Research Article

Fuzzy Inference System for Evaluating Leanness index of Software organizations

Mrs.Mona Deshmukh[a], Dr.Amit Jain[b], Prof. Arun kumar[c] Dr. Arvind sharma[d]

[a,b] Department of CSE, School of Engineering, Sir Padampat Singhania University India
email:[a]mona.deshmukh17@spsu.ac.in

Article History: Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 4 June 2021

Abstract: The ever changing market and customer demands have been a driving force for organizations to shift from the plan driven approach to more flexible, responsive, and adaptable approaches like the agile and lean approach. Organizations need to think about and adapt new strategies and innovative ideas to ensure every aspect of sustainability. The purpose of this research is to develop assessment model (a decision support tool) for evaluation of overall fitness level of a software organization. The tool takes into account the agility, leanness and sustainability aspect to derive the overall lean fitness of an organization to the rapidly changing market.

Keywords: Agile,Lean,Fuzzysystem,sustainability,Greeen IT, enablers

1. Introduction

Agile is a mindset, its incremental, iterative and flexible to change and focuses on process improvement. Whereas Lean software development is also becoming popular concept for process optimization. Continuous learning, experimentation and flexibility to change are some of the common features of Lean and agile. Methodologies such as agile are being widely used in software organizations for process improvement. While the focus of agile is to develop useful product in an incremental and iterative manner with an mindset which is adaptable and flexible to change, lean start-up has emerged as an methodology which helps in further optimisation of the software development process, Lean is iterative and incremental and believes in short development cycle with a focus on continuous improvement. Due to globalization, increased completion and changing customer requirements/demands organizations are facing constant completion to sustain in the current scenario. (Sharifi and Zhang, 1999). These basic circumstances has prompted a significant update in business needs, essential vision, and in the practicality of contemporary models (Sharifi and Zhang, 1999).The purpose of this research is to develop a tool,which will assist is evaluating the Lean fitness of an software organization keeping the agile,lean and sustainability criterias into account. Aim is to develop a Leanness assement tool using the Fuzzy logic infernce sytem which will help the experts to identify their organizations sustainability in the ever changing market and assist in better decision making.

2. Literature Review

Growing strain to reduce cycle time,enhance qulity and quick responsiveness to changing customer requirements are the major factors for oganisations to adapt to he agile development methodology. Even though agile software development methods were originally designed for single, small teams, during recent years, large organizations have increasingly adopted them (Hossain et al. 2009; Larman and Vodde 2010; Leffingwell 2007). According to the Agile manifesto agility is all about-flexibility-small iterations i.e delivering features in small outcomes, -empowered employees,customer collaboration-self organized teams ,all these factors have made Agile most popular framework in the software domain as compared to the traditional plan driven approach.These Agile principles are guidelines towards achiving satisfied customers and delivering a high quality product. Agile is more concerned towards shortening the feedback loop between the specified requirements and the development team,as a result it helps towards increased customer collaboration ensuring that the requirements map to the axctual needs of the customer ad provide value.

Lean is a methodology which focses on reducing waste and maximizing customer value by developing prodeucts which add value to the customer. Lean is all abiut builing the right procut wheras agile is about building them in a right way. The lean startup framework follows the validated leanring approach which leads to product discovery and identifying the right solution. since the Indian Government is zeroing in on expertise based cycles, the extension and development of the lean based businesses isn't restricted.(Girish et.al 2017). Lean leads to elimination of wastes like task switching,over processing,waitng time,defects,inventory thereby optimizing the development process.

The term "Sustainable development" was first introduced in the world conservation strategy poposed by thee United Nations Environment Programme UNEP and the International Union for the Conservation of Nature IUCN in 1980. Sustaainability can be termed as the capability to sustain.According to (Kahn 1995) the three pillars of sustainablity are social sustainability,economical sustainability and eviourmenal sustainability.Green IT and sustainability is an approach towads developing green software in relation with green engineering[5].the aim of sustainable software rngineering is to optimize the usage of natural resourses and energy [5].Muthu et al (2019) have defined the three dimensions of sustainability as shown in the figure 1.

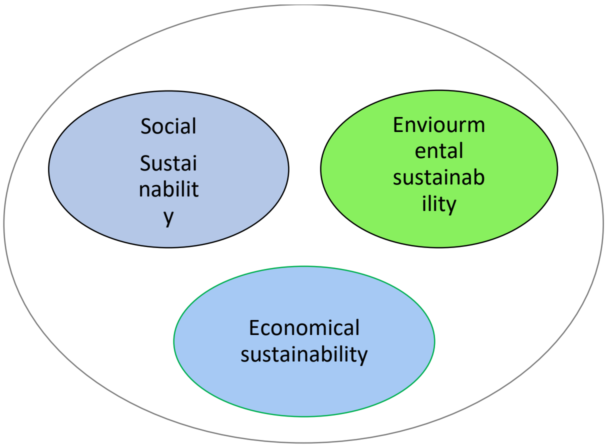

Figure 1: Sustainability/ Green IT dimensions

In this research we have tried to identify and define the Agile,Lean and sustainability enablers and criterias for software organizations. The enablers have been reviewd and validated from industry experts in lean and agle methodology. Further a decision support tool has been designed and developed using the fuzzy matlab tool to evaluate the fitness of a software organization.Fuzzt theory was introduced by Dr. Lotfi Zadeh, a professor of mathematics from U.C. Berkeley 1965[20].Fuzzy logic is based on a concept where the membership of a set is defined as a range of values rather than crisp value like 0 or 1 or true or false. Fuzzy logic uses a range of values between the interval of true and false to define the membership of an object. These values can be used to define logic expressed in form of rules for the fuzzy inference system,it comprises of the fuzzy sets,fuzzy membership function,linguistic variables and fuzzy if-then – else rules.Fuzzy sets and linguistic rules are widely used in qualitative assessments. However in a scenario where information is quantitative, expressing them in terms of numerical amounts are allowed, while in researches where qualitative data is required the gathered information can suffer from ambiguity and vagueness. Studies have shown that many mangers have difficulty in expressing their opinion in exact figures rather than using natural language which necessitates linguistic assessment. (Beach et al., 2000; Gerwin, 1993). Fuzzy logic uses three steps shown in figure 2 to transform these linguistic information into crisp values.

