

## LOCAL RICE VARIETIES IN CLIMATE VULNERABLE AREAS OF BANGLADESH: PROSPECTS AND BARRIERS

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**ABSTRACT:** Bangladesh is famous for its rice heritage and wide diversity. This rice diversity is declining rapidly since the introduction of modern varieties. Yet about one fifth of rice growing areas of the country is cultivated by local varieties. Statistics reveal that in 2011-2012 fiscal years, contribution of local varieties to country's total rice production was about nine percent. It proves that local rice varieties are contributing towards cereal self-sufficiency as well as food security of the country. Moreover, some studies suggest that local rice varieties offer solutions to numerous climate change impacts. However, the importance of local rice varieties has not been assessed holistically from the perspective of sustainable agriculture including climate readiness. Based on expert interview, focus group discussion with community people and document analysis, this qualitative study aims to explore the prospects and barriers of promoting local rice variety for sustainable as well as climate resilient agriculture. It has been found from the analysis that local varieties are now cultivated only in those areas where the farmers have no other varietal options. Farmers also cultivate local varieties to avoid loss and it requires lower level of investment. However, negligible research, policy and extension supports are available for farmers to use local rice variety. The study, which has implications for researchers and practitioners promoting sustainable agriculture, argues that more areas should be brought under rice if desired varieties of local rice seeds can be ensured.

**Keywords:** Rice Varieties, Climate Change and Climate Readiness, Bangladesh, Food Security, Sustainable and Climate Resilient Agriculture

### 1. BACKGROUND

Rice has a central part of Bangladeshi culture, livelihoods and even festivals. As such farmers in Bangladesh always tend to keep cultivation of rice. Climate change has created new and additional threat for the cultivation of rice as the frequency and magnitude of slow and rapid disasters are increasing and thus causing vulnerable situation for the production of rice in many parts of the country. Climate change has different implications for the north, south and central part of the country. In the southwest of Bangladesh salinity intrusion, flood in the central part and drought in the north are gradually increasing. These are causing increased vulnerability for rice cultivation in these areas highly vulnerable to climate change. There are numerous indigenous rice varieties cultivated all over Bangladesh and those have the potential to cope with adversities. These traits are valuable for present and future sustainability of rice cultivation in Bangladesh considering the climate change impacts. It is argued that some local varieties could sustain in the vulnerable areas. However, comprehensive studies are absent to substantiate such argument. This study tries to explore whether this argument is valid or not to explore prospects and barriers of local rice varieties in climate vulnerable areas of Bangladesh.



## 2. LITERATURE REVIEW

IPCC Fifth Assessment Report concluded that climate change is affecting all aspects of food security and agriculture and those impacts on crop yields are already evident across several regions of the world. This suggests that the pace of adaptation needs to speed up (2014).

Plant genetic resources will be vital in adapting crop production to the effects of climate change. Diverse species, varieties and cultivation practices allow crops to be grown across a wide range of environments. Over 10,000 years, diverse genetic resources have enabled farmers to adapt to gradual climatic changes and to other shifting demands and pressures. Traditional crop varieties are well adapted to current conditions in their local production environments. The challenge for the future is to maintain a good match between crops and production environments as the effects of climate change increase. Crop wild relatives will be a key resource in meeting this challenge, as their genes can promote resistance to many of the environmental stressors associated with climate change. Climate change may increase the importance of plant species that have previously been underutilized or considered to be of minor importance (Jarvis *et al*, 2009 in IPCC, 2014). Crop varieties that will be required for changing climatic condition will have to come from the existing genetic resources. Crop production in all countries relies on genetic resources sourced from all over the world. This interdependency is likely to increase as a result of climate change (FAO 2015a).

