# SCITECH

# Critical Success Factors of Agile Software Development - A Systematic Literature Review

Trailokya Raj Ojha*
Department of Computer Science and Engineering, Nepal Engineering College, Nepal
*Corresponding Author: trailokyaro@nec.edu.np

**Abstract**

Agile software development has gained more popularity due to its capacity to manage constantly changing needs and generate high-quality software in less time. However, several success factors are required for an agile project to succeed. Agile development technique, delivery strategy, project team training, customer and staff involvement, management commitment, organizational culture, communication, and project management process are critical success factors (CSF) discovered in this study. This study's goal is to locate and evaluate these crucial elements of the agile software development methodology's success. A systematic literature review was conducted to study and analyze the previous studies to identify the CSFs in agile development. The findings of the literature review indicate that technical, people, organizational, and process factors are crucial for the success of agile projects. Each CSF falls into any one of these factors. Overall, this study's findings emphasize the significance of CSFs in the agile software development process. Organizations and software development teams can enhance their agile processes and raise the likelihood of project success by being aware of these aspects. Teams may create high-quality software in less time while simultaneously fulfilling the goals and expectations of the customer by concentrating on different success factors.

## Introduction

Software has currently become one of the most important and necessary aspects in this contemporary world due to the growing demand for information technology. In a time when augmented reality, the Internet of Things, and other cutting-edge technologies are being used all over the globe, software development enterprises are striving for optimized tools and methods. The rapid development of software development tools and methods has benefited all kinds of software development enterprises; worldwide software development businesses are still looking for specialized answers to their problems so they can respond to changes rapidly and, at the same time, maximize return on investment. The success of the project depends on meeting its deliverables within a certain budget while maintaining its quality, scope, and deadline. The most crucial tool for achieving project deliverables in any company is project management. Applying knowledge, abilities, tools, and strategies improves control over material and human resources (Dyba & Dingsoyr 2009). By boosting productivity, and dependability, and offering customers higher-quality products, it helps to strengthen customer relations. Agile, a project management style, has recently been adopted by the majority of software-based businesses for effective and efficient project development (Dyba & Dingsoyr 2009). The core concepts of Agile include quick deployment of solutions, early and frequent delivery of customer-valued products, resource utilization, quick problem detection, focusing on clients, effective communication and collaboration, adapting to changes, and

adaptability. The primary goal of this study is to review the critical success factors of the agile software development process.

To conduct the study, a systematic literature review (SLR) technique was used. The SLR is a research technique used to thoroughly discover, assess, and summarize the body of literature that is currently accessible on a specific subject or research question. The procedure entails a thorough screening of the identified articles for relevance and quality after a systematic search of appropriate databases and other sources. According to Kitchenham (2004), the objective of a systematic literature review is to provide a rigorous, transparent, and replicable summary of the current state of knowledge on a particular topic or research question. It can be used to identify gaps in the existing literature and guide further research in a particular field.

The agile development approaches, delivery strategy, project team training, customer and staff involvement, organizational culture, project management process, management commitment, and communication are the success criteria found by this process. In addition, this study introduces a taxonomy that classifies all these critical success factors (CSF) into technical factors, people factors, organizational factors, and process factors.

In this study following research questions are answered:

RQ1: What are the success factors in agile software development (ASD)?

RQ2: What are the most critical success factors that need to be taken care of during the implementation of ASD?

RQ3: How the identified critical success factors can be mapped into a robust framework?

The answers to these questions will be useful in determining the importance of CSFs for a successful software development process improvement and may help software companies that use agile methodologies to focus on addressing them to get a higher return on investment and customer satisfaction in less time.

### Agile software development methodologies

Agile software development emphasizes adaptability, customer interaction, and continual improvement. It is a collaborative, iterative approach to software development. It is built on the Agile Manifesto, a set of guidelines that puts people and interactions ahead of processes and working software, customer collaboration, and adapting to change. Several characteristics of agile software development have been found in the literature. According to Dyba and Dingsoyr (2009), the fundamental characteristics of agile development include communication and collaboration, accepting conflicts, and supporting creativity and innovation. Managers serve only as facilitators, and the design and execution processes are iterative and inseparable. According to a survey conducted by Vijayasarathy and Turk (2008), using agile development will make it possible to meet customer expectations and produce high-quality software. Other advantages of implementing agile development include higher levels of flexibility, reduced expenses for development, more frequent delivery of functional software, and more reusable code. Agile development might be considered a method to deal with the complexity of the various parts of software development, which exists in a relatively complicated area (Pelrine 2011).

