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FACTORS INFLUENCING ENERGY EFFICIENCY IN AGRO-BASED INDUSTRY CLUSTERS

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Abstract: Consolidating agro-based industries in India is a role played by Micro, Small, Medium enterprises (MSMEs). Three main things are at stake if these clusters are to live on in the face of globalization: their economic sustainability, their environmental impact and their social accountability. Energy utilization efficiency plays an important role towards the economic viability as well as environmental sustainability of energy-intensive agro-based industries. Enhanced energy efficiency (EE) results in lower costs and less environmental impacts. This study investigates the factors influencing energy consumption in an agricultural industrial cluster. The Cobb-Douglas production function determines the significance of this input based on 80 sectors related to agriculture. Looking at specific energy consumption helps measure energy efficiency while Principal Component Analysis (PCA) is used to analyze its driving forces. These variables are analyzed using multiple regression models.

Keywords: Agro-based industries; Energy Efficiency; Principal Component Analysis; Regression model; Specific Energy Consumption

1. Introduction

The Indian economic system depends heavily on agro- based totally industries, which use agricultural resources to produce gadgets with delivered price and employment. These sectors, which include dairy, chicken, fisheries, and agricultural processing, encourage rural development and lessen local inequality. In India, agro-based totally industries often organise into clusters that improve collaboration, creativity, useful resource sharing, economies of scale, supply chain effectiveness, and marketplace accessibility. Government projects to promote agricultural productivity and rural industrialization also are made easier to execute by using those clusters [1-4)].

Karnataka is a top example of agro-based clusters that be triumphant because of their numerous agro-climatic situations and abundant resources. Karnataka's clusters advantage from present infrastructure and marketplace get admission to, since the state is famous for producing coffee, spices, sugarcane, and silk [5-7)].

Sustainability and competitiveness in those clusters depend upon an know-how of energy performance. Increasing electricity efficiency may also lower expenses and intake of strength, which is a prime factor of operational expenses. Increasing energy efficiency is in keeping with worldwide sustainability targets and climate change mitigation due to its excessive electricity consumption and environmental effect. It facilitates agro- based industries stay aggressive and sustainable whilst contributing to economic increase and environmental conservation. It does this by way of making sure green resource utilisation, financial sustainability, environmental renovation, and social advancement [8-12)].

2. Background of Agro-based Industry Clusters

Agro-based industrial clusters have gained much interest in modern years, especially the consideration toward energy efficiency - as it is significant for sustainability and cumbersome competitiveness of agro- industrial domains. These studies help in widening the horizon of energy efficiency exploring n number of dimensions: managerial, technical, institutional and economic factors determining sectoral demand for energy. The most important aspect for enhancing energy efficiency has been stated to be the technological developments. Their will to reduce energy journey begins by adopting modern, high-efficiency technology and equipment. Applications such as automation and control systems can also help reduce energy loss in industrial processes by ensuring that the system does not waste any more than it needs to. These systems provide control over machinery and processes, such that energy is not wasted unnecessarily while also making the entire system efficient [13-16].

In addition to automation, another avenue with significant potential for reducing energy costs and environmental burden is the integration of renewable sources such as biomass and solar power streams. Having a positive environmental impact, the organic materials used in biomass energy production will give society a more reliable and sustainable alternative to fossil fuels while lowering overall greenhouse gas emissions. Because it is a clean, solar power takes advantage of the sun light and renewable energy which could have more benefit in high regions with higher tropical climate [17-20].

In fact, those renewable energies has been demonstrated that if combined with the traditional energy systems cost savings and environmental benefits can be significantly reduced. Taking examples where solar panels can complement energy requirements and reduce dependence on the grid, thereby cutting down electricity bills. Biomass energy works in much the same way, being used as an input to certain processes but controlling its carbon emission across an industry.

Also, using energy management system and practices is very much required for getting good in energy efficiency These work involves the analysis of energy usage patterns, monitoring areas in which improvements can be made are and doing all actions taken towards reduction of more energie. It is a precursor to realize substantial costs savings and reinforces the sustainability scenario of agro-based industrial cluster through effective energy management.

Enhancing energy efficiency requires regular equipment maintenance and process optimisation. Satish argues that agro-based businesses' high energy demand may be attributed in large part to inefficient production procedures [21]. According to their study, optimising manufacturing processes and making sure that maintenance is done on a regular basis may improve energy efficiency. Furthermore, real-time monitoring systems and energy audits have been shown to be useful instruments for locating and resolving energy consumption inefficiencies [22-24].