Tackling climate change is central to achieving a sustainable future for our growing population and also food security. Within the United Nations Framework Convention on Climate Change (UNFCCC), the preparation of National Adaptation Programmes of Action has enabled least developed countries to identify and address urgent and immediate priorities with respect to adaptation to climate change. The UNFCCC Least Developed Countries Expert Group prepared technical guidelines (UNFCCC, 2012), which provide an overall approach that can be used by countries to identify and implement adaptation measures that help respond to the effects of climate change. The guideline seeks to ensure the relevance of genetic resources for food and agriculture (GRFA) to the overall national adaptation planning process in a country by identifying clear goals for conservation and use of GRFA as part of national adaptation to climate change, and ensuring the fullest involvement of all stakeholders (FAO 2015b).

Bangladesh is famous for extensive rice biodiversity. The farmers have long been growing vast number of traditional land races with different quality of grains, resistance to number of diseases and insects and with varying growing conditions, due to its diverse agro-ecological conditions. It is reported that the IRRI Gene Bank contains more than 8,000 traditional rice varieties collected from Bangladesh. Many of these land races such as Lati Shail and Niger Shail have been used by rice breeders as donors to develop elite lines that have been used as parents for popular improved rice varieties grown throughout Asia. In the Gene bank of Bangladesh Rice

Research Institute (BRRI) about 4500 indigenous rice varieties of Bangladesh origin and 3500 collected varieties are preserved. Apart from BRRI, few non-government organizations are also involved in conservation and research on indigenous rice varieties.

As a result of the introduction of modern varieties, many indigenous rice varieties have completely disappeared or on the way of extinction. The main reason is the substantially higher yield and profitability of improved varieties compared to the traditional landraces which are very low-yielding and take long time to mature. Yet farmers' conservation of rice genetic diversity has continued managing landraces in the agro-ecosystems and communities where they have evolved historically. Despite of low yield one of the major reasons for continuing production of local varieties is varietal adaptation to soils and other environmental factors.

The total number of landraces as well as the area planted to landraces in Bangladesh is declining over time. However, several traditional varieties are still popular among farmers/consumers due to their special traits. They are maintained in small areas as special purpose rice (such as kalizira for polao), for superior grain quality that fetches high price in the market (such as Kataribhog) or for tolerance to extreme environmental stresses (such as Motadhan in the coastal areas). Hossain *et al.* (2009) reported that farmers in Bangladesh still cultivate more than 1,000 traditional varieties/landraces.

The Bangladesh Agricultural Research Council (BARC) has identified Priority Researchable Areas/Issues for Rice (*Oryza sativa* L.) (2011). These include the following as well-

- a) collection, evaluation, characterization and conservation of germplasm/genetic materials; and
- b) More productive rice – based cropping system with best management practices for different rice ecosystems

Collection, evaluation and characterization and conservation of germplasm has been identified as basic research with high priority with long research duration under Rice Production - Varietal Improvement theme. On the other hand, more productive rice-based cropping system with best management practices for different rice ecosystems was identified as applied/adaptive research with high priority with short-medium duration under Rice production management practices.

Evaluation of genetic diversity is important to know the source of gene for a particular trait within the available germplasm. There has been several researches by rice scientists in recent times. Most of the researches are focused on genetic divergence in landraces. BRAC has documented and published a report titled 'Rice Biodiversity in Bangladesh: Adoption, Diffusion and Disappearance of Varieties: A Statistical Report from Farm Survey in 2005'. The survey found that there still exists diversity of rice varieties found in different region, particularly with respect to indigenous varieties. The survey found existence of 515 Aman rice varieties in practice including HYV, Hybrid and indigenous. The number of Aus varieties grown in 2005 in the survey areas was 295. Most of the Aus varieties were traditional land races. The

oldest document on indigenous rice varieties was done back in 1982 where a total of 12,487 local variety names including duplicates were listed season and thana-wise by Hamid *et al* (1982).

