Original Article

Case Study: Risk Assessment of Indian Pulse processing firms using FMEA Techniques – Evidence from selected states of India

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Abstract

The pulse value chain played significant role in agriculture and other industry sector such as food , pharma industry. The pulse value chain consists of sequences of business activities that perform significant activities, from primary production transformation into the final product to marketing for final consumption to the consumer. Pulse value chain develops different framework structures for developing competitive business strategy development to identify the significant constraints in a compressive manner. However, pulse processing firms face many risks, i.e., production risk, operation risk, supply risk, etc., which hampers the growth of these firms. The paper aims to identify pulse processing firms' risk factors and measure the severity of the risk. The risk assessment of pulses processing firms creates the opportunity for continuous quality improvement of the pulse value chain, and their performance also develops quality up gradation of pulse processed food. The present study is based on 25 pulse processing firms selected firms from the states of Uttar Pradesh, Rajasthan, and Delhi/NCR. The study applied FMEA (Failure mode Effect Analysis) and Pareto Analysis to identify the potential risk and determine their severity index with the help of the Pareto analysis chart, and applied the ANOVA method to generate the frequency of F- the value of risk factors impact on pulse firms understand the level of significance of risk factors.

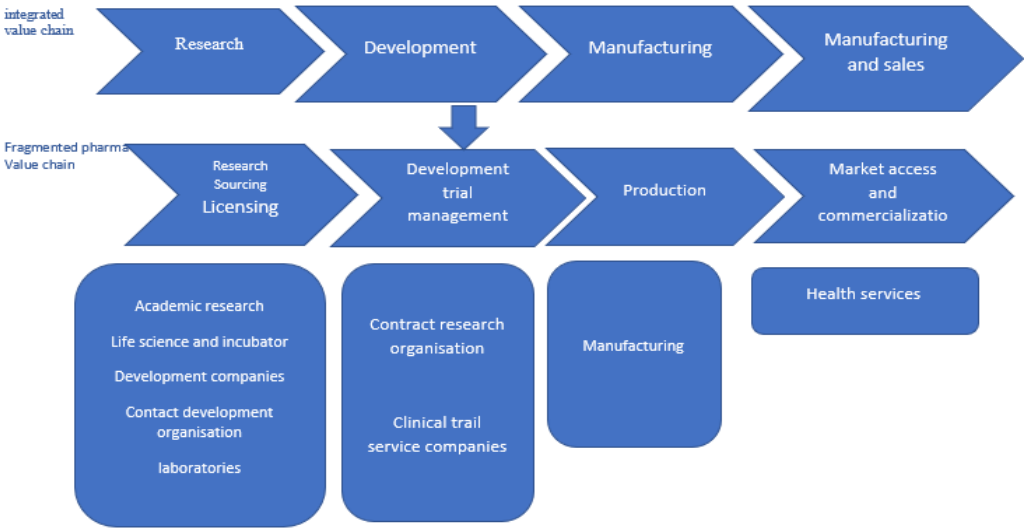
Keywords: Pulse processing firms, risk assessment.

INTRODUCTION

Pulses is consider as edible sources of protein fibres, that replacing the protein substitute easily, pulses generate the vital sources of protein requirement , and used in various pharma industry for developing protein based medicine and food product, At present pulses are largely used in pharmaceutical industry for making various medicine. The pulses value chain are consider for establishing the link between food producer, processor , to wholesaler , retailer to consumer and establish the linkages with pharmacratic industry. Pulses are applied as medical treatment to control certain harmful diseases, Pulses are considered medicine for heart diseases, sugar control, and blood pressure, which make frequent consumption and also control cholesterol levels (Abeysekara, 2016). The pulses constitutes a rich dietary fibers compound nourishes the second brain (Ridaurar, 2015). Pulses production technology reduces constraints in pulses cultivation. It emphasizes the expansion of area under short-duration varieties, the development of multiple pest resistance varieties, and promotes the use of micro-nutrients like zinc and Sulphur(Reddy, 2009). Pulses are considered a rich source of protein fibre is required in every diet for human beings, and feeding cattle provide energy. the pulses value chain has attributes to transform the traditional food value chain into the international market chain and implement the global gap-certified schemes for cost control and food safety compliances. Pulses value chain built the relationship between value chain structure and pharmaceutical industry to generate the food safety and developed quality standards and made up-gradation of small farmers, .the pulse value chain developed the framework structure of model has achieved three objectives: transaction cost economics, production network, and technological capability. (Hedda et al., 2017), the pulses value chain followed the governance concept of universalism and its norms for improving the condition of workers. The pulse value chain is defined as the full range of value-adding activities required to bring a product through the different production phases, including procurement of raw material,