It is difficult to overstate the contribution organisational procedures and personnel training to the cause of energy efficiency. Energy use may be significantly decreased by teaching staff members about energy-saving techniques and the value of conservation. They suggest that in order to promote an energy-saving culture among agro-based clusters, energy efficiency initiatives and public awareness efforts are crucial [25–30]. Results from Nagesha, show that proactive energy management methods are associated with better levels of energy efficiency [31].

Initiatives to improve energy efficiency are mostly driven by governmental regulations and financial incentives. Studies demonstrate how financial incentives and regulatory frameworks affect the uptake of energy- efficient technology. According to a study, government grants, subsidies, and tax breaks may greatly motivate businesses to make investments in energy-saving technologies. Additionally, adhering to energy standards often calls for the adoption of more effective procedures, which supports energy saving initiatives even more [32-37]. It is well known that energy efficiency in agro-based sectors has both financial and environmental advantages. Enhanced energy efficiency lowers the environmental impact of agro-based sectors in addition to lowering operating expenses. Energy-efficient methods help to sustainable development by minimising greenhouse gas emissions and preserving natural resources. This combined effect of financial savings and environmental preservation highlights the significance of energy efficiency as a top strategic goal for clusters of agro-based industries [38-41].

The research emphasises the multidimensional character of the elements that influence energy efficiency in agro-based manufacturing clusters. Technological innovation, process optimisation, worker training, government laws, and the goal of environmental sustainability are all important factors in increasing energy efficiency. Continued research and policy assistance are required to promote energy-efficient methods and maintain the long-term growth of agriculture-based companies. The present study aims to contribute to this field by analysing data from an agro- based manufacturing cluster in Davangere district, Karnataka, a southern Indian state.

3. Methodology of the work

Karnataka's agro-based totally business cluster is a primary contributor to the country's agricultural manufacturing and average financial boom. Karnataka, with its precise agro-climatic situations, is certainly one of India's maximum effective agricultural states, producing a extensive variety of commodities. The state has a huge range of agricultural plants, consisting of grains, pulses, and oilseeds, in addition to end result, veggies, and spices. Karnataka is India's best producer of espresso and spices, accounting for 70% of the usa's coffee and 30% of the spices. Karnataka's agro-based totally business cluster is strategically assorted at some point of areas, with good sized clusters specialising in various agricultural operations. For instance, the Hubli-Dharwad region is famous for its sugarcane output and sugar turbines, whilst the Malnad region is cited for its coffee plantations. The country authorities has released a number of steps to sell the status quo of the agro-based industrial cluster, together with agricultural enter subsidies, infrastructure development, and market connections. However, the enterprise confronts a number of problems, which includes water shortages, land fragmentation, and fee volatility. Despite those obstacles, Karnataka's agro-primarily based economic cluster gives numerous potentialities for enlargement and diversification, mainly in natural farming, meals processing, and agro-tourism. With the appropriate policies and investments, the cluster has the capability to play a key role in Karnataka's transition to sustainable agricultural boom and monetary success.

A "random sampling methodology" is applied to select MSME enterprises within the agro-based industry cluster. The sample size for a finite population is calculated using a particular formula.

$\{Z^2 N\sigma^2\}$

additives make a contribution to the output. Traditionally, capital, land, and hard work were the primary additives in manufacturing models. However, energy has currently been identified as a essential thing in monetary hobby, equivalent to capital, land, and exertions. As a end result, contemporary financial theories now consist of electricity as a distinct thing of production, main to the adoption of the KLME (capital, labor, cloth, and strength) model for analysis. Among the special practical forms used to represent production in economics, the multiplicative Cobb-Douglas shape is often hired due to its effectiveness in taking pictures many production strategies. Consequently, the importance of electricity among the inputs is determined the usage of the Cobb-Douglas manufacturing characteristic as follows:

where:

$$n = \frac{p}{\{(N-1)e^2 + Z^2\sigma^2\}} \quad (1)$$

p

$$Y = AK^{\alpha}L^{\beta}E^{\gamma} \quad (2)$$

n = size of the sample required for a given precision and confidence level;
N = finite population size;
Z = standardized variate at a given confidence level (1.96 for 95 % and 2.57 for 99 % confidence level),
e = acceptable error or the precision required (about 5 % of mean value),
σp = standard deviation of the population (estimated through pilot study or past experience).