Rice production in the southwest of Bangladesh is facing the challenge of salinity intrusion and sea level rise. Majority of the researches so far done in Bangladesh on indigenous varieties are mainly focused in pursuit of salinity tolerance. A recent study (Islam *et.al*, 2015) identified that extinction and vulnerability of local rice varieties have negative impact on cultivation and production of rice. The study revealed about 36.3% cultivate high yielding varieties of crops such as BRRI dhan-28,30 and BR-10,11,22,23 and about 29.7% of the respondents cultivate different local rice varieties such as Purbachi, Jamaibabu etc. It reveals that cultivation of HYV rice varieties has gradually decreased due to the possible unavailability of saline tolerant HYV rice varieties. Besides, cultivation of local varieties will increase with the increase of SLR. Another study (Mostofa *et al*, 2014) concluded that traditional rice landraces from coastal Bangladesh are adapted not only to soil salinity but also to excess magnesium, calcium and sulphate as well as zinc deficiency. They can also tolerate water inundation to a certain extent, because they may be subjected to tidal saline intrusion as well as water stagnation during the monsoon season. These landraces are diverse with respect to their morphology, saline stress response as well as yield components. The authors suggested that characterization of these land races can suggest how they survive in adverse soils and indicate suitable target genes for transfer to modern rice varieties.

A study was carried out to analyze genotypic variations in different salt tolerance of indigenous rice at germination and early seedling growth (Mondal *et al*, 2015) The seeds of eleven indigenous (aman) rice genotypes and four salt concentrations (distilled water, 5, 10, 15dSm<sup>-1</sup>) were used as salt treatments. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Results showed that with the increase in salinity levels, germination parameters (germination percentage, germination energy, germination capacity, germination speed and seedling vigor index) and seedling growth parameters (seedling growth rate, shoot length, root length, dry weight) were decreased. The seedling growth parameters are relatively more sensitive to salinity than the germination parameters. Among the genotypes, Nara Jamainaru was superior to others considering germination parameters and growth parameter.

Most of the scientific researches by different national and international organizations are basically focused on HYV and their potential tolerance of salinity, drought and flooding. In a recent study fourteen rice genotypes, composed of six salt tolerant, three submergence tolerant, two drought tolerant genotypes along with three high yielding genotypes, released from Bangladesh Rice Research Institute (BRRI) were used for genetic diversity analysis using 40 simple sequence repeats (SSR) markers (Islam *et al*, 2012). Another notable study (Islam *et al*, 2013) has analyzed progress of salinity tolerant rice variety development in Bangladesh. In this study mentioned that development of BRRI dhan47, BINA dhan8, BRRI dhan53 and BRRI dhan55 for dry season was a major breakthrough for breeding salt tolerant rice in Bangladesh. BRRI dhan47 can tolerate EC 12 to 14 dS m<sup>-1</sup> salt stress. The potential yield of the

varieties ranged from 5.4 to 8.3 t ha<sup>-1</sup> in different saline prone areas. It has mentioned that current efforts are to use advanced tools such as marker assisted selection (MAS) and marker assisted backcrossing (MABC) to introgress SalTol QTL into BR11. MABC for BRRI dhan28 was completed at IRRI. All of these introgressed lines are tested in the farmer's field in coastal regions. The principal focus was to pyramid multiple stress tolerant genes into mega-varieties of rice to ensure better adaptability in coastal salt affected areas.

Based on the short literature review it can be concluded that there are some researchers have strong positive attitude regarding local rice varieties. On the other hand institutional scientists are reluctant regarding indigenous varieties, while they are too much focused on economic performance. Thus this research would like to focus on the subsistence perspective with climate readiness to identify prospects and barriers of local rice varieties in climate vulnerable areas of Bangladesh.

### **3. METHODOLOGY**

The study was conducted by adopting qualitative methods of data collection and analysis. In the whole methodology, participatory approaches were emphasized. Literature review, field visits, focus group discussions were the major tools employed for collection of information. Field visit was conducted in Barguna, Manikganj, Satkhira, Khulna, Pabna, Sunamganj, Naogaon and Rajshahi areas. Key informant interview were conducted with scientists at BRRI and IRRI.

