A Fuzzy TOPSIS Based Approach for Prioritization of Management Related Critical Success Factors in Agile Software Development (ASD)

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Annex A

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS/MPhil thesis written by Ms **Saqlain Abbas** Registration No. **00000320595**, of College of E&ME has been vetted by undersigned, found complete in all respects as per NUST Statutes/Regulations, is free of plagiarism, errors and mistakes and is accepted as partial fulfillment for award of MS/MPhil degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the thesis.

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Abstract

Software Engineering is primarily linked with the development of successful software systems. To meet this goal of Software Engineering, different software development processes are defined in the literature. There are two types of software development methodologies defined by their methodologies: traditional and agile. There had been no significant progress towards Software Engineering fundamental goal with conventional software development methodologies. To pursue successful software development, software development companies have started using agile methods. Although agile adoption may be challenging, the challenges vary from context to context. Consequently, it is imperative to investigate the factors contributing to successful project outcomes in agile software development. Due to this need, this study examine management related Critical Success Factors (CSFs) of Agile Software Development (ASD) and categorized and prioritized them using a Fuzzy TOPSIS approach. A Systematic Literature Review (SLR) is used to find out critical success factors from several management related organizations in this study. We identified Forty-one CSFs from the existing study and validated them using a questionnaire designed to survey industrial agile software development experts. The Fuzzy TOPSIS approach is used in the next step to prioritize identifies critical success factors. From a managerial perspective, prioritizing essential factors of success facilitates decision-making. Fuzzy TOPSIS shows that honoring regular working schedule, Team member with high competence and expertise and Defined timeline of each phase are the highest priority success factors. Prioritization based technique of the identified success factors will help researchers and experts in focusing on the critical areas that are significant for the successful adoption of ASD practices.

Keywords: *Fuzzy TOPSIS, Agile Software Development, Quality Assurance, Software Process Improvement, Fuzzy positive ideal solution, Fuzzy negative ideal solution, Critical success factors, Analytical hierarchy process.*

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CHAPTER 1: INTRODUCTION

This research chapter gives a vital view of Agile Software Development and the motivation, problem statement, research objectives, research question, research contributions, research significance, research techniques, and thesis organization. The summary of chapter is provided at the end of chapter.

1.1 Overview of Research

Software is much significant for the all features of the present day world, software programming development itself is certainly not an ideal interaction. Indeed, even those product projects previously carried out may require costly on-going maintenance and restorative deliveries or administration packs. Different researchers defined various solutions but agile is better over them in large level organizations from management perspective. With the passage of time, Agile Software Development (ASD) methods have evolved as a software development procedure that dynamic base adjusts system progress activities throughout the project lifecycle [1]. The primary goal of SE is to develop effective software systems. In Software development organizations, success of a software product is assessed in terms of money, scope, time, and quality. These strategies ensure that software solutions are delivered quickly, at a low cost, and high customer satisfaction [2]. The traditional and agile software development methodology is used in the software development field to achieve this goal of the software engineering discipline [2]. The extensive acceptance of an ASD methods appears due to its capacity to deliver practical and administrative procedures that continually modify and respond to changes during development, the software requirements, and the implementation. These methods are established on incremental and iterative software development processes that encourage the periodic, ongoing delivery process [3].

In ASD methods, user functionalities are divided into different iterations and then deploy the project functionalities iteration to iteration. In the agile manifesto, several frameworks or models represent to minimize the issues related to management, e.g., “Scrum”, “Feature-driven development”, “Extreme programming”, and “Adaptive Software Development” [4]. Agile development methodologies have revealed refinement in the development of frequently tested

and deliverable solutions reducing time-to-market and enhancing changeability across the product life cycle [5].

From the last few years, due to the massive acceptance of agile methods for software development, seek the researcher's attention to investigate the aspects that increase the success of software products. Initially, the agile development methods deign for small-scale. By responding quickly and iteratively to clients' requirements, such techniques boost the chance of success [6]. Due to their effectiveness, these methods are widely used in the build out of larger systems [7]. Despite the several advantages of agile practices, it entails many issues related to business management perspective, e.g., insufficient planning, changing requirement, lack of management support, continuous testing, customer involvement, organizational culture, and regular delivery of software [8]. At present, agile methods are considered a popular software development approach in every management organizations. Whoever, almost 67 percent of software development companies using agile methodologies [9]. There is not only one key success factor is to choose agile method but a success depends on different success factors. Consequently, it is required to investigate and prioritize important success factors of agile processes to implement agile software development methods effectively. Several researchers identified the agile-related success factors in different contexts [2][3][4] [5][6][7][8][9] . However, existing literature has given little attention to investigating and prioritizing the agile development-related critical success factors depends on their relatively significance to software project success [9]. The success factors illustrate the essential areas on which to concentrate to grow agile techniques [10]. In literature, no systematic model specifies the important aspects that might contribute to the success of ASD of management issues that mention above. The development of such a model helps researchers and practitioners in focusing on essential areas important for the effective implementation of agile methods. In this research, we have identified the success factors considered in the agile project management literature. In this article [11], Bellman introduced the fuzzy set, many researchers have been contemplating decision making. Fuzzy set theory combined with MCDM has finalized in a new decision concept; [12] we now have to deal with uncertain and incomplete data and knowledge in this way. The most important thing to keep in mind is the moment that, when we want to analyze, decide, or determine something, we use the natural language with expressions that do not have simple, definitive meanings. As a result, we express the fuzzy numbers using linguistic variables, which display subjective judgments for decision-makers in a quantitative format. Several experts featured develop improvement models that can assist product

development companies in establishing a quality framework, reducing development time and cost, and increasing customer satisfaction [12, 13]. In order to deal with uncertainty in supplier selection, MCDM and fuzzy set theory are widely used [13], as it provides understandable language to deal with uncertain criteria. As well as it has ability to combine quantitative and qualitative analysis. However, unknown constraints, objectives, and consequences constrain decision-making in the real world.

The Systematic Literature Review approach is used in this thesis to use the control to identify the factors. According to [14] developed a strong framework for cloud-based analytical hierarchy process is used to determine software development outsourcing factors. In article [15], author developed a case study in a Gear motor company by applying a fuzzy AHP approach to solve the supplier selection problem. In this research, our aim to discuss the process improvement management issues in the management field by categorizing, prioritizing, and reporting specific factors and their categories that may influence activities directly or indirectly. Two methods were used to empirically validate and prioritize the critical success factors [16]: a review of the existing literature and a Google form base survey experts (researchers, practitioners). Selecting and arranging multiple factors and categories is far too complicated. Moreover, expert opinions that contain ambiguity or uncertainty are much more difficult to obtain [17]. Quantitative prediction of the given problems is much more difficult for humans than qualitative prediction. They can verbally or qualitatively express their feelings [18]. The Fuzzy TOPSIS technique is used in the industry and a variety of other fields for MCDP [19, 20]. The comparison study between Fuzzy TOPSIS and AHP was carried out in [21]. This is observed that Fuzzy TOPSIS results are superior to AHP's for supplier selection in decision-making. From this research study [22] chose a supplier using the fuzzy TOPSIS method. Researcher calculates the closeness coefficient for suppliers ranked between the positive ideal solution (FPIS) and the negative ideal solution (NIS). Further, author developed a fuzzy multi-object and linear model to overcome the un- certainty of the information in supplier selection [23]. We proposed that using the fuzzy TOPSIS approach will be helpful for the Prioritization of Critical Success Factors in management related organizations field. In this research, we implemented the complete TOPSIS approach. After the implementation of the Fuzzy TOPSIS, we compared the results with AHP approach and then validated from the industrial experts with the help of a questioner based survey.

1.2 Motivation

Successful and effective software systems are the goal of SE. Software quality is a crucial aspect of a software project [24]. The practice of agile development has evolved over the past two decades [25]. Agile approaches were first established for small management industries, collocated projects. However, several giant firms, including Nokia, Amazon, and Ericsson, have moved away from classic waterfall-style approaches to the agile methodology in recent years. For a management business to prosper, the crucial success factors recognize those areas that require the most attention [26][27]. Prioritizing critical success factors assist managers to stay aware of what is essential in their organization related to management [28]. Throughout the years, software engineering academics have presented many critical success factors that are thought to be strongly linked to the success story of software projects. In the last few years, due to the massive acceptance of agile methods for software development, seek the researcher's attention to investigating the aspects that influence the success of software management projects [29]. Several researchers identified the agile-related success factors in different contexts of agile project management and prioritized them [30]. Prioritization of the identified success factors helps decision-makers in effective decision making. Various multi criteria decision making techniques are used in literature of management for prioritization, but vagueness and uncertainty are the main issue in decision-making projects [31]. Several researchers used the Fuzzy AHP, ANP and Classical AHP to prioritize success factors. Our research findings will provide a prioritization based technique of the existing management related success factors, which aid the scholars and field experts to highlight the essential areas that are significant for the productive acceptance of agile methods.

1.3 Problem Statement

In the Agile Software Development domain, a lot of different challenges related to management exist and many researchers map into their studies. Identified factors play a vital role in the success of any project. Various researchers investigated the success factors of agile software development from existing literature of agile management project and mapped them into corresponding categories e.g., organizational, process and people [2][3]. These success factors are significant to projects success and help decision-makers in effective decision-making to select best one success factor which increase the management scope. They used AHP method

to prioritize and classified the success factors. However, the AHP method does not deal effectively with uncertainty and vagueness of human judgment, as it is a complex task to convert qualitative field expert reviews into quantitative values [32]. Moreover, this technique does not provide consistent judgment and ranking due to its interdependency between alternatives and criteria. As the result, the prioritizations are vague and uncertain that leads to inaccurate decisions by decision-makers.

1.4 Aims and Objectives

Based upon the identified problems, we define the following Research Objectives for this thesis.

- RO-1: To extract and examine the management related SF's of agile software development from existing literature.
- RO-2: To experimentally validate the identified management related SF's from practitioners.
- RO-3: To evolve a prioritization technique of the investigated success factors through the implementation of Fuzzy-Topsis.

1.5 Research Questions

Based upon the research objectives, we explain the three research questions for this research.

- RQ-1: What are the management related SF's of the agile software development methodology in the existing literature?
- RQ-2: What role can management related CSFs and their categories play in successfully implementing of ASD?
- RQ-3: How were the investigated success factors prioritized using Fuzzy Topsis approach?

1.6 Research Contribution

These are the Contribution of research base study:

- This study help out to remove the vagueness and uncertainty of management literature in the agile software development domain.

- Prioritization of the ASD critical SF's by introducing the Fuzzy TOPSIS approach.
- This study is not only limited for the ranking, but also proposed taxonomy contribute to increase and recognize main areas of software process improvement in ASD domain.
- Our proposed taxonomy contributes to build a model which provides help to execute the software management process activities.
- This research study shows the importance of the factors and their categories in ASD domain on the basis of priorities which is assigned by using the fuzzy TOPSIS approach.
- This study contributes in the academia and industry to drive the critical success factors in the ASD environment.
- The result of this study will contribute to the cost-effective and time-saving solution of the decision making problem in agile management projects.

1.7 Research Significance

The importance of this research study is provide taxonomy of CSF's identified through management field by using the Fuzzy TOPSIS approach, which can be used by industrial practitioners to develop prioritization knowledge and understanding. It will provide for the cost effective and positive ideal solution for the industry.

This research study provides the complete understanding of the managerial critical success factors and their categories in the academia field. The results if this study can be used as input and proposed a model in academia. Furthermore, it can be used for the complete understanding of the software process activates.

1.8 Research Methodology

Using the SLR approach [10], investigates, categorizes, and evaluates existing research in a particular research field. A major motivation for adopting the SLR strategy is to recognize the exploration as a whole and help organize the data. The SLR technique will provide more precise and scientific results and with the help of SLR we can easily identify the number of research areas. Recent studies have used this systematic literature review strategy for similar projects [11, 13, 33,34]. According to [10], there are three main phases in a systematic literature review (the first part is planning, the second is conducting, and the third is reporting the results). All the steps of SLR briefly discussed in Chapter 4.

1.9 Structure of Thesis

The thesis is managed as follows: The first section discusses Introduction of using the fuzzy TOPSIS approach to organize the CSF's of management related issues in the agile software development domain. Chapter 2 presents the Preliminary Studies. In this chapter we discussed the some preliminary studies which are very important to understand the concept of the ASD in management point of view and critical success factors. Chapter 3 contains the literature review of the fuzzy TOPSIS approach, that how this approach is used in previous studies. Chapter 4 comprises the Research Methodology in which we review the existing literature from 20008 to 2022 in our Selected SLR studies. In this thesis, we performed the complete SLR and select the primary studies. Chapter 5 is the proposed solution. In this chapter, we perform the prioritization of the management critical success factors. Chapter 6 contains results and evaluation of our case study analysis using the fuzzy TOPSIS approach in which we prioritize and classify different critical success factors. Chapter 7 defines the overall conclusion and Future work of this research.

1.10 Chapter Summary

Whole chapter illustrates the step by step introduction of the proposed research work. First we discussed about ASD in term of management. Secondly, elaborated the advantages and disadvantages about ASD. After that we discussed the complete steps of software development process. In next step of this research, we find CSF's related to management. Then, we discussed the significance of the prioritization of those identified SF's. Furthermore, we applied Fuzzy TOPSIS approach for the prioritization of the success factors. Then, we solve multi-criteria decision-making techniques, and we discover many limitations about other approaches. In the end, after comparison with other approaches we finalized that Fuzzy AHP approach is ideal to get accurate results that leads to accurate decisions by decisions makers.