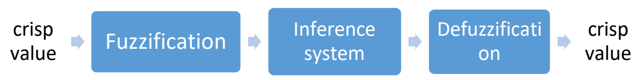

Figure 2: Fuzzy Logic

Fuzzification is the method of defining the inpiuts and outputs of a system into fuzzy sets and converting fuzzy values into crisp values.Fuzzy inference is the fuzzy logic written inform of fuzzy rules which maps the input to the output which can aid in decision making.Defuzifucation is a process of convering the output of the fuzzy inference system into crisp values.

3. Conceptual Model

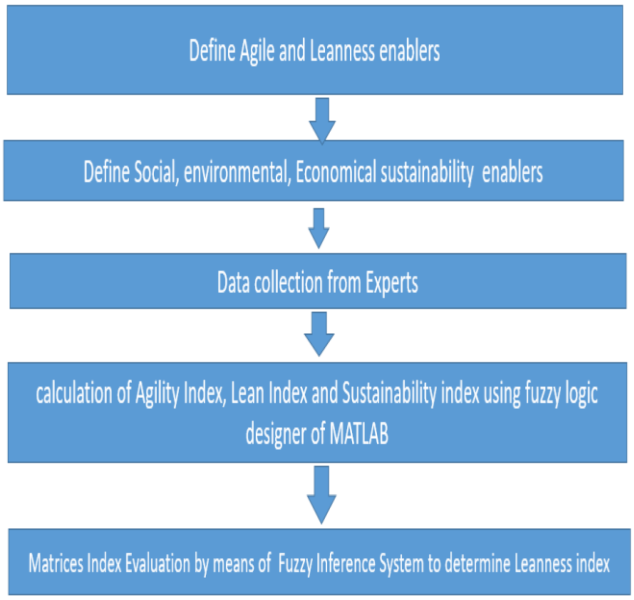

Figure 3: Conceptual Model

Figure 3 represents the conceptual model for the proposed system. A conceptual model for agility assessment was developed identifying 20-criteria (Vinodh et al., 2008). The proposed Leanness fitness model consists of 5 enablers as shown in figure 4,70 criterias and 204 sub-criteras. The enablers were verified and reviewed from industry experts.The data is collected from industry experts and an aggregate value for each enabler is considered.

Figure 4: Green Fitness enablers

A.The enablers and their respective criterias are shown in table [1-5].

Table I : Economical Sustainability

	Cycle time reduction	**High Value Addition**	**Minimizing Costs**	**Efficiency**	**Flexibility**	**Cost Management**	**Well defined Organizational structure**
Cycle time reduction	**1**	**3**	**5**	**7**	**9**	**9**	**3**
High Value Addition	**3**	**1**	**5**	**3**	**3**	**5**	**5**
Minimizing Costs	**5**	**5**	**1**	**5**	**7**	**9**	**7**
Efficiency	**7**	**3**	**5**	**1**	**5**	**5**	**3**
Flexibility	**9**	**3**	**7**	**5**	**1**	**3**	**3**
Cost Management	**9**	**5**	**9**	**5**	**3**	**1**	**7**
Well defined Organizational structure	**3**	**5**	**7**	**3**	**3**	**7**	**1**

Table II : Social Sustainability

	Satisfy the needs of current generation	Regional Self-Reliance of a Company	High Education Levels	High Employment	Responsivness to customer demands	Long Product Life	developing the ability of future generations to meet their demands
Satisfy the needs of current generation	**1**	**3**	**7**	**7**	**3**	**5**	**9**
Regional Self-Reliance	**3**	**1**	**7**	**7**	**5**	**5**	**9**
High Education Levels	**7**	**7**	**1**	**7**	**7**	**9**	**3**
High Employment	**7**	**7**	**7**	**1**	**7**	**3**	**5**
Responsivness to customer demands	**3**	**5**	**7**	**7**	**1**	**3**	**9**
Long Product Life	**5**	**5**	**9**	**3**	**3**	**1**	**9**
developing the ability of future generations to meet their demands	**9**	**9**	**3**	**5**	**9**	**9**	**1**

Table III : Enviourmental Sustainability

	Energy Efficiency	Reducing Hazards and Emissions	Reducing Toxicity	Environmental Performance
Energy Efficiency	1	3	5	7
Reducing Hazards and Emissions	3	1	3	3
Reducing Toxicity	5	3	1	3
Environmental Performance	7	3	3	1

Table IV : Leanness Criteria

	Elimination of zero value activities	Continuous Improvement Practiced	Multi Functional Team	JIT Production and Delivery	Integration of Suppliers	Single Piece Production	Zero Defect Production	Focus on Manufacturing Process	Focus on Hardware and Software Technology	Emphasis on Waste Elimination	Customer Satisfaction	Reducing Time of Operations	Reducing Inventories and Space	Reducing Unit Costs	Reducing Over Production	Reducing Wait in Process (Lead Time)	Reducing Unnnecessary Processing	Reducing Operator Movement	Avoid Interruptions	Remove Errors	Integration Of Functions	Decentralization
Elimination of zero value activities	1	3	5	7	3	3	5	7	9	5	3	3	3	3	5	5	3	3	5	3	5	5
Continuous Improvement Practiced	3	1	3	5	7	9	3	5	7	7	3	3	3	3	3	3	3	7	5	4	5	5
Multi Functional Team	5	3	1	3	5	7	7	7	3	3	3	7	3	9	3	5	3	7	3	9	3	5
JIT Production and Delivery	7	5	3	1	3	5	7	9	3	3	9	7	3	9	3	5	3	7	3	9	3	5
Integration of Suppliers	3	7	5	3	1	3	5	7	9	3	3	9	7	3	3	3	3	3	5	5	7	3
Single Piece Production	3	7	7	5	3	1	3	5	7	9	5	3	7	3	3	3	3	3	3	3	9	3
Zero Defect development	5	3	7	7	5	3	1	3	5	7	3	7	3	9	3	7	3	9	3	5	3	7
Focus on Process improvement	7	5	7	9	7	5	3	1	3	3	5	3	5	3	9	7	3	9	3	5	5	9
Focus on Hardware and Software Technology	9	7	3	3	9	7	5	3	1	3	3	5	3	5	3	9	7	3	9	3	3	3
Emphasis on Waste Elimination	5	7	3	3	3	9	7	3	3	1	3	5	7	8	5	3	7	3	9	3	9	5
Customer Satisfaction	3	3	3	9	3	5	3	5	3	3	1	3	5	7	3	7	3	9	9	3	9	3
Reducing Time of Operations	3	3	7	7	9	3	7	3	5	5	3	1	3	3	5	3	5	3	7	4	9	3
Reducing Inventories and Space	3	3	3	3	7	7	3	5	3	7	5	3	1	3	3	5	3	5	3	9	3	9
Reducing Unit Costs	3	3	9	9	3	3	9	3	5	8	7	3	3	1	7	9	7	3	5	7	5	7
Reducing Extra Fetures	5	3	3	3	3	3	3	9	3	5	3	5	3	7	1	3	5	7	9	9	9	9
Reducing Wait in Process (Lead Time)	5	3	5	5	3	3	7	7	9	3	7	3	5	9	3	1	4	3	5	7	7	7
Reducing Unnnecessary Processing	3	3	3	3	3	3	3	3	7	7	3	5	3	7	5	4	1	3	5	7	9	9
Reducing Operator Movement	3	7	7	7	3	3	9	9	3	3	9	3	5	3	7	3	3	1	3	5	5	3
Avoid Interruptions	5	5	3	3	5	3	3	3	9	9	9	7	3	5	9	5	5	3	1	9	3	3
Remove Errors	3	4	9	9	5	3	5	5	3	3	3	4	9	7	9	7	7	5	9	1	7	7
Integration Of Functions	5	5	3	3	7	9	3	5	3	9	9	9	3	5	9	7	9	5	3	7	1	9
Decentralization	5	5	5	5	3	3	7	9	3	5	3	3	9	7	9	7	9	3	3	7	9	1

