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An economic analysis of rice-based cropping sequence at NICRA adopted village in Darrang district of Assam

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Abstract
This research paper presents an economic analysis of rice-based cropping sequences in a NICRA (National Innovations on Climate Resilient Agriculture) adopted village in the Darang district of Assam. Climate change poses a significant threat to traditional agricultural practices in the region, jeopardizing food security and farmer livelihoods. NICRA's interventions aim to enhance agricultural resilience by promoting specific cropping patterns. The study evaluates the economic viability and sustainability of cropping sequences involving rice, a staple crop in the region, under changing climatic conditions. Data were collected through field surveys, farmer interviews, and secondary sources to assess the cost of cultivation, gross returns, net returns, and benefit-cost ratios of different cropping patterns.
The findings revealed that adopting diversified rice-based cropping sequences can significantly enhance farm income and resilience to climate variability. The rice-toria cropping sequence yielded in net profit of Rs. 70,609.64 with benefit cost ration of 2.10, whereas rice-fallow system accumulated a net profit of Rs. 27844.73 with benefit cost ratio of 1.53. The analysis highlights that integrating pulses and oilseeds with rice not only improves soil health but also optimizes resource use and increases economic returns. The study underscores the importance of policy support for promoting sustainable cropping systems and provides recommendations for enhancing the economic stability of smallholder farmers in the Darrang district.
Through this economic analysis, the paper contributes valuable insights into the potential benefits of rice-based cropping sequences in climate-vulnerable regions, emphasizing the need for adaptive strategies to ensure food security and sustainable agricultural development in Assam. The findings can inform future research on developing and promoting more resilient and productive cropping systems that address the specific needs of Assamese farmers. Additionally, the information can be used by agricultural extension services to provide targeted recommendations to farmers in the region.

Keywords: Rice-based cropping sequences, NICRA, Darrang district, Assam, economic analysis, climate change, agricultural resilience, farm income

Introduction
Agriculture in Assam is predominantly characterized by rice cultivation, which serves as the backbone of the state's agrarian economy. As the primary food crop, rice supports the livelihoods of a significant portion of the population, especially smallholder farmers. However, the traditional rice monocropping system, which involves cultivating only rice season after season on the same land, has led to several agronomic and economic challenges. These include declining soil fertility, increased pest and disease incidence, and heightened vulnerability to climatic fluctuations (Baruah *et al*., 2020) [2]. Moreover, Erratic rainfall patterns, rising temperatures, and increased occurrences of floods and droughts disrupt traditional farming practices, threaten crop yields, and jeopardize the livelihoods of countless Assamese farmers (Verma *et al*., 2016) [14]. In light of these issues, there is a pressing need to explore alternative cropping strategies that can enhance agricultural productivity, economic returns, and resilience to climate change.
The National Innovations on Climate Resilient Agriculture (NICRA) initiative, launched by the Indian Council of Agricultural Research (ICAR), aims to address these challenges by promoting climate-resilient agricultural practices across India.

NICRA's multi-pronged approach emphasizes promoting climate-smart agricultural practices, including the adoption of drought-tolerant crop varieties, water-efficient irrigation techniques, and diversification of cropping patterns. A central tenet of this strategy involves advocating for rice-based cropping sequences – integrated planting patterns that incorporate additional crops alongside the staple rice cultivation (Bhuiyan *et al*., 2017) [3]. One of the key strategies advocated by NICRA is the diversification of cropping systems, which involves integrating rice with other crops such as pulses and oilseeds.This approach is believed to enhance soil health, optimize resource use, and provide better economic returns compared to traditional monocropping systems (Das *et al*., 2018) [5].

The Darrang district of Assam, with its predominantly agrarian landscape and susceptibility to climatic variability, presents a unique case for studying the impacts of rice-based cropping sequences under the NICRA framework. Traditionally, farmers in this region have relied on rice monocropping, which has become increasingly unsustainable due to declining yields and profitability. Diversified cropping sequences, which involve growing multiple crops in rotation or simultaneously on the same piece of land, offer a potential solution to these problems by enhancing soil fertility, reducing pest and disease incidence, and improving economic returns (Hazarika and Bora, 2019) [8].