As illustrated in Table 1, the necessary sample size for the agro-based industry cluster is determined following the completion of a pilot study that employs specified energy consumption (SEC) as the criterion variable. The administration of a structured questionnaire is the primary method of data collection for this research. This questionnaire requests information regarding unit profiles, material inputs, production specifications, energy consumption, outputs, waste management practices, technological details, and related factors.

Table 1. Details of sample size estimation

Product Cluster	**Population Size**	**SEC Estimated through Pilot Study**			**Required (Executed) Sample Size**
		Mean	**e**	**σp**	
Agro-based Industry	450	49.12 GJ/Unit	2.43 GJ/unit	9.81 GJ/Unit	68 (80)

Because of the ambiguities around the true population number and limitations in the field survey, a higher sample size of 80 is used instead of the needed 68. More precisely, a sample of 80 units is chosen at random from a population of 450 units in order to guarantee sufficient representation and reliability of the results.

4. Factors Affecting Energy Efficiency

In the context of the "production function," various input
where:
Y = value of output of a SSI firm in the cluster;
K = value of capital (current value of plant and machinery);
L = labour cost; E = energy cost;
A, α, β, and γ = parameters that when estimated describe the quantitative relationship between the inputs and the output.

The Cobb-Douglas production function becomes a multiple regression equation once logarithms are applied to both sides of the equation. The coefficients of the input variables may be used to determine how significant they are in explaining the variance in the output variable when all inputs and outputs are stated in monetary terms. The resultant production function is shown in Table 2.

Table 2. Production Function Analysis

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	1902.076	2245.653		.847	.403
	Capita	1036.0	474.59	.234	2.18	.036

l	81	9		3	
Labor	.001	.007	.022	.204	.840
Energ y	.031	.005	.677	5.77 2	.000
a. Dependent Variable: Production					

The regression model is powerful, as evidenced through a noticeably large F-value. The independent variables give an explanation for a big portion of the variance in output cost, indicated by means of high adjusted R^2 values. Excluding labor, the electricity and capital additives are crucial in explaining the variance in production price. Notably, the energy thing is the maximum sizable in explaining the variance in output fee. Capital, represented via the cutting-edge value of plant and machinery, is also statistically great in explaining the version in production cost, though it's miles barely much less crucial than the strength element. This underscores the importance of power on this agro-based industry cluster.

The energy efficiency of MSME companies in Indian agro-based industrial clusters varies significantly, as indicated by the specific energy consumption (SEC). This suggests that the variety in EE cannot be exclusively attributable to manufacturing procedures, indicating the presence of non-technology variables [42)].

Twenty variables were chosen from the questionnaire to determine the important parameters that affect Specific Energy Consumption. The obtained data underwent reliability testing using SPSS software version 20, with Cronbach's Alpha serving as the reliability coefficient. The test, performed on a group of 80 participants, resulted in a Cronbach's alpha score of 0.863, suggesting that the measure had strong internal consistency and reliability.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the variables is 0.714, suggesting that the ratio for analysis falls inside the variety of common to remarkable. The Bartlett's Test of Sphericity, which assesses whether the correlation matrix is an identity matrix, has a significance price of 0.00. The final results of this evaluation refutes the null speculation, offering evidence that the variables are actually linked and may be used for component evaluation.

Factor analysis is used for information discount, identifying a small quantity of factors that specify maximum of the variance in lots of variables. Principal Component Analysis (PCA) is used for extracting elements, specifically whilst the correlation matrix is singular. The answer is turned around using varimax rotation for higher interpretation. Only Eigenvalues more than one are considered, ensuing in six additives that explain about seventy eight% of the variability inside the unique twenty variables. The first six factors account for almost seventy eight% of the full variance, significantly reducing records complexity with only a 22% loss of information. Therefore, a version with six elements safely represents the statistics [43-44)]. Figure 1 shows the scree plot with eigen values.

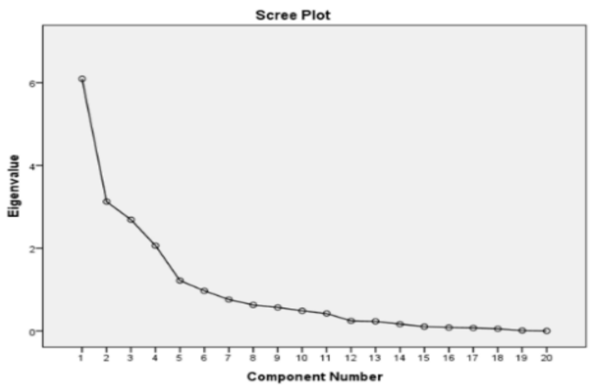

Fig. 1: Scree plot

Table 3 shows that variables with correlation coefficients greater than 0.50 under each derived component are considered significant. These significant variables are used to appropriately name the factors. The factors are then ranked based on their average scores.