Table V : Agility Criteria

	Responsiveness	Adaptability	Rapid Increase in Productivity	knowledge driven employees	Fully empowered Employees	Effective Product Life Cycle	Flexible Product Service life	Continuous Product Improvement	Cost Management	Automation	Module Integration	Change in Business and Technical Process	Efficient Time Management	Supply Chain Management	Flexibility to reconfigure	Long Term Gains	Strategy View	Innovative Culutre	Customer Integrated Process	Focus on Hardware and Software Technology	Quick Response	high quality and Customized Product	Synthesis Of Diverse Technologies	Bringing Products to market quickly	Process Flow	Product Modularization	Modelling tools	Rapid Prototyping
Responsiveness	1	3	3	3	3	3	3	3	3	3	3	3	3	5	5	3	3	5	3	7	3	9	7	5	4	3	1	1
Adaptability	3	1	3	3	3	3	3	5	5	3	3	3	3	3	3	3	7	5	4	3	1	1	3	5	3	7	3	9
Rapid Increase in Productivity	3	3	1	3	5	3	7	3	9	3	7	3	9	3	5	3	7	3	9	9	3	5	3	7	3	9	9	3
knowledge driven employees	3	3	3	1	3	5	3	7	3	9	7	3	9	3	5	3	7	3	9	9	3	5	3	7	3	9	3	9
fully empowered Employees	3	3	5	3	1	3	5	3	7	3	9	7	3	9	3	5	3	7	3	9	3	9	3	9	3	9	9	3
Effective Product Life Cycle	3	3	3	5	3	1	3	5	3	5	3	7	3	9	3	9	3	9	3	9	7	3	7	3	7	3	3	3
Flexible Product Service life	3	3	7	3	5	3	1	3	5	3	7	3	9	9	3	9	7	3	7	3	3	9	3	9	9	3	9	3
Continuous Product Design Improvement	3	5	3	7	3	5	3	1	3	5	3	5	3	7	3	9	3	5	3	3	7	3	7	3	5	7	3	3
Cost Management	3	5	9	3	7	3	5	3	1	3	5	3	5	3	7	3	9	3	9	9	7	3	9	3	5	3	3	7
Automation	3	3	3	9	3	5	3	5	3	1	3	5	3	7	3	9	9	7	3	3	9	7	3	9	3	5	3	9
Information Technology Integration	3	3	7	7	9	3	7	3	5	3	1	3	5	3	7	3	9	9	9	5	3	7	3	9	3	9	3	3
Change in Business and Technical Process	3	3	3	3	7	7	3	5	3	5	3	1	5	3	7	3	9	3	3	3	7	3	9	9	3	9	3	9
Efficient Time Management	3	3	9	9	3	3	9	3	5	3	5	5	1	5	3	9	9	3	5	5	3	5	3	7	3	9	7	3
Supply Chain Management	5	3	3	3	9	9	9	7	3	7	3	3	5	1	5	3	7	3	9	3	5	3	5	3	7	3	3	9
Flexibility to reconfigure	5	3	5	5	3	3	3	3	7	3	7	7	3	5	1	5	3	9	9	3	3	3	3	7	3	9	7	3
Long Term Gains	3	3	3	3	5	9	9	9	3	9	3	3	9	3	5	1	3	3	7	3	9	3	9	7	3	9	3	5
Strategy View	3	7	7	7	3	3	7	3	9	9	9	9	9	7	3	3	1	5	3	9	3	9	3	3	7	3	9	3
Innovative Culutre	5	5	3	3	7	9	3	5	3	7	9	3	3	3	9	3	5	1	5	3	9	9	3	3	9	3	9	3
Customer Integrated Process	3	4	9	9	3	3	7	3	9	3	9	3	5	9	9	7	3	5	1	5	3	7	3	3	3	9	9	3
Focus on Hardware and Software Technology	7	3	9	9	9	9	3	3	9	3	5	3	5	3	3	3	9	3	5	1	5	3	7	3	5	3	7	3
Quick Response	3	1	3	3	3	7	3	7	7	9	3	7	3	5	3	9	3	9	3	5	1	5	3	3	3	9	3	7
high quality and Customized Product	9	1	5	5	9	3	9	3	3	7	7	3	5	3	3	3	9	9	7	3	5	1	1	3	9	9	9	3
Synthesis Of Diverse Technologies	7	3	3	3	3	7	3	7	9	3	3	9	3	5	3	9	3	3	3	7	3	1	1	7	3	7	7	3
Bringing Products to market quickly	5	5	7	7	9	3	9	3	3	9	9	9	7	3	7	7	3	3	3	3	3	3	7	1	5	9	7	3
Flow Process	4	3	3	3	3	7	9	5	5	3	3	3	3	7	3	3	7	9	3	5	3	9	3	5	1	7	7	3
Product Modularization	3	7	9	9	9	3	3	7	3	5	9	9	9	3	9	9	3	3	9	3	9	9	7	9	7	1	7	3
Modelling Tools	1	3	9	3	9	3	9	3	3	3	3	3	7	3	7	3	9	9	9	7	3	9	7	7	7	7	1	9
Rapid Prototyping	1	9	3	9	3	3	3	3	7	9	3	9	3	9	3	5	3	3	3	3	7	3	3	3	3	3	9	1

