Assessment of Project Management Agility in Private Real Estate Companies in Addis Ababa

Kemeriya Geremew Nuro

A Thesis Submitted to the Department of Civil Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirements of Masters of Science in Civil Engineering (Specialization in Construction Engineering and Management)

Office of Graduate Studies

Adama Science and Technology University

October, 2022

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DECLARATION

I hereby declare that this Master Thesis **"Assessment of Project Management Agility in Private Real Estate Companies in Addis Ababa,"** is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Kemeriya Geremew Nuro _____ _____

Signature Date

APPROVAL PAGE OF ADVISOR

I, the advisor of the thesis entitled, and developed **"Assessment of Project Management Agility in Private Real Estate Companies in Addis Ababa,"** by Kemeriya Geremew Nuro, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Meseret Getnet (Ph.D.) _____ _____

Major Advisor/Supervisor Signature Date

APPROVAL OF BOARD OF REVIEWERS

We, the undersigned, members of the Board of Reviewers of the thesis by Kemeriya Geremew Nuro have read and evaluated the thesis entitled **"Assessment of Project Management Agility in Private Real Estate Companies in Addis Ababa," and** examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Civil Engineering (Specialization in Construction Engineering and Management).

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ACKNOWLEDGEMENT

First and foremost, I would like to thank almighty Allah for helping me throughout this research project, and I would like to express my deepest appreciation to my advisor Dr. Meseret Getnet for his time and effort in reviewing the progress of this paper and providing valuable feedback, guidance, and encouragement.

Furthermore, I would like to thank to all organizations and individuals who contributed directly or indirectly to this paper especially by sacrificing their time in filling the questionnaires and provided the necessary materials and support for the realization of this paper. Finally, Special thanks and love go to my family and friends for their encouragement and support through the tough times.

ABSTRACT

Construction projects in the world are facing significant problems of cost overruns, time delay, poor quality, and poor health and safety issues. The Ethiopian construction industry also faces delays, poor quality, cost overruns, low involvement, and stakeholder satisfaction. One reason for this is that Ethiopia's construction industry still relies on traditional approaches rather than modern management systems. Now a days, agile construction management can be most impactful and provide benefits in construction project management. There are limited numbers of studies done with the main target of management from broader context, but none so far has attempted research on agility within construction project management or agility within construction companies. The main objective of this research was to assess the project management agility of private real estate companies which are found in Addis Ababa. Measures containing five enablers, fifteen criterion and thirty-eight attributes was identified by using reviewed literatures and first questionary survey. The population of this study includes private real estate companies in Addis Ababa. The studied real estate companies were chosen by purposive sampling technique and the data was analyzed by using relative importance index and Fuzzy logic approach. Mixed methods research approach was employed. Using the measures, project management agility of companies has been assessed and current level of project management agility of companies were found out. Besides computing agility index, the weaker attributes have low performance and less than the value of Fuzzy performance importance index value based on Pareto principle (20%) also have been identified and some solutions were proposed. Statistical validity of using Fuzzy logic with identified measures was done. Generally, this research contributes a theoretical foundation on how to assess project management agility practice in construction sectors. Practically, real estate companies can use those identified measures to regularly check their project management agility levels and plan for future improvements to deliver what is expected for their customers and to ensure efficient and effective management system.

Keywords/terms: Agility Assessment; Construction Industry; Fuzzy Logic; Real estate.

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LIST OF ACRONYMS

APM	Agile Project Management
IT	Information Technology
TPM	Traditional Project Management
AM	Agile Management
ASC	Agility of Supply Chain
SDLC	Software Development Life Cycle
TSDM	Traditional Software Development Methodology
AL	Agility Level
FAMI	Fuzzy Agility Measure Index
FPII	Fuzzy Performance Importance Index
RII	Relative Importance Index
FRAI	Fuzzy Readiness Agility Index
ITSM	Information Technology Service Management Agility
CBE	Commercial Bank of Ethiopia
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
TQM	Total Quality Management
FMS	Flexible Management System
FAI	Fuzzy Agility Index

1. INTRODUCTION

1.1 Background of the Study

Project management is one of the most common forms of organizing management systems in today's enterprise. However, principles and methods proved their practical applicability and effectiveness 20-30 years ago don’t provide effective project management when transporting into modern competitive economic conditions. The new market circumstances have highlighted the necessity to reconsider the existing project management paradigm and produced a demand for an adjusted project management concept (Ozornin et al., 2019).