Crop diversification has been extensively studied and advocated as a means to improve agricultural sustainability and profitability. Several studies have demonstrated the benefits of integrating crops like pulses and oilseeds with rice. For instance, Hazarika and Bora (2019) [8] found that diversified cropping sequences not only improve yields but also enhance farm income by providing multiple sources of revenue. Similarly, Sharma *et al*. (2017) [12] emphasized that diversified cropping systems are crucial for maintaining soil fertility, reducing dependency on chemical fertilizers, and mitigating the risks associated with market and climate variability.Among these sequences, the combination of rice and toria (*Brassica campestris* L.) cultivation has emerged as a promising strategy to enhance agricultural productivity, profitability, and resilience to climate variability. Toria, also known as Indian rapeseed, is an oilseed crop well-suited for cultivation in the rice fallow period, offering rotational benefits such as soil fertility improvement and pest management

Despite the recognized benefits of crop diversification, there is a paucity of empirical evidence specifically evaluating the economic performance of rice-based cropping sequences in NICRA-adopted villages. This study aims to fill this gap by conducting a comprehensive economic analysis of various rice-based cropping patterns in a NICRA-adopted village in the Darrang district. By focusing on key economic indicators such as the cost of cultivation, gross returns, net returns, and benefit-cost ratios, this research seeks to provide actionable insights for policymakers, researchers, and farmers.

The relevance of this study extends beyond the Darrang district, as it provides insights that can be applied to other regions facing similar agronomic and economic challenges. By demonstrating the economic benefits of diversified cropping sequences, this research aims to encourage policymakers to support and promote sustainable agricultural practices that enhance resilience to climate change. Moreover, the findings can help researchers and extension workers develop targeted interventions and recommendations for farmers, ultimately contributing to improved agricultural productivity and economic stability in the region.

Materials and Methods

The present study aimed to work out the cost and return of rice-based farming system adopted by the respondent farmers along of NICRA village Kamapara of Darrang district of Assam. Medium duration rice variety Numali was followed by the toria variety TS-38 among the beneficiary of the project. 20 beneficiaries of the project and other 20 random villagers who followed solo rice cropping was selected and thus, total 40 households were finally selected for the study for collection of relevant data and information with respect to rice based cropping system.

To assess the economic viability of NICRA-promoted rice-based cropping sequences, this study employed a multi-pronged data collection approach. A purposive sampling technique targeted the villagers actively participating in NICRA's programs within Darrang district (Bryman, 2016) [4]. From the village, a random sample of farmers adopting the rice-based sequences was chosen for further investigation. Data collected through structured field surveys designed to capture details of the specific cropping sequences practiced, land allocation, production costs per crop, average yields under Darrang district conditions, and market prices for harvested produce (Dillman, 2007) [6]. Additionally, secondary data from NICRA reports, government agricultural statistics, and relevant academic sources supplemented the primary data collection. Comprehensive analysis involved descriptive statistics to understand the economic landscape, cost-benefit analysis to assess the profitability of each sequence, and comparative analysis to evaluate NICRA's sequences against traditional practices. Rigorous data management practices ensured confidentiality and anonymity throughout the research process.

The sample households were stratified in to threesize groups, on the basis of their farm size. As onlyfew farmers were found to have more than 3 ha of land hence, the stratification was done as follows:

Group I: Less than 1 ha
Group II: Between 1 - 2 ha
Group III: Above 2 ha

Table 1: Distribution of sample households according to the stratification

Sl. No.	Distribution of sample households according to the stratification							
	Cropping sequence		No. of respondents/group			Total	System duration (Days)	No. of households under different farming systems
	Kharif	Rabi	I	II	III			
1.	Rice	Fallow	10	7	3	20	140	60.47%
2.	Rice	Toria	12	6	2	20	230	39.53%
Total			22	13	5	40		

Different cost concepts were used to calculate the costs associated with the rice-based cropping system based on the data gathered. For the purpose of analyzing the returns from rice based cropping system various types of farm income and Benefit Cost ratio, Relative Economic Efficiency was worked out to determine the percentage change of net return of different cropping sequence over existing cropping sequence.

Cost concept: The different cost components used in the analysis were as follows.

Variable cost: It included labor cost, seed cost, machinery cost, fertilizer cost, insecticide cost, herbicide cost, irrigation cost, interest on working capital and other miscellaneous cost.

