

## EFFECTIVENESS OF RESEARCH-EXTENSION LINKAGE ON THE ADOPTION OF SALT-TOLERANT RICE VARIETIES IN COASTAL BANGLADESH

J. Nain<sup>1\*</sup>, M.H. Rahman<sup>2</sup>, M.A. Sarker<sup>2</sup>

### Abstract

Bangladesh's coastal regions face increasing soil salinity due to climate change, threatening rice production on more than 30% of cultivable land. Salt-tolerant rice varieties (e.g., BRRI dhan47, BRRI dhan67, Binadhan-8, Binadhan-10) offer adaptive solutions. However, adoption remains limited and uneven, partly due to weak research-extension linkages. This study investigates how effective coordination between research institutes (BRRI, BINA) and the Department of Agricultural Extension (DAE) influences adoption among farmers in Satkhira and Khulna districts. Salt-tolerant rice varieties offer a promising solution to the challenges of climate change and soil salinity in Bangladesh. A mixed-method study was conducted using survey data from 60 researchers and extension personnel (BRRI, BINA and DAE) and adoption data from 200 farmers in Satkhira and Khulna districts. Linkage performance was assessed across planning, management & implementation and monitoring & evaluation dimensions. Strong research-extension linkage was reported by 85% of respondents. Planning performance was the highest-scoring dimension, followed by management & implementation and monitoring & evaluation. Farmers with stronger linkages had significantly higher adoption scores (mean: 72.09 vs. 56.66). Binadhan-10 and BRRI dhan67 were the most adopted varieties. Strong research-extension linkage facilitates adoption of salt-tolerant rice technologies. However, dissemination challenges, particularly related to grain quality and seed availability remain.

**Keywords:** Research-extension linkage, Salt-tolerant rice, coastal area, Technology innovation and adoption.

### Introduction

Bangladesh has made remarkable progress in rice production over the past few decades, achieving near self-sufficiency despite mounting population pressures and limited arable land. Rice, the staple food of the country, accounts for nearly 70% of calorie intake and provides livelihoods for millions of rural households. However, the sustainability of this progress is increasingly threatened by climate-induced challenges. Among these, soil salinity in coastal regions poses one of the most pressing threats to agricultural productivity. Salinity intrusion, driven by sea-level rise, tidal surges, and upstream freshwater withdrawal, already affects more than 1.05 million hectares of cultivable land in southern

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<sup>1</sup>Adaptive Research & Extension Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202

<sup>2</sup>Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh

\*Corresponding author's E-mail: [poragbina@gmail.com](mailto:poragbina@gmail.com)

Bangladesh, reducing cropping intensity, yield potential, and overall farm income (Rashid *et al.* 2023). The situation is expected to worsen under future climate change scenarios, directly undermining national food security. To address these challenges, national agricultural research institutes such as the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Institute of Nuclear Agriculture (BINA) have developed a suite of salt-tolerant rice varieties including BRRI dhan47, BRRI dhan67, Binadhan-8, and Binadhan-10 (Rashid and Nasrin 2014). These varieties are specifically designed to withstand moderate to high salinity levels while maintaining acceptable yield levels. Despite their technical potential, the adoption of these varieties among coastal farmers has been uneven and often limited. Studies suggest that poor dissemination, weak institutional coordination, market disincentives and socio-economic barriers constrain their widespread use (Ma *et al.* 2024). As a result, many farmers continue to rely on traditional or less suitable varieties, leaving them vulnerable to salinity stress and crop failure. One critical factor influencing technology adoption in agriculture is the strength of research-extension linkages (Parven *et al.* 2023). Effective collaboration between research organizations and extension agencies ensures that new technologies are not only developed but also adapted to local needs, disseminated efficiently and evaluated systematically. The Department of Agricultural Extension (DAE) working alongside BRRI and BINA plays a central role in bridging scientific innovation and farm-level practice. Strong linkages enable timely flow of information, farmer feedback, and participatory problem-solving, while weak linkages can result in a disconnect between scientific advances and field realities. Globally, literature has emphasized that research-extension partnerships are crucial for technology adoption (Raufu *et al.* 2024), yet empirical evidence on their effectiveness in the specific context of climate-resilient rice technologies in Bangladesh remains limited.

