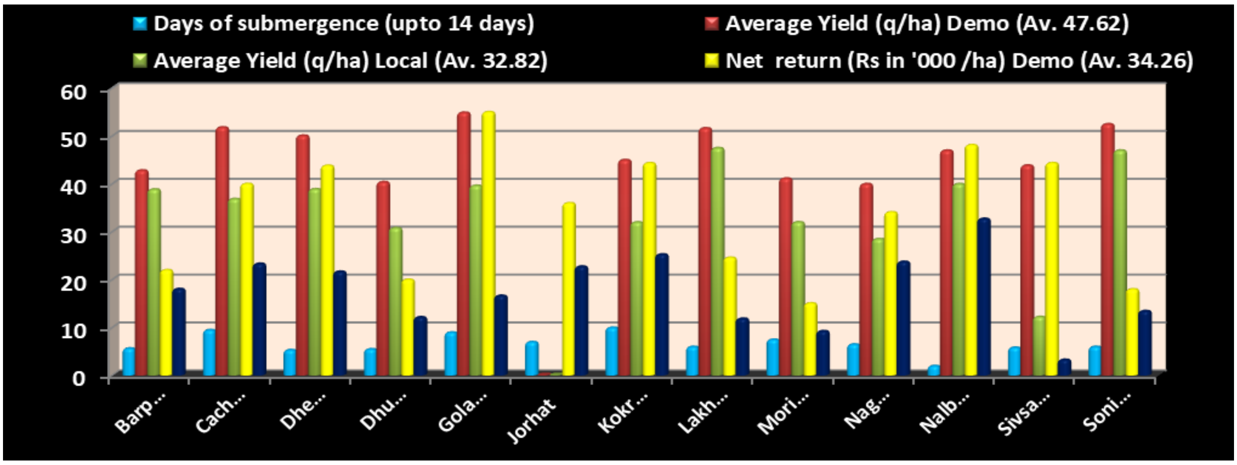


Fig 3: Performance of Bahadur Sub 1 under the submergence condition

The graphical demonstrations illustrate that the variety adopted in districts resulted in high yields. The variety was demonstrated in 16 districts by 2640 farmers covering an area of 1090.71 ha. The Golahat district of Assam has shown maximum yield and maximum returns.

Performance of staggered planting rice variety 'Gitesh'

The baseline survey highlighted that farmers faced losses due to their inability to transplant High-Yielding Varieties (HYV) of rice at the optimal time with seedlings of the appropriate age, primarily due to water stagnation. It also indicated that flood events resulted in damage to the Kharif rice crop between July and August, even if transplanting was feasible. To counter such challenges, farmers commonly employ strategies such as double transplanting using either traditional or improved varieties, or transplanting over-aged seedlings of photosensitive traditional Sali varieties like Panisali, Goyaswari, Malchira, etc., once floodwaters recede.

The adoption of traditional photosensitive rice varieties with older seedling ages has historically led to diminished yields (15 quintals per hectare). In response to this, a technological intervention was introduced in the form of the high-yielding rice variety 'Gitesh,' known for its flexibility in seedling age requirements ranging from 30 to 60 days (Sarma and Saikia, 2009) [5]. This variety was trialed in farmers' fields within the project area, demonstrating an average yield of 40 to 42 quintals per hectare for 45-day-old seedlings (Table 5). The adoption of the 'Gitesh' variety resulted in a significant increase in yield ranging from 42.02 to 62.16%, accompanied by higher net returns compared to existing varieties and practices.

Performance of short duration HYV rice 'Luit' for post and pre flood situation

Following the recession of floodwaters, farmers in the project area either cultivated traditional photosensitive low-yielding varieties until late August or left the fields fallow during the kharif season. Conversely, it was observed that farmers resorted to cultivating early ahu (summer) intruded rice varieties under irrigated conditions to offset losses incurred during the kharif season. However, this crop often faced challenges from flash flooding during harvesting due to its extended growth period. To address this issue, a short-duration, photo-insensitive rice variety 'Luit' (100-105 days) was introduced for demonstration in the project area to mitigate flood risks both pre and post-flood periods. The baseline survey indicated the absence of such short-duration rice varieties (100 days) being cultivated in the project area prior to the introduction of this particular variety.