Table 3. Factor rankings based on factor analysis

Component	Variables	Correlations (Factor loadings)	Mean variable score	Average variable score	Factor name	Rank
1	i) Governments effort	0.880	3.725	3.37	Government policy factor	VI
	ii) Government incentives	0.874	3.6			
	iii) Risk coverage	0.794	3.35			
	iv) Government regulations	0.763	3.475			
	v) Maintenance cost	0.592	3.625			
	vi) Importance of technology	0.495	2.45			
2	i) Willingness to adapt	0.806	4.7	4.01	Attitudinal factor	II
	ii) Attitude towards change	0.700	4.1			
	iii) Willingness to invest	0.594	3.225			
3	i) No. of energy efficient tech.	0.783	2.95	3.46	Technology factor	IV
	ii) Degree of satisfaction	0.686	3.675			
	iii) Liking towards technology	0.633	3.775			
4	i) Ego, prestige, status	0.767	3.625	3.87	Knowledge factor	III
	ii) Awareness about environment	0.693	3.7			
	iii) Concern for environment	0.676	4.375			
	iv) Adequacy of information	0.547	3.775			
5	i) Turnover	0.786	2.7	3.40	Personal factor	V
	ii) Educational qualification	0.750	3.25			
	iii) Ownership	0.666	4.25			
6	Government subsidies	0.846	4.225	4.23	Subsidy factor	I

The rankings suggest that the 'Subsidy component' has the maximum significance for sectors that include electricity performance, while the 'Government Policy aspect' is of least importance. Personnel in the agro-based totally business assert that authorities subsidies are crucial for promoting power efficiency. The 2nd most massive thing is the 'Attitudinal aspect', which refers to the level of take care of the environment and the choice to put money into power-efficient era, given the supply of subsidies. Individuals who select no longer to invest in strength- green practices have a lack of expertise about environmental problems and explicit concerns approximately the excessive fees associated with maintenance. Consequently, these sectors see a decrease within the adoption of electricity-green techniques.

Non-technical judgements based on perception were used to develop the criteria in Table 3, which was compiled from in-person interviews performed throughout the survey. To investigate the impacts on energy efficiency, these factors are added to the technical information obtained from the questionnaire and put into a multiple regression analysis. Thus, ten variables in all are analysed: four technical factors (the cost of energy (TF1), the number of workers (TF2), the floor space area (TF3), and the capital invested (TF4), and six non- technical features determined from factor analysis. The questionnaire is the source of the technical variables, which are then converted into a five-point Likert scale.

The SEC in the agro-based sector was the dependent variable in multiple regressions using the factor scores from principal component analysis. Ordinary Least Squares (OLS) regression analysis was performed to look at the relationship between SEC and ten components. With no departures from the homoskedasticity or normalcy assumptions and no issues with multicollinearity, the OLS technique performed quite well. The forward selection method in SPSS was used to optimise the equations.

In statistical modelling, evaluating model fit is essential, and R2 is a typical metric for doing so. A linear connection is shown by an R^2 of 0, but a value of 1 denotes a perfect match. An Adjusted R^2 of 0.823 and a significant F change of 0.000 were found in this investigation, indicating the utility and potent explanatory ability of the model. A significant correlation between the independent and dependent variables was revealed by the R value of 0.932.

Table 4 provides the standardized beta coefficients from the Collinearity statistics table. These coefficients are used to form the regression equation. A higher beta coefficient indicates a greater influence of that factor on energy efficiency (the dependent variable).