Agile principles state that value addition should take precedence over plan adherence. The value that consumers receive from receiving functional software frequently and quickly can be increased (Dingsøyr et al. 2012). With agile development, the software development team is expected to deliver early and then get feedback quickly, allowing for easier modifications, higher quality, and ongoing testing. According to Highsmith and Cockburn (2001), two of the most difficult issues facing business and technology today are addressed by agile practices: first, the need for an inventive approach to software development and, second, the requirement for a work environment that is dynamic and responsive to frequent changes. According to Cockburn and Highsmith (2001), the agile philosophy prioritizes the importance of people over traditional software development methods. Since a skilled team is essential, the value of each team member increases as the development process becomes more agile.

*Critical Success Factors*

The Critical Success Factor (CSF) approach to identifying and evaluating an organization's performance was first designed in 1979 and it was later improved and gained widespread acceptance (Bullen & Rockart 1981, Rockart & Crescenzi 1984). Bullen & Rockart (1981) define the CSF as the small number of areas where strong competitive performance will ensure the individual, department, or organization. CSFs are a select few crucial areas where "things must go right" for the business to succeed and for the manager to reach their objectives. Critical success factors are areas of importance where everything needs to be done correctly through the company process to thrive the accomplishment and to meet the objectives of the manager (Nasehi 2013). According to different studies by Reel (1999) and Bytheway (1999), CSFs in software projects are related to basic project management approaches or the marriage of software engineering and business strategy. According to a different case study, CSFs in software projects include a variety of elements, including the estimating and validation phase of the development life cycle, executive management, project management, resource management, and strategic-level planning (Boghossian 2002).

When Walid and Oya proposed a new framework to determine crucial success and failure elements in 1996, the hunt for the success and failure criteria in the adoption of agile methodology began. They have proposed a new framework for fundamental variables and their impact on their effective and efficient contributions to project success. They used empirical research to gauge the viability of applying the suggested design. The survey's findings show that although the importance of these factors varies by industry, project managers' managerial abilities, team members' commitment and technical expertise, project attributes, and environmental factors can be just as important as organizational factors (Belassi and Tukel 1996). Pikkarainen et al. (2012) studied the case of successful implementation of agile software development projects in three different Finnish software companies. The study highlighted the significance of management's belief in and support for agile. The study also discovered that firms implementing agile methodologies needed to strengthen the development team and modify agile practices to meet organizational requirements.

It is required to look at the relationships among the different agile success criteria before conducting a factor analysis. We reviewed the studies on agile software development's CSFs (Aldahmash et al. 2017). As a result, the CSFs for agile software projects were narrowed down to eight success factors - delivery strategy, team capability and training, customer involvement, agile development approaches, communication, organizational culture, project management process, and top management support (Aldahmash et al. 2017).

**Methodology**

*Systematic Literature Review*

In this study, we have selected the systematic literature review technique to investigate the critical success factors in agile software development methodology. The literature shows that numerous studies have looked at the success elements of implementing agile methods in an organization. A systematic literature review (SLR) is a kind of secondary research study used to evaluate existing primary literature and studies relevant to the research question in a systematic and organized manner. This SLR is done for the evaluation of all the relevant data containing the success factors of agile software development. The research questions concerned with the study are listed in the introduction section. According to Kitchenham (2004), planning the review, carrying out the review, and reporting the review are the three primary stages of SLR.

*Planning of Mapping*

In the planning phase, the authors must first identify and clarify the various components of the study objective to ensure that research questions have not already been addressed in earlier reviews. Therefore, defining the research questions mentioned in the introduction section was an important phase in this

procedure. The search is done by using academic databases such as IEEE Explorer, ACM digital library, Science Direct, Research Gate, Springer, Google Scholar, and other sources.