CHAPTER 2: PRELIMINARY STUDIES \BACKGROUND STUDIES

This chapter is based on the preliminary studies to understand better the model related to this research. At the start of the chapter, the basic concept of ASD related to management is discussed. And then, multi-criteria decision making techniques used in this study are described.

2.1 Explanation of the ASD concept.

The technological growth in the past decade has made software an essential part of all aspects of modern life, while software development is also a complicated process [35]. Although various software engineering methodologies have been applied to the software development process on management issues in the past, it has not yet been reliably effective and still face some issues. Two types of methodologies exist in software development: traditional and agile software development. In the early years of creating any system, developers made the development process easy because the customer's needs were stable [35]. However, development processes increasingly faced dynamic projects over time. Agile methodologies were developed to deal with these complexities. Agile methods can help organizations remain competitive in this rapidly changing marketplace by reducing market time and costs.

Main idea of agile development process was initially suggested by seventeen software experts who applied a set of "lightweight" processes and assigned a set of standards for software development [36]. ASD is a set of software development methodologies that is dynamic and iterative. Informing the ASD philosophy, they advocated strategies based on best practices and their experience with previous software development projects that were successful and unsuccessful in terms of what works and what does not in practice. They all approached software development from different perspectives [37]. A primary goal of the Agile Manifesto according to management is the value of people, processes, and device, developing software over extensive page work, customer involvement over contract discussion, and showing to change over existing a plan.

A core component of management ASD is to prioritizing customer satisfaction by delivering valuable software as early as possible. To accomplish this, the customer needs to be on-site

with the team of software developers and initiative-taking, active, and consider themselves responsible as project members. However, they all promoted close association between business and software teams, as opposed to software teams working in isolation. Furthermore, this manifesto also involves customers or end-users in all the design and development processes. It promotes the formation of self-managed, collaborative, and autonomous teams that will provide an enormous competitive improvement over firms that employ traditional development methods [37]. The most potent development force is a software team that works well together. In recent years, agile development is now the dominant method [38]. Because of the highly unique environment and the constant changes, there are various management related issues that project managers face, such as requirement changes, organizational priorities shifting, and unmanaged changes in projects [39]. This issue is also very conspicuous in all world software industry, which means a concept of modification is needed to fix it. Agile methodologies are being used in the global software industries working on management to resolve these problems, and this practice is comparatively new for every country organizations [40]. A variety of anecdotal evidence has emerged about the progress of software development products using agile methods [41].

2.2 Overview of the issues in ASD

In 2001, agile practices began to be defined in software development products, which had been used in producing for a decade [4]. Traditionally, software development methods have been slow at responding to changing requirements and expectations of clients. Agile methodologies were created as a response to this trend [5]. In the past 25 years, there have been numerous approaches to software development that can be classified into two main categories Traditional or Agile. It's already discovered that software products implemented management issues adopting agile procedures have a better success rate than those implemented using traditional development methodologies [6]. Several reasons have been cited for bold and unsuccessful software projects, such as minimum user interaction, short requirements, repeating requirements, bold expectations, uncertain objectives, less project management, low technology, non meet with standards, and quality control issues [7]. Having the ability to respond rapidly to changing circumstances, agile methodologies evolved [8]. Agile principles define how software developers can continuously deliver operational software at short intervals by relying on technical excellence and simple design [9]. Despite the various acceptance of ASD methodologies in different software organizations, the researchers focus on identifying

the agile related success factors and prioritizing these factors. This research identifies the success factors from literature of management through a systematic literature review and prioritizes these factors with the Fuzzy TOPSIS approach.

2.3 Explanation of Critical Success Factors

Software products are primarily intended to produce an effective and well responded product that fulfill user specifications within the barriers of essential resources. Therefore, identified the features that contribute to manufacturing the application should be necessary [29]. Critical success factors are organization-specific, and managers can benefit from understanding their prioritization. A successful project meets all the criteria linked with its timeframe, cost, and performance. Fuzzy TOPSIS is a systematic weighting method that is not extensively researched to rank the success factors through software development devices in agile software development issues related to management field. Some studies used the Fuzzy AHP, ANP and Classical AHP to prioritize SF's and create a process of the identified success factors which correlate to existing problem of ASD [29][30][31]. Our findings will provide a scientific classification that will aid software development companies to change their management techniques for evaluating and upgrading software development processes.

Furthermore, the success factors identified will aid in developing a generic model that will aid in the execution of software development processes activities related to management in Agile Software Development organizations. We used a systematic literature review technique for expert opinion methodology to identify some of the critical success factors from current management literature and priorities those factors. We then organized the identified factors into different categories and presented them as taxonomy. Based on the relative weight of each CSF and its groups, we have prioritized the CSFs and their groups. Few researchers have used Classical AHP and ANP to rank factors as part of a Multi decision making techniques Problem [30]. However, these multi decision-making methodologies cannot make results with the uncertainty and vagueness of a person judgment [31]. For the ranking of CSFs and the prioritization of their categories, we used the Fuzzy AHP. The replies of field experts usually are vagueness and ambiguous, making the whole activity more complex [42]. Fuzzy TOPSIS is a well-established method for converting qualitative responses into numeric values that have find out applications in different categories, including multi type decisions issues and others [43]. Therefore, we applied the Fuzzy TOPSIS methodology to get an accurate and more

precise hierarchy base technique of identified SF's from management perspective, so practitioners made accurate decisions based on that prioritization list.

Chapter Summary

In the primary research study, many researchers conduct the SLR approach for the identification of management related success factors and used AHP approach for the prioritization of categories. The AHP approach has many limitations. One of the main issues is that it does not deal with the vagueness and uncertainty of human judgment. Moreover, due to interdependency between alternatives and criteria does not provide consistent ranking on the base of human judgment. In this research, we tried to overcome all these issues by the help of Fuzzy TOPSIS approach. In the end, it is concluded that many researchers ranked the success factor on frequency basis. But we used the expert opinion, for the identification of success factors.

CHAPTER 3: LITERATURE REVIEW

This chapter presents the literature review of different studies conducted regarding Agile Software Development and MCDM techniques. Different studies for ASD success factors and MCDM techniques are presented.

3.1 Background Studies

In the last few years, many organizations used the Agile Software Development approach for their product development process. Software development methods continually evolve due to new technologies and user needs. Organizations must continuously adjust new systems, techniques, and rules to remain reasonable in today's active e-commerce atmosphere. Agile methods provide rapid deployment of software projects at low cost with maximum user satisfaction. Therefore, ASD strategies are gradually recognized for the tremendous flexibility they offer organizations to adapt to changing needs and bring products to market in unexpected ways.

R. et al. [44] describes, comparing the strength and shortcomings of Analytical hierarchy process. In this paper author believed to be an important aspect in decision making strategy. Anyway, in real conditions rank reversal exists. Research paper indisputably shows that the last outcome is explicitly comparative with scale used. AHP multi decision making method recognize simply free measures for making pairwise connections. In multicriteria decision making issues the human feelings are changed over into quantitative numbers and human feelings change from one to another. Intellectually, human feelings can not quantify. Considering specific drawbacks, this methodology cannot be blocked considering the way by which strategy gives a basic, reasonable, suitable, effective and significant procedure for insightful gathering to make better decisions. Finally proposed method of this study can not consider uncertainty when a boss is making a decision, in light of the fact in every practical sense, nature is clashing, and decision making is develop just regarding the current situation and pioneer's skill. Attique et al. [45] narrate, comparative study of testing challenge, tool support, solutions and agile methods. Author states that a technique has been drilled in the business which helps for fast programming improvement named as agile methods. Agile

methods are cost effective for organizations like extreme programming. As the advancement in the agile quick development of programming so getting some margin for exhaustive testing is troublesome. In this study the author distinguish significant difficulties which might emerge during agile testing and they can connect with the testing of management. The identification and definition of key challenges in agile development is the main part of the research. Limitations of the research is the progression of time, the utilization of agile in the software organizations increments, more agile techniques and tools are accessible for the development of the software. Juyun et al. [46] describes, development of agile software challenges and issues with scrum. Old software development techniques like spiral model and waterfall model linked with high issues of documentation and heavy design. Using agile software development methods as including extreme programming and scrum need to minimize work load of customers and developers. There have been not many experimental field concentrates on issues and difficulties of ASDMs. Subsequently, the point of this exploration paper was to find the issues and difficulties of one specific agile technique. At last, the paper examines issues and difficulties of the Scrum strategy found through a top to bottom contextual investigation. Barbara et al. [47] states, software literature review as systematic. Proof based examination and practice were grown at first in medication since research showed that well-qualified assessment based clinical advice was not applicable as guidance in view of the aggregation of results from scientific tests. In this unique situation, proof is defined as a mixture of best quality scientific concentrates on a special topic or exploration question. Main technique of mixture was software literature review but on expert opinion SLR is a hard technique to define literature. Research focused on current position of evidence based software engineering and concentration on articles related to SLR. Research methodology is to generate four question related to SLR issues and asked to practitioners to defined and resolved. Hu-Chen et al. [48] states, systematic literature review of effect analysis and failure mode using multi criteria decision techniques. Effect analysis and failure mode procedure was embraced by the auto business for quality and security improvement in design and production. EAFM is a gathering-focused, organized, and proactive reliability quality administration strategy for the recognizable proof of potential disappointment modes in items, cycles, and administrations to assign restricted assets for executing improvement work. Deciding the risk prioritization of disappointment modes in EAFM is a complex test that requires multi-criteria decision making method. Main problem of EAFM much confident specialists in utilizing different techniques and theories to upgrade the evaluation capacity. Subhas et al. [36] states, identification of

valuable success factors for development practices of agile software adaptation. Agile software development is presently an arising computer programming approach, comprising a set of standards at first introduced by a gathering of 17 programming specialists, and presently rehearsed by numerous product experts. Every one of these experts had their own various methods of reasoning about how they considered about software development. Face to face meeting is a best option over the whole documentation as frequent delivery of software products over complete product. The general objective of the paper is to work on the comprehension of the arising ASD approach utilizing a review based study. In this study, they increased the art of research around here by directing an overview based study for recognizing factors according to the point of view of the ASD specialists that will influence the progress of undertakings that take on ASD rehearses. Author conducted a survey of large scale study having results of 241 respondents.

Arezo et al. [35] defines, A case study of IT based critical success factors in quantitative approach of software development projects. Different approaches which have been applied before to manage stock of software engineering approaches. Software development process is still a complicated process and different types of issues which caused to rejection of software products. Top advantages have affected the primary concern of the software improvement process in organization and caused hazard problems. This study tried to find out that how can improve agile software development process to minimize the above problems. Author proposed an agile method approach to minimize problems related to software development. However, still there are a few projects which face difficulties during implementation and some achievement factors did not appear to be sufficiently powerful. Jiangping et al. [37] describes, empirical success factors research in improvement process of agile software. Agile software development has a huge advantage for practitioners over who maintain the point of view that a product improvement organization is just a heap of twisty little individuals generally similar. ASD has many steps to apply like work should be based on documentation, face to face meeting with customer, software delivery is frequently etc. Researcher define a P company which has more than 600 staff. The market circumstance has changed significantly after monetary emergency, P organization needs to change their delicate product advancement interaction to address the difficulties of coming environment of business. This paper has two parts and first one is software analysis and second is to design and applied a model of ASD success factors in P Company. Subhas et al. [40] outlines, agile software development success factors. Agile software development method is a famous as it started with seventeen experts and now

applicable for many organizations. The standards they advocated prime to the rise of the agile software process reasoning depend on accepted procedures and their past progress and disappointment encounter with numerous product improvement projects in regards to what works and what doesn't. Every one of these specialists had their own various methods of reasoning about how they moved toward software development. Software practitioners inspired by agile software development methods because there were two stories of success or fail behind the agile philosophy. In this research, we audit the boundaries that influence the progress of activities embracing ASD techniques in light of past episodic and reasonable experience stories. Constraints of this is research is that the agile techniques are not applicable for whole organizations.

Mohd et al. [41] states, comparative study of software projects critical success factors. From first day, software engineering faced different types of problems in developing a software and its maintenance. Brooks stated that software development related issues not have a best way to resolved. Defining success factors was only way to minimized the threat and increased the success of software. There has been no complete review written about various undertaking sizes in different areas and in numerous nations. Author asked questions related to software problems and tried to fix it by using the success factors approach through the survey. In view of the examination of our broad literature search, 26 critical success factors introduced which are related success of project. Limitation of study is that the success factors changed according to nature of software, means success factors will be different for different organizations. Nagy et al. [49] defines, agile software development success factors of multi-dimensional. Software is important and utilized in numerous organizations and industries with various disciplines. Author described a table that showed sixty percent of software failed or challenged in almost every organizations. Different researchers defined various solutions but agile is better over them in large level organizations. Phases of life cycle in agile projects advancement start with project initiation which is making the task group, plan the user requirements and assets required. Agile development has much advantages than traditional software development. There is not only one key success factor is to choose agile method but a success depends on different success factors. Key point of study to find out various critical success factors to improve project scope. A survey conducted by researcher to collect the critical success factors from different practitioners and various organizations. Agile is not usable for small level organizations because it increased cost of the project. Victoria et al. [50] states, occurrence relevant model of critical success factors for projects of software development. At the point

when project classification frameworks and rules are not coherently coordinated with project targets, qualities and climate, this might give the critical motivation to why numerous projects are accounted to neglect to follow through on time, financial plan or don't give worth to the client. Basic purpose of research is to identify critical success factors and develop an occurrence relevant model and categories these factors. CSF,s ranked on the bases of frequency in literature and citation of previous studies from both traditional and agile perspective. A possibility fit model expands this by featuring the need to match project qualities and project management strategy to these CSFs. This examination is theoretical and meta-scientific in its concentration. An essential undertaking for future examination should be to test the possibility fit model created utilizing exact information.