Traditional project management principally draws from the linear organization and unique mechanical viewpoints of the systems engineering and quality sectors of the 1950s and 1960s. In essence, traditional project management approaches view development as a clearly defined collection of tasks like requirements, design, coding, and testing. The project manager presumes to be in possession of nearly all the knowledge regarding the objectives and potential solutions for the project. Scope, scheduling, or resource deviations are therefore difficult to understand (Dybå et al., 2014).

Traditional construction project management has certain restrictions on today's dynamic development environment. In conventional project management, the team must first map out all the project's specifics before it can get underway. It works efficiently only if important requirements are frozen in the early stages. It's challenging to manage changes in the later stages of project development (Uikey & Suman, 2012).

Traditionally, each phase of a construction project is carried out by its own team, each team passing on its performance one after another. Typically, projects begin with the planning phase. not every but many problems arise from a lack of collaboration and communication among the project team members. Due to the improvised nature of construction operations, coordinating critical path activities and monitoring project schedules become difficult. Many construction projects thus experience delays and associated expenses like penalties. (Mohamed & Moselhi, 2019).

Since projects are constantly evolving, a well-planned process is needed to ensure their success. Exceedances that may occur in a large construction project are very difficult to due to the vast number of factors involved, it is extremely challenging to quantify any potential exceedances in a large construction project. Cost overruns, scheduling delays, or irrational procedures can all lead to the failure of building projects. A new method of managing building projects is necessary because failure is unavoidable. Reviewing project management and execution in detail to identify the best tools and approaches to use will help to promote a more effective approach (Lalmi et al., 2021).

Agile methodology is a type of project management process, mainly used for software development, where demands and solutions evolve through the collaborative effort of self-functional teams and their customers. During the past few decades, fundamental changes have taken place in project development, planning, and execution. This has resulted from adopting innovative methods, such as various forms of agile project management, in place of the conventional waterfall project management. It is mostly appropriate for difficult projects like construction projects (Abd El Halim, 2020).

Agility in project is the ability of a project to respond to a changing environment effectively. This may include the capability of a project to be adapted to the dynamism that exists in the stakeholders' needs, technological changes, etc. To assure such a capability, it is necessary to assess the extent of projects' adaptability to change. This could be done by expressing the agility in terms of some quantifiable parameters (Mafakheri et al., 2008).

Agile maturity and agility assessment are brought as new concepts into the field because of unsuccessful adaptation of agile principles/practices. Sufficiency and usability of the current maturity models for organization to be agile is subject to research studies. There is still a fundamental need to assist organizations in assessing their agile capability and introducing roadmaps in adopting agile principles/practices (Top & Demirörs, 2014).

Ethiopia has long history of project management and building construction such as obelisk of Axum constructed 4th Century AD, Lalibela Rock Hewin churches constructed in 13th Century, Fasiledes (Fasil Gimb) constructed in the 17th Century and many others. And still construction sector is playing greater role in the development of Ethiopian economy.

It is creating job opportunities to the wide unskilled workforce (due to its labor-intensive nature), creating market opportunities for suppliers, facilitating the growth of other sectors and generating income for the government. Despite of its contribution Ethiopian construction industry is still dependent on conventional approach rather than using improved and modern management systems. The industry is facing challenges of delay, poor quality, cost overrun, poor engagement and low satisfaction of stakeholder (Garomsa, 2019).

Real Estate development is considered as one of the biggest business investments in the country with the transaction of billions of birrs in the market. Concerning the projected future housing demand, in addition to the existing need, the actors in the sector are increasing in number (Selam, 2016).

The level of adopting and applying good practices is associated with capacity and competitiveness of the stakeholders in the industry. In this regard, government of Ethiopia, in its construction industry development policy, has identified capacity building as one of the major areas of concern for construction industry development. Each dimension of competitiveness needs detailed study to prioritize the improvement actions. One of the dimensions of competitiveness is construction management practice (Mengistu & Mahesh, 2019).

1.2 Statement of the Problem

Construction projects are very expensive and their failure results loss of huge amount of money and resource. The success of any construction related project largely depends on the management system and process. Traditional method of construction management is inflexible and fails to respond on customer requests and changes. Due to these, projects are known by delay, cost overrun, safety problem, quality related issue, and resource wastage. The Ethiopian construction industry lags behind the principles of project management. The industry is still plagued by cost overruns, late completions, and late schedules (overtime). It is not growing as expected and is not adopting latest project management approaches and techniques (Garomsa, 2019).