*Search String*

The search query used for the extraction of relevant literature was:

*{Critical success factors} AND ({Agile} OR {ASD} OR {Agile Software Development})*

*Primary study selection*

The papers have been selected by exploring their title, abstracts, and conclusion. The research papers having unclear objectives and ambiguity were not selected.

Inclusion criteria

To include any research paper in the study, it should satisfy the following criteria:

i.      It must be published in a Journal or at a Conference.

ii.     The paper must be written in the English language and available as a full-text article.

iii.    The primary study must focus on critical success factors in agile software development.

Exclusion criteria

The research articles are excluded if they fall into any of the following categories:

i.      Articles that do not describe success factors in agile software development.

ii.     The articles are written in any other language than English.

iii.    All the studies are not available electronically.

iv.     Non-peer-reviewed articles.

v.      Unpublished research papers and thesis.

*Database*

The search is done by using academic databases such as IEEE Explorer, ACM digital library, Science Direct, Research Gate, Springer, Google Scholar, and other sources. The papers published after 2000 are considered in this study. Past research papers (Aldahmash 2017), (Van Kelle et al. 2015), (Livermore 2007), (Iqbal et al. 2019), (Wan et al. 2011), (Kalenda 2018), (Chow and Cao 2008), (Mishra et al. 2009), (Sheffield and Lemétayer 2013), (Stankovic 2013), (Hoda et al. 2017), (Stelzmann 2010), (Wan and Wang 2010), and (da Silva and dos Santos 2015) were selected for the review purpose in this study. These studies have demonstrated several agile development success factors. Details of the selected papers and the filtration of these papers are shown in Table 1.

Table 1: Filtration of Papers

| Database Name | Number of papers | Title filtration | Abstract Filtration | Selected papers | Reference |
|---|---|---|---|---|---|
| IEEE Explorer | 844 | 9 | 6 | 4 | [17][18][19][20] |
| ACM Digital Library | 141 | 12 | 5 | 1 | [21] |
| Science Direct | 238 | 5 | 2 | 4 | [22][23][24][25] |
| Research Gate | 136 | 23 | 10 | 2 | [16][26] |
| Springer | 132 | 14 | 6 | 1 | [27] |
| Google Scholar | 981 | 22 | 7 | 2 | [28][29] |
| **Total** | **2472** | **85** | **36** | **14** | |

**Findings**

Even in situations with high levels of process maturity, the agile software development practice has a detrimental effect on project performance. In this study, the CSFs are selected if such factors are validated in multiple studies. Different agile software development critical success factors discovered in different previous studies are presented in Table 2.

Table 2: Agile software development CSFs

| Dimensions | Success Factor | Articles |
|---|---|---|
| Technical Factor | Agile development technique | [16][22][27][29] |
| | Delivery strategy | [16][18][22][23][24][28] |
| People Factor | Project team training | [20][29][23][27][28] |
| | Customer and staff involvement | [22][23][26][27] [29] |
| | Management commitment | [17][18][19][21] |
| Organizational Factor | Organizational Culture | [20][23][24][28][29] |
| | Communication | [20][17][27][29] |
| Process Factor | Project management process | [22][24][25][29] |

The conceptual framework for the category-wise distribution of CSFs in ASD found from existing studies is explained below and demonstrated in Figure 1.

*Technical Factors*

From the study and analysis of previous studies related to critical success factors in agile software development methodologies, it is found that agile development technique and delivery strategy were found as major CSFs under technical factors.

Agile development technique

The project members must be conversant with the chosen method or technique before using an agile method or technique. All members of the agile development project team must understand the concepts, ideas, and terminology utilized by the chosen agile technique or practice (Chow and Cao 2008) and (Stelzmann et al. 2010).

