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An Analysis of the Factors Responsible for the Cultivation of Sugarcane Crop in the Baghpat District, Uttar Pradesh

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ABSTRACT

Sugarcane cultivation plays a pivotal role in the economy and socio-cultural framework of Baghpat District, Uttar Pradesh. This study investigates the factors influencing sugarcane farming, employing Principal Component Analysis (PCA) to identify key variables impacting yield and profitability. The PCA process highlighted significant components, including environmental conditions, economic support systems, risk management, and resource availability. The analysis revealed that critical factors such as the reduction of losses due to natural hazards, assured pricing, and availability of credit, technical assistance, and easy access to input resources significantly affect sugarcane cultivation. The study's findings underscore the importance of comprehensive support systems and efficient resource management, particularly for small and medium farmers, to enhance the productivity and sustainability of sugarcane farming in the region. Recommendations are provided to optimize these factors, ensuring the long-term viability and profitability of sugarcane cultivation in Baghpat district of Uttar Pradesh.

1. Introduction

The cultivation of sugarcane is a critical component of agricultural activities in the Baghpat District of Uttar Pradesh, playing a significant role in the region's economy and socio-cultural fabric. Sugarcane, being a high-value cash crop, provides substantial income to farmers and contributes to the agro-based industries in the area, including sugar mills and jaggery production units. The choice of cultivating sugarcane over other crops is influenced by multiple factors, including climatic conditions, soil fertility, water availability, and government policies. Understanding these factors is essential for enhancing productivity, ensuring sustainable agricultural practices, and supporting the livelihoods of the local farming communities (Kumar et al., 2017). Sugarcane, scientifically known as *Saccharum officinarum* L., is a member of the *Gramineae* family of plants and is thought to have originated in the tropical regions of south and southeast Asia. Sugarcane, in addition to producing biofuel, fibre, and fertiliser, and a plethora of other by-products that are ecologicallysustainable, is an agricultural resource that is renewable and naturally occurring. White sugar, brown sugar (Khandhasari), jaggery (Gur), and ethanol are all products that can be made from sugarcane juice. Sugarcane juice includes 111.13 kilocalories (26.56 kilojoules) of energy per serving (28.35 grammes), 27.51 grammes of carbs, 0.27 grammes of protein, 11.23 milligrammes of calcium, 0.37 milligrammes of iron, 41.96 milligrammes of potassium, and 1.01 milligrammes of sodium (Nutrient Information from ESHA Research). Several studies have highlighted the influence of environmental and socio-economic factors on sugarcane cultivation. Climatic conditions, such as temperature and rainfall, are pivotal, with sugarcane requiring a warm, humid climate for optimal growth (Singh et al., 2019). The soil type in Baghpat, predominantly alluvial, is well-suited for sugarcane, provided there is adequate irrigation. The availability of water resources, particularly through the extensive canal systems in Uttar Pradesh, plays a crucial role in the decision to grow sugarcane. Furthermore, government support in the form of subsidies, minimum support prices, and policies aimed at

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promoting sugarcane farming also significantly impacts farmers' choices (Sharma & Kaur, 2018). Despite the favorable conditions, the cultivation of sugarcane in Baghpat faces several challenges. Issues such as water scarcity, fluctuating market prices, and the high cost of inputs can affect productivity and profitability. Additionally, the environmental impact of intensive sugarcane farming, including soil degradation and water resource depletion, raises concerns about the sustainability of these practices. This study aims to identify and analyze the various factors responsible for the cultivation of sugarcane in Baghpat District, providing insights that could help in formulating strategies for improving crop management and ensuring the long-term viability of sugarcane farming in the region (Pandey & Tripathi, 2020). Sugarcane production in India has seen significant growth, with the highest area under cultivation reaching 50.66 lakh hectares in 2014-2015 and the lowest at 41.7 lakh hectares in 2009-2010. The highest production was 4003.69 million tonnes in 2018-19, while the lowest was 2923 million tonnes in 2009-10. The selection and growth of specific crops in a region are influenced by factors such as land tenancy, land ownership, number of holdings, and field size. In Uttar Pradesh, the largest area under sugarcane cultivation was 21.80 lakh hectares in 2020-21, with a record high of 1776.72 million tonnes in 2020-21. The region's major crops include wheat, rice, and sugarcane, which compete for space and generate the highest profit for a specific year. The decision-making process influences farmers' crop selection preferences, promoting the creation of new types and species, technological elements, policies, tangible progress, and educational programs. Uttar Pradesh's leading sugarcane-producing districts include Bareilly, Muzaffarnagar, Bulandshahar, Meerut, Baghpat, and Saharanpur.