The average yields of the rice variety 'Luit' per hectare were determined to be 30.0, 26.3, and 36 quintals in post-flood situations (kharif) and 23.35, 28.93, and 31.39 quintals in pre-flood situations (rabi) during the years 2013, 2014, and 2015, respectively (Table 5). 'Luit' exhibited commendable performance with higher net returns (Table 5) while effectively evading flood-related risks.

Performance of HYV of rice 'Joymati' during pre-flood situation

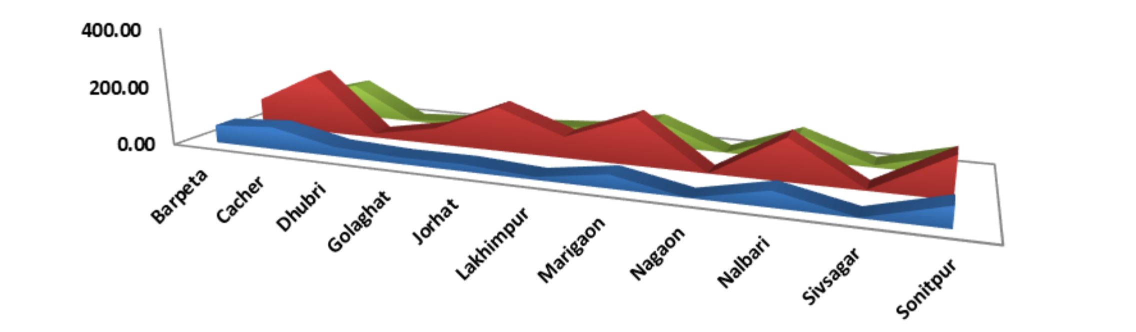
The cultivation of rice as Boro or early ahu (summer rice) emerged as a prevalent practice to mitigate losses incurred during the kharif season due to flooding. Farmers were noted to transplant early ahu rice in February using various non-descript varieties. However, this crop was frequently submerged by floodwaters during maturity, resulting in crop damage due to its prolonged growth period and short stature. In response to this issue, an intervention was introduced by introducing a new High-Yielding Variety (HYV) of Boro rice known as 'Joymati' to address the challenge. 'Joymati' rice variety exhibited characteristics of non-lodging behavior, increased plant height, and a yield potential of 5.1 tons per hectare.

Upon evaluation, it was observed that farmers could successfully harvest the 'Joymati' rice variety as it avoided flood damage by maturing relatively early and not being completely submerged during harvest time. The yields ranged from 42.37 to 50.76 quintals per hectare, showcasing an 11.30 to 55.2% increase in crop yield compared to existing varieties (Table 5).

Institutional Intervention for Climate resilient varieties in Village level.

Seed bank for quality seed production of situation specific rice varieties

Flood is the major constraints of crop production during *kharif* season where the NICRA project uner KVK Dhubri has been implemented. Different situation specific high yielding rice varieties have been introduced in the village to cope up with aberrant weather conditions since the inception of the NICRA projects. High yielding rice varieties of staggered planted 'Gitesh', submergence tolerant 'Swarna Sub 1', short duration 'Luit', summer HYV 'Joymati' etc were demonstrated and farmers had accepted these varieties due to special advantages of the varieties and comparatively higher yield over traditional varieties. However, farmers do not get quality seeds of such varieties in time.



	Barpeta	Cacher	Dhubri	Golaghat	Jorhat	Lakhimpur	Marigaon	Nagaon	Nalbari	Sivsagar	Sonitpur
Swarna Sub 1	61.17	76.35	32.00	22.13	23.38	9.75	44.00	0.28	50.75	1.83	66.25
Ranjit Sub 1	98.30	206.85	15.00	55.40	150.52	72.62	160.30	0.14	140.00	4.15	136.63
Bahadur Sub 1	60.7	118.3	5.52	18.8	26	40.75	88.5	0.839	86.5	7.9	68

Fig 4: Area covered under seed bank for quality seed production of rice varieties in different districts of Assam