Mikhail et al. [51] defines, finding CSF's in agile investigative projects. Efforts are extending rapidly in business to get maximum information from data which they access. In this manner, seeing more about how to actually lead, support, and oversee analytics tasks can make favor organizations understand how to expand the business value from drives. Main reason for our review is to look at factors that may possibly influence the progress of agile examination projects. Utilizing an agile task life cycle can give a trial, iterative methodology that can be a compelling method for resolving a portion of the vulnerability and permit project partners to learn and develop a powerful arrangement. This research makes commitments to both comprehensions of the achievement factors for investigation projects and the achievement factors for agile projects by and large. Chow and Cao did their study when agile practices were immature because agile mature in last decades to use in large scale organizations. Tsun et al. [52] describes, a review based study of CSF's in projects of agile software. Author states, software is so significant for the all features of the present day world, software programming development itself is certainly not an ideal interaction. Indeed, even those product projects previously carried out may require costly on-going maintenance and restorative deliveries or administration packs. The test is the way software advancement the board can be improved to keep away from the above issues of waste and inefficiency. Understanding into the critical success factors that help software advancement projects utilizing agile techniques to succeed. Research organized CSF's coming from agile literature and divided into 4 types of organization, people, process and technical. A survey conducted to collect responses from different countries. Research has different constraints that all data did not support agile methods, possibility of biasness in conducted survey and sample size is still for large scale agile software development. Prerana et al. [1] states, agile methodology critical success factors

in Nepal software organization. Project is brief undertaking embraced to make an extraordinary item, administrations or result with a definite start and finishing. Project is begun to satisfy the market interest, to take advantage of the business needs, to satisfy client's interest, to adjust with advancements in technology and to team up with valid requirements. Project management is the main part required in any industry to meet to project expectations. Different little, medium and enormous software industries are created in Nepal to fulfill the product need of clients. Author shows that software development process is still a challenge in Nepal and this might cause of software rejection. Many software industries are using agile software development but still agile has different challenges. Research basic purpose to identify critical success factors of agile process that make help to complete the project with extra perfection. Size of an organization matter to select the method of software development.

Tasneem et al. [53] outlines, finding and analyzing the agile software development critical success factors applying mind map. Choosing the right strategy, perfect team, perfect practices, and using them enough, decide the outcome of programming improvement. In this research, a subjective report is done among the success factors of progress from past examinations. Success factors coordinate with their respective standards to show the much important factor for agile methodology achievement. Author likewise shows that the 12 standards identify poorly for some factors arising from subjective and quantitative past examinations. Aspects and factors are introduced utilizing critical success Aspects and factors mind map model. Mind map is a shape based process for covering thoughts and plans, and resembles an optic reasoning product that helps organizing data, helping in better examination. Author stated that some of CSF's related to agile software development were poorly defined and various were clear to further use.

Karla et al. [54] describes, agile software projects success factors related to technology, process and people. Agile software Advancement have become vital over the years for industries of the advanced world. Basically, software improvement itself is very hard intricate process. Literature has various elements that affect software development procedures in ASD. This study is a methodical survey of the basic SF of agile software development tasks. Author identified 14 SF's and divided in to 3 categories as people, process and technology. Moreover, essential examinations were short listed to recognize the outline of agile development industries, activities, attributes, and indications of agile investigations in these products.

Researcher explained that the process of questioning some people about their opinion without a group decision has limitations.

Saru et al. [55] explains, failure and success factors that affect software executions applying agile software technique. Agile software development has various elements behind the achievement and disappointment of projects. Research paper addresses the achievement, disappointment, and discarded factors in agile software development. A case study is introduced relying upon these factors after the executions of small projects. Each group gathered into 10 participants and developed the tasks with different types of methodologies. Each meet up kept up with the page work from beginning customer stories and factors utilized on the projects. Ultimate results are figured out in view of the examination of efficiency, precision, using time effectively, risk examination, and item nature of the project. Final results are identified utilizing the various methodologies. User requirements or stories were identified by clients and personnel but due to the lack of domain knowledge, various authorities and organizational restrictions, it was very hard for students to follow this process. Vikash et al. [56] defines, people factors in project management and agile software development. With the rising popularity of agile Strategies, numerous software industries are creating some distance from traditional techniques to applied agile development approaches. Rather than being divining, Agile is fairly versatile and individuals focused. It advocates a little and cooperative group that work intently together but In any case, group size is a factor that spin limitations by individual's factors. When agile software development process applied than these key factors were to be considered. Research targets distinguishing the fundamental individual element to consider while embracing agile process for a group to be successful. The strategy utilized is the investigation of three various sized agile groups creating items in similar advancements and utilizing Scrum. Both goal and emotional measures were utilized and the outcomes are considered by survey. Author stated that there is less chance to work properly of agile development process having minimum number of respondent's teams.

Mohammad et al. [57] shows, a well ordered existing study review of CSF's to enhance the success of agile software development projects. Motivation behind this study is to distinguish the CSF's in agile software development and how these factors add to outcome in an agile tasks. To research and recognize the CSF's and their relating achievement credits, a precise writing survey was directed. Nine basic journal search engines identified to search relevant data about research and 24 studies related to research were chosen. Resulted data were divided

into different categories to filter the relevant data by using keywords. Now, success factors and success attributes analyzed on the basis of frequency to enhance success of project. Research has different limitations like explanation of theories defined in research study and theoretical validity of existing literature. Abdullah et al. [25] defines, CSF's review of agile software development. Given the advancement and expanding use of agile strategies and practices, the effective reception of agile is significant. During the last ten years, critical success factors of agile improvement research grew quickly. This paper expects to survey the literature on critical success factors of agile software development over the most recent years which utilized experimental approaches to recognize the success factors. In this research, eight elements are chosen as CSF's for ASD. Author divided these eight critical success factors into four categories as organizational, technology, process and people. Limitation of research is the sample size of critical success factors which was very small for agile development. Davood et al. [58] define, decision making multi criteria review for the maintenance delivery enhancement. Direct expense of maintenance for organizations has been expanding recently. Equipment's using in manufacturing are increasing complexity and required skilled faculty which is also increasing the maintenance cost day by day. In existing literature different approaches present to manage the maintenance like integrated life cycle and reactive maintenance. First of all it covers the reviews and develop a criteria of set to define several techniques. Secondly author compared all the defined methods based on developing criteria. In this research still a lot of limitations for modeling various parts of maintenance which should discovered and solved. Literature strategy puts the chief's decision in any case and assists with choosing a technique for their decision-making by the management of maintenance disregarding vulnerability rate and issue complexity.

Martin et al. [59] draw, an application and survey of multi decision making criteria methods. Nowadays, countless decisions are being produced using different criteria, so the choice must be made by giving weights to various criteria and every one of the weights are get from expert opinion. Multi decision making criteria is relating to structure and tackle decision and arranging issues including various criteria. Main purpose of the survey is to make decision from many choices exist for a problem. Author state in this research there is not even a single solution to obstacle these problems. Major issue turns out to be more intricate when various models exist for other options. Basic ideal answer for multi criteria decision making issue should be gotten without the ideal data joining. Research survey of different criteria decision can help to understand the value of multi criteria decision making. Numerous applications involve MCDM

in deciding the drawbacks of a system, research issues can be solved by using proper techniques for tackling the issue. Rohan et al. [60] draws, decision making of multi criteria: the over view of different problems and methods selection. Multi criteria decision making method allowed to take a decision in the presence of multiple decision making criteria. Issue of MCDM derived from two basic sub issues that are multiple attribute decision making and multiple objective decision making. Issues explicitly assumes a significant part in fields of investment choice, project assessment, monetary advantage assessment, Staff evaluation, etc. different techniques introduced to tackle decision making issues. Short listed part of paper is managed as follows: In the following area we give point by point overview and a detailed survey of MCDM procedures. Results coming from survey should be prioritize by using analytical hierarchy process from top to bottom. AHP did not deal with uncertain and vague data or information.

Margriet et al. [61] outlines, decision making of multi criteria's. Searching best operation condition in research is a major goal. Functionality in a system is noted or considered on the bases of performance criteria. From many cases performance criteria are different and hard to find best one. The point in making best is to search an ideal value for every one of those reactions that can be utilized as the basis on which the frameworks performance is considered. Principal subject is to make a choice out of an array of conditions that will result in an admirable or acceptable arrangement of a multicriteria issue. MCDM methodology is used to point out a best solution from different options. Constraint of research is that producing techniques do not use any main information to build the importance of criteria.

Nese et al. [62] defines, Fuzzy application for decision making process of financial evaluation performance. Major purpose of the study to create a new evaluation process by the help of both accounting based financial performance and analytical hierarchy process to prioritize the sectors of Turkish industry of manufacturing. Accounting based financial performance used for quantitative information of investor and analyst to evaluate the position within a company over the time. Author identified twenty five financial measures of performance for an industry. Research based measures are combined to a group because they provide same information. Researchers applied the both AFP and value based financial performance together to prioritize the organizational sectors. Fuzzy AHP is used to assign the weights and both TOPSIS and VIKOR are used to prioritize the sectors of organization. Main constraint of research is the rapidly change in companies provide the automatically change in tools for the financial performance. Zu ¨lal et al. [63] shows, selecting problem of personnel by the approach of Fuzzy

AHP. The author states that the worldwide market, current companies bear high degrees of competition. Whole success of organization depends on the selection of their personnel. Basic and fundamental objective of organizations is to look for additional strong approaches to positioning of a set worker or faculty who have been assessed regarding various skills. In this sort of multi-criteria examination, analytical hierarchy process is proposed as a tool for executing a various measures execution plot. One of the important part of decision making is to model the problem in subgroups. AHP is the best tool to formalize the major problem using hierarchical approach for pair wise comparisons. Research present and examine a Fuzzy choice supportive network to help the organization to make the decision. The constraints of the study is that all information required for Fuzzy AHP approach are unique, we do not be guaranteed to hope to have same outcome for a similar staff determination issue.

Muhammad et al. [64] states, a process of Fuzzy AHP of success factor prioritization for the perspective of management change in global development of software. Research defined that the software development life cycle has a crucial and important part of requirements change in every phase of development. A few investigations have been led to address the complexities of requirement change management exercises. In any case, there is no review directed to focus on the success factors of RCM from the global software development point of view. Author covered the research limitations by applying the fuzzy analytical hierarchy approach technique in requirement control management process regions. Requested for a changes in requirements are not an issue, and the issue is the way to really address the changes. Basic purpose of study is to conduct the survey and prioritize the success factors on the bases of their importance, using the Fuzzy analytical hierarchy process. Author research has a potential danger that should be covered for the study discoveries. For example conducted survey responds has a total number of 81 which is not strong enough for the success factors validity. Iftikhar et al. [65] report, application of Fuzzy AHP methods in a tie breaking procedure. Author states, analytical hierarchy process is a conventional strong decision making procedure to deciding priorities among various criteria, comparing the different decisions for each criteria. AHP method has a main advantage to handle the multi criteria issues which is easy to understand and cover both qualitative and quantitative information. In reality, the vast majority of the data or information acquired from field expert included ambiguous and uncertain data. In literature several approaches are discussed which used to assign the weights from comparisons of pairwise matrices. In this research Fuzzy AHP is used to break the tie situation and decide the position

among students when they get same marks in examination. Fuzzy AHP approach not applicable to calculate the rigid weights.

Arif et al. [43] defined, prioritization and software improvement of success factors on the bases of fuzzy AHP in global software development. Larger part of the product advancement associations are scaling the improvement exercises in the space of global software development. Different benefits are main cause to bring software products to globalization. Instead of benefits GSD faced different types of limitations like the distance make separate team members from each other. By using high technology, it is shocking to note that presence of minimal experimental research finished to investigate SPI exercises in GSD field. The given SPI principles and models could help the product improvement associations to keep up with the nature of the framework and fulfill the client needs. Success factors were recognized by reviewing accessible literature and focused on prioritization from the conducting survey with the SPI specialists. Fuzzy Analytical hierarchy process is used to convert the qualitative feelings to numerical expressions. Constraint of research is that author conduct only 21 interviews and used total 17 categories.

Pornwasin et al. [66] shows, prioritization of reverse logistic barriers solutions using fuzzy AHP and TOPSIS. Throughout the past ten years, ecological issues have turned into a significant issue in different industries adding electronic organizations because of an expansion in natural awareness. Decision makers need to consider ecological issues in every action of their association along their supply network. Different companies has several solutions for sustainability development in case to reduce of waste and produced value on the returning of used products like reverse logistic. RL centers on amplifying value from the returned thing or limiting all RL cost from the backward. Applying law and rules to force the stakeholders to take care of waste electronic equipment's. Research focused on defining issues in Thailand electric industry and prioritize decision to tackle industrial barriers. A fuzzy approach is defined to prioritize ranks step by step and TOPSIS is used to assigning weights to solutions. PHP has limits because of ease to use AHP, for example, the critical scale is not equal and absence of vagueness. Gholamhossein et al. [67] defines, critical success factors prioritization using TOPSIS approach of TQM. Pharmaceutical company as a fundamental piece of medical services framework, completes research and grows new drug and organic items and after that fabricates and markets these items. Expenses have consistently been rising and presently it frames a critical portion of any public Gross domestic product. Use of total quality management

involved to help different companies to maintained best quality standards of services and products. TQM applied to increase the profit, market satisfaction, team works and many other facilities. Research study plans to recognize and focus on control success factors for fruitful execution of TQM in the drug business. Fuzzy strategy for request of desired by likeness and used to prioritize success factors and applied TOPSIS technique to assign weights to defined success factors. Research limitations is that TQM is a vast technique which is usable in major countries and large organizations but this methods is cost increment for short industries.