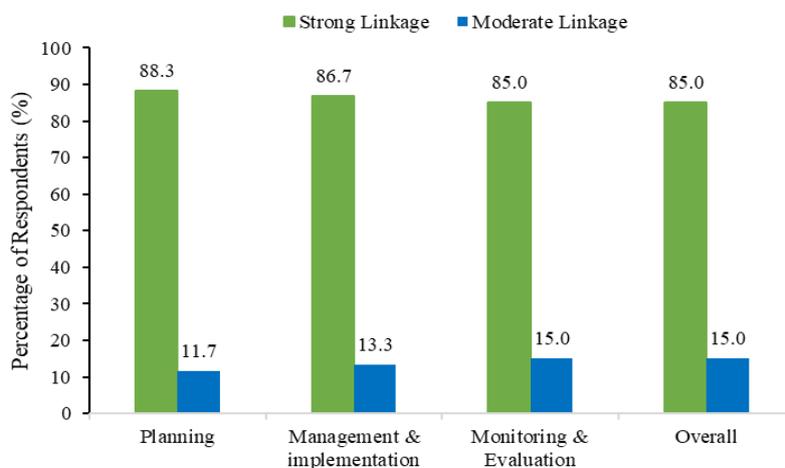
Given the vulnerability of coastal Bangladesh to salinity intrusion and the strategic importance of salt-tolerant rice varieties, it is essential to understand how institutional linkages influence adoption outcomes. While several studies have documented the agronomic performance of salt-tolerant varieties little attention has been given to the role of institutional effectiveness, coordination and linkage quality in shaping farmer adoption decisions (Haque *et al.* 2024). This gap is particularly relevant as Bangladesh seeks to strengthen its agricultural innovation system in line with national food security and climate adaptation strategies. Therefore, this study investigates the effectiveness of research-extension linkages in promoting the adoption of salt-tolerant rice varieties in selected coastal districts of Bangladesh. Specifically, it evaluates linkage performance across planning, management & implementation and monitoring & evaluation dimensions and examines how linkage strength correlates with adoption rates and outcomes among farmers.

## Methodology

This study employed a mixed-methods approach to assess the effectiveness of research-extension linkage on the adoption of salt-tolerant rice varieties. It was conducted in two coastal upazilas: Shymnagar in Satkhira and Paikgachha in Khulna. A total of 60 respondents comprising 40 researchers (20 from BRRI and 20 from BINA) and 20 extension personnel from the Department of Agricultural Extension (DAE) were selected. Structured questionnaires were used to collect data on planning, management & implementation and monitoring & evaluation indicators. Adoption data were collected through 200 farmers' interviews. Linkage strength was assessed using a scoring method and adoption rates were compared between strong and weak linkage groups. Data were analyzed using descriptive statistics and t-tests.

## Result and Discussion

The linkage performance between researchers and extension personnel was the main focuses of the study. Linkage performance as perceived by a respondent was measured by summing up a respective score in all ten statements regarding planning, management & implementation, and monitoring & evaluation of research-extension linkage activities. The observed range was 32 to 50 against the possible score from 10 to 50.



**Fig. 1. Categorically Research-Extension Linkage Performance.**

According to Fig. 1 an overwhelming majority (88.3%) of the respondents had the perception that there existed a strong research extension linkage while planning for such activities. Only 11.7% perceived a moderate linkage and no one thought that their existed a weak linkage. The results indicated that in planning performance of the researchers and DAE personnel had a strong linkage performance. Where, majority (86.7%) of the respondents had the perception that there existed a strong research extension linkage while

management and implementation for such activities. Only 13.3% perceived a moderate linkage and no one thought that their existed a weak linkage. The mean and standard deviation were 42.52 and 4.73, respectively. The result indicated that in management and implementation performance, the researchers and DAE personnel had a strong linkage performance.