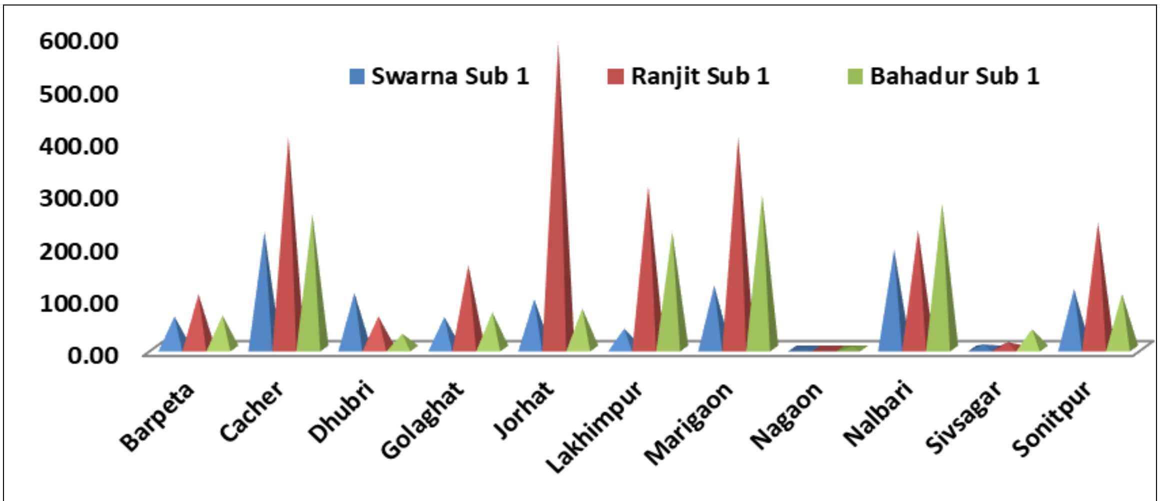


Fig 5: No. of farmers covered under seed bank for quality seed production of rice varieties in different districts of Assam.

Technological intervention: To solve the problem of quality seed in time, seed production programme for production of quality seed of high yielding staggered variety 'Gitesh', short duration rice variety 'Luit', submergence tolerant rice variety 'Jalashree', 'Swarna Sub 1', summer rice variety 'Joymati', and toria variety 'TS 36' etc was demonstrated in farmer's field under institutional intervention module of NICRA programme.

Fig 6: Pictures of the farmers' field demonstration.

Results: After introduction of seed production programme, farmers could grow suitable variety of rice matching with their agro ecological situation. Good quality of seeds for farmers becomes available in time.

Maintenance of Community nursery for post flood situation: Flood has been a major problem of NICRA village causing serious damage to transplanted rice. On the other hand, farmers cannot transplant *kharif* rice in time due to dry spell which is common in flood affected area. In both the situation, Farmers requires seedlings either for re-transplanting in post flood situation or staggered seedlings for delayed planting.

Technological intervention

In such situation, Community nursery had been maintained under NICRA project for supplying quality seedling of *Sali* rice variety 'Gitesh' or 'Luit' to the needed farmers.

Results

Farmers from NICRA villages under KVK Dhubri were supplied with seedlings of short duration rice variety 'Luit' in post flood situation for an area of 5 ha during 2016 and staggered seedling of 'Gitesh' was maintained for transplanting in 1 ha area in aberrant weather condition during 2012 -15.

Fig 7: Pictures of the demonstration plots.

Custom Hiring Centre

For ensuring timely availability of farm implement for various agricultural activities, a farm machinery Custom Hiring Centre was established in the NICRA village of Dhubri districts. The revenue generated from this centre was deposited in a bank account opened at UBI, Hakama branch, Bilasipara.