generating other inputs, assembly of physical transformation, and acquiring required services (Tadesse Getachew, 2019). (Marie et al., 2018), the pulse value chain developed the relationship between producer and stakeholder. It promoted the upstream and downstream process of the agriculture system, which enhanced firms' pulse production and distribution capacity. The pulse value chain has generated the benefit of developing a framework structure to evolve agriculture and the food system. (Pandey et al., 2019) , which increases the availability of quality seed, supports price, develops procurement, and maintains the buffer stock of pulses. (Teodoro et al., 2019), The pulse value chain generates a nutritional value of pulses for human development and generates the sustainability of the agricultural system. (Abram et al. 2021), the sustainable pulse value chain applied the supply response simulation model techniques, which made a direct impact on the positive influence of price allocation of pulse legumes and made the negative influence on yield capacity and increased prices of pulses. (Laurette Dube et al., 2017)the pulse value chain has diversified pulse production techniques which could be possible through convergent techniques for the development of the pulse sector and developed the framework structure and focused on significant health to provide an environmental benefit. (Meera et al. 2018).

Figure1.1 the given figure illustrates the Pharma value chain and integrated value chain



The Pharma value chain define the structure of value chain process in pharmaceutical industry, from the stages of research and development , to manufacturing and sales it includes various value chain activities which define the value addition process by enhancement of research and development, development trail management , production and material access and commercialization function.

Pulses Value Chain

The pulse value chain establishes a distribution network which consists of backward and forward linkage of pulse production and made distribution of pulses and consider the enabling factors which support the pulse value chain. (very et.al. 2022), sustainable global pulse value chain develops certain objectives to meet core competency, inclusiveness towards pulse production, generate sustainability dimension, develop scalability and access easy to finance are defined to generate the actual process of which generate the domestic price of all pulse legumes. The risk assessment is an important part of pulse processing firms, which improves the pulse value chain. The FMEA consider a better risk assessment technique to identify the potential risk and shows their severity index of risks through RPN (risk priority number) FMEA is a systematic technique of identifying and preventing risk in the system, product, and process problems before they occur. It is implemented to prevent problems, enhance safety, and increase customer satisfaction [(Khan et al., 2003) (Thakore, 2015). FMEA tool was applied to eliminate the potential risk, improve the product's reliability, and develop the parameter to generate the risk priority number. RPN (risk priority number) has determined the risk factors and suggested an alternative that avoids the possible risk. (Sutrinso, 2015), FMEA in firms for ranking and mitigating the risk of all products strongly supports the sustainability paradigm in the manufacturing process. FMEA affects the process of generating the total quality maintained, which can be achieved in product design and development. The contribution of FMEA to achieve TQMs through multiple methods and generate the outcome research conducted through implemented FMEA.(Doshi, 2016), Failure Mode and Effects Analysis (FMEA) is a quality tool

applied in the manufacturing sector to identify potential failures and their impact on processes to Develop product design so continuous quality improvement can be achieved. The FMEA techniques determine failure in operational mode and the general scope of improvement in the manufacturing process (Wang et al., 2009). FMEA has been categorized into different functional levels as severity, occurrence, and detection, which focus on designing the manufacturing component and assembling process which to develop subsystem process, and calculate RPN, is the product of the occurrence (0), severity (S), Detection (D) of a failure, RPN = S x O x D. The three risk factors are evaluated based on (0 to 10) ten-point scale. The Failure modes with higher RPN values are assumed to be high risk and have higher priorities than those with lower RPN values (Rana, 2017).

Types of Risk.

FMEATYPES	USAGE
System	Focuses on global system functions
Design	Focuses on components and subsystems
Process	Focuses on manufacturing and assembly processes
Service	Focuses on service functions

Source: APPLICATION OF FAILURE MODE & EFFECT ANALYSIS (FMEA) FOR CONTINUOUS QUALITY IMPROVEMENT – MULTIPLE CASE STUDIES IN AUTOMOBILE SMEs (2022)

The risk assessment of pulse processing firms could be possible with risk mitigation strategies and tools, which include FMEA techniques ANOVA (Analysis of variance)method with SPSS software, to find out the significance level of risk factor and determine the potential risk with the help of Risk priority number and through Pareto analysis developed line chart to show the severity index of the risk factor which made an impact on pulse firms performance and consider the different functional area of pulse processing firms and develop pulse value chain practices which are affected through risks.