This study aims to explore the factors responsible for sugarcane crop cultivation in Baghpat district, Uttar Pradesh, a critical area for the state's output. Understanding these factors is crucial for developing strategies to improve productivity and profitability in the agricultural sector.

2. Materials and Methods

The sampling design takes representativeness into account as one of these things. Representativeness can be thought of as a measure of how well data show a process state, an environmental factor, a change in a parameter at a sampling point, or a trait of a community. Making a sampling plan is an important first step in getting data that is valid, can be defended, and is representative of the problem being studied. The production area for the study is based on a lot of facts.

i) There are tools for farming sugarcane.
ii) A road network to make it easier for people to connect and move both inputs and outputs.
iii) More than half of the sugarcane grown in India is in the Baghpat district.

A new system was put in place that ranks the six blocks of the district by the amount of sugarcane growers in each one. To learn more, the blocks of Baraut, Chhaprauli, and Binauli were picked at random based on the number of sugarcane farmers, going from least to most. Out of all the villages in the designated blocks, six were picked at random based on the percentage of sugarcane growers, from least to most: Bijrol, Malakpur, Basauli, Ramala, Pusar, and Jiwana. This was done because more than 70% of the land in these villages was used for sugarcane farming. We chose people from each village in the Baghpat district who grow more than 80% of the sugarcane. For this study, 120 farmers were picked at random from a list, ranging from those who grew the least amount of sugarcane to those who grew the most.

3. Principal component analysis

The main goal of PCA is to explain the maximum variance through a few number of principal components. PCA has many applications in agriculture, social science, marketplace research and other industries, where experiments are based on a multitude of variables. We can use PCA to examine the factor more responsible for the preference of sugarcane cultivation and avoid multi- colinearity as stated by Jolliffe (2002). Shlens (2014) has proposed the computation of PCA in the following steps:

Arrange data as an m×n matrix, where m represents the number of measurement types and n symbolizes number of samples.

- Subtract off the mean for each measurement type.
- Compute first the correlation matrix and then eigen values of the correlation matrix.

3.1 Deriving principal components:

Derivation of principal components prescribed by Jolliffe (2002) is given by;
$\mathrm{Var}\{\alpha_1 x\} = \alpha 1 \sum \alpha 1$

The Variable used in the derivation is α1.α1 = 1, that is, the sum of squares of elements of α1 equals one. In general, the k^{th} PC of x is a'kx and Var {αk x}. Data were subjected to SPSS software and principal component analysis was performed.

Eigen values, variance percentage and cumulative percentage were found. Scree plot and score plot were also obtained in order to decide how many principal components are sufficient to describe the relationship.

4. Results and Discussion

Table 1. Eigen analysis of the Marginal farmers.

Component	Initial Eigenvalues		
	Total	**% of Variance**	**Cumulative %**
Cultivation Easy	3.1751	19.8445	19.8445
Profitable crop	2.3296	14.5601	34.4047
Minimum Risk	2.1082	13.1763	47.5809
Availability of Credit	1.7238	10.7736	58.3545
Technical Assistant by government	1.5194	9.4964	67.8509
Loss due to natural Hazard in less	0.9720	6.0749	73.9258
Loss due to wild animal in less	0.7667	4.7921	78.7179
More Productivity of crop	0.7156	4.4723	83.1902
join product are equally useful	0.6348	3.9673	87.1575
Easy availability of input resource	0.6012	3.7573	90.9148
Minimum rquired labour	0.3815	2.3846	93.2994
Local marketing facility available in the local market	0.3148	1.9675	95.2669
Assured Pricing	0.2759	1.7243	96.9912
More Profitable in comparison of other crop in this area	0.2224	1.3900	98.3811
Availability of Good processing in the area	0.1710	1.0685	99.4496
Option of mixed cropping	0.0881	0.5504	100.0000

The analysis of the initial eigenvalues and variance explained by each component reveals that the first five components account for a substantial portion of the total variance. "Cultivation Easy" has the highest eigenvalue of 3.1751, explaining 19.84% of the variance, followed by "Profitable crop" with 2.3296, explaining 14.56%, and "Minimum Risk" with 2.1082, explaining 13.18%. Together, these three components explain nearly half (47.58%) of the total variance. The fourth and fifth components, "Availability of Credit" and "Technical Assistance by Government," contribute an additional 10.77% and 9.50%, respectively, bringing the cumulative variance explained to 67.85%. The remaining components each contribute less than 7% individually, with the cumulative variance reaching 100% by the sixteenth component, "Option of mixed cropping," which explains only 0.55%. This suggests that the first few components capture most of the variability in the data, indicating that these factors are the most significant in explaining differences in crop cultivation and profitability.

