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A Game-Theoretic Approach To The Study Of Major Crops Cultivated In Assam

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ABSTRACT

A variety of risks, such as climate circumstances, price changes, and pest and disease infestation, can all have an impact on agricultural productivity of a particular area. This study employs game theory to discover the crops that maximise net profit for farmers under risk based on numerous features of the farmers. Data on crop production and profit were obtained from a random sample of 60 farmers from various areas in the state of Assam. The games were built using the net profit from each harvest. The Maximax, Maximin, Regret, Utility, and Laplace criteria of game theory were used in the analysis.

Keywords: Crops, game theory, agricultural production, decision criteria.

1. INTRODUCTION

Agriculture has been practised in India since the Neolithic period. In terms of agricultural output, India stands second in the world. Agriculture employed more than half of the Indian workforce in 2018 and generated 17-18% of the country's GDP (gross domestic product). Agriculture and associated industries such as animal husbandry, forestry, and fisheries accounted for 17.5% of GDP in 2016 and employed around 41.49% of the workforce in 2020. India has the world's largest net cropped area, followed by the United States and China. Agriculture's economic contribution to India's GDP is continuously falling in tandem with the country's broad-based economic growth. Nonetheless, agriculture is India's most populous economic sector and plays an important part in the country's overall socioeconomic fabric.

Assam's agriculture industry in the north-eastern state of Assam has enormous potential. This likelihood is particularly strong due to the existence of the Brahmaputra and Barak rivers. These two rivers keep the area fruitful all year. The soils of the Brahmaputra and Barak River valleys are so fertile that most agricultural products may be grown in most locations of the Indian subcontinent. Even the weather is agreeable. We can't deny that Punjab, Haryana, West Bengal, and Maharashtra produce more crops than Assam. However, when we examined the opposite side, we discovered that they utilise several artificial tactics to achieve this goal.

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Assam's climate is suitable for maximum cereals production, such as tea, rice, jute, rubber, sugarcane, wheat, potato, cotton, pulse, oil, and various fruits. Tea is the main commercial crop of this state. Even, the land is world-famous for this green grain. Every year Assam alone produces more than 57% of whole India's tea production and supplies it to different states and countries around the globe. Depending upon Assam's tea production, India upgraded its rank into number 2nd position after China (2019 report). Along with tea, it exports rice, jute, areca nuts, and more other crops to other places. There are still so many possibilities for rice, tea and jute cultivation in Assam. Implementing modern ideas in agriculture will definitely grow this region's socio-economic condition to a better level.

Horticulture sector in Assam deals with fruits, vegetables, spices, floriculture, potato, onion, medicinal and aromatics and mushroom cultivation. Besides it deals with bee keeping, food processing, micro irrigation and post-harvest management including Cold-chain development. The Horticultural Growth rate in Assam contributes in large towards overall of growth of Agriculture in the state. During 2014-15 the Growth rate of Horticulture in the state is increased to 7.6 % over 6.6 % in 2013-14. Major Fruit crops of the state – banana, pine apple, papaya, Assam lemon, orange, guava, litchi, jack fruit and mango. Major tuber crops grown potato, sweet potato and tapioca, among spices – chilli, turmeric, ginger, onion, coriander, garlic, black pepper with different types of Rabi and Kharif vegetables are grown in Assam. Flowers like marigold, gerbera, anthurium, lilium, tube rose etc. High value crops like straw berry, passion fruit are gradually becoming popular for cultivation because of higher return. In addition, mushroom production is being considered as profitable farming activities for unemployed youths. Recent research by Barman et al [3] shows profitability analysis of major Crops cultivated in Assam based on analysis of primary data. Here, we provide game theoretic explanations to tendency of different farmers to favour cultivation of different crops based on different criterions and risks. Other studies related to profitability in cultivation of different crops can be found in [1], [2], [7], [8].

2. Methodology

2.1. Study Area

This study was conducted in the state of Assam. Assam occupies an area of $78{,}438\ \text{km}^2$ with a population of 31,205,576 according to population census of 2021. It is located on latitude $26{:}2006^0\text{N}$ and longitude $292{:}9376^0\text{E}$. There are 35 administrative districts in the state.

2.2. Data Collection

Data on vegetables production were collected from a random sample of 60 farmers cultivating each of the vegetables from the different districts of state of Assam while data on fruit production was also collected from random samples of 60 farmers cultivating each of the crops in the state. The districts selected are Golaghat, Jorhat and Dibrugarh. Following [6] approach, unsuccessful production period represented a bad situation where negative climatic conditions, low yields and low product prices were predominant. On the contrary, the

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successful production period represented a good situation where positive climatic conditions, high yields and high product prices were predominant.

