

Multi-Criteria-Based Prioritization of Threats Affecting Sustainability of Micro and Small Scale Industries Using AHP and Mitigating the Major Threats Using Retrofitting

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Abstract—For Micro and Small Scale Industry (MSSI), to sustain itself in the present scenario is very challenging, as there are so many domestic as well as global threats. Challenges like competition from large and medium sectors, pricing, advanced technology, funding, raw material availability, marketing the finished product, infrastructure, etc. are faced by MSSI. In this paper, a multi-tier approach will be carried out to identify and mitigate the factors, which affect the MSSIs. In the first step, the various threats and challenges will be listed down, and an expert system tool will be employed to find out the major threats or challenges as the second step. There are numerous tools available for this purpose. In this paper, Analytic Hierarchy Process (AHP) is used to list down the factors based on its severity. As the final step of this approach, a suitable solution is provided to mitigate the factors, which affects MSSI's sustainability. In this case, the existing set-up was modified to accommodate the changes in the raw material, which in turn directly increases the production and machine utilization.

Index Terms—retrofitting, MSSI, AHP

I. INTRODUCTION

Micro and Small Scale Industry (MSSI) plays a vital role in order to lead India to distinct and dynamic position among globally developing economies. MSSI growth in the past decade is tremendous and it can be easily understood with the help of numbers given by Ministry of Micro Small and Medium Enterprises (MSME, Government of India) related to the total MSSI, production, employment, and export [1]. Even though there is scope for development, MSSI faces many problems like seasonal lack of demand for the finished product, work capital demand, non-availability of raw materials, power shortage, labor demands (both skilled and non-skilled), management problems, equipment problems and marketing problems. Industry should offer more training; government policy (legislative and regulatory framework) should be more friendly [2], socio-economic factors (age, gender and educational

qualification) should be taken into account [3]. Financial and Economic Barrier (FEB), and Behavioral and Personal Barrier (BPB) are the two top hindrances to the improvements of energy efficiency in Small-Scale Industries (SSI) [4]. The cost of the raw material and finished product also plays a major role in the sustainability of an oil producing MSSI [5]. For the present project's purpose, the data are collected in a small-scale cottonseed oil producing industry. This industry extracts only cottonseed oil and produces about 40 tons of oil per month during 4-5 months of a year. If the major threats or challenges are eliminated or at least mitigated, the industry will be able to make more profit and also will be able to sustain itself in the market. The overview of major threats or challenges is shown Fig. 1.

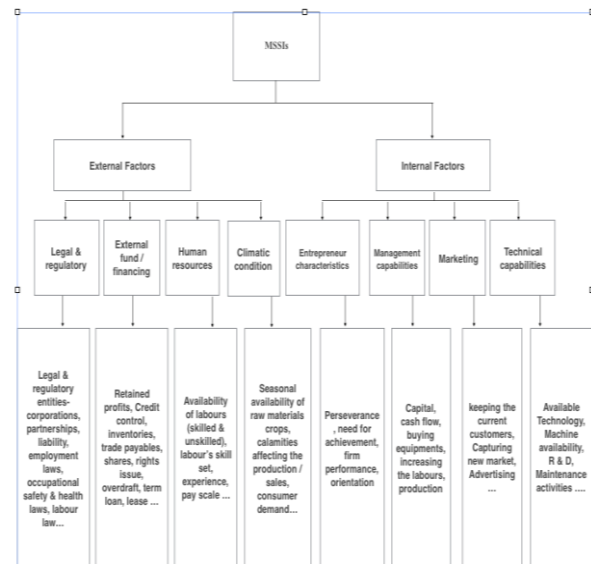


Figure 1. Factors affecting the growth of MSSI

The factors, which influence the growth or sustainability of MSSIs, can be classified broadly into external and internal factors. The factors which can be influenced or altered internally by the management like marketing, technology, R&D, capital etc., come under internal factors. The factors, which cannot be controlled like climate, legal entities, external funds etc., come under

external factors. There are many articles available about how these factors affect the growth/sustainability of MSSIs or Small and Medium Scale Enterprises (SMEs) [6]-[10].