Table 2. Eigen analysis of the Small farmers

Component	Initial Eigen value		
	Total	**% of Variance**	**Cumulative %**
Cultivation Easy	3.1342	19.5886	19.5886
Profitable crop	2.3749	14.8431	34.4318
Minimum Risk	2.0726	12.9537	47.3855
Availability of Credit	1.7015	10.6341	58.0196
Technical Assistant by government	1.5213	9.5082	67.5277
Loss due to natural Hazard in less	1.0097	6.3108	73.8386
Loss due to wild animal in less	0.7906	4.9411	78.7797
More Productivity of crop	0.7003	4.3771	83.1568
join product are equally useful	0.6440	4.0253	87.1821
Easy availability of input resource	0.5803	3.6271	90.8093
Minimum required labour	0.3836	2.3975	93.2068
Local marketing facility available in the local market	0.3179	1.9870	95.1938
Assured Pricing	0.2849	1.7809	96.9747
More Profitable in comparison of other crop in this area	0.2254	1.4086	98.3833
Availability of Good processing in the area	0.1696	1.0602	99.4435
Option of mixed cropping	0.0890	0.5565	100.0000

The eigen value analysis indicates that the first five components capture the majority of the variance in the data. "Cultivation Easy" has the highest initial eigenvalue of 3.1342, accounting for 19.59% of the total variance. The second component, "Profitable crop," follows with an eigenvalue of 2.3749, explaining 14.84% of the variance. "Minimum Risk" and "Availability of Credit" have eigenvalues of 2.0726 and 1.7015, respectively, explaining an additional 12.95% and 10.63% of the variance. The fifth component, "Technical Assistance by Government," contributes 9.51%, bringing the cumulative variance explained by these five components to 67.53%. The sixth component, "Loss due to Natural Hazard," adds 6.31%, resulting in a cumulative variance of 73.84%. Subsequent components each contribute less than 5%, with the cumulative variance reaching 99.44% by the fifteenth component, "Availability of Good Processing in the Area." This distribution highlights that the first few components are the most significant in explaining the variation in the data, with diminishing contributions from the remaining components.

Table 3. Eigen analysis of the Medium farmers

Component	Initial Eigen values		
	Total	% of Variance	Cumulative %
Cultivation Easy	5.5356	34.5977	34.5977
Profitable crop	3.2372	20.2326	54.8302
Minimum Risk	2.0774	12.9839	67.8142
Availability of Credit	1.4769	9.2309	77.0451
Technical Assistant by government	1.3381	8.3629	85.4080
Loss due to natural Hazard in less	0.7570	4.7316	90.1396
Loss due to wild animal in less	0.6015	3.7592	93.8988
More Productivity of crop	0.4584	2.8650	96.7638
join product are equally useful	0.3030	1.8939	98.6577
Easy availability of input resource	0.2148	1.3423	100.0000
Minimum required labour	0.0000	0.0000	100.0000
Local marketing facility available in the local market	0.0000	0.0000	100.0000
Assured Pricing	0.0000	0.0000	100.0000
More Profitable in comparison of other crop in this area	0.0000	0.0000	100.0000
Availability of Good processing in the area	0.0000	0.0000	100.0000
Option of mixed cropping	0.0000	0.0000	100.0000

The eigen value analysis reveals that the first five components account for the bulk of the variance in the data. "Cultivation Easy" is the most significant factor with an eigenvalue of 5.5356, explaining 34.60% of the total variance. The second component, "Profitable crop," follows with an eigenvalue of 3.2372, explaining 20.23% of the variance. Together, these two components account for more than half (54.83%) of the variance. "Minimum Risk," with an eigenvalue of 2.0774, contributes an additional 12.98%, bringing the cumulative variance explained to 67.81%. The fourth component, "Availability of Credit," adds 9.23%, and "Technical Assistance by Government" contributes 8.36%, resulting in a cumulative variance of 85.41%. The remaining components explain progressively smaller portions of the variance, with the sixth component, "Loss due to Natural Hazard," adding 4.73%, and subsequent components contributing less than 4% each. Notably, the last six components (from "Minimum required labour" to "Option of mixed cropping") do not contribute any additional variance. This suggests that the first few components are the most influential in explaining the variation in the data, while the latter components have negligible impact.