Fixed cost: It included interest on fixed capital, land revenue and other taxes, rental value of owned land and depreciation on farm implements and farm buildings.

Cost A_1= It included Total Variable Cost + Depreciation on farm implements + Land revenue

Cost A_2 = Cost A_1+ Rent paid for leased in land
Cost B = Cost A_2+ interest on value of owned fixed capital (excluding land) + imputed rental value of owned land

Cost C = Cost B + imputed value of family labour

Return analysis
The following types of farm income were considered for analyzing the returns from rice based cropping systems

Gross income (GI) = Quantity of total product X price of main product)

Farm business income = GI – Cost A_1
Family labour income = GI – Cost B
Net income = GI- Cost C

Farm investment income = Farm business income -imputed value of family labour

Net return over variable cost = Gross income- total variable cost

Benefit-Cost Ratio: Gross farm Income/Total cost

Relative Economic Efficiency (REE)
The relative economic efficiency (REE) of the system was calculated and expressed in percentage (Samanta T.K, 2015) [10].

REE% = (B− A)/A × 100Where, A = Net return of existing system & B = Net return of diversified cropping system.

The economics were computed as per market prices during crop season.
To ensure reliability and validity, the study followed rigorous protocols in data collection and analysis, adhering to methodologies outlined by similar studies in agricultural economics (Singh and Sharma, 2017) [12].
The study pertained to the FY 2023-24.

Results and Discussion
The economic analysis of the Rice-Toria (*Brassica campestris* L.) cropping sequence compared to sole rice cropping in NICRA (National Innovations on Climate Resilient Agriculture) adopted villages in the Darrang district of Assam provides crucial insights into the comparative economic performance and potential benefits for farmers. Through meticulous data collection and analysis, it was revealed that the Rice-Toria sequence outperformed sole rice cropping in terms of average net returns per hectare. The Rice-Toria sequence yielded an average net return of INR 70,609.64, while sole rice cropping yielded INR 27844.73per hectare.
Table 2 showed the per-hectare cost of the rice-based farming system under investigation. According to the study, the total cost per hectare for rice-fallow and rice-toria farming systems were found to be Rs. 52537.23and Rs.64190.58 respectively. In both cropping systems, hired and family labor accounted for the largest portion of the total cost.

Table 2: Cost of different Rice based farming system adopted (Rs/ha)

Particulars	Farming systems	
	Rice- fallow	Rice- Toria
Seed	1200.15 (2.17)	1985.93 (3.11)
Fertilizers, manures value of plant protection	6650.25 (12.82)	7790.91(12.59)
Hired labour	7670.20(14.59)	11200.20(18.00)
Other cost (including oil & machinery charge)	3540.21(6.85)	4550.25(7.38)
Interest on working capital	2440.90(4.71)	3050.85(4.94)
Total Variable Cost (TVC)	21501.71(40.93)	28578.14(42.93)
Imputed value of family labour	10550.85(19.77)	14000.55(22.50)
Depreciation on farm implements & farm buildings	1750.43(3.38)	1865.76(2.98)
Land revenue	88.70(0.17)	95.00(0.15)
Rental value of owned land	15090.22(28.96)	15550.67(24.93)
Interest on fixed capital	3555.32(6.80)	4060.60(6.57)
Total fixed capital (TFC)	31035.52(59.07)	35612.58(57.10)
Total Cost (TVC + TFC)	52537.23(100.0)	64190.58 (100.0)
Cost A_1	23340.84	30538.90
Cost A_2	23340.84	30538.90
Cost B	41986.38	50150.67
Cost C	52537.23	64151.22

Figures in parentheses are the percentage to the total cost

The variable cost of rice-fallow (Rs.21501.71) and rice-toria (Rs.28578.14) were less than the total fixed cost. There was no leased in or leased out land, as the values for Costs A_1 and A_2 were equal. The values of cost A_1 andA_2were estimated as Rs. 23340.84 for rice-fallow and Rs. 30538.90 for rice-toria cropping sequence. The value of cost B and cost C for rice-fallow and rice-toria cropping sequence were Rs. 41986.38, Rs. 52537.23and Rs. 50150.67, Rs. 64151.22respectively.