Delivery Strategy

Two things are crucial for the successful delivery of an agile development project Chow and Cao (2008). First and foremost, you must frequently produce functional software. Second, you ought to present the most crucial characteristics first. Each member of the team should be aware of their role in the delivery strategy and how to carry it out.
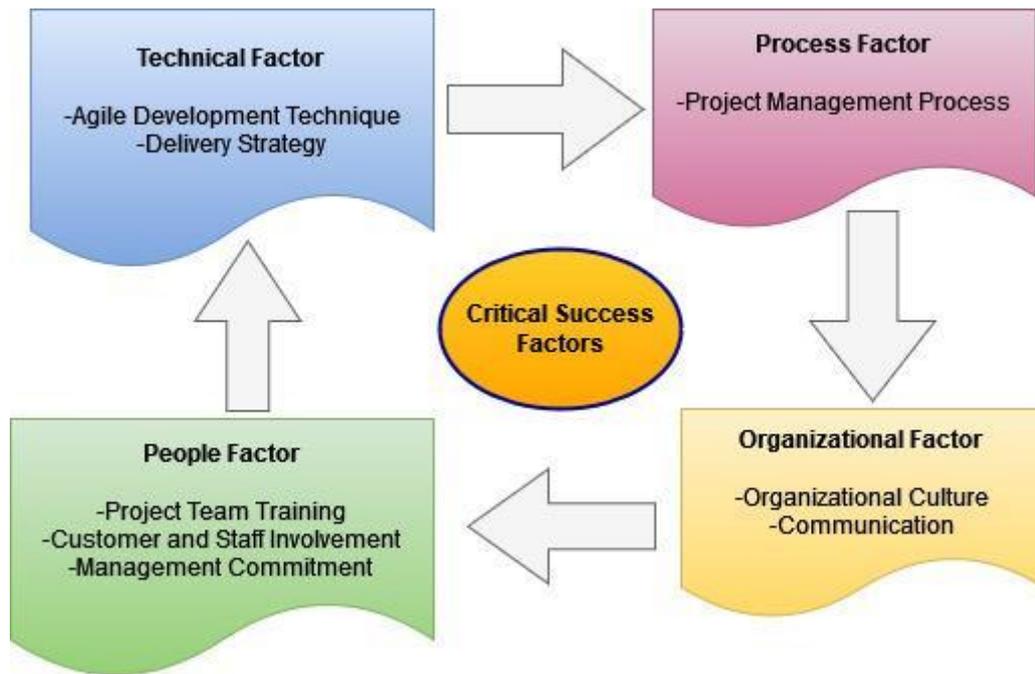
Figure 1: Category-wise distribution of CSFs in Agile software development

*People Factor*

People are the most important success factor in any project. Proper utilization of human resources leads the project toward success. In the case of agile methodology, people are the major factor for the successful completion of the project. From the study and analysis of different studies, project team training, customer and staff involvement, and management commitments were found as CSFs under the people factor.

Project team training

Motivated individuals should be the foundation of agile development. Any project needs the appropriate people to succeed, but agile projects require more of them since they rely so heavily on the competence of their team members. Regular training programs for the project team are crucial CSF for agile software development since they educate team members about new regulations, trends, tools, and methodologies. It has consistently benefited the organization and process improvement productivity. Training agile team members can raise the company's profile, enhance team dynamics and creative problem-solving skills, and provide them with the ability to manage agile projects. During the agile development project, a focus on training and ongoing learning should be made (Misha et al. 2009). According to Livermore Livermore (2007), obtaining training on the adopted agile methods or practices is significantly correlated with successful agile adoption.

Customer and Staff Involvement

In an agile development strategy, the active involvement of staff and customers is necessary for the successful completion of the project. It is an important CSF because it measures how much the employees trust, acquire, use, believe in, own, and adhere to the project. The involvement of customers is crucial for producing frequent releases of functional software and accepting changes in requirements. Customers will be happier with agile development if they are more involved (Misha et al. 2009). It is thought that customer cooperation and dedication affect how successfully agile software is implemented (Hoda et al. 2017).

Management Commitment

It is the most critical success element for the implementation of process improvement. Management commitment in a company refers to the degree of backing, funding, realization, and involvement of higher and lower-level management in the software process improvement initiative. A study conducted by Livermore (2007) found that the success of agile projects is strongly linked to the level of support from top management. Therefore, the involvement and support of management play a critical role in the success of agile projects.