Mandić et al. [68] sketch, efficiency analysis of Serbia companies of insurance using TOPSIS and Fuzzy AHP. Effect of the financial crisis on the protection business was less affected than it was on the banking business. Therefore, monetary crisis and resulting downturn forced significant changes to the institutional and business scene. Nature of financial summaries is a complicated classification that is essentially impacted by the assessments of clients of budget reports. Condition of financial reports of insurance agencies is impacted by a few elements. In the all-out financial area the insurance as per the capital and the quantity of personnel is in second highest place. Basic point of research is to propose a model for assessing the financial boundaries of the insurance agency working in Serbia. From 2007 to 2014 the 28 insurance companies come to account. Author research proposed a model on the behalf of two multi criteria decision making techniques are Fuzzy analytical hierarchy process and TOPPSIS for ideal selection. Estimating the presentation of an insurance agency is basic to for economy. Vagueness and complexity of the worldwide market, as well as expansion in the movement of data, are significant barriers to precise execution measurement.

Saeedeh et al. [69] outline, bank rankings through the evaluation of performance by integrating TOPSIS and Fuzzy AHP. Bank business as a help area is unavoidably situated in the focal point of worldwide conflict. It is straightforwardly or in a roundabout way impacted by the victories and disappointments of organizations. Banks go about as an arbiter between the individuals who supply assets and the people who request reserves. Performance estimation is a way that shows productivity and effectiveness of the exercises. Researcher used different performance measures but the ratio analysis is widely used. Author used TOPSIS and Fuzzy analytical hierarchy process to evaluate the weights of group and sub groups. Because of the rising privatization of banks in Iran, the overall outcome of private banks is vital. Being educated regarding the achievement level of private banks, can assist clients with pursuing choices on the utilization of banking administrations as well as buy the bank's shares.

Magdalena et al. [70] states, determine the best suited energy technologies of low emission development in Poland utilizing integrated TOPSIS and fuzzy AHP techniques. For an ongoing time of execution of manageable improvement strategy, energy arranging has become tough because of the association of different methods such as economically, social and environmental. Study created major constraints for decision makers to select a decision from energy alternatives. Researcher's defined different methods to tackle decision making issues like cost benefit analysis and multi criteria decision making. In this research, a mixture MDCM method is generated which based on fuzzy analytical process and fuzzy methods for an ideal decision making process through fuzzy TOPSIS. Research technique is used to evaluate and list down five low emissions energy technologies in Poland. Greatest inconsistency among renewable energy systems and atomic innovations exists for social and environmental aspects.

Shahmir et al. [71] outline, application of fuzzy AHP and TOPSIS for multi criteria decision making method to the reservoir system of Indus in Pakistan. Conflicts emerge over water asset activities and frameworks assuming they have assorted purposes and asset values. The fundamental justification behind the conflict is that the water asset projects are figured out how to advance conflicting benefits for flood control, regeneration, water providence and hydropower. Flood control benefits are quantified and easy to measure in financial value but other reservoir like environmental or natural resources difficult to measure. Multi criteria decision making technique is usable for environmental modeling. Applicable methodology is needed to prioritize the groups of issues into subgroups and help for decision maker to select one of them. Such as fuzzy AHP and TOPSIS technique has additionally been utilized for tackling generated issues. Constraint of research is that TOPSIS required normalization of multi dimensions issue.

Table 1: Summary of Literature review

Author(s)	**Proposed technique**	**Methodology**	**Evaluation Criteria**	**Limitations**
Sorin Nadaban[72]	General view of Fuzzy Topsis	Implementation of the Fuzzy Topsis approach practical	Comparison with other approaches	Implementation of the Topsis no other approaches.
Francisco Rodrigues [13]	Compression between Fuzzy AHP and Fuzzy Topsis	Complete implementation of the both approaches.	Comparison with Fuzzy AHP approach	Fuzzy AHP have many limitations like does not support group

				decision making, change adequacy.
Shameem [73]	Classification of the barriers through Fuzzy AHP	Implementation of the Fuzzy AHP approach and then validated by questioner	Validation is done through By survey from industrial experts.	The bias in this study is related to the results gathered through a survey and mostly respondent from Asian so not satisfaction results.
Yaghoobi[26]	Prioritization of CSFs of projects by using AHP	Industrial experiment Study	By the Ques-tioners style	It does not performed the quantification and validation.
Feng[74]	fuzzy TOPSIS process depends on a new distance covers through an app. to credit risk eval-uation.	A new distance cover between IFSs is initiate, and its properties are indicate.	No Evaluation perform in this study.	It does not performed the quantification and validation.
Taibi [75]	Investigate the existing Process and issues	By using the interviewed to identify the issues	interviewStyle	Limited number of interviewed conducted in this research study.
pourjayad [76]	Hybrid multi criteria decision making approach	Proposed the hybrid approach to solve the multi criteria problem	Validation per-form by Ques-tioner survey	Limited number of techniques Study of five journals research publications.

3.2 Chapter Summary

In this chapter, we studied the various research article related to Agile Software Development, MCDM approaches, Fuzzy TOPSIS approach and Classical AHP approach. In ASD domain mostly performed the systematic literature for the investigating the factors and categories. In research study, validation performs by conducting the interviews and questionnaire survey from the small organization in the Asia. From this study, mostly receive the limited number of respondents. In the literature, we discuss many issues like, vagueness and unclearness of human judgment in decision making, requirement change problem, and management issues.

CHAPTER 4: METHODOLOGY

This chapter will provide the details about research background, research methods used and the data analysis methods.

4.1 Research Setting

To get the study goal, we used the Systematic Literature Review (SLR) approach to recognize management related SF's of agile software development from existing studies and then conducted an empirical investigation to confirm the findings. SLR is diverse from a literature review as it is carried out systematically and organized. Many researchers applied this method to collect the existing studies data [10][73][32][31]. The results acquired using the SLR approach are accurate and real [77]. The essential inspirations for utilizing the SLR procedure are to help with perceiving the investigation all in all and give an efficient strategy to separate the information [78]. A SLR technique easy to identifies in several research areas that require less research and those that require more research [78]. According to Kitchenham et al. [47], three primary phases in SLR are "Planning the review," "Conducting the review," and "Reporting the review." Figure 1 explains the proposed research methodology.

Figure 1 shows all the steps which we followed in this study. It gives us a clear picture of all the processes for the understanding of proposed research methodology. Initially, we identify the agile-related success factors from existing studies through a Systematic Literature Review. Agile experts validate these identified success factors through an online Questionnaire survey approach. The confirmed factors are further categorized into their respective categories. After that, apply the Fuzzy AHP technique to prioritize the validated success factors. As a result, concerning our proposed methodology, first, we investigate the success factors of ASD. Following are the three main phases of SLR.

1. Planning the review
2. Conducting the review

3. Reporting the review

4.1.1 Phase1- Planning

The scheduling is the critical phase in conducting SLR. In this phase, the author develops a protocol for their research. The author selects appropriate data repositories and formulates a search string based on their research questions. Define their inclusion, exclusion, and quality criteria.

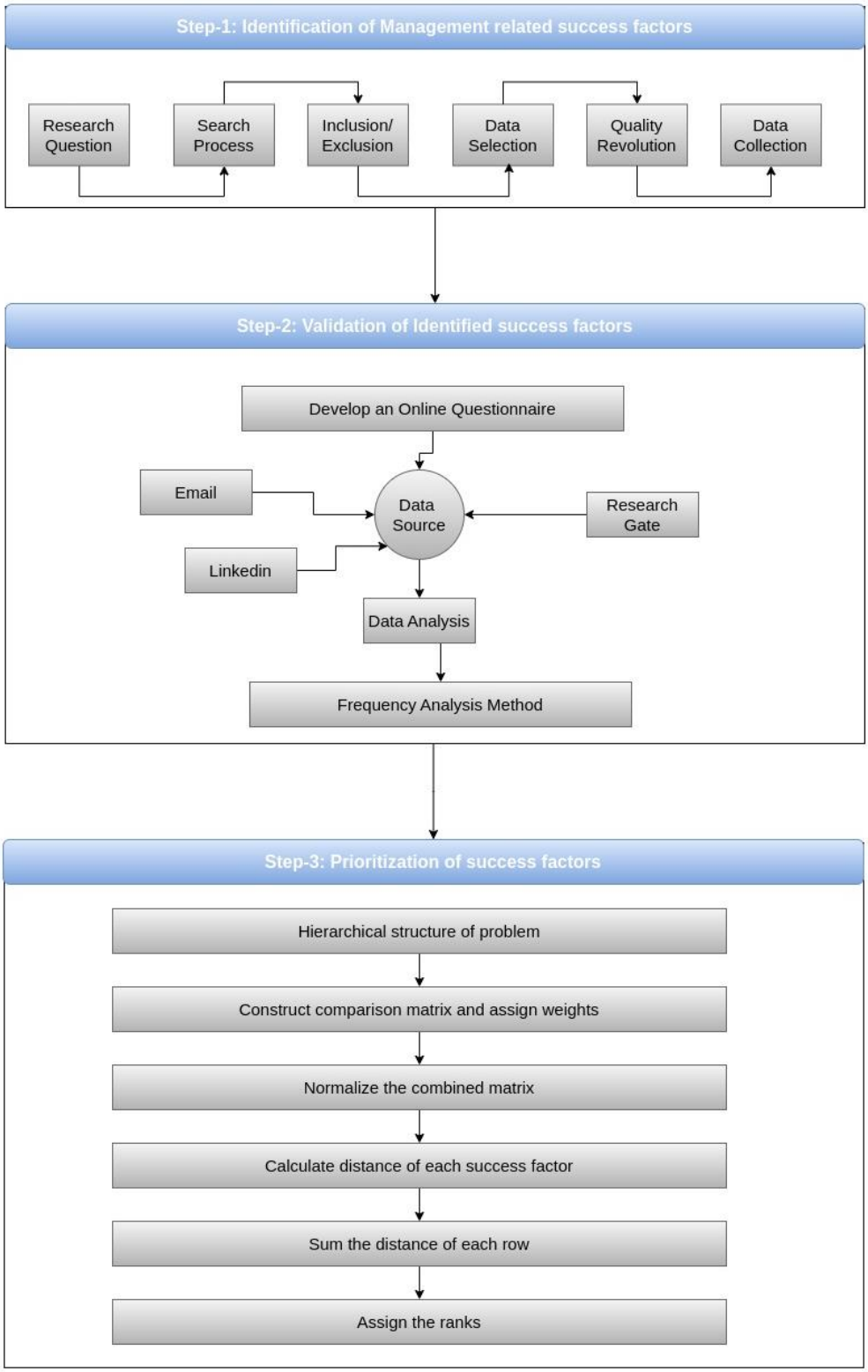

Figure 1: Proposed Methodology

4.1.1.1 Digital Collection Source

Following are the data collection sources for our research.

- IEEE Digital Library
- ACM Digital Library
- Google Scholar
- Springer
- Science Direct

4.1.1.2 Search String

We develop our search string to find general keywords/Synonyms from research questions expressed in our research. We used the Boolean operators "OR" and "AND" for search string formulation according to our research questions synonyms and keywords as shown in Table 2

Table 2: Research questions synonyms and keywords

Keywords	**Synonymous**
ASDM	("ASDM" "OR" "ASDM" "OR" "Agile Software Development Method")
Management Goals	("management perspective" OR "management point of view")
Category	("listing" OR "category" OR "classification" OR "grouping")
Factors	('factors' 'items' OR 'elements')
Prioritization	("listing" OR "prioritize" OR "ordering" OR "ranking")

4.1.1.3 Inclusion Criteria

- A list of the selected study must be published in a conferences and journal.
- The selected papers must be written in English.
- The selected articles discuss the success factors of agile software development methodology from management perspective.
- The selected articles discuss the multi-criteria decision-making techniques.
- The selected articles discuss the multi-criteria decision-making techniques.
- Include any publications on the topic that are presented through case studies or surveys

4.1.1.4 Exclusion Criteria

- The papers which do not discuss the multi decision making methodologies .

- Do not permit the complete text.
- Failure to write papers other than English.
- Excluded from our study duplicated articles.
- The redundant studies were not consider, only the best one was come to account.
- Discard the studies that do not provide detail information about the study subject.

4.1.1.5 Quality Assessment Criteria

To conduct best-quality research, it is necessary to define the quality of the selected research paper. To examine the quality of selected papers following questions were used. Table 4.2 shows the quality assessment criteria.

Table 3: Quality assessment criteria

QA	Quality Assessment Criteria
QA1	Does this research methodology discuss the research questions?
QA2	Does the study address the agile software development methodology related success factors from management point of view?
QA3	Does the study address the categorization and prioritization of the management related success factors in agile development?
QA4	Does this study address the survey based research?