B Input and output parameters

To Define the Linguistic variables for estimating Lean Fitness we have used the linguistic variables and membership functions from previous studies and adjusted according to research needs. Therefore based on the study conducted by Yang and Li (2002) and considering the human way of perceiving things the Linguistic variables are selected to access the performance rating. Matching the above linguistic variables with Fuzzy number is done according to the same study by Lin et al.2006.The input parameters and their membership functions are described in table 6.

The Matlab 2015a Fuzzy tool FIS editor was used to create the input and output parameters as shown in figure

5. We have defined three input parameters and one output parameter for the FIS system.

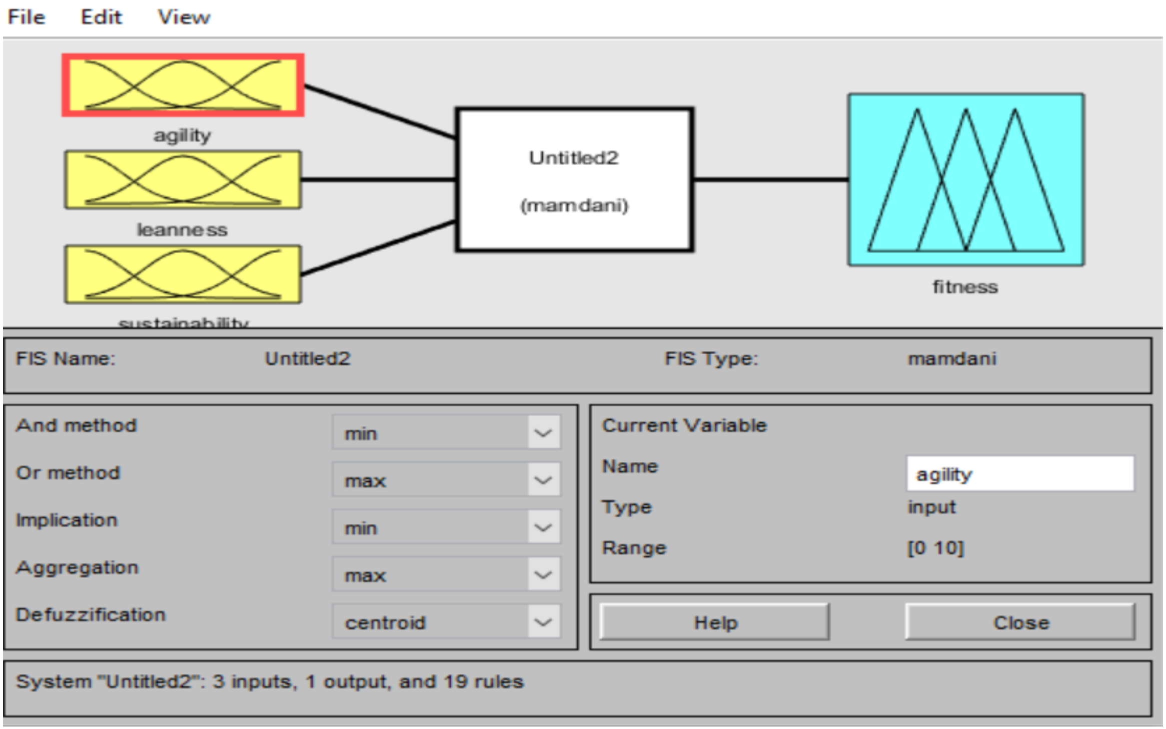

Figure 5: Input and Output parameters

To measure the fitness index of the organization linguistic variables and membership function for the inputs and output parameters are defined as shown in table VI and table V.

Table VI: Linguistic variables for inputs

Natural Language Expression	Fuzzy Equivalent	Natural Language Expression	Fuzzy Equivalent	Natural Language Expression	Fuzzy Equivalent
Agility index : Range [1-10]		Leanness index : Range [1-10]		Sustainability index :Range [1-10]	
Not Agile	[-4 0 4]	Not Lean	[-4 0 4]	Not Sustainable	[-4 0 4]
Average Agile	[4 4.5 6.5 7]	Average Lean	[4 4.5 6.5 7]	Average Sustainable	[4 4.5 6.5 7]
Agile	[6.9 10 14]	Lean	[6.9 10 14]	Sustainable	[6.9 10 14]

The range specified for the input parameters is in the range of 0-10, experts were asked to assign a numerical value to evry criteria of each enabler in the range of 0 -10. Similarly the membership functions are secified using the Matlab 2015a fuzzy logic tool and validated from the experts.

Table V: Linguistic variables for ouput

Natural Language Expression	Fuzzy Equivalent
Fitness Index: Range [0 1]	
Not Fit	[-0.3 0.0 0.4]
Average Fit	[0.4 0.45 0.65 0.7]
Fit	[0.69 1.0 1.4]

The membership functions for inputs and ouputs parameters are specified using he fuzzy inference system as shown in the given figures[5-7].