Resilient Varieties & Systems

In flood affected areas following module and resilient practices could be followed:

Module	Resilient practice	*Suitability of the practice in the village for farming situation
Staggered planting rice variety under aberrant weather situation	Staggered planting rice variety 'Gitesh'	Rain fed, medium land situations, temporary or shallow flooding/ moisture stress situations
Submergence tolerant variety of rice	Submergence tolerance rice variety 'Swarna Sub-1', Ranjit Sub 1, Bahadur Sub 1	Rain fed, lowland/ medium land, shallow flooding, prolonged (10 -15 days) situations
Short duration rice variety for post flood situation as late crop as well as for pre-flood situation to escape flood	Short duration HYV rice 'Luit' or Dishang under pre & post flood situation	Rainfed / irrigated, lowland/ medium land under pre & post flood situation
Semi deep water rice variety	Semi deep water rice variety 'Dipholu'	Rainfed, lowland, semi deep water situations
Water saving	System of rice intensification	Irrigated, lowland/ medium land situations, temporary or shallow flooding situations at harvest
Situation specific rice variety to escape flood damage	Summer rice variety 'Joymati'	Irrigated, lowland/ medium land situations, temporary or shallow flooding situations at harvest
Crop diversification	Crop diversification through Toria (Var. TS 36, TS 38, TS 48, 67)	Rain fed/ irrigated, lowland/ medium land situation during Rabi seasons
Crop diversification	Crop diversification through Summer Mung	Rain fed/ irrigated, lowland/ medium land situation during summer seasons
Contingency crop	Contingency crop Black gram	Medium land situations

Annexures

Table 1: Major contingencies of the project villages

Contingencies	Season			Regular			Sporadic			Crops affected most
	May - September	*October - January*	February - April	Severe	Moderate	Mild	Severe	Moderate	Mild	
Flood	√			√						*Sali* rice, Summer rice
Drought like situation		√						√		*Sali* rice, rabi crops
Hail storm	√		√	√						Summer rice, Jute, Banana, Areca nut

Table one depicts the rainfall pattern of the region and its affect on the crops

Table 2: Performance of climate resilient rice variety "Swarna Sub 1" under flash flood affected area

District	Area (ha)	No. of farmers	Days of submergence	Average Yield (q/ha)		% Increase in Yield	Cost of cultivation (Rs./ha)		Net return (Rs./ha)		B: C		Extent of Adoption by farmers (%)
				Demo	Local		Demo	Local	Demo	Local	Demo	Local	
Barpeta	61.17	61.00	5.67	43.07	38.53	11.82	35000.00	33666.67	21643.50	17754.00	1.66	1.52	25.67
Cacher	76.35	222.00	8.50	52.60	35.88	32.89	40375.00	33500.00	41225.00	21762.50	1.60	1.25	35.00
Dhubri	32.00	106.00	5.33	40.32	27.46	49.68	25190.16	23357.02	19884.04	9478.53	1.76	1.45	6.00
Golaghat	22.13	60.00	9.00	55.55	38.35	30.88	41080.00	34860.00	56132.50	14988.50	2.36	1.43	100.00
Jorhat	23.38	94.00	11.00	45-50	30-40	33.40	48003.00	27477.00	35297.00	23480.00	2.36	2.17	
Lakhimpur	9.75	38.00	0.00	49.75	45.00	10.55	45650.00	35550.00	22875.00	15200.00	1.50	1.43	0.40
Marigaon	44.00	120.00	7.50	40.19	32.89	21.76	37000.00	31818.50	16250.00	10700.00	1.43	1.34	95.00
Nagaon	0.28	2.00	13.00	28.00	23.60	15.71	19690.00	17700.00	22710.00	18160.00	1.15	1.02	40.00
Nalbari	50.75	188.00	0.00	45.50	38.50	7.00	29500.00	29500.00	42225.00	28178.50	1.58	1.30	26.50
Sivsagar	1.83	8.00	5.83	39.20	7.35	80.70	30303.84	11406.58	38701.91	1933.67	2.28	0.39	46.17
Sonitpur	66.25	113.00	7.50	50.00	43.75	12.85	27000.00	25000.00	16400.00	10500.00	1.70	1.51	62.50
	387.89	1012.00	6.67	44.42	33.13	27.93	34435.64	27621.43	30304.00	15648.70	1.76	1.35	43.72

Table two is a compilation of data of the cultivated land days of submergence and the yield across the districts of the state. The cost inculcated for cultivation and the net return is also calculated in the given table