4.1.2 Conducting the Review

During this phase of SLR, we perform our evaluation by using the created question and selecting the primary studies. First, the articles are chosen using standard methods. Then, after the papers have been retrieved, they are synthesized using the established criteria. In the following section, we describe the further activities in detail.

4.1.2.1 Primary Studies Selection

In this research, we used the drive method proposed by Afzal et al. [59] to select primary studies. Figure 2 describes the whole tollgate technique that we used to identify papers for this study.

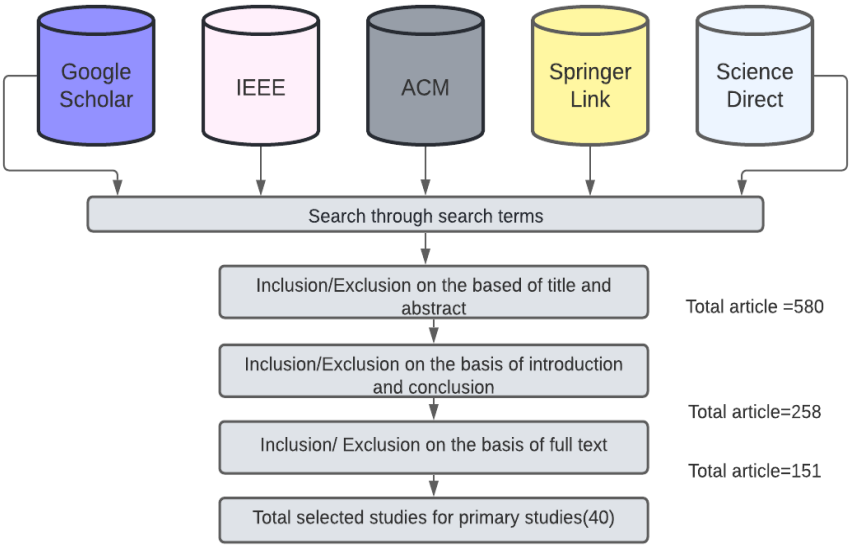

Figure 2: Tollgate approach for selection of primary studies

There are following five phases in the tollgate approach, as shown in Table 4 and in Figure 2.

Table 4 shows tollgate Approach can be divided into five basic phases/phases:

Phase 1: Find relevant articles using a search string.

Phase 2: Based on the title and abstract, include or exclude studies.

Phase 3: Based on the introduction and conclusion, include and exclude studies.

Phase 4: Based on the Full text, include and exclude studies.

Phase 5: The final step is to choose which studies will be included in SLR.

Table 4: Selected Primary studies using Tollgate approach

E-Databases	First Stage	Second Stage	Third Stage	Fourth Stage	Fifth Stage
IEEE	150	80	42	27	12
Science Direct	80	38	20	10	5
Google Scholar	180	65	40	17	16
Springer Link	105	45	32	14	8
ACM Digital Library	65	30	17	9	4
Total	580	258	151	77	45

4.1.2.2 Data Extraction

The data is extracted from the literature based on the paper title, publish year, author name, research approach, Agile development-related success factors, categorization, and prioritization.

4.1.2.3 Data Synthesis

In this stage, the extracted data of the selected studies are created and assessed compared to the search string based on research questions. We find out different factors based on a range of research. From 45 articles, 23 success factors of agile development-related from management field are identified.

4.1.3 Reporting the Results

Based on value evaluation measures, the selected particular studies evaluated during this phase, and a final list of introductory studies is planned. The selected research papers discuss the agile development success factors from management perspective. In addition, some studies examine the genetic classification and prioritize the success factors. In this SLR, we prefer studies with a 50% quality assessment score.

4.2 Research Duration

Research starts from the 06/02/2022 to identify the problem and then we start work on this research. From 03/05/2023 start the conducted Systematic literature review and after that we implemented the Fuzzy TOPSIS approach 03/25/2023. Results are evaluated 04/11/2023 performed by the Questionnaire style from the industrial experts. After that we start the write-up on 05/01/2023.

4.3 Methods Used

A data collection phase refers to the process of gathering needed data and preparing them for analysis. Several approaches can be applied to gather the problem related data, so it is worth mentioning this. That is also important to note down that the data collection process differ depends on the type of research method used. In this study we used the two different methods for data collection.

• Systematic Literature Review

• Web-Based Questionnaire survey

We conducted the SLR for the data collection and understanding of the domain. Through systematic literature review we find out management related CSF's according to from the existing literature. At the second stage we conducted the questionnaire survey for collecting and validating these identified success factors from agile field experts.

4.4 Sample Size & Technique

This research applied the literature review and Questionnaire survey to get data according to problem. We approached the industrial experts to collect data. In this questionnaire respondents belong to different countries. We get all the statics from experts which we applied in research.

4.5 Data Analysis

We sent the questionnaire to 431 people for survey, and we got 120 total responses from the experts including the software tester, researchers, requirement engineers and developer. Questionnaire forward to the respondents via email and social media. We gathered 110 responses complete and 10 were incomplete so we remove the incomplete responses.

4.5 Evaluation Methods and Criteria

This research study perform the questionnaire-style survey for evaluation of management related CSF's. The questionnaire survey was designed to gather information or data from field experts that would assist in recognizing and validating management related critical success factors and groups in the agile software development and management related organization domain. One hundred twenty experts took part in our survey, including software developers, software designers, testers, and researchers. Members were invited via email, Facebook, and LinkedIn via social media networks. There were 120 responses total from the experts, however, some were incomplete. Those incomplete responses were removed from the study, and we considered only 110 complete responses. Every respondent was directly associated with an agile software development project and a domain. This online survey was conducted from the 05 March 2023 to 25 March 2023. We used the 5-points to express their feelings like: "Strongly agree", "Agree", "Disagree", "Strongly Disagree", and Other".

CHAPTER 5: PROPOSED SOLUTION

5.1 Fuzzy Set Theory

Fuzzy set concept, initially proposed by Zadeh et al. [25] extends classical set theory. That were designed to cope having ambiguity and uncertainty in practical life challenges and control these uncertainties in the multi conditions judgment making issues [26]. The main involvement of the Fuzzy set principle is to deal with ambiguous and uncertain data in real-world decision-making problems. In our proposed methodology, we applied the Fuzzy TOPSIS technique to prioritize the SF's of the agile software development methods in management perspective. The background of Fuzzy TOPSIS is discussed in the following section.(HP).

5.2 Proposed Approach

From first day, software engineering faced different types of problems in developing a software and its maintenance. Software development related issues not have a best way to resolved. Defining success factors was only way to minimized the threat and increased the success of software products in agile software development. Fuzzy TOPSIS is among the most effective probable multi criteria decision making methods to prioritize the critical success factors related to management field for agile software development process. it is commonly used to evaluate alternative measures, solve practical decision-making problems, and improve computing efficiency. Furthermore, TOPSIS is currently being used to solve multi criteria decision making problems in several existing research studies [19, 20, 30, 31, 33]. As a result, the goal of using Fuzzy TOPSIS in this paper is to find the best positive and negative solutions for ranking agile software development success factors of those organizations which based on management environment.

5.2.1 Definition 1

A triangle Fuzzy number is indicated by triplet ˇ A = (a1,a2,a3) . The fuzzy triangular number ¯a defines the µ ¯ a(x) membership features.

5.2.2 Definition 2

A fuzzy collection ¯ a, µ ¯ a is membership function mapping each one element x into X of an individual number in the [0, 1] interval. The fuzzy triangular number ¯ a can be represented as follows ¯ a = (a1,a2,a3) .

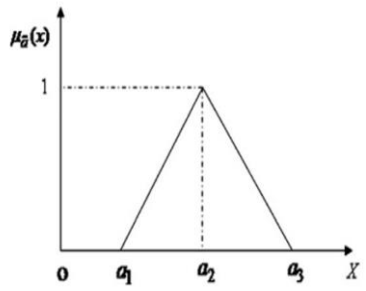

Figure 3: Fuzzy Number System

Figure 3 shows the Fuzzy number system which use in this study.

• a1 shows the minimum grade μ a that μ a=0

• a2 shows the full grade μ a that μ a=1

• The Area for data from the assessment is the lower and upper limits of the available a1 and a3.

These Fuzzy TOPSIS equations were taken from the [35] research study which is briefly defined and use in the equations.

$$\mu^{-}\,a(x)=\begin{cases} x-\frac{a1}{a2}-a\,1 \text{ if } a1 \le x \le a2 \\ x3-\frac{x}{a3}-a2 \text{ if } a2 \le x \le a3 \\ 0 \text{ otherwise} \end{cases} \quad (5.1)$$

A trapezoidal FN is defined with the help of its membership function.

$$\mu^{-}\,a(x)=\begin{cases} 0 \; if \; x < a1 \\ x-\frac{a1}{a2}-a1 \; if \; a2 \le x \le a1 \\ x-\frac{a2}{a3}-a2 \; if \; a2 \le x \le a3 \\ 0 \; if \; x > a3 \end{cases} \quad (5.2)$$

5.3 Implementation of the Fuzzy TOPSIS

Software is important and utilized in numerous organizations and industries with various disciplines. Almost sixty percent of software failed or challenged in almost every organizations which are concentrated with management business point of view. Literature defined various

solutions but agile is better over them in large level organizations. Key point of our study to find out various CSF's of agile software development to improve project scope and maximize the boundary of management facilitators. In multi criteria decision making problems, this fuzzy TOPSIS approach could be used to analyze both qualitative and quantitative data in agile software development. By assigning weights to the decisions made by decision-makers and assigning ratings to criteria by using triangular fuzzy numbers. The fuzzy numbers are usually exemplified using this μ icon. And (1, 1, 3),(1,3,5),(3,5,7) these three digits in each set are well-known as fuzzy numbers. These three numbers are the triangle's lower, center, and upper ends. The crisp digits (1, 3, 5, 7, 9) are swapped with fuzzy numbers on the extent of relative significance. It is realized that assigning a one-digit to any phrase was not reasonable. For example, we say the moderate value is four, but what about 4.5 or 5.5. To resolve these concerns theory of fuzzy numbers was proposed. In the Fuzzy TOPSIS technique, decision-makers decided based on linguistic variables. The human judgment is ambiguous. These uncertainties and ambiguity were removed through the Fuzzy TOPSIS multi-criteria decision-making technique. In this technique, fuzzy numbers are utilized. Using the fuzzy number scale, field experts or practitioners give us feedback on which success factor is most important or least important. The linguistic variable and fuzzy numbers used in this approach are shown in the Table 5.

Table 5: Linguistic Term

Sr No	Term	Abbreviation.	Fuzzy No.
1.	Very low	V.L	(1,1,3)
2.	Low	L	(1,3,5)
3.	Average	A	(3,5,7)
4.	High	H	(5,7,9)
5.	Very high	V.H	(7,9,9)

Table 6: Operation Law and Expression's

Operation law	Expression
a1+a2	(a1, b1, c1) + (a2, b2, c2) = (a1+a2, b1+b2, c1+c2)
a1-a2	(a1, b1, c1)-(a2, b2, c2) = (a1-a2, b1-b2, c1-c2)
a1*a2	a1*a2 = (a1, b1, c1)*(a2, b2, c2) = (a1*a2, b1*b2, c1*c2)
a1/a2	(a1, b1, c1)/ (a2, b2, c2) = (a1/a2, b1/b2, c1/c2)

These are the operation laws and expressions are defined as follows:

The vertex method is used to calculate the distance between two or more triangular. Like if $\tilde{x}$ = (a_1,b_1,c_1),$\tilde{y}$ = (a_2,b_2,c_2) Are two triangular FNs then

$$d(\tilde{x},\tilde{y}) = \sqrt{\frac{1}{3}\left[(a_1-a_2)^2+(b_1-b_2)^2+(c_1-c_2)^2\right]} \qquad (5.3)$$

This Fuzzy TOPSIS equation is used by researchers to calculate the distance between two or more triangular FNs by using vertex method Nadaban [38].

5.4 Work Flow

In Fuzzy TOPSIS approach various decision-makers were used for assigning Linguistic Term and Fuzzy numbers for each category and their respective success factors. We used subjective weighting method for weight assignment. Decision makers use these terms to mark their decision. The decision maker assigns the linguistic variables to any success factors use these variables that shown in Table 5.1.

“Low” = L

“Very Low” = V.L

“High” = H

“Very High” = V.H

“Average” = A

This table shows the implementation of the fuzzy TOPSIS. All the steps which are followed in this approach will discussed in detail Chapter 6.

Table 7: Project Administration “Decision Maker1”

Criteria	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	V.L	A	A	H	L	L
CSF2	A	V.L	L	H	L	H
CSF3	A	L	V.L	H	L	L
CSF4	H	H	H	V.L	L	L

CSF5	L	L	L	L	V.L	A
CSF6	L	H	L	L	A	V.L

Summary

This chapter discussed about the problem in Multi criteria decision making domain. In management organizations adopting agile software development process facing the issues related about prediction because human cannot predict accurately that is why we studied some approaches related to the multi criteria decision making and it have some advantages and disadvantages. Multi-criteria decision-making problems can be effectively solved by the Fuzzy TOPSIS approach to prioritize the success factors and resulted best outcome as management related organizations needed. For this purpose, we proposed the Fuzzy TOPSIS approach which is best for the predication and get positive ideal solution. Fuzzy TOPSIS help to remove uncertainty and ambiguity in MCDM issues for prioritization of critical success factors of agile software development. We implemented Fuzzy TOPSIS on the identified critical success factors of ASD pick out by practitioners of different management organizations and prioritize them. In this method, the decision maker helps to an effective implementation of this approach. Finally, we got the results and validated them from the industry through Google Form survey.