2.3. Decision Criteria

There are several well-known approaches to decision making under uncertainty, although none is really satisfactory. Maximax, Maximin, Regrets, Utility and Laplace were determined as the major criteria of game theory considering that these criteria would explain the primary producers' characteristics [4].

- Maximax (Optimist). The maximax criterion indicates that the decision-maker should choose the alternative which maximizes the maximum value of the outcome. This optimistic approach implies that the decisionmaker should assume the best of all possible worlds.
- **Maximin (Pessimist):** This pessimistic approach implies that the decision-maker should expect the worst to happen. The maximin person looks at the worst that could happen under each action and then choose the action with the largest payoff. They assume that the worst that can happen will, and then they take the action with the best worst-case scenario.
- **Regret criterion:** The regret of an outcome is the difference between the value of that outcome and the maximum value of all the possible outcomes, in the light of the particular chance event that actually occurred. The decision-maker should choose the alternative that minimizes the maximum regret he could suffer.
- **Utility criterion:** The utility criterion approach implies that the farmer is a risk averter. A risk averter is someone who prefers a more certain return to an alternative with an equal return but which is riskier.
- **Laplace criterion:** This is when the probabilities of several chance of events are unknown, they should be assumed equal, and the different actions should be judged according to their payoffs averaged over all the states of nature.

Strategies	**Characteristics marketing conditions**
Good conditions	Successful marketing Increases in product prices Good climatic conditions Pest and diseases free
Bad conditions	Unsuccessful marketing Decreases in product prices Bad climatic conditions Pest and diseases infestation

Table-1. Strategies of players which represent production and marketing conditions.

Strategies Characteristics marketing conditions

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2.4. Results and Discussions

The study was purely based on farm level primary data generated through field survey and was collected with the aid of well framed pre-tested questionnaire based on multi-stage random sampling technique. The villages were selected on basis of availability of irrigation facilities, agricultural activities of farmers. In the final stage, households were selected at random from each village and required information was collected. The sample size was 60 farm households. The collected data were processed and analysed using various statistical techniques. The following table shows the profitability of different crops in rupees (Rs) per acre land cultivated by farmers of Assam and their preferred crops along with it for different game theoretic criterions.

Producers	Criterion	Net profit (in Rs. per acre)	Preferred Crop
Optimistic	Maximax	16500	Mustard
Pessimistic	Maximin	12250	Pulses
The least regrets	Regret	7300	Potato
Risk averter	Utility	8000	Paddy
Prudent	Laplace	10400	Brinjal

Table 2: The profitability of crops in rupees (Rs) per acre land for different criterion.

The maximax criterion:

Based on maximax criteria, the player is optimistic about production, weather and pricing conditions. This means that the farmer selects the combination of activities which will maximize his income in good conditions. Mustard had the highest profit of Rs.16500 per acre land in good condition (Table-2). An optimist farmer will therefore cultivate mustard on his land.

Maximin criterion:

According to the maximin strategy the player, in this case the farmer tries to choose the best of the worst. The farmer is regarded as a pessimist based on this criterion. This means that the farmer selects the combination of activities which will maximize his minimum income. This strategy gives the farmer maximum security. According to this criterion, the highest net profit under bad condition is obtained from pulses at Rs.12250/acre. Pulses are certainly bound to be attractive to pessimist due to the low levels of risks from insects and climatic disturbances in Assam. Also, low levels of capital are involved protecting growers from heavy losses. The gestation period is fairly short resulting in low levels of labour requirement and interest on capital.

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Regret criterion:

The minimization of the possible regrets of producer was aimed with this criterion [5]. In order to minimize risk, the farmer will choose the alternative with least regret in his production. In this study, the next best alternative is potato. From the results of the analysis, the regret of the producer was estimated at Rs.7300/acre. (Table-2).

Utility criterion:

This criterion assumes that the producer is risk averter. To determine the utility values, the lowest value of strategies was determined and subtracted from all the results of related strategy [5]. For risk averter farmers would prefer to paddy with net profit of Rs.8000/acre (Table-2).

Laplace criterion

According to Laplace criterion, when the probabilities of conditions are not known, the probabilities of the good and bad conditions are equal. Good and bad conditions were given equal weights. The farmer is regarded as being prudent. The weighted value of each strategy was found by multiplying both of two conditions with 0.5 and then added together [5]. From the result of the analysis, the highest weighted value was Rs. 10400. This value was obtained for Brinjal production.

CONCLUSIONS

Decision making will be influenced by farmers' characteristics. Decision criteria used in the study are maximax, maximin, regret, utility and Laplace criteria. Optimistic farmer will choose Mustard while pessimistic will cultivate pulse on the land. This is due to the fact that optimistic farmers are not risk averse while pessimistic farmers are risk averse in nature.

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