Table 3: Performance of climate resilient rice variety "Ranjit Sub 1" under flash flood affected area

District	Area (ha)	No. of farmers	Days of submergence	Average Yield (q/ha)		% Increase in Yield	Cost of cultivation (Rs./ha)		Net return (Rs./ha)		B: C		Extent of Adoption by farmers (%)
				Demo	Local		Demo	Local	Demo	Local	Demo	Local	
Baksa	1.00	3.00	8.00	41.00	38.25	7.18	33000.00	32700.00	16200.00	13200.00	1.49	1.40	40.00
Barpeta	98.30	103.00	5.33	44.53	39.00	14.19	35166.67	33833.33	24283.00	18266.67	1.69	1.54	27.00
Cacher	206.85	401.00	6.50	53.75	37.88	31.40	40375.00	33500.00	43000.00	24963.00	1.64	1.39	46.00
Chirang	15.00	34.00	12.00	53 q	32q	0.66	29500.00	28000.00	36750.00	12000.00	2.25	1.43	0.35
Dhemaji	3.00	12.00	9.50	42.90	0.00	52.00	29820.00	0.00	37718.00	0.00	2.00	0.00	50.00
Dhubri	15.00	61.00	3.00	43.00	39.00	9.00	30350.00	28500.00	18985.00	16465.00	2.00	2.00	12.00
Dibrugarh	27.00	75.00	3.33	50.10	25.48	101.85	30833.33	27833.33	69366.67	23133.33	2.25	0.83	
Golaghat	55.40	158.00	13.00	57.57	41.44	27.94	41080.00	34860.00	59667.50	19005.50	2.45	1.54	100.00
Jorhat	150.52	582.00	5.00	55.47	32.54	30.20	48888.50	25223.50	34324.00	23596.00	2.43	2.07	
Kokrajhar	4.80	24.00	8.80	48.20	34.40	28.10	54179.80	47228.40	49068.00	24711.00	2.33	1.72	18.40
Lakhimpur	72.62	308.00	6.50	52.02	46.95	11.01	45650.00	33050.00	25530.00	12500.00	1.56	1.37	0.60
Morigaon	160.30	402.00	14.25	47.11	34.16	36.95	36500.00	32000.00	20482.00	12398.00	1.53	1.38	95.00
Nagaon	0.14	1.00	13.00	32.00	22.40	30.00	20180.00	16260.00	24820.00	17500.00	1.23	1.07	80.00
Nalbari	140.00	225.00	12.50	47.50	37.50	10.00	29500.00	29500.00	48287.50	32187.50	1.72	1.38	82.50
Sivsagar	4.15	12.00	7.71	43.36	13.41	69.25	33284.99	20090.01	42256.73	3695.91	2.28	0.66	36.71
Sonitpur	136.63	239.00	6.00	56.25	52.50	9.17	28900.00	28517.00	19550.00	13733.00	1.87	1.68	62.50
	1090.71	2640.00	8.40	47.65	32.99	29.31	35450.52	28193.47	35643.03	16709.68	1.92	1.34	46.50

Table three is a compilation of data of the cultivated land days of submergence and the yield across the districts of the state. The cost inculcated for cultivation and the net return is also calculated in the given table. The techniques adopted is also depicted in the table

Table 4: Performance of climate resilient rice variety Bahadur Sub 1" under flash flood affected area

