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RESEARCH ARTICLE

An Economic Analysis of Rice Based Cropping Sequence and Its Adoption Behaviour in Udalguri District of Assam, India

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ABSTRACT

Rice is the most important food crop of Assam, India with various rice-based cropping systems developed in diverse ecosystems of the state, including rice-fallow, rice-rice, rice-rapeseed (Toria), jute-rice, and rice-vegetables. With the increasing demand for food products over the past ten years, the adoption of double and triple cropping has gained attention as strategies to increase the farmers income. Intensifying the usage of existing agricultural land is one of the most important strategies to boost productivity and farm income. Net profit for farmers can be increased through crop diversification and intensification with productive and efficient crops like pulses, oilseeds, and vegetables. Inclusion of pulses, oilseeds, vegetables after cereal in rice based cropping sequence are more profitable than adding cereal after cereal. The study was conducted by Krishi Vigyan Kendra Udalguri in Udalguri district of Assam, India. A three-stage random sampling design was employed to study a total of 120 households for data collection on rice-based cropping systems. Costs involved in rice based cropping system were worked out using different cost concepts. For return analysis, various types of farm income and Benefit cost ratio, Relative Economic Efficiency was worked out to determine the percentage change of net return. A regression model was worked out to determine the adoption pattern. The findings indicate that incorporating pulses, oilseeds, and vegetables after cereal crops in the rice-based cropping sequence is more profitable than adding additional cereal crops. Among the tested cropping sequences in the study area, the Rice-Potato sequence emerged as the most viable option, capable of enhancing farm profitability and food production, particularly in rainfed medium land areas of Udalguri district of Assam, India. These findings provide valuable insights for improving agricultural practices and promoting sustainable farming in Assam.

Key words: *Cropping sequence; Cost and return; Adoption behaviour; Economic efficiency.*

More than 70 per cent of the population of Assam relies on agriculture as their primary source of income, which accounts for around 17 per cent of the state's GDP. The average operational holding of Assam is 1.11 ha and more than 75 percent farmers are small and marginal in nature.Rice is the most important cereal crop of Assam. The predominant rice based cropping systems in the state are mainly rice-fallow, rice-rice, rice-rapeseed (Toria), jute-rice and rice-vegetables etc. growing under varied ecosystems and the predominant cropping sequences are winter rice–fallow–autumn rice and winter rice–toria–fallow, where the diversification index is heavily influenced by rice (*Kalita et.al, 2018*). Besides, at farmer’s level, potential productivity and monetary benefits act as guiding principles while opting for a particular crop/ cropping system (*Baishya et al., 2016*).

Over the last decade, considering the growing demand for agricultural commodities double and triple cropping have become more focused points for increasing farmers' income. It is one way to expand production and increase the farm income by intensifying the use of existing agricultural land. Diversification and intensification of cropping systems with profitable and efficient crops like pulses, oilseeds, and vegetables has great potential to generate the maximum net profit per unit investment per unit time to farmers. In cropping system; inclusion of pulse, oilseed and vegetable is more beneficial than cereals after cereals. (*Kumpawat, 2001 and Raskar and Bhoi, 2001*)

Under Assam's climatic conditions, crop intensification and diversification with the wise use of the limited irrigation capacity available will result in higher yields and better net returns. In a cropping system, inclusion of pulses, oilseeds, and vegetable crops is preferable to cereals next after cereals. The only option left is to intensify and diversify the rice-based cropping system throughout the winter (rabi) and summer seasons as it is difficult to substitute rice with any other crop during the rainy season due to the soil and climatic conditions of NER of India, farmers preference. In the existing farming environment, cropping sequence must be intensified. Oilseeds, pulses, and vegetable crops are getting more attention due to higher prices due to rising demand.

Importance of prevailing rice based cropping system is recent days losing ground due to decrease in factor productivity. Therefore, identification of suitable rice-based cropping systems with higher resource use efficiency fitting to the local agro ecological situation is the need of hour for improving the profitability and employment generation in agriculture. Because of a decline in factor productivity, the importance of the existing rice-based agricultural system is currently declining. To increase the profitability of agriculture and create employment, it is imperative to find viable rice-based cropping systems with higher resource use efficiency that are compatible with the local agroecological context. Being a staple diet, rice is a crucial crop for the millions of people in Assam. However, rice-based systems in this area have low productivity, mostly as a result of the widespread biotic and abiotic stress due to rainfed farming. Every year million hectare of crop area are damaged by floods and droughts. In this stressed region, rice production is not only insufficient but also unstable. Farmers in this region are afraid of losing not just their crops but also their inputs in the event of a flood or drought, farmers in these locations utilise minimal inputs, further contributing to their low productivity and profitability

Agriculture is the main occupation of the inhabitants of Udalguri district and contributes a major part in the district economy which, however, is of subsistence type. Rice is the main crop which covers about 80 per cent of the gross cropped area. Farmers of the district are habitual in growing rice as mono cropping keeping field fallow after the harvest of the crop (*Ojah et al, 2020*). However, portion of farmers practices rice based cropping system mainly Rice-Toria, Rice-Jute, Rice-vegetables under rainfed medium land situation. But due to poor management practices and delay in sowing productivity is very low. In order to increase the system productivity, profitability, and cropping intensity of the district as well as the state, it is necessary to identify an appropriate rice-based cropping sequence.