### *Organizational Factor*

Organizational factors play a vital role in the successful implementation of agile methodology. Organizational culture and communication are considered the CSFs for agile under organizational factors.

Organizational culture

Organizational culture is considered one of the important success factors. Agile software development can be impacted by a variety of organizational aspects or elements, which are referred to as organizational culture. A dynamic culture is required to react to the changes that occur during the agile development process, and it is a crucial component of the shift to agility (Misha et al. 2009). Three organizational culture facets that can affect agile development have been identified by Wan and Wang (2010): the culture of working overtime, the culture of mistrust inside the organization, and the absence of a collaborative culture.

Communication

Communication is important in every part of life and is equally important in software development. It is even more important in agile software development as agile need frequent communication with customer and co-workers. In agile projects, there is a lot of involvement from customers, frequent feedback, dynamic changes, and self-organizing teams (Aldahmash 2017). This means that effective communication is necessary between project members and customers. A study conducted by Stelzmann et al. (2010) emphasized the importance of direct communication in agile development. They suggested that direct communication can help to improve the communication process in agile projects.

### *Process Factor*

It is important to identify a clear process for software development and train the staff for the introduced process. From different studies, it is found that the project management process is CSF for the agile methodology that falls under the process factor.

Project management process

The project management process is one of the critical success factors for the successful implementation of agile methodology. It's crucial to have a well-thought-out and size-appropriate project strategy when starting an agile development project. The success of the project and the standard of the software can be enhanced by selecting the appropriate project management methodology Chow and Cao (2008). The project factor is a reliable gauge of software development agility (Sheffield & Lemétayer 2013). The project management procedure should give the project team more control and maximize the abilities of the development team. Due to the numerous adjustments and iterations involved with agile projects, a flexible approach to project management is required.

### *Answer to the research questions*

RQ1: The research question RQ1 is answered after identifying the four different factors such as technical, people, organizational, and process factors. This is illustrated in Figure 1 and demonstrated in sections 3.1 to 3.4.

RQ2: The research question RQ2 is answered after defining eight different CSFs in agile software development. Such CSFs are agile development technique, delivery strategy, project team training, customer and staff involvement, management commitment, organizational culture, communication, and project management process. These CSFs are defined in sections 3.1 to 3.4 and illustrated in Figure 1.

RQ3: The RQ3 is answered by categorizing different CSFs into four different factors as illustrated in Figure 1.

**Conclusion**

Agile software development is a flexible, cooperative, and iterative methodology that enables teams to swiftly adapt to changing needs, enhance customer communication, find and fix issues early on, and promote a culture of continuous improvement. The objective of this study was to review the previous research works and to identify the critical success factors for agile software development methodology. After reviewing the previous studies, four different factors namely technical, people, organizational, and process factors with eight critical success factors for successful implementation of agile software development were introduced. Such eight CSFs are agile development technique, delivery strategy, project team training, customer and staff involvement, management commitment, organizational culture, communication, and project management process. By taking into account the crucial success factors in ASD, software companies can work regarding an approach that will highlight those significant process areas within the company that need to be enhanced to provide more value, which will ultimately lead to an increased return on investment and profitability. The result of this study might help software companies' successful implementation of agile methodology which might help the organization advance and succeed.

**References**

Dyba, T. and Dingsoyr, T. 2009. What do we know about agile software development?. IEEE Software, 26(5), 6-9.

Kitchenham, B. 2004. Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1-26.

Vijayasarathy, L. and Turk, D. 2008. Agile software development: A survey of early adopters. Journal of Information Technology Management, 19(2), 1-8.

Pelrine, J. 2011. On Understanding Software Agility: A Social Complexity Point Of View. Emergence: Complexity & Organization, 13.

Dingsøyr, T., Nerur, S., Balijepally, V., and Moe, N. B. 2012. A decade of agile methodologies: Towards explaining agile software development. Journal of systems and software, 85(6), 1213-1221.

Highsmith, J. and Cockburn, A. 2001. Agile software development: The business of innovation. Computer, 34(9), 120-127.