Literature Review

The literature review discussed the importance of risk assessment of firms through different techniques such as failure mode effect analysis (FMEA) and ANOVA, as well as discussed. The sustainable pulse value chain role in pulse firms etc. (Sharma, 2018), the FMEA techniques have been applied in various phases of the life cycle of the product to prevent failure from the system and to identify risk (Bouti and Kadi et al. (1994), The risk assessment performed through FMEA method which investigates the higher failure mode from the operation that causes, failure of effect, (Hovmark et al., 1994) developed the guidelines for design work, analysis of product features, and product design mechanism. (Russomanno et al. (1999), the FMEA developed the knowledge for simulation of subsystems and made a comprehensive expert system for failure modes and effects analysis. (to Braglia et al. (2003), FMEA characterize as an alternative multi-attribute decision-making approach for prioritizing risk. (Dong and Kuo et al. (2009) and enhanced assessment techniques, which evaluate the current rankings for failure modes through RPN (risk priority number). (to Lough et al. (2009), FMEA develops the relationship between functions and risk design to develop a mathematical mapping from product function to risk assessments. (Wolforth et al. (2009), The designing of the subsystem of each component in programmable through FMEA, (Hassan et al. (2010), FMEA identify the risk in developing design phase through the quality/cost-based conceptual process (QCCPP). (Wu et al. (2010), FMEA identifies the risk with their three-dimensional as an early product development approach. (S. Kahrobaee et al. (2011) identified the potential risk in the system and developed the quantitive Method called risk-based failure (F. Mozaffari et al. (2013) . failure modes and effects analysis (FMEA) has applied for the design of geo satellite application, which uploads FMEA techniques to analyze the risk. (Janaki ram and Keats (1995), FMEA is used as a conceptual tool for designing the process of quality improvement in the designing process. (Juttner , 2005) ,supply chain risk ,management develop business perspective to analyse the risk, which conducted through exploratory quantitative survey with the support of supply chain manager,(Celestine , 2018), supply chain risk management developed strategies used to mitigate risk and improve supply chain performance , which are heterogeneity in nature has applicable in strategic decision making also support of simulation modelling, (Amulya

,2021), supply chain risk management identify the uncertain risk and developed competitive business environment , also developed integral function of a supply network which faces unpredictable challenges due to, economic policy and made globalization have raised Uncertainty and challenges .(Iwan et al, 2009), supply chain risk management has consist of different stages of supply chain risk , which involve activities as identifying supply chain risk , assessing the probabilities and developed the severity to prioritize the risk which developing an action for mitigating risk.. (Prakash et al., 2017), supply chain risk management is a complete process for supply chain management based on risk stratification, risk management, and developed risk management process, which guide a model for firms to manage risk, develop future direction, which provides to the new Method, tools, and technique to address the risk. (Amulya Gurtu et al., 2021), supply chain risk management developed globalization, raising Uncertainty and other constraints. Supply chain risk management is a systematic approach for recognizing, ranking, mitigating, and monitoring potential supply chain disruptions. (ozlem bak 2018), supply chain risk management bridges the gap of synthesizing information into different categories based on the design, relationship, process, and developed economic fact. (change, 2012), supply chain risk management evolved into an important strategic decision related to the line of future requirements and opportunities in SCRM. The SCRM developed the report to generate critical insight into supply chain risk management's present and future scope.

Research objective

1. To analyze the risk assessment of pulse firms through FMEA (failure mode effect analysis) and determine the Pareto Analysis chart of all risk factors.

Research method: The case study method adopted the empirical research, has conducted in three states of India, Uttar Pradesh, Rajasthan, and Delhi/NCR region of sizes (25) pulse processing firms. The research identifies the significance level of individual risk factors impacting pulse firm and determines the frequency of the F-value and significance of the level of risk factors. The FMEA technique is applied to identify the potential failure in a process or system and generate the risk priority number to show the risk severity level. A developed line chart has been determined through the Pareto analysis to determine the potential Pareto analysis of supply risk, the Pareto analysis of potential critical operational risk, and demand risk analyses to define the severity of risk factors.