CHAPTER 6: EXPERIMENTAL RESULTS AND EVALUATION

The basic purpose of this research is to uncover and give an understanding of the management related CSF's that assist in the progress of agile software development projects. In the agile software development domain, Qatani et al. [3] classify the agile success factors into the "Organizational, People, Process, Technical and project" category. Rooh et al. [29] states in two steps. First of all collect data from survey and basic literature and second stage is the implementation of analytical hierarchy process (AHP) on the collected data that generate priority based motivators with the help of AHP model, the 21 success factors of project management are divided into four main types, i.e., "organization management," "team," "customer and technology," and" process." The SLR identifies these success factors based on the existing literature. With the help of a Systematic Literature Review, we identified 41 success factors from our selected primary studies. These identified critical success factors will help to achieve success in the agile software development domain. We have converted the identified factors into four dimensions by following the Rooh et al. [29] classification schemes. After that, we conduct an online questionnaire survey to empirically validate the identified factors from the literature. Some identified factors discard based on the empirical validation by agile experts. The Figure 4 shows the classification of the identified success factors.

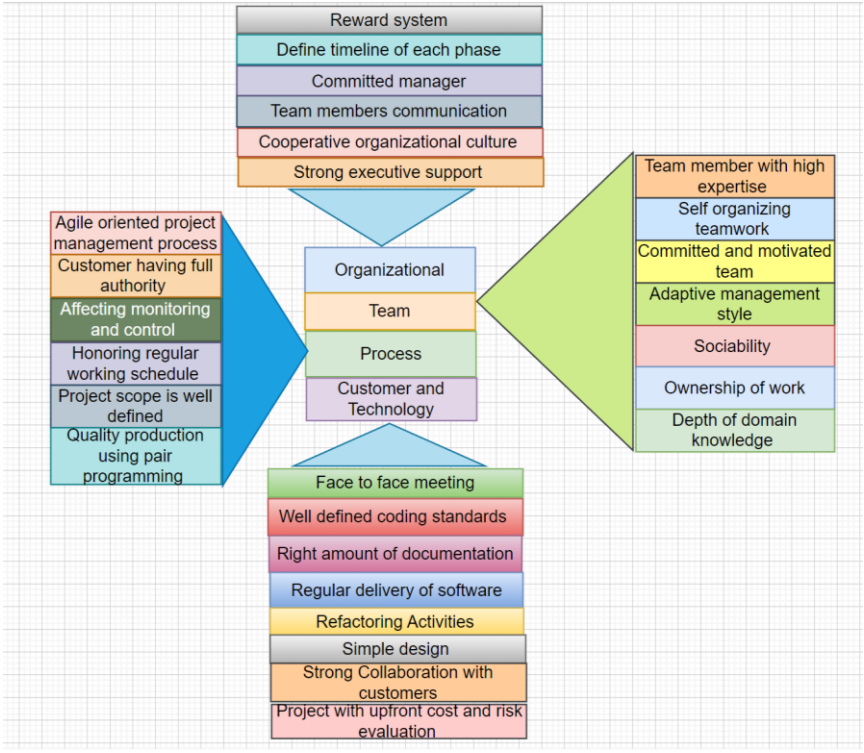

Figure 4: classification of the identified success factors

6.1 Prioritization of the agile critical success factors with respect to their categories

The Fuzzy TOPSIS approach has been applied for prioritization of management related CSF's of agile software development with respect to their categories.

6.2 Hierarchical structure of critical success factors and their respective categories

The Figure 5 shows the identified management related success factors of the agile software development method and their respective classification. In level 1 the goal of our research is present. In level 2 the major categories of the identified success factors are present. In level 3 the sub-Factors of each category is present.

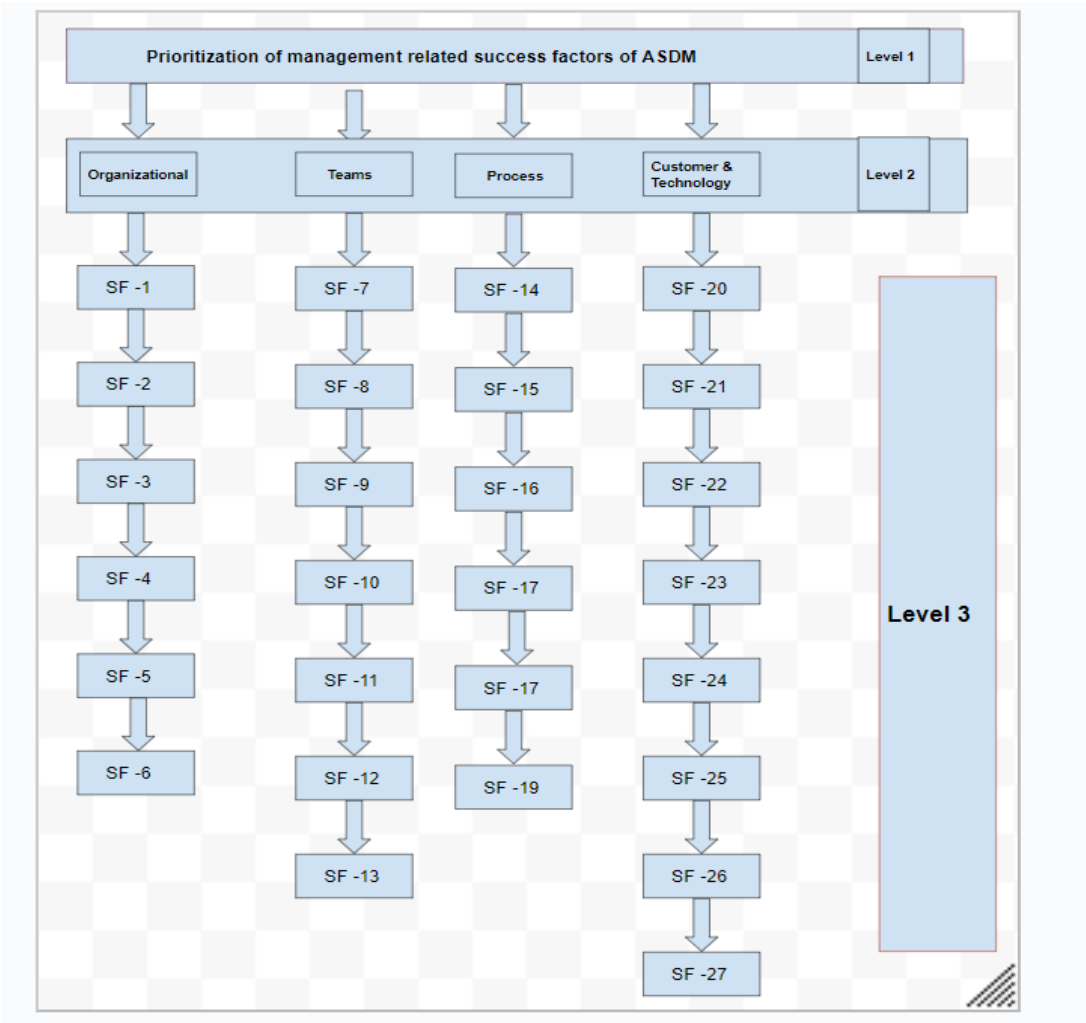

Figure 5: Hierarchical representation of the CSFs and their respective categories

6.2.1 Assign Weight Criteria to each Critical Success Factors by Decision Maker bst

The Fuzzy TOPSIS is used in this study to prioritize the management related CSFs in agile software development methods. In addition, group decision-making is aided by Fuzzy TOPSIS [81].

As a result, in this section, decision-makers assign the Linguistic Term and Fuzzy Number to each of the factors listed in Table 8: Three decision-makers were used for assigning Linguistic Term in Table 9 to Table 22 and Table 23 to 27 shows the Fuzzy numbers for each category. Decision makers use these terms to mark their decision.

• "Low" = L

• "Very Low" = V.L

• "High" = H

• "Very High" = V.H

• "Average" = A

Table 8: Critical Success factors with alternatives

Sr. No	Critical Success Factors	Alternative
1	Strong executive support	CSF1
2	Cooperative organizational culture	CSF2
3	Communication among team members	CSF3
4	Committed manager	CSF4
5	Defined timeline of each phase	CSF5
6	Reward System	CSF6
7	Team member with high competence and expertise	CSF7
8	Self-organizing teamwork	CSF8
9	Committed and motivated team	CSF9
10	Adaptive management style	CSF10
11	Sociability	CSF11
12	Ownership of work	CSF12
13	Depth of domain knowledge	CSF13

14	Agile oriented project management process	CSF14
15	Customer having full authority	CSF15
16	Effecting monitoring and control	CSF16
17	Honouring regular working schedule	CSF17
18	Project scope is well defined	CSF18
19	Quality production using pair programming	CSF19
20	Face to face meetings	CSF20
21	Well defined coding standards	CSF21
22	Right amount of documentation	CSF22
23	Regular delivery of software	CSF23
24	Refactoring activities	CSF24
25	Simple design	CSF25
26	Strong collaboration with customer	CSF26
27	Projects with upfront cost and risk evaluation	CSF27

Decision Maker 1:

Table 9: Categories

Criteria	**Organizational**	**Team**	**Process**	**CS and TE**
Organizational	V.L	H	H	A
Team	H	V.L	H	H
Process	H	H	V.L	A
CS and TE	A	H	A	V.L

Table 10: "Organizational" Decision Maker1

Criteria	**CSF1**	**CSF2**	**CSF3**	**CSF4**	**CSF5**	**CSF6**
CSF1	V.L	A	A	H	L	L
CSF2	A	V.L	L	H	L	H
CSF3	A	L	V.L	H	L	L
CSF4	H	H	H	V.L	L	L
CSF5	L	L	L	L	V.L	A
CSF6	L	H	L	L	A	V.L

Table 11: "Team" Decision Maker1

Criteria	**CSF7**	**CSF8**	**CSF9**	**CSF10**	**CSF11**	**CSF12**	**CSF13**
CSF7	V.L	A	A	H	H	H	A
CSF8	A	V.L	A	H	H	H	A

CSF9	A	A	V.L	A	H	H	L
CSF10	H	H	A	V.L	H	H	H
CSF11	H	H	H	H	V.L	L	V.L
CSF12	H	H	H	H	L	V.L	A
CSF13	A	A	L	H	V.L	A	V.L

Table 12: "Process" Decision Maker1

Criteria	CSF14	CSF15	CSF16	CSF17	CSF18	CFS19
CSF14	V.L	A	A	H	A	A
CSF15	A	V.L	A	L	L	L
CSF16	A	A	V.L	A	A	A
CSF17	H	L	A	V.L	L	L
CSF18	A	L	A	L	V.L	H
CFS19	A	L	A	L	H	V.L

Table 13: "Customer and Technology" Decision Maker1

Criteria	CSF20	CSF21	CSF22	CSF23	CSF24	CSF25	CFS26	CFS27
CSF20	V.L	A	H	A	L	A	A	A
CSF21	A	V.L	H	A	L	A	A	H
CSF22	H	H	V.L	A	H	A	A	A
CSF23	A	A	A	V.L	H	A	A	L
CSF24	L	L	H	H	V.L	A	H	A
CSF25	A	A	A	A	A	V.L	A	A
CFS26	A	A	A	A	H	A	V.L	A
CFS27	A	H	A	L	A	A	A	V.L

Decision Maker 2:

Table 14: Categories

Criteria	Organizational	Team	Process	CS and TE
Organizational	V.L	A	H	A
Team	A	V.L	A	H
Process	H	A	V.L	L
CS and TE	A	H	L	V.L

Table 15: "Organizational" Decision Maker2

Criteria	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	V.L	A	A	H	A	L
CSF2	A	V.L	L	H	L	H
CSF3	A	L	V.L	H	A	L
CSF4	H	H	H	V.L	L	A
CSF5	A	L	A	L	V.L	A
CSF6	L	H	L	A	A	V.L

Table 16: "Team" Decision Maker2

Criteria	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13
CSF7	V.L	H	A	H	A	H	A
CSF8	A	V.L	A	H	H	H	A
CSF9	A	A	V.L	A	A	H	L
CSF10	H	H	A	V.L	H	L	H
CSF11	H	L	H	H	V.L	L	V.L
CSF12	H	H	H	H	L	V.L	A
CSF13	A	A	L	H	V.L	A	V.L

Table 17: "Process" Decision Maker2

Criteria	CSF14	CSF15	CSF16	CSF17	CSF18	CFS19
CSF14	V.L	A	A	H	A	A
CSF15	A	V.L	A	A	L	A
CSF16	A	A	V.L	H	A	A
CSF17	H	A	H	V.L	L	L
CSF18	A	L	A	L	V.L	A
CFS19	A	A	A	L	A	V.L

Table 18: "Customer and technology" Decision Maker2

Criteria	CSF20	CSF21	CSF22	CSF23	CSF24	CSF25	CFS26	CFS27
CSF20	V.L	A	H	A	A	A	A	A
CSF21	A	V.L	H	H	L	A	A	H
CSF22	H	H	V.L	A	H	H	H	A
CSF23	A	A	A	V.L	A	A	A	L
CSF24	A	L	H	A	V.L	A	H	A
CSF25	A	L	A	H	A	V.L	A	A
CFS26	L	A	H	A	H	A	V.L	A
CFS27	A	H	A	L	A	A	A	V.L