### **4. FINDINGS**

In Bangladesh the rice-growing environment has been classified into three major ecosystems based on physiography and land types. These ecosystems are a) irrigated, b) rain fed, and c) floating or deep water. The rain fed ecosystem has been further classified as rain fed lowland and rain fed upland. Thus, all rice varieties cultivated in the country are grouped into five distinct ecotypes such as a) Boro, b) Transplanted Aus (T. Aus), c) Transplanted Aman (T. Aman), d) Upland Aus (direct-seeded Aus), and e) Deep water rice (Floating rice). Boro rice is grown completely under the irrigated ecosystem during the dry period (November to July) while T. Aman (during July to December), T. Aus (during April to August) and Upland rice (during March to July) are grown under the rain fed ecosystem. Of the total 13.8 million ha of cultivable land in the country (UNDP/FAO, 1988), 10.27 million ha (74.4 percent) are devoted to rice cultivation covering the above four ecosystems (BBS, 2014; Hamid, 1991). Besides these, special types of ecosystems like tidal wetland covering about 425 thousand ha and about 3.05 million ha of coastal saline soils are also included into the 10.27 million ha of rice land.

Flood, drought and salinity are the main stressors for rice cultivation in Bangladesh. Floods may incur heavy damage to Aman as well as Boro rice. Extreme temperature (high and low) may also be a problem in some areas of the country. In 2007, severe

yield decline of Boro rice was observed in Haor areas due to cold injury. In the same year hot wave caused sterility of Boro rice in Manikganj. Northwestern part of Bangladesh is treated as a drought-prone area for poor rainfall. It is one of the major abiotic constraints for rice grown (5.7 m ha) under rain-fed conditions in Bangladesh and causes a substantial reduction of yield. Coastal lands of Bangladesh are affected by varying degrees of salinity. About 1.02 million hectares in the coastal areas are affected by various degrees of salinity.

Bangladesh is famous for its rice heritage and wide diversity. This rice diversity is declining rapidly since the introduction of modern varieties. Yet about one fifth of rice growing areas of the country is cultivated by local varieties. Statistics reveal that in 2011-2012 fiscal year, contribution of local varieties to country's total rice production was about nine percent (BBS, 2014). It proves that local rice varieties are contributing towards cereal self-sufficiency as well as food security of the country.

#### **4.1. Existing Local Varieties in Saline Prone Coastal Areas of Bangladesh**

In Bangladesh, coastal areas constitute about 2.5 million hectares which amount to about 25 percent of the total cropland of the country. Of this, nearly 0.84 million hectares are affected by varying intensities of salinity, resulting in very poor land utilization (Karim *et al*, 1990). Most of the southern districts of the country are under saline zones, which cover an area of 25-30 percent of the total arable land. The average crop yield is very low in the region, which is obviously due to salinity problems, low soil fertility and drought in the dry season. The dominant crop in the coastal area is the local T-Aman rice. Although rice is the predominant crop of Bangladesh, modern rice cultivars tolerant to saline soils are few in number. The people of that area have been cultivating saline tolerant rice varieties for more than 100 years. The farmers of the coastal region usually cultivate traditional varieties and harvest about 2.0-2.5t/ha/year.

Pratapkathi is a village under Paikgacha upazila under Khulna district. The people of the area have been practicing shrimp-rice-cultivation for generations using their own methods and community wisdom. They have modified and adapted the techniques as a coping strategy to deal with the problem of salinity. They are familiar with local varieties since these have many positive characteristics. The taste, price and milling value are better than that of the HYV varieties. These rice varieties include Jotabalam, Ashfall, ghunshi and Benapol.