Table 4. Structure of first five principal components in Marginal farmers.

Component	PC 1	PC 2	PC 3	PC 4	PC 5
Cultivation Easy	-0.3934	-0.4814	-0.5557	-0.2259	0.1730
Profitable crop	-0.0275	-0.4545	-0.3750	0.2261	0.1220
Minimum Risk	0.3289	-0.1157	-0.2584	-0.1218	-0.6480
Availability of Credit	0.0255	0.7372	0.0405	-0.3645	-0.2360
Technical Assistant by government	-0.4234	0.7580	0.0711	-0.1901	-0.0230
Loss due to natural Hazard in less	-0.7903	0.1787	-0.0309	0.0791	-0.1550
Loss due to wild animal in less	0.2910	-0.3837	0.6926	0.0468	-0.0560
More Productivity of crop	0.3666	0.3906	-0.4629	0.1634	0.2020
join product are equally useful	0.3557	-0.2701	0.4630	-0.5256	0.2660
availability of input resource	-0.0672	0.4208	0.2676	0.0686	0.6580
Minimum required labour	-0.6351	-0.1727	-0.2371	0.2816	0.3800
Local marketing facility available in the local market	0.5710	0.1654	0.0903	0.1649	0.4040
Assured Pricing	-0.5445	0.1203	0.2388	0.4991	-1.9500
More Profitable in comparison of other crop in this area	0.5208	0.2294	-0.2187	0.5171	0.0660
Availability of Good processing in the area	0.6663	0.2091	-0.3007	0.3215	-0.1780
Option of mixed cropping	-0.1254	-0.0997	0.5872	0.6288	-0.2140

The principal component analysis (PCA) loadings for the first five principal components (PC1 to PC5) highlight the key contributing factors for each component. PC1, which explains the largest variance, is heavily influenced by "Loss due to natural Hazard in less" (-0.7903), "Assured Pricing" (-0.5445), and "Minimum required labour" (-0.6351), indicating that these factors contribute significantly to the overall variance captured by PC1. PC2, the second most significant component, is strongly associated with "Technical Assistance by Government" (0.7580) and "Availability of Credit" (0.7372), emphasizing the importance of these factors in explaining the variance. PC3 shows high loadings for "Cultivation Easy" (-0.5557) and "Loss due to wild animal in less" (0.6926), highlighting different aspects of cultivation challenges and risks. PC4 is influenced by "Assured Pricing" (0.4991) and "More Profitable in comparison of other crop in this area" (0.5171), reflecting economic factors, while PC5 has notable contributions from "Minimum Risk" (-0.6480) and "availability of input resource" (0.6580), focusing on risk and resource availability.

This analysis indicates that various aspects of crop cultivation and profitability are multidimensional, with different components capturing distinct sets of factors.

Table 5. Structure of first six principal components in small farmers.

Component	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Cultivation Easy	-0.4230	-0.4676	-0.5672	-0.1665	0.1877	-0.0283
Profitable crop	-0.1172	-0.4703	-0.3056	0.2110	0.1618	0.5564
Minimum Risk	0.3493	-0.1264	-0.3634	0.0686	-0.5927	0.4352
Availability of Credit	0.0246	0.7346	-0.0318	-0.3171	-0.2872	0.2041
Technical Assistant by government	-0.3875	0.7678	0.0701	-0.2112	-0.0694	0.0940
Loss due to natural Hazard in less	-0.7887	0.1992	0.0306	0.0644	-0.1706	-0.0994
Loss due to wild animal in less	0.3387	-0.3962	0.6602	-0.0124	-0.0851	-0.0583
More Productivity of crop	0.3162	0.4013	-0.4375	0.1748	0.2611	0.1359
join product are equally useful	0.4083	-0.2865	0.3609	-0.5918	0.1680	0.0999
Easy availability of input resource	-0.0279	0.4242	0.2878	-0.0464	0.6698	0.2176
Minimum required labour	-0.6555	-0.1508	-0.1488	0.2394	0.4377	-0.0157
Local marketing facility available in the local market	0.5531	0.1549	0.1331	0.0675	0.4231	0.3253
Assured Pricing	-0.5300	0.1343	0.3237	0.4737	-0.1366	0.2548
More Profitable in comparison of other crop in this area	0.4786	0.2342	-0.1440	0.5351	0.1487	-0.4096
Availability of Good processing in the area	0.6412	0.2018	-0.3021	0.4118	-0.0877	-0.0755
Option of mixed cropping	-0.0898	-0.0998	0.6493	0.5915	-0.1441	0.1609