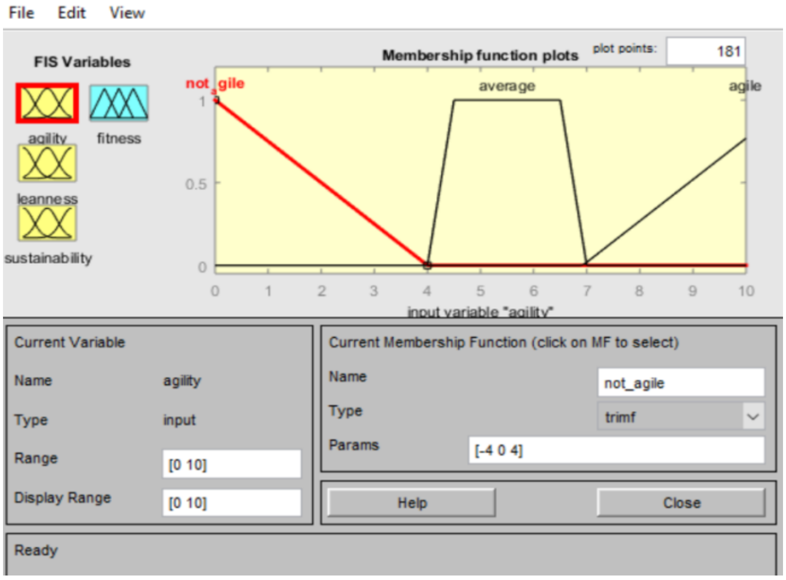

Figure 5: Membership function for agility

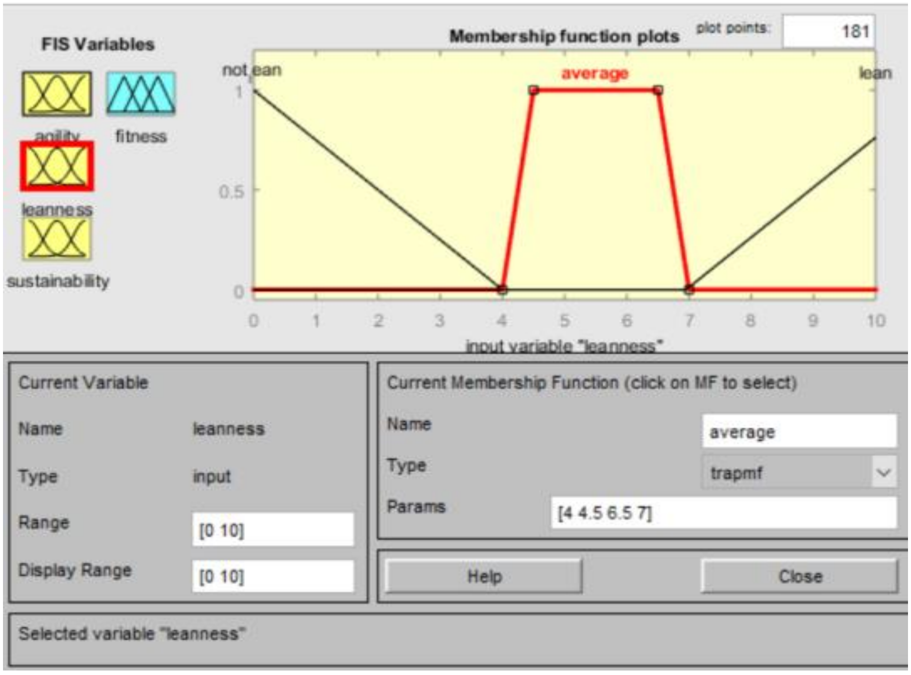

Figure 6: Membership function for Leanness

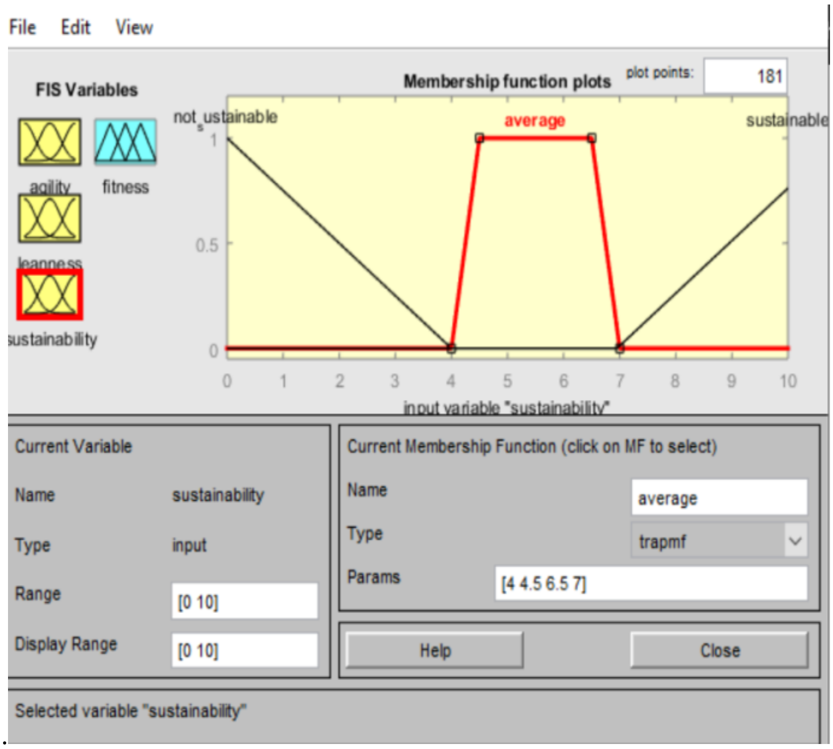

Figure 7: Membership function for sustainability

C.Fuzzy Rule base for defined criterias

Fuzzy If-then rule is an essential component of a fuzzy system hence every fuzzy system must have a If-then rule.The If-then rule can also be called as a fuzzy implication or a fuzzy conditional statement. The form of fuzzy If-then rule can be specified as: IF a is X THEN b is Y.The fuzzy rule base is a composition of knowledge collected from the experts.we have defined the rule base for the proposed system as shown in the figure 8.