FMEA (Failure mode effect analysis) Method

FMEA Failure mode effect analysis identifies the potential risk in the product's system, process, and design. Different steps are applied to analyze potential failure modes and their respective causes. This technique generates the potential source of failure of the system and assigns a number to each risk factor to set priority are assessed accordingly (Mariajayaprakash, 2013), RPN is the product of the occurrence (o), severity (s), and detection (d) of a failure, RPN = S x O x D. The three risk factors are evaluated based on a ten-point scale, with higher RPN values are assumed to be higher risk. They are required to analyze their performance (Wang et al., 2009).

ANOVA (Analysis of variance): ANOVA Analysis of variance (ANOVA) is a statistical procedure concerned with comparing the means of several samples. The ANOVA can be modified as a form of a t-test for two independent models or more than two groups. The ANOVA technique tests the level of significant differences between class means and analyzes the variances. The ANOVA test of the hypothesis is based on a comparison of two independent variables, which estimates the population variance. To perform the ANOVA techniques, the following assumptions are required: a. The observations are performed on one independent or more variable. B. and are classified on each group come from a normal distribution C. which generates the population variances in each group are homogeneous. (Ostertagová et al., 2013).

Result and Discussion

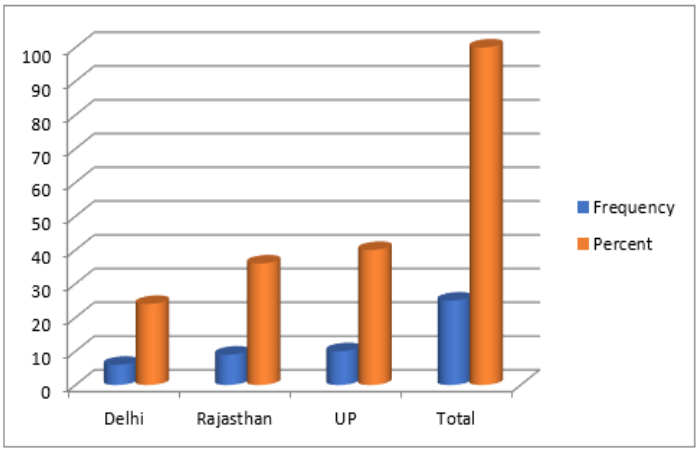
The primary data collection was conducted on pulse firms of (25) sizes from Uttar Pradesh, Rajasthan, and India's Delhi / NCR region. The Kanpur location of Punki industrial area from Uttar Pradesh, Vis karma industrial area of Jaipur from Rajasthan State, and Delhi/ Narela Industrial area of Delhi region of all pulse processing firms. The survey identified that few large pulse processing companies have adopted sustainability practices, followed the sustainable global pulse value chain practices, and adopted sustainability measures that promote the high range of pulse-based commodities, from exports to supply to local markets and intermediaries.

The given table has been prepared based on a questionnaire and composed pie chart, which shows the status of the firm's adopted sustainable strategies and business practices.

Table 1.1: The given table illustrates the sample sizes of all States, including Delhi, Rajasthan, and Uttar Pradesh sample size and determines the frequency in the year (2022)