METHODOLOGY

The study was conducted by Krishi Vigyan Kendra Udalguri in Udalguri district of Assam, India. The field investigation was started in the second week of March and completed by the middle of May 2021. The data collected pertains to the year 2021. The sampling design followed for the study is three stage random sampling design. Blocks formed the first stage unit, villages were the second and the sample farmers were the third and ultimate stage of units of sampling. From eleven development blocks, two blocks were randomly selected for the study. Thus, Udalguri Development Block and Rowta Development Block were selected as first units of sampling. In the next stage, three villages were selected from each block viz. Chamuapara, Dhuptol, Dongpara, Aminpara, Jhargaon no.1 and Borigaon. After selection of villages, the entire household from each village were listed and twenty household from each selected village were purposively selected. Thus, total 120 households were finally selected for the study for collection of relevant data and information with respect to rice based cropping system.

The sample households were stratified in to three size groups, on the basis of their farm size. As only few 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

Distribution of sample households according to the stratification

Cropping sequence	No. of respondents/group			No. of households under different farming systems	
	I	II	III	No.	%
Rice-fallow	50	5	-	55	45.83
Rice-toria	15	20	3	38	31.67
Ahu rice-Sali rice	-	-	5	5	4.17
Rice-potato	-	20	2	22	18.33
Total				120	

Both primary and secondary data was collected for analysis and interpretation. The primary data was collected on pre-tested schedule by adopting personal interview method from 120 respondents. Based on the data collected the costs involved in rice based cropping system were worked out using different cost concepts. For the purpose of analysing 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. To empirically quantify the relative influence of various factors in the decision of the respondents to adopt different cropping sequence, a regression model was worked out.

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

Variable cost: It includes labour cost, seed cost, machinery cost, fertilizer cost, insecticide cost, weedicide cost, irrigation cost, interest on working capital and other miscellaneous cost.

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

Cost A1 = It includes Total Variable Cost + Depreciation on farm implements + Land revenue

Cost A2 = Cost A1+ Rent paid for leasedin land

Cost B = Cost A2+ 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 A1

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 :

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

$$REE = B- A/A \times 100$$

Where, A = Net return of existing system

B = Net return of diversified cropping system.

Logistic regression model : This study has hypothesized that the probability of a farmer adopting cropping sequence (*Li*) depends on the attributeslike age, literacy level, farm size, income, access to input and access to extension services. The index variable Li indicating whether a farmer is adopting diversified cropping sequence or not and it has been expressed as a linear function of the independent variables. Thus, the logit regression model has been specified as Equation (1):

$L\,i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + ui$…(1)

Where,

Li = Index variable (Dichotomous variable, it takes the value of one if a respondent is adopting cropping sequence and otherwise, takes the value zero)

X_1 = Age of the respondent (years),

X_2 = Education level of respondents (years),

X_3 = size of holding (ha),

X_4 = Income of households (Rs),

X_5 = Access to extension service (measured index worked out on scale 1-5)

X_6 = Access to input (measured index worked out on scale 1-5)

β_0 = Constant,

βis = Parameters to be estimated, and

ui = Error-term.

RESULTS AND DISCUSSION

The present study aimed to work out the cost and return of rice-based farming system adopted by the respondent farmers along with its adoption behaviour in two blocks of Udalguri district of Assam. The identified existing rice based cropping systems in the study area were Rice-fallow, rice-toria, Ahu rice-Sali rice and rice-potato.