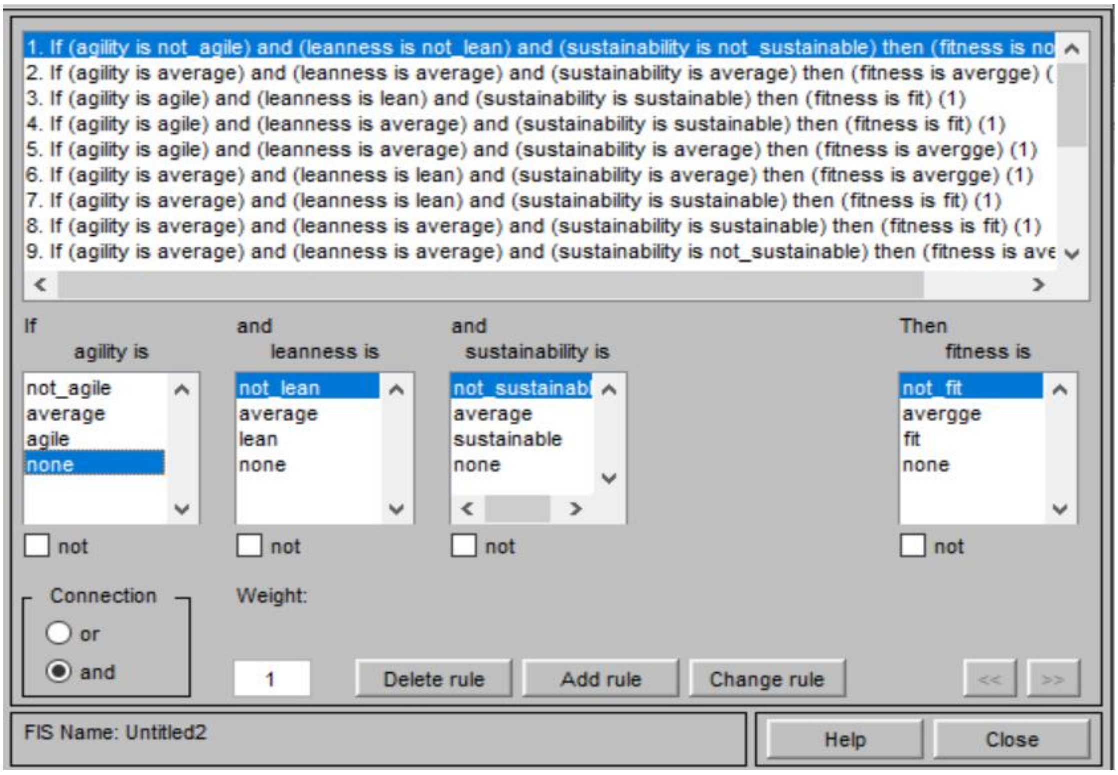

Figure 8: Rules for the FIS

4.Experimntal Results

In this study,the proposed method is applied to evaluate the fitnees of a software organization.Data for the criterias is collected from industry experts for the agility,lean and sustainability enablers.figure 9,10,11,12 and 13 show the results of the experiment done using MatlabR2015a.