Table 4. Multiple Regression Results in Agro-based Industry Cluster

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-943917	211455		-4.464	.000
GOVTPOLFACT	78552	26205	.299	2.998	.006
ATTDFACT	42051	35833	.105	1.174	.250
TECHFACT	-187339	34687	-.439	-5.401	.000
KNWDFACT	-153831	42337	-.279	-3.633	.001
PERSNFACT	-264443	50475	-.532	-5.239	.000
SUBDYFACT	-67064	32670	-.167	-2.053	.049
TF1	406040	81357	.522	4.991	.000
TF2	111505	43160	.188	2.584	.000
TF3	-110927	80274	-.147	-1.382	.178
TF4	203872	71794	.313	2.840	.008
Dependent Variable: SEC					

The resulting regression equation obtained is, where:
Y = Energy Efficiency (SEC) or (Depending on the analysis required)
b0 = Constant

$$Y = b_0 + b_1F_1 + b_2F_2 + b_3F_3 + \cdots + b_nF_n$$

b1, b2, b3, ……, bn = Coefficients of the independent variables
F1, F2, F3, ..., Fn = Factor Scores

$$SEC = -943917 + 0.299 \times F1 - 0.439 \times F3 - 0.279 \times F4 - 0.532 \times F5 - 0.167 \times F6 + 0.522 \times F7 + 0.188 \times F8 + 0.313 \times F10 \quad (3)$$

Based on the data, it is evident that the 'human component' is the most critical need for energy efficiency in almost all of the cluster's agro-based businesses. Turnover, education, and ownership are crucial components of the personal component. People are more inclined to invest in energy-efficient technologies as their income and education levels rise, which boosts energy efficiency and lowers SEC (Specific Energy Consumption). Another crucial factor is building ownership.

Energy-efficient technology is often implemented based on economic considerations. The cost of energy, labour force size, and capital expenditure are the technical factors that directly affect energy efficiency. Curiously, the 'subsidy component' is found to have the lowest rank in this regression analysis, suggesting that individuals see government subsidies as less significant than indicated by the factor analysis. The elements that have less importance are the 'attitudinal factor' and 'floor space area'. Based on this investigation, the influence of energy-efficient technology and general environmental challenges is small due to poor knowledge and insufficient information from enterprises.

5. Conclusion

The specific energy consumption (SEC) is used to assess the energy efficiency level. Multiple regression analysis was used to assess the energy efficiency in the agro-based industrial cluster and look at all the many affecting factors. Regression analysis considers aspects that are both technical and non-technical. The human component and the cost of energy element have the most effects on energy efficiency in this business, according to the beta coefficients.

It may be concluded from the present study that clusters of agro-based sectors have a great deal of promise for improving energy efficiency. The goal is to raise public knowledge of energy-efficient technologies and provide financial and economic incentives to encourage advancements in energy efficiency and lessen the effect on the environment. Improving energy efficiency measures might have a major impact on this specific economic sector's ability to expand sustainably.

References

1) Basappaji, K. M., and N. Nagesha. "Assessment of cleaner production level in agro based industries–a fuzzy logic approach." Energy Procedia 54 (2014): 127-134. doi: 10.1016/j.egypro.2014.07.255.
2) Reddy, A. K. "Barriers to improvements in energy efficiency". Energy policy, 19(10), 953-961(1991). doi: 10.1016/0301-4215(91)90115-5.
3) DeCanio, S. J. "Barriers within firms to energy- efficient investments". Energy policy, 21(9), 906-914 (1993). doi: 10.1016/0301-4215(93)90178-I.
4) Painuly, J. P., & Reddy, B. S. "Electricity conservation programs: barriers to their implementation". Energy Sources, 18(3), 257-267 (1996). doi: 10.1080/00908319608908765.
5) Weber, L. "Some reflections on barriers to the efficient use of energy". Energy policy, 25(10), 833- 835 (1997). doi: 10.1016/S0301-4215(97)00084-0.
6) Sorrell, S., Schleich, J., & Scott, S. "The Economics of Energy Efficiency: Barriers to Cost-Effective Investment". Energy Studies Review, 14(1), 186-192 (2006). doi: 10.15173/esr.v14i1.482.
7) Altham, W. "Benchmarking to trigger cleaner production in small businesses: drycleaning case study". Journal of Cleaner Production, 15(8-9), 798- 813 (2007). doi: 10.1016/j.jclepro.2006.07.005.
8) Rao, P., la O'Castillo, O., Intal Jr, P. S., & Sajid, A. "Environmental indicators for small and medium enterprises in the Philippines: An empirical research". Journal of cleaner production, 14(5), 505-515 (2006). doi: 10.1016/j.jclepro.2005.03.016.
9) Lin, C. M., & Li, C. P. "The Role of National Productivity• Organizations in Promoting Green Productivity in Small and Medium Enterprises". In APO World Conference on Green Productivity, Manila (1996).
10) Saaty, T. L. "Decision making with the analytic hierarchy process". International journal of services sciences, 1(1), 83-98 (2008). doi: 10.1504/IJSSCI.2008.017590.
11) Madu, C. N. "An economic decision model for technology transfer". Engineering Management International, 5(1), 53-62 (1988). doi: 10.1016/0167-5419(88)90026-9.
12) Kablan, M. "Prioritization of decentralized electricity options available for rural areas in Jordan". Energy Conversion and Management, 38(14), 1515-1521 (1997). doi: 10.1016/S0196-8904(96)00106-9.
13) Kagazyo, T., Kaneko, K., Akai, M., & Hijikata, K. "Methodology and evaluation of priorities for energy and environmental research projects". Energy, 22(2- 3), 121-129 (1997). doi: 10.1016/S0360-5442(96)00132-6.
14) Mohsen, M. S., & Akash, B. A. "Evaluation of domestic solar water heating system in Jordan using analytic hierarchy process". Energy Conversion and Management, 38(18), 1815-1822 (1997). doi: 10.1016/S0196-8904(96)00115-X.
15) Yusuff, R. M., Yee, K. P., & Hashmi, M. S. J. "A preliminary study on the potential use of the analytical hierarchical process (AHP) to predict advanced manufacturing technology (AMT) implementation". Robotics and Computer-Integrated Manufacturing, 17(5), 421-427 (2001). doi: 10.1016/S0736-5845(01)00016-3
16) Chedid, R. B. "Policy development for solar water heaters: the case of Lebanon". Energy Conversion and Management, 43(1), 77-86 (2002). doi: 10.1016/S0196-8904(01)00008-5.
17) Bhattacharyya, S., & Dey, P. K. "Selection of power market structure using the analytic hierarchy process". International journal of global energy issues, 20(1), 36-57 (2003). doi:

10.1504/IJGEI.2003.003596.
18) Kablan, M. M. "Decision support for energy conservation promotion:: an analytic hierarchy process approach". Energy policy, 32(10), 1151-1158 (2004). doi: 10.1016/S0301-4215(03)00078-8.
19) Campuzano, L. R., Hincapié Llanos, G. A., Zartha Sossa, J. W., Orozco Mendoza, G. L., Palacio, J. C., & Herrera, M. "Barriers to the Adoption of Innovations for Sustainable Development in the Agricultural Sector—Systematic Literature Review (SLR)". Sustainability, 15(5), 4374 (2023). doi: 10.3390/su15054374.
20) Laurett, R., Paco, A., & Mainardes, E. W. "Measuring sustainable development, its antecedents, barriers and consequences in agriculture: An exploratory factor analysis". Environmental Development, 37, 100583
(2021). doi: 10.1016/j.envdev.2020.100583.
21) Satish, G. J., & Nagesha, N. "A case study of barriers and drivers for energy efficiency in an Indian city". International Journal of Energy Technology and Policy, 13(3), 266-277 (2017). doi: 10.1504/IJETP.2017.10001381.
22) Rodriguez, J. M., Molnar, J. J., Fazio, R. A., Sydnor, E., & Lowe, M. J. "Barriers to adoption of sustainable agriculture practices: Change agent perspectives". Renewable agriculture and food systems, 24(1), 60- 71 (2009). doi: 10.1017/S1742170508002421.
23) Barbosa Junior, M., Pinheiro, E., Sokulski, C. C., Ramos Huarachi, D. A., & de Francisco, A. C. "How to identify barriers to the adoption of sustainable agriculture? A study based on a multi-criteria model". Sustainability, 14(20), 13277 (2022). doi: 10.3390/su142013277.
24) Mishra, B., Gyawali, B. R., Paudel, K. P., Poudyal, N. C., Simon, M. F., Dasgupta, S., & Antonious, G. "Adoption of sustainable agriculture practices among farmers in Kentucky, USA". Environmental management, 62, 1060-1072 (2018). doi: 10.1007/s00267-018-1109-3.
25) Nagesha, N. "Ranking of barriers to energy efficiency in small industry clusters using analytic hierarchy process: an empirical study of three Indian clusters". South Asian Journal of Management, 12(2), 75 (2005).
26) Alayón, C. L., Säfsten, K., & Johansson, G. "Barriers and enablers for the adoption of sustainable manufacturing by manufacturing SMEs". Sustainability, 14(4), 2364 (2022). doi: 10.3390/su14042364.
27) Mohseni, S., Baghizadeh, K., & Pahl, J. "Evaluating barriers and drivers to sustainable food supply chains". Mathematical problems in engineering (2022). doi: 10.1155/2022/4486132.
28) Nagesha, N., & Balachandra, P. "Barriers to energy efficiency in small industry clusters: Multi-criteria- based prioritization using the analytic hierarchy process". Energy, 31(12), 1969-1983 (2006). doi: 10.1016/j.energy.2005.07.002.
29) Singh, G., Daultani, Y., & Sahu, R. "Investigating the barriers to growth in the Indian food processing sector". OPSEARCH, 59(2), 441-459 (2022). doi: 10.1007/s12597-021-00553-1.
30) Vyas, S., Narasima Venkatesh, A., Acharjee, P. B., Jangali, S. G., Singh, C., & Khan, Z. Z. "The Opportunities and Challenges of Implementing Green Internet of Things (IoT) Towards Energy Saving Practices in the Current Environment". In Proceedings of Second International Conference in Mechanical and Energy Technology: ICMET 2021, India (pp. 11-19). Singapore: Springer Nature Singapore (2022, June). doi: 10.1007/978-981-19- 0108-9_2.
31) Nagesha, N. "Cleaner Production: A brief literature review". Materials Today: Proceedings, 5(9), 17944-
17951 (2018). doi: 10.1016/j.matpr.2018.06.124.
32) Purwandani, J. A., & Michaud, G. "What are the drivers and barriers for green business practice adoption for SMEs?". Environment systems and decisions, 41(4), 577-593 (2021). doi: 10.1007/s10669-021-09821-3.
33) Kumar, S., Raut, R. D., Aktas, E., Narkhede, B. E., & Gedam, V. V. "Barriers to adoption of industry 4.0 and sustainability: a case study with SMEs". International Journal of Computer Integrated Manufacturing, 36(5), 657-677 (2023). doi: 10.1080/0951192X.2022.2128217.
34) Tumpa, T. J., Ali, S. M., Rahman, M. H., Paul, S. K., Chowdhury, P., & Khan, S. A. R. "Barriers to green supply chain management: An emerging economy context". Journal of cleaner