The cost different rice based farming system on per hectare basis was presented in Table 1. From the study, the per hectare total cost of rice-fallow, rice –toria, *Ahu* rice-*Sali*rice and rice-potato farming systems were found out to be Rs 51878.76., Rs. 61832.29, 77650.94 and Rs. 117954.69 respectively. The cost of cultivation was the highest in rice-potato cropping system followed by *Ahu* rice-*Sali*rice, rice-fallow and rice –toria. Among the components of the total cost, hired and family labour occupied the highest share in all the cropping systems. It could be noted that the total fixed cost were highest in *Ahu* rice-*Sali* rice (Rs. 38911.92) which has maximum average farm size and lowest in Rice-fallow system (30643.98) having lowest farm size manifesting direct relationship with the farm size. Rental value of owned land was highest in case of Rice-Potato (Rs. 16945.38). This might be

Table 1. Cost of different Rice based farming system adopted (Rs/ha)

Particulars	Farming systems			
	Rice- fallow	Rice- Toria	Ahu Rice-Sali Rice	Rice- Potato
Seed	1125.19 (2.17)	1925.89 (3.11)	2453.01 (3.16)	45125.88 (38.26)
Fertilizers, manures value of plant protection	6611.21 (12.82)	7782.99(12.59)	10821.25(13.94)	8813.23(7.47)
Hired labour	7523.23(14.59)	11132.16(18.00)	14411.19(18.56)	12883.38(10.92)
Other cost (including oil & machinery charge)	3532.21(6.85)	4561.28(7.38)	6596.87(8.50)	4321.92(3.66)
Interest on working capital	2442.94(4.71)	3051.94(4.94)	4456.70(5.74)	9248.77(7.84)
Total Variable Cost (TVC)	21234.78(40.93)	26528.37(42.93)	38739.02(49.89)	80393.18(68.16)
Imputed value of family labour	10253.89(19.77)	13893.15(22.50)	17165.21(22.11)	14445.22(12.25)
Depreciation on farm implements & farm buildings	1752.33(3.38)	1845.36(2.98)	1785.21(2.30)	1756.21(1.89)
Land revenue	89.23(0.17)	90.12(0.15)	92.41(0.12)	93.47(0.08)
Rental value of owned land	15023.12(28.96)	15413.78(24.93)	16569.45(21.34)	16945.38(14.37)
Interest on fixed capital	3525.41(6.80)	4061.51(6.57)	4629.60(5.96)	4321.23(3.66)
Total fixed capital (TFC)	30643.98(59.07)	35303.92(57.10)	38911.92(50.11)	37561.51(31.84)
Total Cost (TVC + TFC)	51878.76(100.0)	61832.29 (100.0)	77650.9(100.0)	117954.69(100.0)
Cost A1	23076.34	28463.85	40616.64	82242.86
Cost A2	23076.34	28463.85	40616.64	82242.86
Cost B	41624.87	47939.14	62411.45	103509.50
Cost C	51878.76	61832.29	79576.66	117954.70

Figures in parentheses are the percentage to the total cost

Table 2. Farm income from different rice based farming system adopted (Rs/ha)

Particulars	Farming systems			
	Rice- fallow	Rice- Toria	*Ahu* Rice-*Sali* Rice	Rice- Potato
Gross farm income	78521.40	126120.23	158984.25	397932.89
Net farm income	26642.64	64287.94	81333.31	279978.20
Family labour income	36896.53	78181.09	96572.80	294423.41
Farm business income	55445.06	97656.38	111757.61	315690.03
Farm investment income	45191.17	83763.23	118367.61	301244.81
Net returns over variable cost	23956.39	57234.87	120245.23	220851.6
Benefit-Cost ratio	1.51	2.04	2.05	3.37
REE (%)	-	141.30	205.27	950.87

due to higher productivity of land and the land was at higher alleviation. Similar finding was reported by (*Devi and Singh, 2020*) in Paddy fish farming systems. It was observed that the total variable costs of *Ahu* rice-*Sali* rice (Rs.38739.02) and Rice-Potato (Rs. 80393.18) cropping sequences was more than total fixed cost due to high input cost accounting 68.16 per cent and 49.89 per cent of total cost whereas, variable cost of rice-fallow (Rs. 21234.78 and rice-toria (Rs. 26528.37) were less than the total fixed cost.There was no leased in or leased out land, as the values for Costs A1 and A2 were equal. The values of cost A_1 and A_2were estimated as Rs. 23076.34, Rs. 28463.85, Rs. 40616.64 and Rs. 82242.86 respectively. The value of cost B and cost C for rice-fallow, rice-toria, Ahu rice-Sali rice and rice-potato cropping sequence were Rs. 41624.87, Rs.47939.14, Rs. 62411.45, Rs. 103509.50 and Rs.51878.76, Rs.61832.29, Rs. 79576.66, Rs.117954.70 respectively.