**Table 1. Distribution of researchers and extension personnel according to their perceived planning, Management and implementation and Monitoring and evaluation performance**

| Linkage performance                       | Categories of the respondents with score range | Frequency | Percent      | Mean  | Standard Deviation |
|---|--|-----------|--------------|-------|--------------------|
| Planning performance                      | Weak linkage (10-23)                           | 0         | 0            | 43.77 | 4.63               |
|   | Moderate linkage (24-38)                       | 7         | 11.7         |       |                    |
|   | Strong linkage (39-50)                         | 53        | 88.3         |       |                    |
| Management and implementation performance | Weak linkage (10-23)                           | 0         | 0            | 42.52 | 4.73               |
|   | Moderate linkage (24-38)                       | 8         | 13.3         |       |                    |
|   | Strong linkage (39-50)                         | 52        | 86.7         |       |                    |
| Monitoring and evaluation performance     | Weak linkage (10-23)                           | 0         | 0            | 42.17 | 4.82               |
|   | Moderate linkage (24-38)                       | 9         | 15.0         |       |                    |
|   | Strong linkage (39-50)                         | 51        | 85.0         |       |                    |
| <b>Total =</b>                            |  | <b>60</b> | <b>100.0</b> |       |                    |

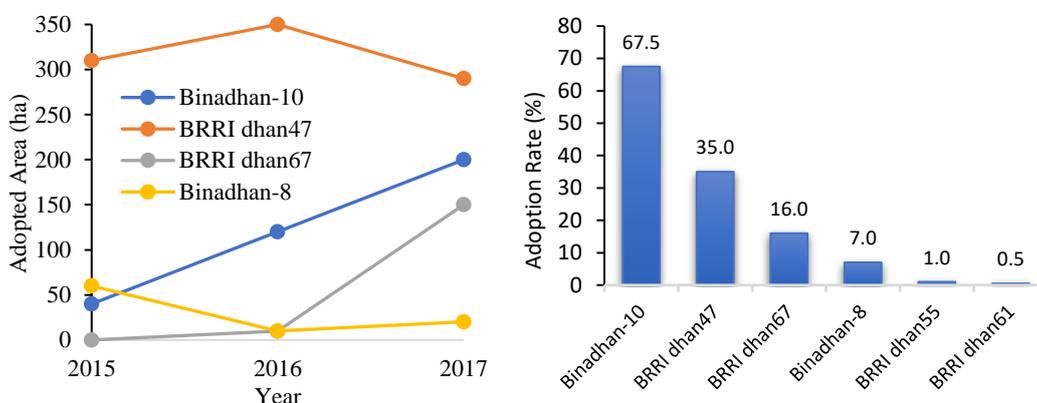
In management and implementation parts they have enough opportunity to implement their research agenda. The figure indicates that an overwhelming majority (85%) of the respondents had the perception that their existed a strong research extension linkage while monitoring and evaluation for such activities. Only 15% perceived a moderate linkage and no one thought that their existed a weak linkage. The mean and standard deviation were 42.17 and 4.82, respectively. The overall linkage performance is that a great majority (85%) of the respondents had strong linkage performance followed by moderate linkage (15%). It is interesting to note that no respondent was found to have weak linkage performance. The mean and standard deviation was 128.48 and 13.22, respectively.

Planning performance scored the highest with a mean of 43.77, followed by management and implementation (mean: 42.52), and monitoring and evaluation (mean: 42.17). Factors such as linkage activity, teamwork, and job satisfaction significantly contributed to overall linkage performance. Farmers with strong linkages showed higher adoption of salt-tolerant varieties, particularly Binadhan-10 and BRRI dhan67, compared to those with weak linkages. However, yield differences between the two groups were statistically insignificant. Varieties such as Binadhan-8 were less preferred due to coarse grain and shattering problems, while low market prices and limited seed availability emerged as major adoption constraints.

This suggests that while institutional collaboration is relatively effective in planning activities, weaknesses persist in translating these plans into consistent field-level implementation and in systematically assessing outcomes. Such imbalances have also been observed in other developing country contexts, where agricultural extension often prioritizes top-down planning over feedback-driven monitoring (Swanson and Claar, 1984; World Bank, 2014). The emphasis on planning reflects institutional strengths in project design, but weak follow-through risks reducing the long-term sustainability of technology dissemination.