Sample Size

	Frequency	Percent
Delhi	6	24
Rajasthan	9	36
UP	10	40
Total	25	100

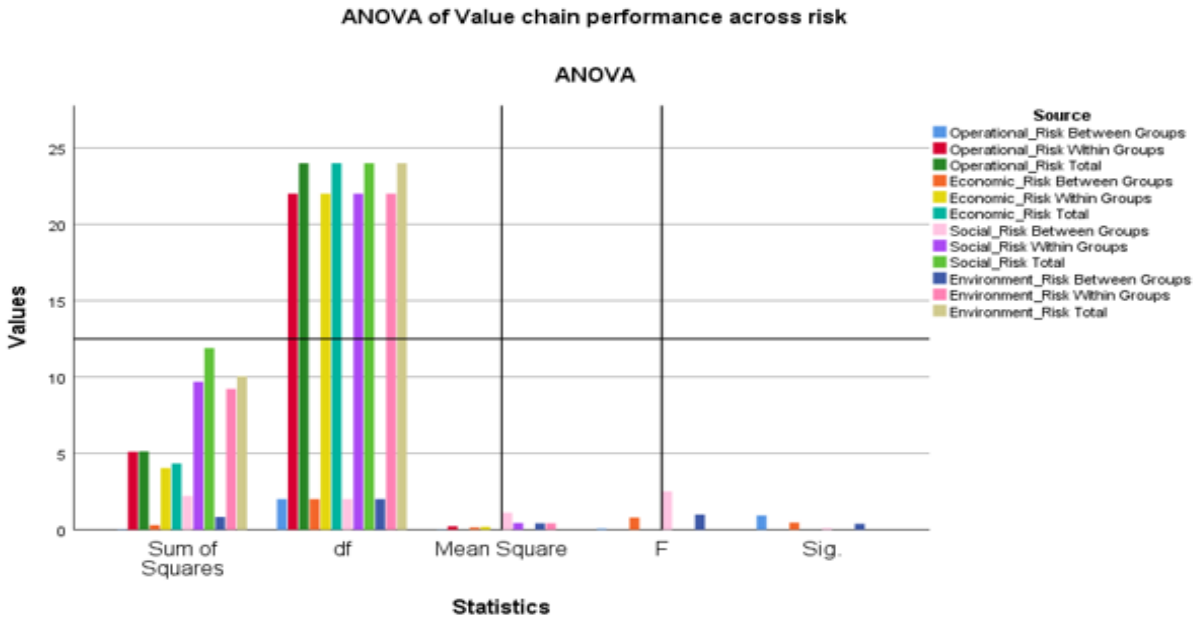


The given (table1.1) and chart describe the frequency percentage of pulse firms in all three states. Comparing the rate shows that 24% of Delhi has pulse firms, 36 % of Rajasthan has pulse firms, and 40% of Uttar Pradesh has pulse firms in the year (2022).

Table 4.2.12 : ANOVA of Value chain performance across risk

		Sum of Squares	df	Mean Square	F	Sig.
Operational Risk	Between Groups	.031	2	.016	.068	.935
	Within Groups	5.094	22	.232		
	Total	5.126	24			
Economic Risk	Between Groups	.293	2	.146	.797	.463
	Within Groups	4.041	22	.184		
	Total	4.334	24			
Social Risk	Between Groups	2.213	2	1.107	0..515	.104
	Within Groups	9.680	22	.440		
	Total	11.893	24			
Environment Risk	Between Groups	.832	2	.416	.993	.387
	Within Groups	9.218	22	.419		
	Total	10.049	24			

Table 1.2 illustrates the ANOVA of value chain performance across risk, determining the individual risk factor, operation risk, economic Risk, social Risk, and Environmental Risk. in the year 2022



The given (table 1.2) illustrates the ANOVA of value chain performance across the risk. The given table 1.2 and table 4.2.12 show the individual risk factors of group mean, between groups, in the group, and of all total firms. The ANOVA table contains risk factors with different frequency levels and significant values. The operational risk analyses and generates the frequency value at .068, with a significance value of .935. The Economic Risk analyses generated the frequency value at .797, and their significant value is .463. The Social Risk creates the frequency value at 0.515, their significance value is .104, the environmental risk generates the frequency value at .993, and their significant value is .387. The table shows that economic risk is highest compared to other risks, which may impact pulse firms.

Table 1.3: The table illustrates that all three states' FMEA failure mode effect analysis determines the frequency and significance value. The value of FMEA can be calculated with the three potential failure modes that have been identified. The failure mode of all Risks has a higher RPN and is, therefore, the highest priority for process improvement in the year (2022).