District	Area (ha)	No. of farmers	Days of submergence	Average Yield (q/ha)		% Increase in Yield	Cost of cultivation (Rs./ha)		Net return (Rs./ha)		B: C		Extent of Adoption by farmers (%)
				Demo	Local		Demo	Local	Demo	Local	Demo	Local	
Barpeta	60.7	63	5.67	42.83	38.87	10.33	35166.67	33833.33	22004	18095.67	1.62	1.53	14.67
Cacher	118.3	255	9.5	51.825	36.875	29.74	40375	33500	40012.5	23362.5	1.565	1.32	35
Dhemaji	5	22	5.33	50.1	38.93	15.85	28604	23718.33	43816	21715	2.53	1.87	36.67
Dhubri	5.52	28	5.5	40.4	30.8	36.835	30350	25620	20010	12200	1.655	1.465	8
Golaghat	18.8	69	9	54.91	39.65	27.765	41,080	34,860	55,013	16,685	2.335	1.47	100%
Jorhat	26	76	7	50-60	30-40	36.6	52532	25970	35,981.00	22,781.00	2.46	2.14	
Kokrajhar	2	5	10	45	32	28.9	37328	34588	44347	25307	2.18	1.73	27
Lakhimpur	40.75	222	6	51.65	47.5	8.85	45650	31550	24600	11899	1.54	1.38	50
Morigaon	88.5	292	7.5	41.165	32.025	27.825	37000	30750	15,072	9,283	1.4	1.3	95
Nagaon	0.839	4	6.5	40	28.5	28.63	22630	17190	34090	23770	1.49	1.38	77.5
Nalbari	86.5	275	2	47	40	7	29500	29500	48125	32750	1.7	1.385	59
Sivsagar	7.9	37	5.83	43.88	12.25	71.31	32916.31	17579.66	44366.94	3309.35	2.35	0.6	39.5
Sonitpur	68	104	6	52.5	47	12.29	27550	26017	18000	13483	1.74	1.585	62.5
	528.81	1452.00	6.60	46.77	35.37	26.30	35437.08	28052.02	34264.42	18049.27	1.89	1.47	42.15

Table 5: Performance of situation specific rice varieties under aberrant weather condition in Dhubri district under NICRA project

Technology Demonstrated	Year	Average Yield (q/ha)		% Increase in Yield	Net return		B: C	
		Demo	Local		Demo	Local	Demo	Local
High yielding delayed planting rice variety 'Gitesh'	2013-2014	42.00	25.90	62.16	23,448	8058	1.87	1.35
	2014-2015	40.50	27.00	50.00	21,400	9350	2.10	1.52
	2015-2016	40.05	28.20	42.02	17319	9382	1.76	1.50
Short duration HYV rice variety under post flood situation - 'Luit'	2013-2014	36.00	-	-	17937	-	1.71	-
	2014-2015	26.30	-	-	9,050	-	1.52	-
	2015-2016	30.00	-	-	13500	-	1.78	-
Short duration HYV rice variety under pre- flood situation - 'Luit'	2013-2014	31.39	-	-	13577.86	-	1.83	-
	2014-2015	28.93	-	-	13821	-	1.61	-
	2015-2016	23.35	-	-	6270	-	1.42	-
HYV of rice under pre flood situation -'Joymati'	2013-2014	42.37	27.30	55.20	20767	9167.95	1.96	1.50
	2014-2015	50.76	44.40	14.32	26374	21640	2.08	1.95
	2015-2016	47.75	42.90	11.30	24258	13,849	1.94	1.58

Demo indicates Demonstrated plots; Local indicates farmers' practices

Conclusion

With the evolving climate scenario, the frequency of extreme weather events is anticipated to rise nationwide, particularly in the northeastern region, leading to increased occurrences of droughts and floods. Analysis of rainfall patterns in Assam and the region reveals that a significant portion, ranging from 65 to 72%, of the total annual rainfall is received during the monsoon period spanning from June to September, consequently resulting in recurrent flooding incidents. Prolonged floods throughout the Kharif season pose a significant obstacle to achieving optimal yields and production, thereby jeopardizing the food security of a majority of small and marginal farmers in the state (85%). In response to these prevalent challenges affecting one-third of the rice-growing areas in Assam and other regions of the country, specific technological interventions have been successfully demonstrated and validated in various districts of Assam under the current project. To bolster agricultural resilience in flood-prone and submergence-prone areas, the introduction of high-yielding rice varieties with distinct attributes such as 'Gitesh,' 'Swarna Sub 1,' 'Ranjit Sub 1,' 'Bahadur Sub 1,' 'Luit,' 'Dishang' during the Kharif season, and 'Joymati' as early ahu varieties could prove beneficial. These varieties have shown promise in the present study and are likely to be embraced by farmers based on their agro-ecological conditions, as evidenced by the outcomes of the ongoing research.

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