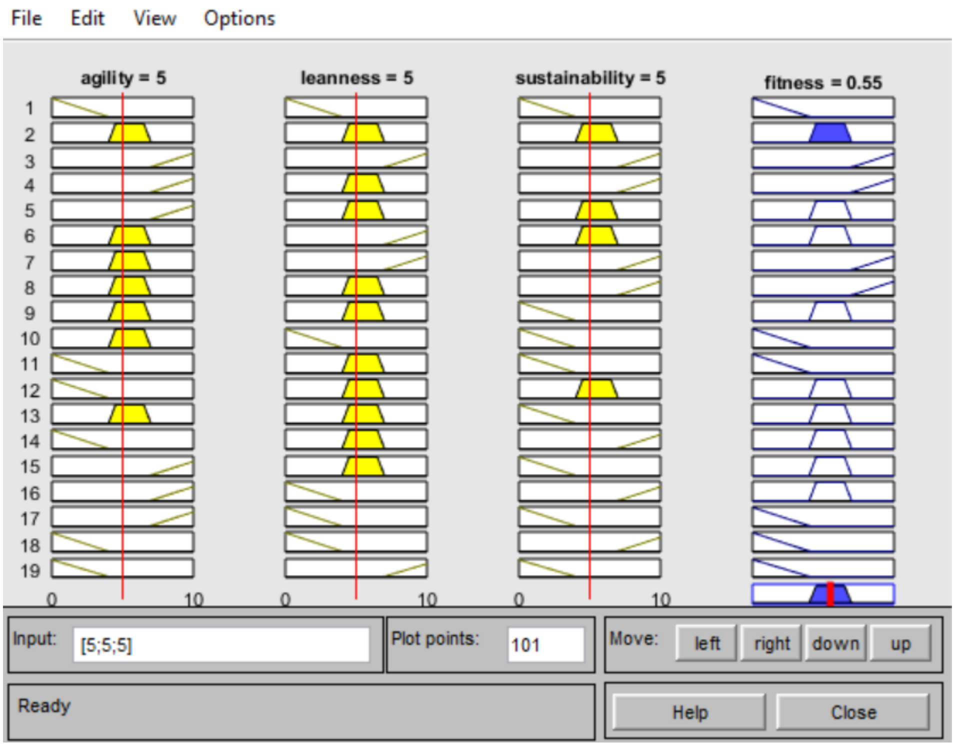

Figure 9: Rule viewer interface for the input and output parameters

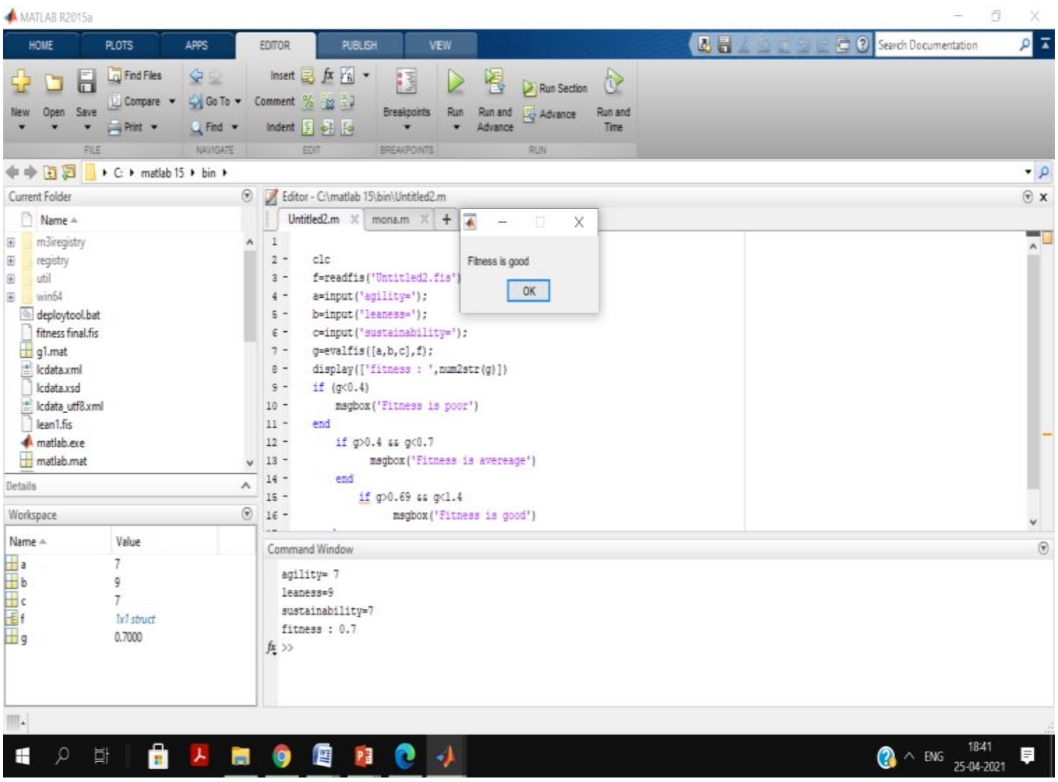

Figure 10: Matlab code

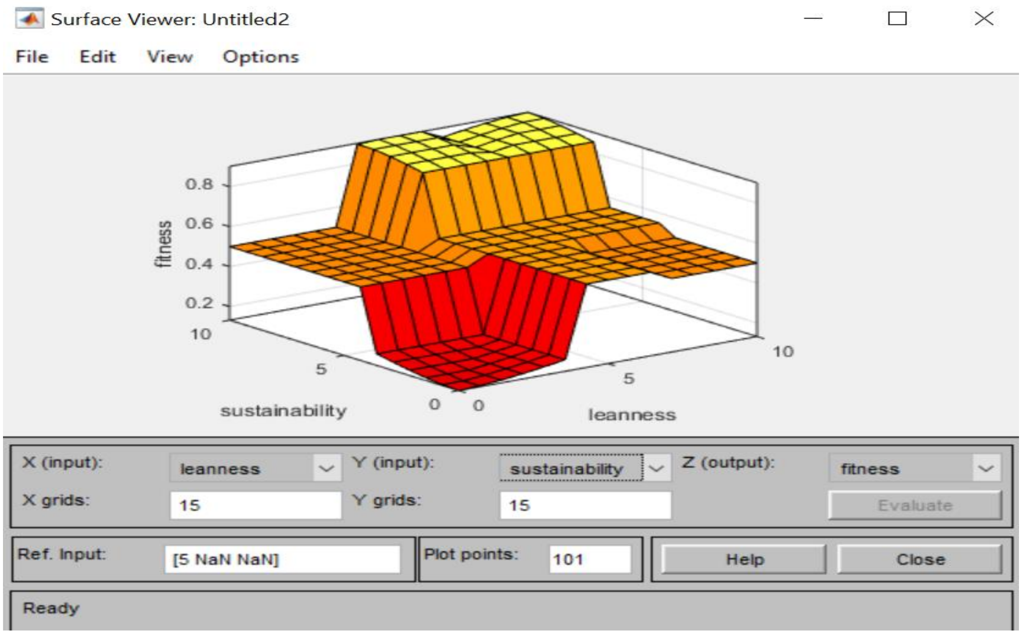

Figure 11: Surface viewer X(input): Leanness,Y(input):Sustainability. Z(output):Fitness