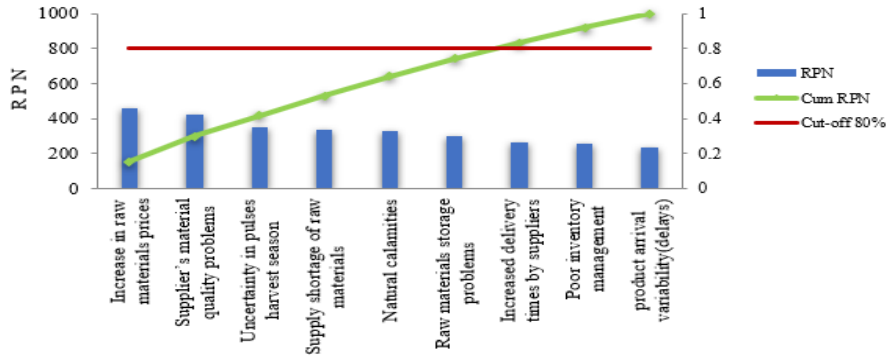
	Total	Uttar Pradesh	Rajasthan	Delhi	F	Sig.
Supply Risk						
Supply shortage of raw materials	334	352	312	336	0.080	0.923
Supplier's material quality problems	422	402	513	335	0.968	0.396
Increase in raw materials prices	455	405	476	510	0.384	0.686
Raw materials storage problems	298	372	257	234	1.064	0.362
Increased delivery times by suppliers	264	266	256	272	0.032	0.969
Uncertainty in pulses harvest season	353	251	408	449	2.096	0.148
product arrival variability(delays)	235	214	299	185	1.181	0.326
Poor inventory management	258	230	344	188	2.229	0.133
Natural calamities	331	205	478	345	6.006	0.009
Operational Risk						
Forecasting errors	291	372	288	159	3.639	0.044
Machine breakdown	290	334	309	191	1.692	0.208
Equipment failure	276	251	386	173	2.047	0.154
Technical problems	307	268	366	294	0.693	0.511
Lack of availability of laborers	284	324	248	265	0.541	0.590
Increased internal order processing times	286	291	365	172	1.334	0.285
Quality problem	352	352	446	229	3.447	0.051
Capacity problem	254	323	281	104	3.363	0.054
Poor production planning	332	319	361	314	0.157	0.856
Poor production scheduling	240	261	291	139	2.761	0.086
Change in production technology	294	280	426	139	3.219	0.060
Bullwhip effect	309	329	334	243	0.450	0.644
Demand Risk						
Demand fluctuations	386	342	425	407	0.360	0.702
Decline in market price	415	382	557	280	2.462	0.109
Lack of market information	333	237	414	386	1.471	0.252
Product Perishability	312	292	380	256	1.657	0.215
Changing consumer taste & preferences	293	285	362	213	0.862	0.437
Market risk	485	480	538	422	0.373	0.693
IT related risk	271	218	384	208	2.759	0.086

FMEA Analysis

The given table illustrates the FMEA failure mode effect and analysis consists of a different risk factor as supply risk, which consists of different supply-related variable risk factors, operational risk consists of different types of operational risk and their variable risk factor, and Demand risk with their variable risk factor of all three states Uttar Pradesh, Rajasthan and Delhi determine their frequency F- value of all risk factor and assign their significance value that how many risks will affect the firms.

Pareto Analysis: Identification of Potential Risks in the year (2022)

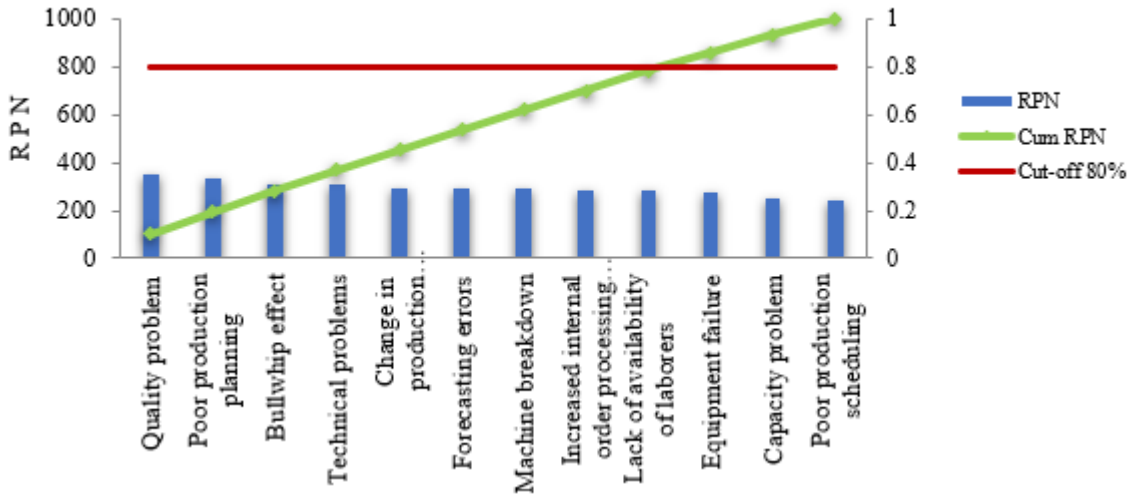
1. Pareto analysis to identity potential/critical supply risks



The given line chart analyses the Pareto analysis of potential/critical supply risk,