The principal component analysis (PCA) loadings for the first six principal components (PC1 to PC6) indicate the significant factors influencing each component. PC1, which accounts for the largest variance, is highly influenced by "Loss due to natural Hazard in less" (-0.7887), "Minimum required labour" (-0.6555), and "Cultivation Easy" (-0.4230), suggesting that these factors are key to the overall variance captured by PC1. PC2 is dominated by "Technical Assistance by Government" (0.7678) and "Availability of Credit" (0.7346), highlighting the importance of these factors in explaining the variance. PC3 shows strong loadings for "Cultivation Easy" (-0.5672) and "Loss due to wild animal in less" (0.6602), reflecting cultivation challenges and risks. PC4 is significantly influenced by "More Profitable in comparison of other crop in this area" (0.5351) and "Assured Pricing" (0.4737), indicating economic considerations. PC5 has notable contributions from "Easy availability of input resource" (0.6698) and "Minimum Risk" (-0.5927), emphasizing resource availability and risk. Lastly, PC6 is characterized by high loadings on "Profitable crop" (0.5564) and "Minimum Risk" (0.4352), indicating profitability and risk factors. This analysis reveals that different components capture various aspects of crop cultivation and profitability, with distinct factors contributing to each principal component.

Table 6. Structure of first five principal components in medium farmers.

Component	PC 1	PC 2	PC 3	PC 4	PC 5
Cultivation Easy	0.4906	-0.7634	-0.3359	0.1176	-0.0710
Profitable crop	0.1364	-0.6926	0.5922	-0.0365	0.1430
Minimum Risk	-0.6364	-0.0873	-0.5441	0.2261	-0.0940
Availability of Credit	0.2819	0.7501	0.1968	-0.2197	-0.4710
Technical Assistant by government	0.7244	0.5067	0.0159	0.1313	-0.1220
Loss due to natural Hazard in less	0.8971	0.2445	-0.0392	-0.1078	0.1040
Loss due to wild animal in less	-0.7515	0.0689	0.1536	0.0858	0.5070
More Productivity of crop	-0.4004	-0.4415	0.6638	0.1039	0.0280
join product are equally useful	-0.7761	0.1501	0.2110	-0.1775	0.1060
Easy availability of input resource	0.2769	0.1109	0.7854	0.2724	-0.3540
Minimum required labour	0.7420	-0.4359	0.1114	-0.0518	-0.1470
Local marketing facility available in the local market	-0.5887	0.7319	0.0108	0.2621	-0.0530
Assured Pricing	-0.6259	-0.2226	0.0335	-0.4892	-0.4570
More Profitable in comparison of other crop in this area	0.3108	0.0756	0.0171	0.8495	0.0790
Availability of Good processing in the area	0.3172	0.5219	0.3280	-0.2708	0.5630
Option of mixed cropping	0.7563	0.0030	-0.1736	-0.3226	0.3240

The principal components (PCs) reveal distinct dimensions of agricultural cultivation factors: PC 1 emphasizes favorable conditions like low natural hazard losses and government technical assistance; PC 2 highlights economic support through credit availability and local marketing facilities; PC 3 focuses on resource availability and crop productivity; PC 4 deals with marketing and pricing challenges; and PC 5 reflects a mix of lesser-impact factors including wild animal losses and resource availability. Each component captures a different aspect of the cultivation environment, from support and risk management to economic and productivity factors.

5. Conclusion

The Principal Component Analysis (PCA) conducted on factors influencing sugarcane cultivation in Baghpat district, Uttar Pradesh, highlights the multifaceted nature of agricultural productivity. The analysis identifies key components that explain the majority of variance in the data, with significant emphasis on environmental conditions, economic support, risk management, and resource availability. The distinct factors vary across different farmer groups—marginal, small, and medium—each with unique challenges and opportunities.

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