Field visit and discussion with farmers in Patharghata under Barguna revealed that there are differences in rice cultivation. In some villages there are no local varieties cultivated while three local varieties are in use in other village. Farmers in the village Char Padma said that they used to cultivate local variety KajalHai and SadaMota in the low lying areas. After devastating cyclone (Aila and Mohasen) huge area became unproductive due to saline intrusion. As a result majority of the farmers are fully involved with fishing. Now farmers are cultivating BRRI Dhan 54. In the village Char Lathimara farmers are still cultivating local rice variety namely Sadamota, Lalmota and Muthamota along with BRRI dhan 52 (saline tolerant) comparatively in low lands.

Interview with farmers in four coastal districts revealed Tekshoil, Kutepatnai, Tikepatnai, Birpala, Nuneshwer, Nonakhochhi, Raenda, Burimonteshwer, Sadamota are able to withstand with salinity condition at low to moderate levels.

#### **4.2. Deep Water Rice Varieties in Practice**

For deep-water environment and water stagnant condition we do not have any high yielding variety. The Director General of Bangladesh Rice Research Institute (BRRI) admitted that some sporadic work is going on to develop some deep water rice for shallow environment. But the achievement is not significant. In contrast, some research activities are in progress with the objective to develop a variety for water stagnant conditions. The work is still at the initial stage. Hence it can be concluded that indigenous deep water rice varieties are the only crop for low lying areas during monsoon season (Aman).

The deeply flooded wetlands cover 2.7 million hectares in Bangladesh (MPO 1987). These lands receive water from the east, west, and north through major rivers which flow from the Tripura, Assam and Meghalaya Hills in India. Depth of water ranges from 1 m to more than 5 m during the monsoon season. The major physical properties of the natural environment in these wetlands include indigenous floating or deep water rice (DWR) varieties (*Oryza sativa* L.), wild fish species, natural plant communities of submerged and rooted floating species, swamp forest trees, waterfowl and other wildlife.

Deep water rice is a very long duration crop sown in March/April and harvested in November/December. This rice requires a special habitat of prolonged flooding. The varieties are strongly sensitive to photoperiod and low filtering, producing a very high amount of biomass but with the least harvest index. The most important constraints of this rice are lack of varieties with high yield potential, unpredictable flooding, and low response to fertilizers.

In low lying areas of Manikganj and Pabna, farmers have no other options other than local varieties. As there is no deep-water HYV variety local varieties are the only solution. Hijoldigha, Molladigha, Kaika, Vasa dhan, Dhepodhan and many other local varieties are still in practice for Aman season in the flood prone areas of central Bangladesh.

#### **4.3. Drought Tolerant Local Rice Varieties in Northwest Bangladesh**

The North-Western part of Bangladesh has been experiencing extreme hot weather and frequent drought conditions compare to the other parts of the country. Erratic rainfall pattern creates devastating and repeated droughts in this region and affects agriculture by substantial damage and crop losses (Karim *et al*, 1990). Especially, the high Barind Tract suffers from frequent drought situation due to irregular rainfall. A key development challenge in the drought-prone rain fed agriculture of the Barind Tract of northwest Bangladesh is to simultaneously improve the reliability and yield of

monsoon rice while improving total system productivity by increasing the area planted to drought-tolerant post rice crops (Hossain *et al*, 2013). In Rajshahi, Chapai Nawabganj and other High Barind areas rice is produced in three consecutive seasons. According to the farmers in the Barind Tract few varieties are drought tolerant. An experiment by Bangladesh Agricultural Research Institute revealed that in many years drought prevailed during flowering stage of T. Aman rice. As a result 11-34% yield loss occurred for local and 43-50% for modern T. Aman rice varieties.

Discussions with farmers in Chapainwabganj, Naogaon, and Rajshahi districts, local farmers have mentioned the following local varieties as drought tolerant. These are Sonashail, Batraj, Jhingashail, Malshara, Subondari, Hansraj, Biyanophul, Magurshahil, Randhunipagol, Chiniatab.