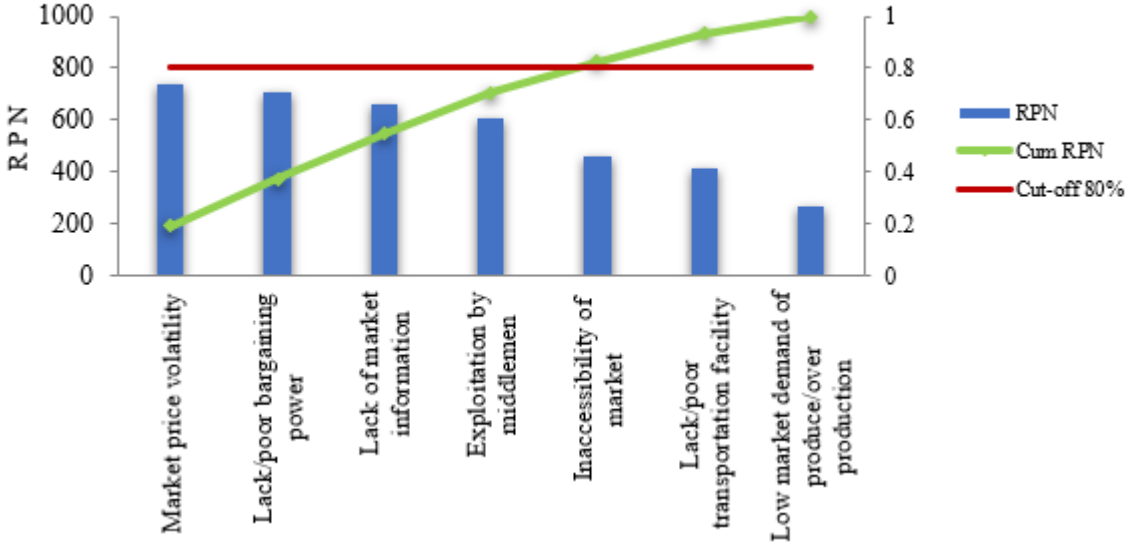
The business will experience loss most from the increase in raw material prices and Supplier material quality problems, so the firm should tackle this first. The firm could also look to Uncertainty in pulses harvest season, Supply shortage of raw materials, Natural calamities, Raw materials storage problems, and Increased delivery times by suppliers. In the pulse processing firm, the Pareto Analysis has enabled him to quickly identify the areas of the critical supply risk that face the most significant challenges, so he can focus his efforts where they are needed most and prioritize issues that will provide the biggest payoff to the business. This will likely save him a great deal of time and money that he might otherwise have spent trying to fix various issues, some of which may have provided minimal benefit. The Potential supply risk is Increases in raw material, Supplier material quality problems, Uncertainty in pulse harvest season, supply shortage of raw material, natural calamities, raw materials storage problems, and increased delivery times by suppliers.

2. Pareto analysis to identify potential/critical operational risks in 2022.



The Pareto analysis was performed to find critical operation risks for the firm. The business will suffer most from quality problems and Poor production planning, so the firm should tackle this first. The firm could also look to the Bullwhip effect, Technical issues, Change in production technology, Forecasting errors, Machine breakdown, and Increased internal order processing times. Pulse processing firm Pareto Analysis has enabled him to quickly identify the areas of critical operational risk that face the most significant challenges, so he can focus his efforts where they are needed most and prioritize issues that will provide the biggest payoff to the business. This will likely save him a great deal of time and money that he might otherwise have spent trying to fix various issues, some of which may have provided minimal benefit. The potential / Critical operational risk has quality problems, Poor production planning, bullwhip effect, technical problems, change in production technology, forecasting errors, machine breakdown and increased internal order processing times, and lack of availability of labor.

3. Pareto analysis to identify potential/critical demand risks in 2022.



The Pareto analysis was performed to find critical operation risks for the firm. The business will lose most from Market price volatility, Lack/poor bargaining power, and lack of market information, so the firm should tackle this first. The firm could also look to exploitation by intermediaries and the Inaccessibility of the market. The Pulse processing firm Pareto Analysis has enabled him to quickly identify the critical demand risk areas facing the most significant challenges, so he can focus his efforts where they are needed most and prioritize issues that will provide the biggest payoff to the business. This will likely save him a great deal of time and money that he might otherwise have spent trying to fix various issues, some of which may have provided minimal benefit. The potential/critical demand risk has market price volatility, lack/ poor bargaining power, lack of market information, exploitation by middle man, and Inaccessibility of the market.