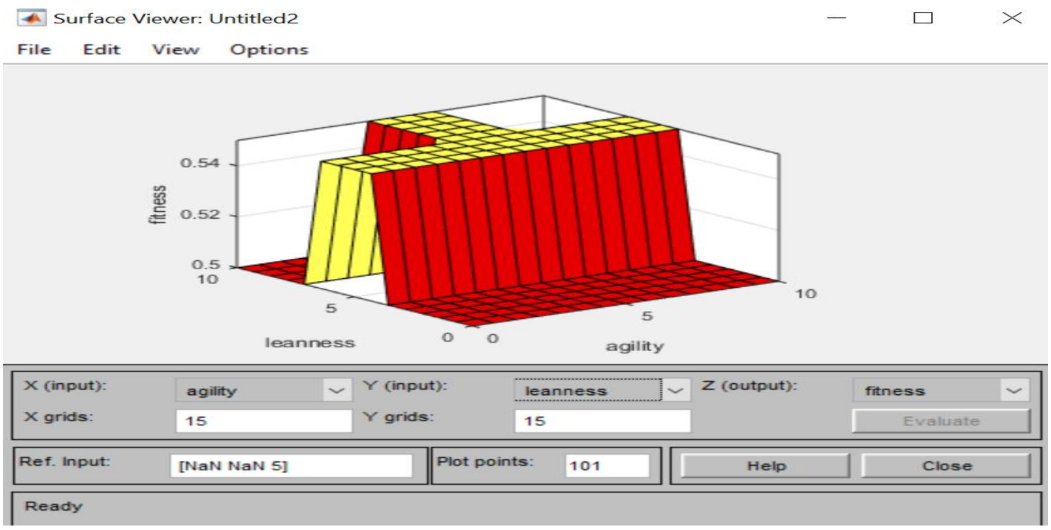

Figure 12: Surface viewer X(input): Agility,Y(input):Leanness. Z(output):Fitness

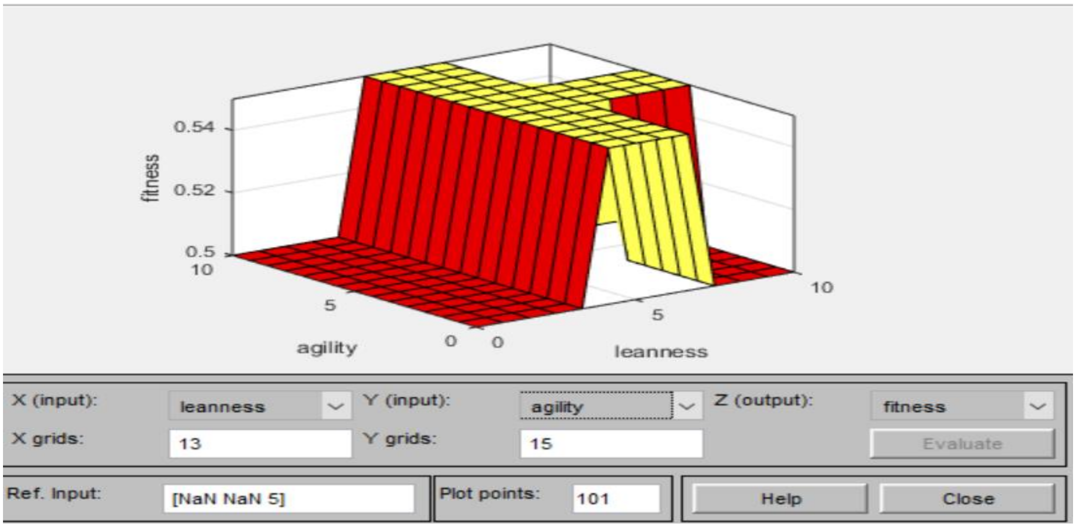

Figure 13: Surface viewer X(input): Leanness,Y(input):Agility. Z(output):Fitness

5.Scope And Conclusion

The integration of Lean,Agile and sustainability criteria in a single sysytem is focused to increase the performance, capability,customer satisfaction,efficiecy and minimize the waste, cost and all sort of variabilities of an software organizations.This fitness index can be used by software organizations to evaluate their efficiency and performance.

This paper represents how the Fuzzy inference system can be utilized to evelop a evaluation model using realistic data.

This FIS can be used as an qualitative evaluator for software organizations to assess their Lean performance and overall efficiency. The proposed model comprehends all the dimensions of leanness,agility and sustainability.This research can be extended by including more performance criterias and also to evaluate the performance and efficiency.

References

1. Eric R. 2011.The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. New York: Crown Business.
2. Xiaofeng W, Kieran C and Oisin C.2012. Leagile software development: An experience report analysis of the application of lean approaches in agile software development journal of Systems and Software 85(6).
3. Yang M, Hong P. and Modi S.2011. Impact of lean manufacturing and environmental Management on business performance: An empirical study of manufacturing firms. International Journal of Production Economics, 29 (2) :251-261.
4. Fuzzy Logic Toolbox for use with Matlab – Users Guide
5. Kahn, M. 1995 . Concepts, definitions, and key issues in Ž . sustainable development: the outlook for the future. Proceedings of the 1995 International Sustainable De¨elopment Research Conference, Manchester, England, Mar. 27]28, 1995, Keynote Paper, 2-13
6. Marín, P, Partanen J, Kuvaja P and Oivo M. 2014. Combining Lean Thinking and Agile Methods for Software Development: A Case Study of a Finnish Provider of Wireless Embedded Systems Detailed.47th Hawaii International Conference on System Sciences. pp.4770-4779.
7. Shah R and Ward P.2007. Defining and developing measures of lean production. Journal of operation management Elsevier. (25):785-805.
8. Srinivasaraghavan, J and Allada V.2006. Application of mahalanobis distance as a lean assessment metric. Int J Adv Manuf Technol. 29(11):1159-1168.
9. Xiaofeng W, Kieran C and Oisin C.2012. Leagile software development: An experience report analysis of the application of lean approaches in agile software development journal of Systems and Software 85(6).
10. Yang M, Hong P. and Modi S.2011. Impact of lean manufacturing and environmental Management on business performance: An empirical study of manufacturing firms. International Journal of Production Economics, 29 (2) :251-261.
11. G. Deshmukh, C. R. Patil and M. G. Deshmukh, "Manufacturing industry performance based on lean production principles," 2017 International Conference on Nascent Technologies in Engineering (ICNTE), 2017, pp. 1-6, doi: 10.1109/ICNTE.2017.7947977.
12. Kahn, M. 1995 . Concepts, definitions, and key issues in Ž . sustainable development: the outlook for the future. Proceedings of the 1995 International Sustainable De¨elopment Research Conference, Manchester, England, Mar. 27]28, 1995, Keynote Paper, 2-1
13. Beach, R., Muhlemann, A.P., Price, D.H.R., Paterson, A. and Sharp, J.A. (2000), "A review of manufacturing flexibility", European Journal of Operational Research, Vol. 122, pp. 41–57J.
14. Lotfi A Zadeh, Fuzzy Logic, Neural Networks, and Soft ComputingPDCA12-70 data sheet,OptoSpeedSA, Mezzovico, Switzerland.
15. S. Zhang, C. Zhu, J. K. O. Sin,andP. K. T. Mok, A novel ultrathin elevated channel low-temperature poly-Si TFT, IEEE Electron Device Lett. 20(4) (1999) 569–571.
16. Hossain E, Babar MA, Paik Hy (2009) Using scrum in global software development: a systematic literature review. In: Proceedings of the 2009 Fourth IEEE International Conference on Global Software Engineering, IEEE Computer Society, Washington, DC, USA, ICGSE `09, pp 175– 184.
17. Leffingwell D (2007) Scaling software agility: best practices for large enterprises. Addison-Wesley Professional.
18. Leffingwell D (2015) Scaled agile framework. http://scaledagileframework.com/
19. Yang, S.L. and Li, T.F. 2002. “Agility evaluation of mass customization product manufacturing”, Journal of Materials Processing Technology.(129):640–644.

20. Zadeh, L.A. 1965. "Fuzzy sets", Information and Control.(8)338–353.
21. Zadeh, L.A. 1975, "The concept of linguistic variable and its application to approximate reasoning", Information and Control. Sci. (9) :43–80.
22. Zadeh, L.A. (1987), "Fuzzy sets, usuality and common-sense reasoning, in: L.M. Vaina (Ed.)", Matters of
23. Intelligence, Reidel, Dordrecht, pp. 289–309.
24. How Lean and Agile Relate and How You Can Win by Using Both. https://www.plutora.com/blog/how-lean-agile-relate. Last updated on November 2020.
25. Mohankumar Kumar Muthu & Banuroopa K Kalyanswamy, 2020. "Green and Sustainability in Software Development Lifecycle Process," Chapters, in: Maria Jose Bastante-Ceca & Jose Luis Fuentes-Bargues & Levente Hufnagel & Florin-Constantin Mihai & (ed.), Sustainability Assessment at the 21st century, IntechOpe.
26. Vinodh, S., Vimal, K.E.K. Thirty criteria based leanness assessment using fuzzy logic approach. Int J Adv Manuf Technol 60, 1185–1195 (2012). https://doi.org/10.1007/s00170-011-3658-y