Decision Maker 3:

Table 19: Categories

Criteria	Organizational	Team	Process	CS and TE
Organizational	V.L	H	A	H
Team	H	V.L	A	H
Process	A	A	V.L	A
CS and TE	H	H	A	V.L

Table 20: "Organizational" Decision Maker3

Criteria	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	V.L	A	A	A	L	L
CSF2	A	V.L	L	A	A	H
CSF3	A	L	V.L	H	L	L
CSF4	A	A	H	V.L	A	L
CSF5	L	A	L	A	V.L	A
CSF6	L	H	L	L	A	V.L

Table 21: "Team" Decision Maker3

Criteria	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12	CSF13
CSF7	V.L	A	H	H	H	H	A
CSF8	A	V.L	A	H	A	A	A
CSF9	H	A	V.L	A	H	H	L
CSF10	H	H	A	V.L	H	H	H
CSF11	H	A	H	H	V.L	A	V.L
CSF12	H	A	H	H	A	V.L	A
CSF13	A	A	L	H	V.L	A	V.L

Table 22: "Process" Decision Maker3

Criteria	CSF14	CSF15	CSF16	CSF17	CSF18	CFS19
CSF14	V.L	A	L	H	A	A
CSF15	A	V.L	A	A	A	L
CSF16	L	A	V.L	H	A	A
CSF17	H	A	H	V.L	L	A

CSF18	A	A	A	L	V.L	A
CFS19	A	L	A	A	A	V.L

Table 23: "Customer and Technology" Decision Maker3

Criteria	CSF20	CSF21	CSF22	CSF23	CSF24	CSF25	CFS26	CFS27
CSF20	V.L	A	H	A	A	A	A	A
CSF21	A	V.L	A	H	L	A	A	H
CSF22	H	A	V.L	A	H	H	H	A
CSF23	H	A	A	V.L	A	A	A	L
CSF24	A	L	H	A	V.L	A	H	H
CSF25	L	A	H	H	A	V.L	A	A
CFS26	A	A	H	A	H	A	V.L	H
CFS27	A	H	A	L	H	A	A	V.L

Table 24: "Category": Weight Criteria by DM1: Weight Criteria by DM2: Weight Criteria by DM3

DMI	C-1	C-2	C-3	C-4
C-1	(1,1,3)	(5,7,9)	(5,7,9)	(1,3,5)
C-2	(3,5,9)	(1,1,3)	(3,5,7)	(3,5,7)
C-3	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)
C-4	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)
DM2	C-1	C-2	C-3	C-4
C-1	(1,1,3)	(5,7,9)	(3,5,7)	(5,7,9)
C-2	(1,3,5)	(1,1,3)	(3,5,7)	(3,5,7)
C-3	(3,5,7)	(3,5,7)	(1,1,3)	(5,7,9)
C-4	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,3)
DM3	C-1	C-2	C-3	C-4
C-1	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)
C-2	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)
C-3	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)
C-4	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)

Table 25: "Organizational": Weight Criteria by DM1: Weight Criteria by DM2: Weight Criteria by DM3

DM1	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(1,3,5)	(1,3,5)
CSF2	(3,5,7)	(1,1,3)	(1,3,5)	(5,7,9)	(1,3,5)	(5,7,9)

CSF3	(3,5,7)	(1,3,5)	(1,1,3)	(5,7,9)	(1,3,5)	(1,3,5)
CSF4	(5,7,9)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(1,3,5)
CSF5	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)	(1,1,3)	(3,5,7)
CSF6	(1,3,5)	(5,7,9)	(1,3,5)	(1,3,5)	(3,5,7)	(1,1,3)
DM2	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)
CSF2	(3,5,7)	(1,1,3)	(1,3,5)	(5,7,9)	(1,3,5)	(5,7,9)
CSF3	(3,5,7)	(1,3,5)	(1,1,3)	(5,7,9)	(3,5,7)	(1,3,5)
CSF4	(5,7,9)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(3,5,7)
CSF5	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)
CSF6	(1,3,5)	(5,7,9)	(1,3,5)	(3,5,7)	(3,5,7)	(1,1,3)
DM3	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6
CSF1	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,3,5)
CSF2	(3,5,7)	(1,1,3)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
CSF3	(3,5,7)	(1,3,5)	(1,1,3)	(5,7,9)	(3,5,7)	(1,3,5)
CSF4	(3,5,7)	(3,5,7)	(5,7,9)	(1,1,3)	(3,5,7)	(1,3,5)
CSF5	(1,3,5)	(3,5,7)	(1,3,5)	(3,5,7)	(1,1,3)	(3,5,7)
CSF6	(1,3,5)	(5,7,9)	(1,3,5)	(1,3,5)	(3,5,7)	(1,1,3)

Table 26: "Teams": Weight Criteria by DM1: Weight Criteria by DM2: Weight Criteria by DM3

DM1	**CFS7**	**CFS8**	**CFS9**	**CFS10**	**CFS11**	**CFS12**	**CFS13**
CFS7	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CFS8	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CFS9	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(1,3,5)
CFS10	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)
CFS11	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(1,1,3)
CFS12	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(1,1,3)	(3,5,7)
CFS13	(3,5,7)	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,3)	(3,5,7)	(1,1,3)
DM2	CFS7	CFS8	CFS9	CFS10	CFS11	CFS12	CFS13
CFS7	(1,1,3)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)
CFS8	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CFS9	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(1,3,5)
CFS10	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(5,7,9)	(1,3,5)	(5,7,9)
CFS11	(5,7,9)	(1,3,5)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(1,1,3)

CFS12	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(1,1,3)	(3,5,7)
CFS13	(3,5,7)	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,3)	(3,5,7)	(1,1,3)
DM3	CFS7	CFS8	CFS9	CFS10	CFS11	CFS12	CFS13
CFS7	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CFS8	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)
CFS9	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(1,3,5)
CFS10	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)
CFS11	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(1,1,3)	(3,5,7)	(1,1,3)
CFS12	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)
CFS13	(3,5,7)	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,3)	(3,5,7)	(1,1,3)

Table 27: “process”: Weight Criteria by DM1: Weight Criteria by DM2: Weight Criteria by DM3

DM1	**CSF14**	**CSF15**	**CSF16**	**CSF17**	**CSF18**	**CSF19**
CSF14	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
CSF15	(3,5,7)	(1,1,3)	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)
CSF16	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)
CSF17	(5,7,9)	(1,3,5)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)
CSF18	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,1,3)	(5,7,9)
CSF19	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,3)
DM2	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19
CSF14	(1,1,3)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
CSF15	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)
CSF16	(3,5,7)	(3,5,7)	(1,1,3)	(5,7,9)	(3,5,7)	(3,5,7)
CSF17	(5,7,9)	(3,5,7)	(5,7,9)	(1,1,3)	(1,3,5)	(1,3,5)
CSF18	(3,5,7)	(1,3,5)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)
CSF19	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(3,5,7)	(1,1,3)
DM3	CSF14	CSF15	CSF16	CSF17	CSF18	CSF19
CSF14	(1,1,3)	(3,5,7)	(1,3,5)	(5,7,9)	(3,5,7)	(3,5,7)
CSF15	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)
CSF16	(1,3,5)	(3,5,7)	(1,1,3)	(5,7,9)	(3,5,7)	(3,5,7)
CSF17	(5,7,9)	(3,5,7)	(5,7,9)	(1,1,3)	(1,3,5)	(3,5,7)
CSF18	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(1,1,3)	(3,5,7)
CSF19	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)

Table 28: "Customer and Technology": Weight Criteria by DM1: Weight Criteria by DM2: Weight Criteria by DM3

DM1	**CSF20**	**CSF21**	**CSF22**	**CSF23**	**CSF24**	**CSF25**	**CSF26**	**CSF27**
CSF20	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)
CSF21	(3,5,7)	(1,1,3)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
CSF22	(5,7,9)	(5,7,9)	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)
CSF23	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)	(5,7,9)	(3,5,7)	(3,5,7)	(1,3,5)

CSF24	(1,3,5)	(1,3,5)	(5,7,9)	(5,7,9)	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)
CSF25	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)
CSF26	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)
CSF27	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)
DM2	CSF20	CSF21	CSF22	CSF23	CSF24	CSF25	CSF26	CSF27
CSF20	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
CSF21	(3,5,7)	(1,1,3)	(5,7,9)	(5,7,9)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
CSF22	(5,7,9)	(5,7,9)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CSF23	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)
CSF24	(3,5,7)	(1,3,5)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)
CSF25	(3,5,7)	(1,3,5)	(3,5,7)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)
CSF26	(1,3,5)	(3,5,7)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)
CSF27	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)	(3,5,7)	(3,5,7)	(3,5,7)	(1,1,3)
DM3	CSF20	CSF21	CSF22	CSF23	CSF24	CSF25	CSF26	CSF27
CSF20	(1,1,3)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)
CSF21	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(1,3,5)	(3,5,7)	(3,5,7)	(5,7,9)
CSF22	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
CSF23	(5,7,9)	(3,5,7)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)
CSF24	(3,5,7)	(1,3,5)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(5,7,9)
CSF25	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)	(1,1,3)	(3,5,7)	(3,5,7)
CSF26	(1,3,5)	(3,5,7)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(1,1,3)	(5,7,9)
CSF27	(3,5,7)	(5,7,9)	(3,5,7)	(1,3,5)	(5,7,9)	(3,5,7)	(3,5,7)	(1,1,3)

6.2 Development of the Questionnaire for Evaluation

The validation of the prioritization list of management related CSFs and their respective categories was accomplished through a questionnaire-style survey approach. As part of the questionnaire survey, we sought information or data from industry experts that may contribute to the legalization of the recognized critical success factors and their groups within Agile Software Development organizations. The survey included responses from 90 experts, including software developers, software designers, testers, researchers, and project managers. All respondents were invited through email, Facebook, and LinkedIn through social media. A total of 100 expert responses have been received, but some have been incomplete. Those responses were removed from consideration, and only 100 complete responses were

considered. Respondents directly interact with the ASD projects and domain. The survey was conducted online from 5th Jan 2023 to 5th April 2023. To express their views, we used the five-point scale :”strongly agree”, ”agree”, ”neutral”, ”strongly disagree,” and ”disagree”.

6.3 Results

In this thesis we used decision linguistic terminology to estimate the weight of criteria and then rank them to evaluate alternatives. Using fuzzy numbers, the linguistic significance of variables was determined (FNs). In article [21] author Francisco used a similar technique for supplier selection. In this paper [23] author Akbar proposed the Fuzzy TOPSIS method for the Ideal solution. This is the most well-known method for resolving MCDM issues. A fuzzy TOPSIS methodology is a known approach for evaluating human based multi criterion decision making problems. Quantitative prediction is stimulating for humans since they can better convey information through their senses. But Fuzzy TOPSIS efficiently translate the qualitative variables into quantitative values.

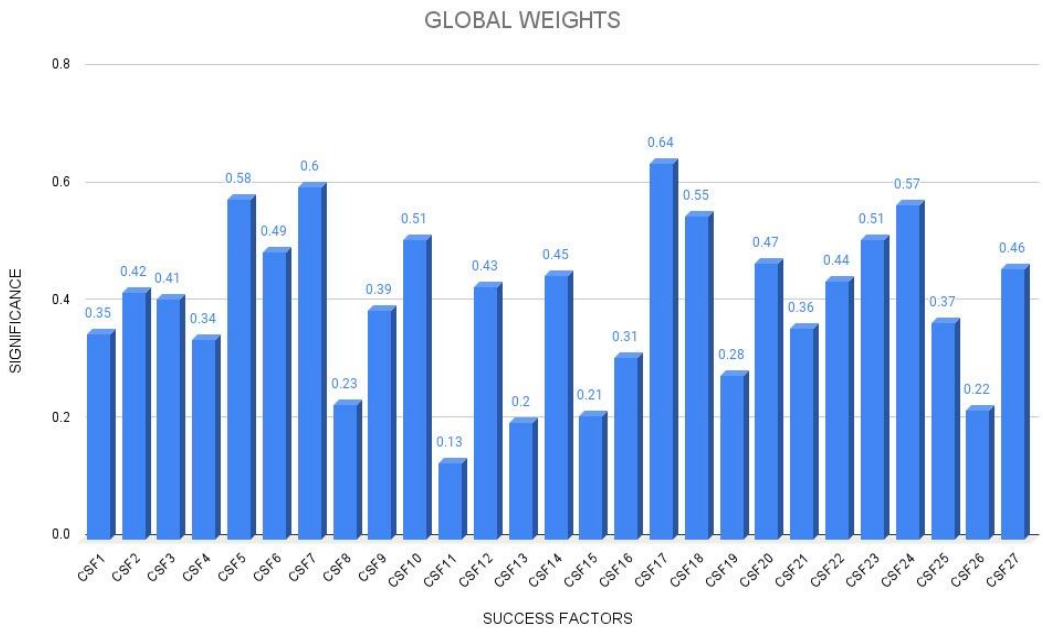

Figure 6: Results of Fuzzy TOPSIS

Figure 6 aids the management related critical success factors prioritization and depicts the results of each CSF after Fuzzy TOPSIS was implemented. The TOPSIS method minimizes

cost criteria while increasing all benefit criteria [28]. According to research [30], the fuzzy TOPSIS method is used to rank energy supply systems in Turkey.