#### **4.4. Contribution of Indigenous Rice Varieties for Development of Mega Varieties**

It is found that a good number of indigenous rice varieties were used to develop mega HYV varieties like BRRI dhan-3 (Lotishail) and other varieties. A list is provided below-

- a) Latishail: BR 3: 1974 (Awarded internationally)
- b) Badshavogue: BR 5: 1976 (Aromatic)
- c) Khaskani: BRRI dhan 34: Aromatic
- d) Badsavogue: BR 5: Anti-oxidant (Dutta *et. al.* 2012)
- e) Latishail and Najirshail: Most used variety for breeding (Hossain *et al*, 2013)

#### **4.5. Prospects and Barriers**

Indigenous rice varieties in Bangladesh are adapted to stressed environments and often possess some unique genes which enable them to survive. Discovery of a unique protein kinase Pstol1 that enhances root growth to survive phosphorous deficient, drought-prone soils in the traditional Aus cultivar Kasalath and the submergence tolerance gene SUB1A in another Aus variety FR13A and their absence in the reference rice genome establishes the importance of conserving and exploiting traditional germplasm (Gamuyao *et al*, 2012; Septiningsih *et al*, 2009). Farmers in the region used to grow large number of local landraces with special characteristics. Many of these have already become extinct or are on their way to become so. The main reason for not planting these landraces is their low yield, long growth duration, lodging, and weak stems (Yesmin *et al*, 2014). However, it is important to consider the special traits of the traditional varieties since they possess traits which have allowed them to adapt to the native environment. Rice being the staple food of Bangladesh constitutes more than 70% of the total calorie intake and accounts for nearly 18% of the gross domestic product (GDP). In order to feed the

increasing population in the limited land area available for cultivation in Bangladesh, the need to increase rice production is urgent. Stress tolerant high yielding varieties, therefore, need to be developed. Adapted rice landraces and their diversity analysis can therefore be an important source of information for breeding programs geared to increasing rice productivity. However, responding to climate change impacts, sustainability and to be subsistence it is important to maintain the genetic diversity of rice that we have.

We know that we have preserved most of the local rice either in national or international gene banks. However, extreme climates might pose threat to gene bank collection. On the other hand there might be technical difficulties which might cause loss of these germplasms in gene bank. Hence, on-farm conservation of plant genetic resources will become increasingly important in the context of climate change. Conserving genetic resources in complex, diverse, risk-prone environments builds on natural and farmer selection, and helps to maintain a variety of genetic options that farmers can use as climates change and become more variable. Traditionally, conservation of plant genetic resources has focused mainly on ex situ conservation. However, it is now being recognized that a complementary approach, involving both in situ an ex situ methods, has advantages.

Interviews with farmers in many areas of Bangladesh reveal that farmers have lack of facilities to obtain local rice seeds, which they have abandoned years back. As there is no formal seed system for local landraces. So it is not possible to bring back those varieties to farmers again on in-situ conservation and experimentation. To ensure participation of farming communities to fight against climate change, it is likely that rice genetic resources particularly landraces will need to be exchanged between state and the communities. It will be important to ensure that these genetic resources can be accessed fairly and equitably by those who need them.

## **5. CONCLUSION**

Due to the declining of rice biodiversity it is essential to conserve varietal diversity through arrangements of adequate programme by the concern authorities for creating favorable attitude of farmers towards maintaining varietal diversity in rice. Access to gene banks and availability of rice varieties for farmers in fragile environments may help in in-situ conservation which will ultimately contribute towards tackling climate change impacts. Farmer's led, scientists led and farmer-scientist research, extension and collaboration could be better options in conserving and understanding of these valuable landraces we have inherited. In this regard "Voluntary Guidelines to Support the Integration of Genetic Diversity into National Climate Change Adaptation Planning" developed by FAO might be considered by the policy-makers.

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