II. METHODOLOGY

The methodology adopted here is a multi-tier approach. There are three major steps involved. In the first step, the major threats and challenges are accounted with the help of an industrial expert. The next step is prioritizing the threats by using AHP, and finally suitable solution is proposed to eliminate or mitigate the threats.

Step 1: Threats & Challenges

The factors affecting the MSSIs are Climatic Condition (CC), Legal & Regulatory (LR), External fund/ Financing (EF), Human Resources (HR), Entrepreneur Characteristics (EC), Management Capabilities (MG), Marketing Capabilities (MC), and Technical Capabilities (TC). Among these factors, CC, HR, MC, and TC play a major role and affect much more than the other ones for the selected MSSIs. These factors are shortlisted based on the company's expert opinion.

Step 2: Analytic Hierarchy Process (AHP)

The AHP is one of most reliable tool to find out the priority scales based on expert opinion and matrix-based calculation. The application and reliability of AHP is discussed by different persons over the years [11]-[14], the calculation is as follows:

(i) Pairwise comparison between the factors

	CC	TC	HR	MC
CC	1	3	3	4
TC	1/3	1	3	3
HR	1/3	1/3	1	2
MC	1/4	1/3	1/2	1

(ii) Steps to get normalized matrix

	CC	TC	HR	MC
CC	1	3	3	4
TC	1/3	1	3	3
HR	1/3	1/3	1	2
MC	1/4	1/3	1/2	1
SUM	23/12	14/3	15/2	10

Normalized matrix

	CC	TC	HR	MC
CC	12/23	9/14	6/15	4/10
TC	4/23	3/14	6/15	3/10
HR	4/23	1/14	2/15	2/10
MC	3/23	1/14	1/15	1/10
SUM	1	1	1	1

(iii) Eigen vector or priority vector is obtained by normalizing the average across the rows

	12/23	9/14	6/15	4/10
	4/23	3/14	6/15	3/10
=1/4	4/23	1/14	2/15	2/10
	3/23	1/14	1/15	1/10

(iv) Ranking of the factors

CC	0.49115
TC	0.2721
HR	0.14465
MC	0.0921

FACTORS; PRIORITY %

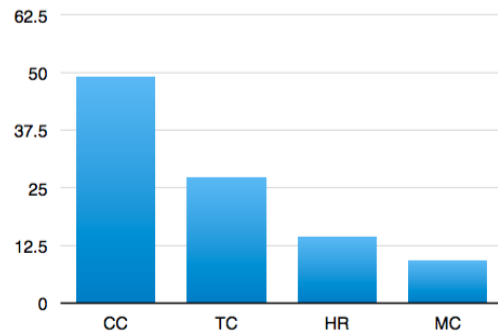


Figure 2. Graph showing the percentage of factors priority based upon AHP

TABLE I: RANDOM INDEX TABLE [16]

N	3	4	5	6	7	8	9
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45

(v) Checking for consistency:

The consistency of judgment can be calculated as follows, and the final values can be compared with Table I the final value varies with the size of matrices. For a 4*4 matrix, the value should be less than 1 [15]. CI is the consistency index, n is the size of matrix, RI is the random consistency index, and CR is the consistency ratio.

$$CI = (\lambda_{\max} - n) / (n - 1) \quad (1)$$

$$CR = CI / RI \quad (2)$$

$$\lambda_{\max} = 23/12 (.49115) + 14/3 (0.2721) + 15/2 (0.14465) + 10 (0.0921)$$

$$= 0.9414 + 1.2698 + 1.0849 + 0.921$$

$$= 4.2171$$

$$CI = (4.2171 - 4) / (4 - 1) = 0.2171 / 3 = 0.0724$$

$$CR = CI / RI = 0.0724 / 0.9$$

$$= 0.0804 \text{ (which is less than 0.1)}$$

$$CR = 8.04\% \text{ (which is less than 10\%)}$$

Step 3: Alternative / Solution for major factors

Based upon the AHP ranking, the major factors affecting this industry are CC and TC. Numerous ideas are discussed in order to eliminate or mitigate the effects due to the factors like seasonal operation of industry,

getting another (additional) machine, closing the SSI, modification of existing set-up to accommodate similar oil production, using the current space for some other productions with additional temporary machines, renting industry as a warehouse during idle months and so on.