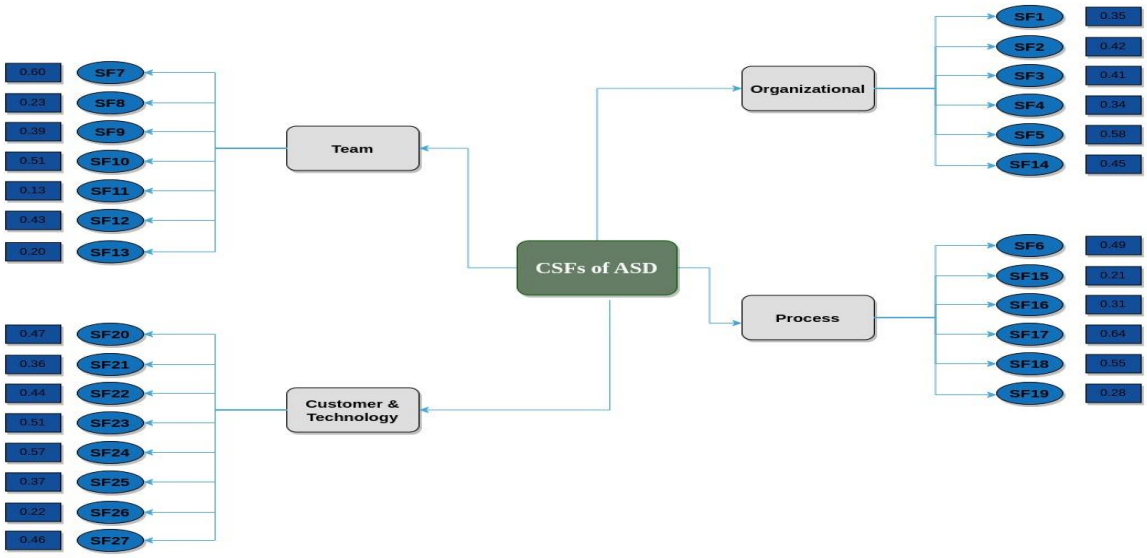

Figure 7: Global weights of success factors

Rank of each critical success factor is calculated using Fuzzy TOPSIS, as shown in Figure 7. Following the implementation of this TOPSIS method, all identified factors are placed in the following table and a ranking number is assigned. We have done prioritization of different critical success factors in our research. Prioritization is required to complete and cover all of the tasks and topics associated with our research. It will enable us to devote our attention to important and urgent tasks, allowing us to focus on lower-priority tasks later. The prioritized critical success factors are discussed in Table 29 below:

Table 29: Prioritized list of the "Critical Success Factors"

Sr No	Success factors	Global Weights	Rank
1	Strong executive support	0.35	19
2	Cooperative organizational culture	0.42	14
3	Communication among team members	0.41	15
4	Committed manager	0.34	20
5	Defined timeline of each phase	0.58	03
6	Agile oriented project management process	0.49	08
7	Team member with high competence and expertise	0.60	02

8	Self-organizing teamwork	0.23	23
9	Committed and motivated team	0.39	16
10	Adaptive management style	0.51	06
11	Sociability	0.13	27
12	Ownership of work	0.43	13
13	Depth of domain knowledge	0.20	26
14	Reward System	0.45	11
15	Customer having full authority	0.21	25
16	Effecting monitoring and control	0.31	21
17	Honouring regular working schedule	0.64	01
18	Project scope is well defined	0.55	05
19	Quality production using pair programming	0.28	22
20	Face to face meetings	0.47	09
21	Well defined coding standards	0.36	18
22	Right amount of documentation	0.44	12
23	Regular delivery of software	0.51	07
24	Refactoring activities	0.57	04
25	Simple design	0.37	17
26	Strong collaboration with customer	0.22	24
27	Projects with upfront cost and risk evaluation	0.46	10

6.4 Comparison of Fuzzy TOPSIS and AHP Results

The classical AHP is a quantitative technique. It does not directly allow the decision makers to handle decision problems when they may be uncertain about their level of preferences due to incomplete information. When the information or evaluations are certain, fixed or exact then AHP method should be preferred. If the information is not specific or exact then Fuzzy TOPSIS method should be preferred. The main difference between these methods is that TOPSIS encourages group decision making, whereas AHP does not .The relative importance scale that used in AHP method is shown in table. In classical AHP technique crisp numbers used in decision matrix. But in Fuzzy TOPSIS method fuzzy numbers used. The linguistic variable and crisp numbers used in this approach are shown in the Table 30.

Table 30: Linguistic terms

Linguistic Variables	Crisp Numbers
Equal	(1)

Moderate	(3)
Strong	(5)
Very Strong	(7)
Extremely Strong	(9)
Intermediate	[(2,4,6,8]

Prioritization of 21 critical success factors from existing literature through AHP and Fuzzy TOPSIS and comparison table shown below,

Table 31: critical success factors from existing literature through AHP and Fuzzy TOPSIS

Sr. No	Success Factors	Weights	AHP Rank	TOPSIS Rank
1	Strong executive support	0.09	18	19
2	Cooperative organizational culture	0.03	20	14
3	Face to face meetings	0.03	19	09
4	Dedicated management	0.04	21	20
5	Team competency in agile development expertise	0.21	11	02
6	Agile development environment	0.14	14	08
7	Team encouragement	0.08	17	16
8	Customer satisfaction	0.39	4	21
9	Strong collaboration with customer	0.37	5	10
10	Sustainable planning	0.09	6	11
11	Use of automated software tools	0.08	16	18
12	Scheduled training for team members	0.22	9	03
13	Strong collaboration and communications	0.04	12	15
14	Risk management	0.25	13	13
15	Knowledge sharing management	0.16	15	04
16	Quality production using pair programming	0.05	10	17
17	Mechanism for change management	0.46	8	12
18	Leadership strong commitment and team autonomy	0.45	3	07
19	Pilot project in case of no experience	0.17	2	05
20	Training, learning, and briefing of top management on agile	0.08	7	01
21	Requirements management using agile-oriented requirement management process	0.57	1	06

The first rank factor, according to the Fuzzy TOPSIS, is “Training, learning, and briefing of top management on agile.” The top-ranking factor, according to AHP, is “Requirements management using agile-oriented requirement management process.” In AHP, only one single expert /decision-maker involve in decision process, indicating a critical situation in which we cannot rely on a single decision maker’s decision. For a better understanding, Figure 6.6 depicts the TOPSIS and AHP comparison in graphical form.

In Figure 8 the comparison of Fuzzy TOPSIS and classical AHP global weights is shown.

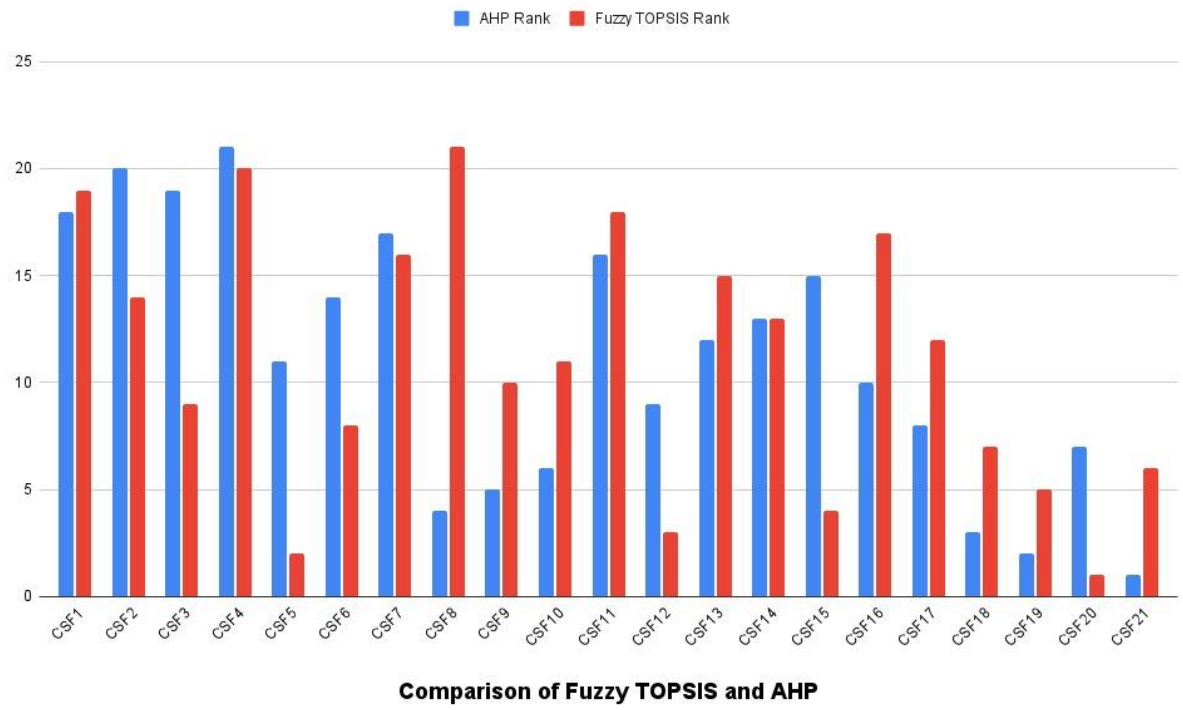

Figure 8: comparison of Fuzzy TOPSIS and classical AHP global weights

6.5 Discussion

6.5.1 RQ1: Critical Success Factors

Analyzing the existing literature in the Agile Software Development field, we identified 27 management related critical success factors. Some factors discard based on the empirical data. For the success of the project in the ASD domain, these CSFs will provide help for software project improvement. These factors have been transformed into four categories, which have been presented in [29].

6.5.2 RQ2: Classification of Critical Success Factors

By identifying and categorizing the importance of each management related success factor by category, we created taxonomy of the Success Factor Integration factors. With the help of existing techniques established by [29], we identified 27 management related critical success factors and classified them into four categories: Organizational, Team, Process, and customer and technology. The ranking factors show that the "Organizational" category is very important because it contains the high weight and high impact. This category is critical for ASD activities in the Management domain, and industry experts have validated it. The respondents unanimously agreed upon the Fuzzy TOPSIS ranking criteria. Our proposed categories will aid in achieving the software project success of Agile Software Products.

6.5.3 RQ3: Prioritization of the Critical Success Factors

The fuzzy TOPSIS protocol is applied to prioritize the identified management related success factors. A fuzzy TOPSIS approach was used to organize the critical success factors and their groups. Fuzzy TOPSIS methods involve multiple decision-makers making their own suggestions. First, set the linguistic term, then assign Fuzzy numbers to each factor and category. Fuzzy TOPSIS is a compelling method for understanding multi-criteria decision-making problems. We classified all factors based on Fuzzy TOPSIS results. "Honoring regular working schedule" is the highest ranking factor. There is a lot of research on management challenges because it is the most important aspect of ASD domain. According to the rankings, "Honoring regular working schedule," " Team member with high competence and expertise," " Defined timeline of each phase," and " Refactoring activities" are the top four success factors that should be adopted to implement Agile practices successfully. Results of the fuzzy TOPSIS reveal that 'Organizational' is the most important category of success factors.

Summary

Based on an analysis of the existing literature, we identified twenty seven management related critical success factors. These CSFs will aid the project's success in the ASD domain by contributing to the Software Project Improvement field. We have converted the identified factors into 4 dimensions by following the Rooh et al. [29] classification schemes. To validate the factors identified from the literature, we conduct an online survey. The management related critical success factors and their groups were organized using the fuzzy TOPSIS approach. First, decision makers determine the linguistic variable and then they assign Fuzzy numbers according to it. According to the Fuzzy TOPSIS results, the factor "Honoring regular working schedule" is the highest-ranking factor. Team member with high competence and expertise and Defined timeline of each phase is ranked second and third respectively. The first ranking factors in the "Organizational factors" category demonstrate the category's importance.

CHAPTER 7: CONCLUSION

7.1 Conclusion

Our research study primarily focuses on identifying and prioritizing management related critical success factors of Agile Software Development. ASD used the Fuzzy TOPSIS method to prioritize critical success factors. The research can assist organizations in the ASD domain tackle key development issues. For instance, practitioners can focus on the following significant factor to enhance the ASD setting and increase the use of process management practices. To confirm the literature review results, the 27 critical success factors of ASD were determined using the questionnaire analysis. It is helpful for ASD teams to remember the CSFs when implementing technology development programs. Based on the Fuzzy AHP approach used for CSF prioritization, the top factor is "Honoring regular working schedule." AHP and Fuzzy TOPSIS are two approaches compared in this paper. The study results indicate that Fuzzy TOPSIS is much more effective than AHP. Classical AHP does not deal with uncertain and ambiguous data while Fuzzy Topsis effectively deal uncertain data due to fuzzy numbers. In the given priority list, CSFs are provided that are likely to assist in the evaluation of ASD strategies. This factor prioritization primarily represents critical areas where organizations should have completed ASD activities successfully. We have assurance in our results, including the ability to manage development implementation challenges, which is critical for the ASD project's success. The study provides both the industrial and academic sectors with an in-depth understanding of ASD activities and ranking criteria, demonstrating the most critical factors crucial to a project's success.

7.2 Future Work

In the future, the model will develop that includes best ASD practices, critical success factors, and, most importantly, industrial experts recommendations. This model will describe some aspects of the ASD fields, allowing industry and academia to gain a better understanding. To gain a better understanding of these approaches, Fuzzy TOPSIS and other techniques such as Classical AHP will be compared in the future. In response to the results of the research study, the model will be developed.

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