**Effect on Adoption of salt tolerant rice varieties**

There were few numbers of salinity tolerant rice varieties have been field tested and released by the Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA). These varieties are BRRI dhan47, 55, 61, 67 and Binadhan-8, Binadhan-10. About 0.6 million ha out of total 0.87 million ha salinity affected area were found suitable for growing the salinity tolerant BRRI dhan47 and Binadhan-8 and Binadhan-10 in saline affected area of Bangladesh. There seems to be a good prospect for increasing the rice area and production in these salinity-affected districts by using the new salinity tolerant BRRI dhan47 and Binadhan-8 and Binadhan-10 by Singh (2014).



**Fig. 2. Variety-wise Adoption of Salt-Tolerant Rice Varieties (2015-2017)**

In order to have a clear understanding of the combined adoption of salt tolerant rice varieties, an overall adoption score was computed for each of the farmer by adding the score of salt tolerant rice varieties. Possible range of the overall adoption score of the farmers could range from 0 to 100, where 0 indicated no adoption and 100 indicated total adoption. Adoption of salt tolerant rice varieties of the strong and weak linkage of farmers was statistically highly significant (t value = 3.653\*\*). That’s means, the strong linkage farmers who has very close relationship with DAE personnel and frequently participate with different events of extension activities like; farmers observation trials, farmers training, field

days and agricultural fair etc. On the other hand, weak linkage farmers have poor relationship with different extension events.

**Table 2. Distribution of farmers according to their adoption**

| Categories      | Number and Percentage of the respondents |                      |                     | Mean & Standard deviation <sup>1</sup> |              |             | t-value (strong & weak linkage) |
|-----------------|--|----------------------|---------------------|--|--------------|-------------|---------------------------------|
|                 | Strong linkage (n=100)                   | Weak linkage (n=100) | All farmers (N=200) | Strong linkage                         | Weak linkage | All farmers |                                 |
| Low (up to 33%) | 7  | 22                   | 29                  | 72.09                                  | 56.66        | 64.37       | 3.653**                         |
| Medium (34-66%) | 33                                       | 33                   | 66                  | (26.33)                                | (33.05)      | (30.80)     |                                 |
| High (>66%)     | 60                                       | 45                   | 105                 |  |              |             |                                 |

\*\* t-value significant at 0.01 level of probability (p-value: 0.01)

The weak and strong linkage of farmers were grouped into three categories, such as low adoption (upto 33%), medium (34-66%) and high (>66%). For strong linkage farmers, the mean and standard deviation were 72.09 and 26.3, respectively and belonging the highest 60% of the respondents had high adoption of salt tolerant rice varieties, while 33% had medium and 7% had low adoption of salt tolerant rice varieties of the farmers. In case of weak linkage farmers, the mean and standard deviation were 56.66 and 33.05, respectively. On the other hand, for strong and weak linkages together, the mean and standard deviation were 64.37 and 30.80, respectively.

Farmers associated with strong linkage systems achieved significantly higher adoption scores (mean: 72.09) compared to weak-linkage farmers (mean: 56.66). Adoption was particularly strong for Binadhan-10 and BRR1 dhan67, both of which have shown high adaptability under saline conditions. These results corroborate earlier findings that institutional effectiveness is a key driver of agricultural innovation uptake in stress-prone environments (Ahmed *et al.*, 2016).

The distribution of adoption levels further highlights the importance of linkage strength; High adoption was achieved by 60% of strong-linkage farmers compared to only 45% among weak-linkage farmers. Low adoption was three times more common among weak-linkage farmers (22%) than strong-linkage farmers (7%). Medium adoption rates were similar across both groups, suggesting that factors beyond institutional linkage-such as seed price, quality, and household resource availability-moderate adoption intensity. These findings imply that while strong research-extension coordination shifts farmers from low to high adoption categories, it may be insufficient to overcome constraints that lock certain farmers in partial adoption modes.