Cockburn, A. and Highsmith, J. 2001. Agile software development, the people factor. Computer, 34(11), 131-133.

Bullen, C. V., and Rockart, J. F. 1981. A primer on critical success factors.

Rockart, J. F. and Crescenzi, A. D. 1984. Engaging top management in information technology. Sloan Management Review (pre-1986), 25(4), 3.

Nasehi, A. 2013. A Quantitative Study on Critical Success Factors in Agile Software Development Projects; Case Study IT Company

Reel, J. S. 1999. Critical success factors in software projects. IEEE software, 16(3), 18-23.

Bytheway, A. J. 1999. Guest editor's introduction: Successful software projects and how to achieve them. IEEE software, 16(3), 15.

Boghossian, Z. J. 2002. An investigation into the critical success factors of software development process, time, and quality. Pepperdine University.

Belassi, W., and Tukel, O. I. 1996. A new framework for determining critical success/failure factors in projects. International Journal of Project Management, 14(3), 141-151.

Pikkarainen, M., Salo, O., Kuusela, R. and Abrahamsson, P. 2012. Strengths and barriers behind the successful agile deployment—insights from the three software-intensive companies in Finland. Empirical Software Engineering, 17(6), 675–702.

Aldahmash, A., Gravell, A. M. and Howard, Y. 2017. A review of the critical success factors of agile software development systems, software, and services process improvement. Proceedings of the 24th European Conference, EuroSPI 2017.

Van Kelle, E., Visser, J., Plaat, A. and van der Wijst, P. 2015, May. An empirical study into social success factors for agile software development. In 2015 IEEE/ACM 8th International Workshop on Cooperative and Human Aspects of Software Engineering (pp. 77-80). IEEE.

Livermore, J. A. 2007, March. Factors that impact implementing an agile software development methodology. In Proceedings 2007 IEEE SoutheastCon (pp. 82-86). IEEE.

Iqbal, J., Omar, M., and Yasin, A. 2019. An empirical analysis of the effect of agile teams on software productivity. In 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET) (pp. 1-8). IEEE.

Wan, J., Luo, W. and Wan, X. 2011, May. Case study on Critical Success Factors of agile software process improvement. In 2011 International Conference on Business Management and Electronic Information (Vol. 1, pp. 628-631). IEEE.

Kalenda, M., Hyna, P. and Rossi, B. 2018. Scaling agile in large organizations: Practices, challenges, and success factors. Journal of Software: Evolution and Process, 30(10), e1954.

Chow, T. and Cao, D. B. 2008. A survey study of critical success factors in agile software projects. Journal of systems and software, 81(6), 961-971.

Misra, S. C., Kumar, V. and Kumar, U. 2009. Identifying some important success factors in adopting agile software development practices. Journal of systems and software, 82(11), 1869-1890.

Sheffield, J. and Lemétayer, J. 2013. Factors associated with the software development agility of successful projects. International Journal of Project Management, 31(3), 459-472.

Stankovic, D., Nikolic, V., Djordjevic, M. and Cao, D. B. 2013. A survey study of critical success factors in agile software projects in former Yugoslavia IT companies. Journal of Systems and Software, 86(6), 1663-1678.

Hoda, R., Salleh, N., Grundy, J. and Tee, H. M. 2017. Systematic literature reviews in agile software development: A tertiary study. Information and software technology, 85, 60-70.

Stelzmann, E., Kreiner, C., Spork, G., Messnarz, R. and Koenig, F. 2010. Agility meets systems engineering: a catalog of success factors from industry practice. In Systems, Software and Services Process Improvement: 17th European Conference, EuroSPI 2010, Grenoble, France, September 1-3, 2010. Proceedings 17 (pp. 245-256). Springer Berlin Heidelberg.

Wan, J. and Wang, R. 2010. Empirical research on critical success factors of agile software process improvement. Journal of Software Engineering and Applications, 3(12), 1131.

da Silva, K. M. B. and dos Santos, S. C. 2015, October. Critical factors in agile software projects according to people, process, and technology perspective. In 2015 6th Brazilian Workshop on Agile Methods (WBMA) (pp. 48-54). IEEE.