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-potato followed by *Ahu* rice-*Sali* rice, rice-toria and rice-fallow as high value crop like potato provides more net income than high yielding field crops. It was mainly due to the higher productivity and high value of the main product in diversified cropping sequence. The gross returns were also higher in rice-potato (Rs397932.89) followed by *Ahu* rice-*Sali* rice (Rs. 158984.25), rice-toria (Rs. 126120.23) and rice-fallow (Rs. 78521.40) cropping sequences. Rice-Potato cropping sequence fetched more farm business income per hectare (Rs 315690.03) as compared to *Ahu* rice-*Sali* rice (Rs 111757.61), Rice-Toria (Rs 97656.38) and Rice-fallow (Rs 55445.06). The Table shows that rice-potato had

Table 3. Effects of different factors on adoption of double cropping (Logit Model)

Variables	MLE co-efficient	SE	Exp β
Intercept	2.4852	1.1797	
Age	-0.1522*	0.0891	1.310
Education level	-0.1421*	0.6984	1.131
Size of holding	0.1770***	0.0593	1.503
Income	0.3253***	0.0315	2.123
Access to extension service	0.8252**	0.4211	6.542
Access to input	0.1891***	0.0753	1.656
Log likelihood	61.0254		
Chi- square	24.63		
Count R^2	0.59		
Numbers of observations	120		

***Significance at 1%, **5% and *10% probability levels respectively.

obtained higher benefit cost ratio (3.37) compared to *Ahu* rice-*Sali* rice (2.05), Rice-Toria (2.04) and Rice-fallow (1.51). it could be inferred that every rupee invested in rice-potato, *Ahu* rice-*Sali* rice, Rice-Toria and rice-fallow net return obtained were 3.37, 2.05, 2.04 and 1.51 respectively.

The highest relative economic efficiency (950.87%) over predominant cropping system winter rice-fallow was recorded in winter rice-potato sequence followed by 188.20 per cent in *Ahu* rice-*Sali* Rice. The lowest relative economic efficiency (141.29%) over predominant cropping system winter rice-fallow was recorded in winter rice-toria sequence. Economic efficiency increases due to inclusion of vegetable crop in rice-based system (*Samanta, 2015*; *Kumar et al., 2014*).

The synthesis of the adoption process presented by *Feder et.al. (1985)* suggests that generally the level and quality of human capital affect the choice of new technologies in agriculture and for early adopters and for an efficient use of inputs, it plays a particularly positive role *(Sheikh et al, 2003)*. Logit model descriptive statistics for the respondents hypothesized to effect adoption of diversified cropping system are presented in Table 3. The probability of the respondent to adopt different cropping sequence depends on socio-economic characteristics like age of the respondents, education level, size of land holding, access to extension service and access to inputs. It could be distinguished from the descriptive statistics that the effects of independent variables were statistically significant at one per cent level of probability. Positive relationship with adoption of rice based cropping system was expected in case of size of land holding, income of the farm, access to input and access to extension service. In contrary, negative relationship was postulated for age of the farmers and education level. These results are in close conformity with the findings recorded in the case of adoption of Bt cotton by *Padaria et. al. (2009).* The value count R^2obtained was 0.59; which is acceptable and indicated good predictive ability of the model. It could be inferred that one-unit change in the positive and significant slope coefficient would increase the probability of a respondent to adopt SRI technology by the appropriate percentage (*Devi and Ponnarasi, 2009*). The variable access to extension service was found to have greatest influence on the adoption decision, tending to boost adoption rate by 6.5 times for every unit increase in the variable, followed by the variables Income of the farmer, access to input, size of land holding, age, and education level. The negative sign for the age and education level indicated that the variables do not have a significant influence on adoption behavior of the respondents.

CONCLUSION

From the present analysis, it can be concluded that, the existing rice based cropping system can effectively be diversified with inclusion of crops like Rapeseed, vegetables, during rabi and summer season along with *ahu* rice during summer under rainfed condition of Udalguri district of Assam. These were feasible systems in both productivity as well as economical point of view. However, Inclusion of short duration pulses in dominant cropping sequence to improve soil health and reduce environmental impact is the need of hour. Among all the tested cropping sequences in the study area, Rice-Potato cropping sequence is most viable and can increase farm profitability and food production under rainfed medium land situation of Udalguri district. Sustainable Intensification of Rice-Potato sequence can produce more food without expanding farm size. Consequently, integrated pests and diseases management is necessary to minimize the overall environmental impact of double cropping. Although various strategies and management practices exist to increase resource use efficiency but farmers rarely apply themmainly due to lack of knowledge. On that account, arranging training programme to upgrade the knowledge of farmers on Integrated disease and pest management, minimum or zero tillage, mulching, recycling and reuse of resources etc., incentivise the farming community to adopt agro-ecologically intensified farming system is necessary.

The government should also take some initiatives for ensuring availability of inputs at reasonable prices at proper time. The yield and production of various cropping sequences may be increased, which can help the farmers to boost revenue and improve living standards, provided modern inputs and production technologies can be made available timely to farmers.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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