TABLE II: FACTORS WITH PRIORITY PERCENTAGE BASED ON AHP CALCULATION

FACTORS	PERCENTAGE
Climatic Condition	49.12
Technical Capabilities	27.21
Human Resources	14.47
Marketing Capabilities	9.21

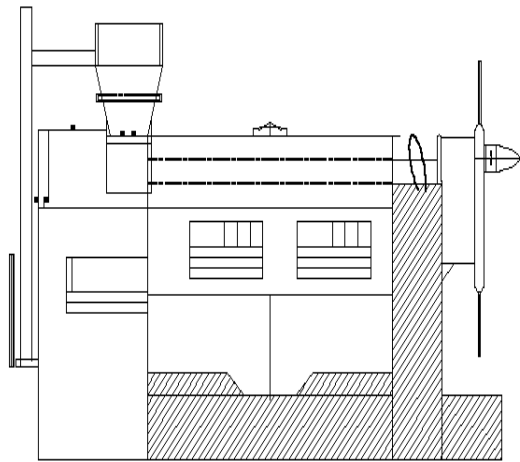


Figure 3. Current M/C set-up

Among various ideas, modification of existing set-up looked more promising in Cost Benefit Analysis (CBA). This process of modifying the existing machine is nothing but retrofitting. There are many cases available throughout the past decades about why and how retrofitting is used [17]-[20]. This option was accepted since it takes less investment compared to the other options like buying new machine, and also, it mitigates the effects due to CC and TC. With the new set-up, there is no need of the machine to sit idle for 4-6 months as it can accommodate to produce neem (*Azadirachta Indica*) seed oil during non-availability of cotton seeds (Gossypium hirsutum; i.e., especially during off season of cotton seeds machine can be utilized for neem seed). In India, neem seeds are available almost throughout the year, and there is a good market demand for neem seed oil as it is used in cosmetics, soaps, and also in some medicines. Fig. 3 shows the existing machine set-up in the industry, and Fig. 4. Shows the proposed modified machine set-up. In the modified set-up, the hopper has a slit, which can allow seeds to be fed on either side depending on the type of the seed. For example, the left side can produce neem oil if the right side is fixed for cottonseed oil, and production of neem oil can be adjusted by the slit of the hopper and operating the left side motor. The right side motor can be operated separately for producing the cottonseed oil. Two motors (one on each side) are provided for energy saving. Thus here, with the

help of retrofitting, both CC and TC can be tackled effectively.

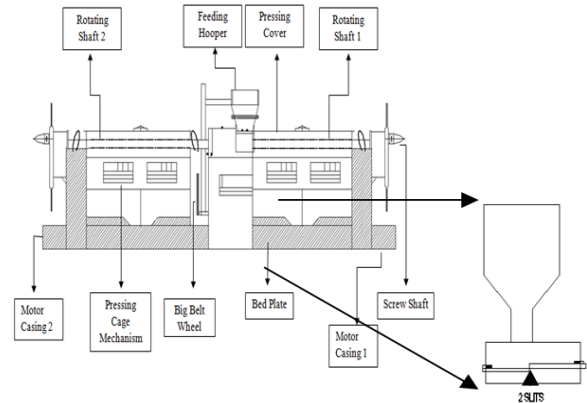


Figure 4. Proposed modified (retrofitted) M/C set-up along with modified hopper

III. RESULT & CONCLUSION

All the factors affecting MSSSI are listed down. With the help of a selected industry expert, the major threats are shortlisted. The shortlisted factors are prioritized by using AHP. The two top ranked calculations from the AHP are climatic condition and technical capabilities. These two factors play a major role in sustainability of the selected MSSSI. The combined percentage of these factors comes above 75% in the AHP. So, finding the solution for mitigating these factors will be a huge boost to the sustainability of the industry. Due to financial and other constraints among the various solutions, retrofitting is selected. The proposed modification of existing machine set-up will mitigate and eliminate the threats due to the above factors mentioned to a major extent. Due to this modification, possibility of producing other type oil is possible in a parallel manner, and further, it reduces the idle time and increases the productivity during the maintenance (only one part can be subjected to maintenance & other part can function). Future works will be implementing the modification and will be noting the improvement. Further, considering all the factors can extend the work.

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