Muttalab (2006) found almost similar result in his study; he observed that 42.00 percent of the farmers had medium adoption of modern rice cultivation practices compared

to 31.20 percent having low adoption and 26.80 percent high adoption. Hamidi (2004) also found similar result in his study; he found that 64.66 percent of farmers had medium adoption of integrated pest management practices in rice cultivation compared to 18.53 percent having low adoption and 16.81 percent high adoption. Mondal (2009) and Rahman (2005), Hossain (2006), Hossain (2004) found similar result.

These results suggest that research and extension actors are actively engaged in joint agenda-setting, problem identification, and implementation processes. The strong perception of linkage effectiveness demonstrates that collaborative structures between BRRI, BINA, and DAE are functional in ensuring the dissemination of salt-tolerant rice technologies. This aligns with earlier studies (Spielman *et al.*, 2012) that highlighted the importance of monitoring and evaluation in creating sustainable feedback loops between research and extension systems.

### **Yield Outcomes and Technology Performance**

Interestingly, yield differences between strong and weak linkage groups were minimal and statistically insignificant, despite higher adoption rates among the farmers. This indicates that adoption alone does not automatically translate into yield advantages. Several factors may explain this paradox:

1. **Seed quality and availability issues:** Many farmers reported poor access to high-quality certified seeds, leading to uneven performance across fields.
2. **Varietal limitations:** Certain varieties, such as Binadhan-8, faced rejection due to coarse grain and shattering problems, which reduce both yield reliability and market acceptability.
3. **Management practices:** Even when varieties were adopted, suboptimal agronomic management under saline conditions may have constrained yield gains.

This finding aligns with Rasheed (2008) and Chowdhury *et al.*, (2012), who stressed that varietal development must be complemented by input delivery systems and farmer training to realize yield potential.

### **Adoption Constraints**

The study identified grain quality concerns, low market prices, and limited seed supply as key barriers. For instance, coarse-grained varieties such as Binadhan-8 were less attractive to farmers despite their salinity tolerance, highlighting a persistent trade-off between stress tolerance and consumer preference. This reflects a broader pattern in varietal adoption where market signals often outweigh agronomic resilience in shaping farmer decisions (FAO, 1997). Moreover, weak seed supply chains limit farmers' capacity to scale

up adoption even when varieties are desirable, pointing to systemic gaps in Bangladesh's seed sector.

### **Institutional and Policy Implications**

The results underscore that strong research-extension linkages are necessary but not sufficient for widespread and sustainable adoption. While they enhance planning and accelerate uptake, adoption bottlenecks persist due to structural issues in seed systems, market dynamics, and varietal characteristics. Policymakers must therefore:

1. Strengthen implementation and evaluation mechanisms, ensuring that farmer feedback loops inform future varietal development.
2. Expand seed multiplication and distribution networks to ensure timely availability of preferred varieties.
3. Integrate market considerations (grain quality, price incentives) into breeding and dissemination strategies.
4. Enhance capacity-building programs to ensure that adoption is accompanied by appropriate management practices.

### **Conclusion**

This study demonstrates that strong research–extension linkages significantly enhance the adoption of salt-tolerant rice in the coastal districts of Bangladesh. Farmers engaged through effective collaboration between BRRI, BINA, and the Department of Agricultural Extension (DAE) exhibited higher adoption rates and a greater likelihood of being in the high-adoption category compared to those with weaker linkages. The results underscore the importance of institutional coordination in bridging scientific innovation and field-level practice, particularly in climate-vulnerable environments. However, the findings also reveal that adoption alone does not automatically translate into yield gains. Constraints such as limited seed availability, poor grain quality and weak market incentives continue to hinder the effectiveness of salt-tolerant varieties. While planning functions of the research-extension system appears strong gaps remain in management & implementation and monitoring & evaluation which restrict the feedback mechanisms necessary for continuous improvement. The implications are clear: strengthening research-extension collaboration must be accompanied by systemic improvements in seed supply chains, market development and varietal improvement programs to achieve sustainable impacts. In conclusion, effective research-extension linkages are necessary but not sufficient for climate-resilient rice adoption. To maximize their potential, they must be embedded within broader strategies that address input supply, market access and value-chain integration. Such an integrated approach will be essential to safeguarding food security and farmer livelihoods in the salinity-prone coastal regions of Bangladesh.

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