Table 3: Farm income from different rice based farming system adopted (Rs/ha)

Particulars	Farming systems	
	Rice- fallow	Rice- Toria
Gross farm income (GI)	80381.96	134800.22
Net farm income	27844.73	70,609.64
Family labour income	38395.58	84649.55
Farm business income	57041.12	104261.32
Farm investment income	46490.27	90260.77
Net returns over variable cost	58880.25	106222.08
Benefit-Cost ratio	1.53	2.10
REE (%)	-	153.58

The returns over cost were calculated for the different cropping sequences represented Table 2. In return analysis, it could be seen from the table that the net returns were higher in rice-toria than rice-fallow as high value crop like toria resulted in more net income. The gross returns were also higher in rice-toria cropping sequence (Rs. 134800.22) than solo rice cropping (Rs. 80381.96). The Table showed that rice-toria had obtained higher benefit cost ratio (2.10) compared to rice-fallow (1.53).

Statistical analysis employing paired t-tests unveiled a statistically significant difference ($p<0.05$) in net returns between the Rice-Toria cropping sequence and sole rice cropping. This underscores the economic advantages of diversifying cropping patterns and incorporating toria cultivation into the agricultural landscape. Qualitative assessments through farmer interviews further highlighted the resilience of the Rice-Toria sequence to climatic variability, particularly during periods of excess rainfall, where toria cultivation served as an effective risk mitigation strategy.

The findings of this study emphasize the economic benefits and resilience-enhancing potential of the Rice-Toria cropping sequence over sole rice cropping in NICRA adopted villages of the Darrang district. By diversifying cropping patterns and integrating toria cultivation, farmers can not only enhance their income and livelihoods but also mitigate risks associated with mono-cropping systems. The rotational benefits of toria cultivation, including soil fertility improvement and pest management, contribute significantly to its enhanced profitability and long-term sustainability (Singh and Sharma, 2017) [12].

Comparative analysis with sole rice cropping reveals the superior economic performance of the Rice-Toria sequence, underlining the importance of crop diversification in maximizing returns and enhancing agricultural resilience. These findings are consistent with previous research conducted by Sharma *et al*. (2019) [11], which demonstrated the agronomic and economic benefits of integrating oilseed crops into rice-based systems. The socio-economic implications of adopting the Rice-Toria sequence extend beyond financial gains, encompassing aspects such as food security, employment generation, and environmental sustainability.

Moreover, the adoption of the Rice-Toria cropping sequence aligns with the objectives of NICRA initiatives aimed at promoting climate-resilient agriculture. By diversifying crops, farmers can reduce vulnerability to climate-induced risks such as droughts, floods, and pest outbreaks, thereby enhancing the overall resilience of agricultural systems.

Conclusion

The study provides valuable insights into the economic dynamics of rice-based cropping sequences in NICRA (National Innovations on Climate Resilient Agriculture) adopted villages in the Darrang district of Assam. Through meticulous data collection, analysis, and comparison, it was demonstrated that crop diversification, particularly through the integration of toria (*Brassica campestris* L.) cultivation, offers significant economic benefits over sole rice cropping.

The findings revealed that cropping sequences involving toria cultivation, such as Rice-Toria, exhibit higher average net returns per hectare compared to sole rice cropping. Additionally, the Rice-Toria sequence demonstrates lower input costs, contributing to its enhanced profitability and economic sustainability. These results underscore the importance of diversifying cropping patterns to maximize returns and mitigate risks associated with mono-cropping systems. Moreover, the adoption of diversified cropping sequences aligns with the objectives of NICRA initiatives aimed at promoting climate-resilient agriculture. By integrating toria cultivation into rice-based systems, farmers can enhance their adaptive capacity to climate variability while improving their income and livelihoods. The rotational benefits of toria cultivation, including soil fertility enhancement and pest management, further contribute to the long-term sustainability of agricultural systems in the region.

Overall, the findings of this study have significant implications for agricultural policy and practice in Assam and beyond. By promoting crop diversification and adopting climate-resilient agricultural practices, policymakers and stakeholders can enhance the resilience of agricultural systems, improve food security, and sustain livelihoods in the face of climate change challenges.

Future research endeavors should focus on assessing the environmental impacts, including soil health and biodiversity, of diversified cropping sequences and exploring innovative strategies to further enhance the economic and ecological sustainability of agriculture in the region.

Conflicts of interest

The authors have no conflicts of interest

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