Scope of study

The case study of all pulse processing firms in India reveals that very few limited pulse firms have adopted the sustainability measure. The pulse value chain considers only a few factors related to profitability and operation and economic part of firms because lack of pulse value chain measures the firms are covering a minimal area, of supply chain distributors, uneven distribution network that shows large low pulses availability in the market, and lack of value addition practices, generate poor quality of pulses in market. The research indicates that how sustainable pulse value chain becomes beneficial for pulse processing, promotes enrichment of pulse quality and availability in the market also, increases the efficiency of the pulse processing firm, generates business opportunities, and develops the value addition of food products, focusing on health-related issues, enhancing soil enrichment, and generating the ability to fix nitrogen properties and establishes the pulse value chain appropriate backward and forward linkage with farmers, grower, producer, processor, distributor, and market were analyzed to provide a better return as a form of profit and quality pulses food. It developed the enabling supportive factors as natural and international environment, with government policies to reorient and enhance the efficiency of the pulse value chain process. The pulse value chain establishes mapping, which develops interlinked with the components value chain. They are enabling the environment and service providers. It is the process of transforming processed food and supply through distribution channels to wholesale and retailers. The research observation shows that a high level of significance of all risk factors implies that pulse firms face high constraints related to all economic, social, and environmental elements. Operation risk generates pressure to adopt sustainability measures and pulse value chain practices, which increases the growth and development of firms and maintains the financial stability of firms. The research generates broad scope of opportunity in pulse sectors through enlargement of the pulse value chain and promoting value addition practices, which increases the quality pulse processing and packaging of pulse food. The sustainability factors increase the prospect of pulse firms in India and create significant job opportunities and skilled labor to provide pulse processing facilities and maintain the supply chain network.

Limitations of study

The case study shows the limitation of all pulse firms because they are facing high constraints related to adopted of sustainable global pulse value chain practices and sustainability measures in their pulse firms due to less fragmentation of the pulse market and lack of supply chain distribution network, which directly hamper the pulse production, supply chain and value addition practices of all pulse firms. All pulses firms are facing hurdles related to most miniature adoption of innovative technology and high adaptation of the traditional techniques of pulse processing mechanism, which generate the high constraint associated with lack of pulse production, machine breakage, lack of innovation and technology, are developing several issues are facing by pulse firms. The last adaptation of the pulse value chain in India generated significant constraints related to less usage of chemical fertilizer, poor quality seed, and limited use of conventional agronomical practices, reducing pulse firms' operation and production capacity. It developed the managerial factor to access and control the resources, which suffers from the limited availability of pesticides to prevent biotic and abiotic diseases, which causes low production of pulse legumes. The pulse value chain suffered from low processing of pulses, inefficient pulse production, and biotic and abiotic constraints such as pest diseases, drought, poor management, and lack of empowered technology. The pulse firms in India facing constrained by a lack of infrastructure and financial services and develop weak linkage between exporters to produce a lack of sustained pulses production.

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Conclusion

The result of ANOVA generated the frequency level to determine the impact of risk factorson pulses firms and made the comparison of adoption of value chain strategies for the pulses value chain, and quantified the risk that shows all pulses processing firms of three states are in decline stage due to high impact factor of chance. It is necessary to adopt risk mitigation strategies for pulses firms. The sustainability measures increase the firm's life and preserve renewable and non-renewable resources. The data analysis outcome shows the actual figure related to all sustainability factors to determine the mean and scattered data near. It is essential that the government and pulses processing adopt risk mitigation technique to avoid risk or reduces their effect. Suitable measures should be adopted to minimize the impact of risk factors, suggesting that all risk factors do impact the value chain performance of the Pulses processing firm. From the data analysis, generate the null hypotheses that the value chain performance get accepted, and the mean should be defined at the individual level. Risk mitigation is the collective performance of removing all risk from pulses firms. It is based on different strategies, tools, and techniques that quantify the number of risks in pulses firms. The reason that all the pulses firms in three states are facing a critical situation and are in the decline phase, the primary cause, is the high fluctuation of pulse prices in the market, poor quality raw pulses production, lack of supply chain network, limited distribution of pulse food product, lack of technology, and unavailability of skilled labor are the significant causes of failure of pulses firm in Indian. The case study generates the importance of pulse companies in national and international markets. Now, all pulses firms must adopt sustainability measures and risk mitigation strategies to reduce loss and enhance the pulses production capacity through different pulse processing techniques FMEA.

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