production, 236, 117617 (2019). doi: 10.1016/j.jclepro.2019.117617.

35) Perdana, T., Ginanjar, T., & NP, A. S. "Development of collaboration in sustainable agribusiness cluster". In MATEC Web of Conferences (Vol. 159, p. 01045). EDP Sciences (2018). doi: 10.1051/matecconf/201815901037.
36) Sharma, J., Bhardwaj, A., & Walia, R. S. "Factors Assessment for Encumbering the Implementation of Sustainability Based Lean Six Sigma Practices in Food Supply Chain" (2023).
37) Bhadu, J., Bhamu, J., & Saraswat, P. "An Analytic Hierarchy Process (AHP) Approach for Prioritizing the Industries 4.0 Technologies (I4. 0T)" (2023).
38) Sakataven, R. S., Helmi, S. A., & Hisjam, M. "Lean implementation barriers and their contextual relationship in contract manufacturing machining company" (2021).
39) Wardana, M. R. K., Sutopo, W., & Hisjam, M. "A Game Theory Model of Salt Price Stabilization Using Warehouse Receipt System" (2023).
40) Yussupov, A., & Suleimenova, R. Z. "Use of Remote Sensing Data for Environmental Monitoring of Desertification" (2023).
41) Agarwal, S., Tyagi, M., & Garg, R. K. "Circular Economy Reinforcement to Diminish GHG Emissions: A grey DEMATEL Approach" (2023).
42) Kotturshettar, B. B. "Study of energy consumption in residential and commercial sector of Hubli city." International Journal for Innovative Research in Science & Technology, 1(11), 83-91 (2015).
43) Satish, G. Jangali, and N. Nagesha. "Energy Consumption Pattern and Environmental Impact: A Case Study of Residential Sector in India." IOP Conference Series: Materials Science and Engineering. 577(1), 012035, (2019). doi: 10.1088/1757-899X/577/1/012035.
44) Satish, G. Jangali, and N. Nagesha. "A Comparative Study of Energy Consumption Pattern and Environmental Impact in Residential Sector of Indian Cities." IOP Conference Series: Materials Science and Engineering. 376(1), 012138 (2018). doi: 10.1088/1757-899X/376/1/012138.