Ethiopia's real estate market has been expanding due to the rising demand for residential homes in urban areas during the past few years. Even with all these real estate developers, the issue of residential homes still cannot be fully addressed. One reason for this is Ethiopian Private real estate companies also didn't adopt latest project management techniques. This is one of the reasons for real estate developers' failure to deliver what is expected (Selam, 2016).

Agile project management may be new as a concept, but aspects of the practices embodied in agility are already in place separately. To ensure the effectiveness of agile project management practices, an assessment of its performance must be done. Research findings show that as the agility of project management increases, the number of realized benefits also increases and getting a better agility allows companies to benefit from superior time, cost, and quality management as well as a sustained competitive edge. Continually assessing project management agility and knowing the agility level is crucially important for companies to make sure that they can continually improve and ensure that they are still providing value to its customers and stakeholders.

There are limited numbers of studies done with the main target of management from broader context, but none so far that I searched and reviewed has attempted research on agility within construction project management or agility within construction companies. The current problems of the construction sector initiate researchers to think of more inventive solutions to move forward the current condition in the classical system of management. This research assesses agility of project management in real estate construction companies to enhance current management systems. Besides, the study also focuses in identifying the weak attributes that the management should focus to improve.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this research was to assess the agility of project management in Ethiopian private real estate companies.

1.3.2 Specific Objectives

The following were specific objectives of this study

- To identify attributes, criterions, and enablers those will enable real estate construction professionals to assess their project management agility comprising of all major aspects.
- To identify the construction project management agility level of private real estate companies.
- To identify the weaker attributes that influence agility of project management in private real estate construction companies.
- To propose solutions for weak attributes to project management agility of private real estate companies.

1.4. Research Questions

1. What are attributes, criterions, and enablers those will enable real estate construction professionals to assess their project management agility comprising of all major aspects?
2. How to identify the construction project management agility level of private real estate companies?
3. What are the weaker attributes that influence agility of project management in private real estate construction companies?
4. How to address those weak attributes to enhance agility of project management in private real estate construction companies?

1.5. Significance of the Study

This study is conducted primarily with the intent of fulfilling the requirements of completing a study on Masters of Construction Engineering and Management. It could also benefit different parties via looking for answers for several questions and it will bring new insight to Ethiopian construction projects. Since most construction project problems arise during and after construction can be avoided by improving the construction management system.

The study will enable real estate owners and construction project managers to focus on weak attributes that affects their project management agility which critically affects the success of their projects.

It will also lay the foundation for further studies to be conducted in the study area and to provide valuable contributions to increase the likelihood of project management assessment methods in the construction sector.

1.6. Scope of the Study

This research was conducted with the aim of assessing project management agility of private real estate companies. As a scope, it tried to assess all aspects of agile project management within the scoped real estate companies and the outputs, findings, and summaries made are solely based on the participant's feedback.

1.7. Limitations of the Study

The current study attempts to address the challenges surrounding project management agility level. However, it has its own limits. The study uses a decision-making data analysis technique because of that it is difficult to use large number of participants in this sort of technique, so it takes three companies as a case company and some older literature is utilized as a source.

1.8. Organization of the Study

This paper is organized in to five chapters. High level content descriptions of each chapter are as follows:

Chapter 1: Introduction

Introduction and background information about the thesis including the problem statement, research questions, general and specific objectives, scope and limitations, and significance of the research work.

Chapter 2: Literature Review

This chapter includes review of relevant materials. It incorporates review of agility related literatures, industry best practices, agile project management and agility assessment related literatures comprising among available agility assessment.

Chapter 3: Methodology

Chapter three contains the research methodology used throughout this thesis work. It shows the methodologies adopted for management agility assessment which is one of the primary objectives of this work, research approach, sampling and data collection techniques, and tools used while analyzing survey data.

Chapter 4.; This chapter covers all aspects required in the development of the project management agility assessment. It includes the selection of enablers, criteria and attributes that are used to measure agility level of real estate Company's project management. It also shows how the analysis is done on chosen case companies and the presented results from survey to measure the agility levels of the case companies. The detailed analysis was included about the results of each company and discussion on the summarized result.

Chapter 5: Conclusions and Recommendations

This chapter summarizes and makes conclusions on the whole research findings. It also included future work suggestions for researchers in the area.

2. LITERATURE REVIEW

2.1. Project

Project is a temporary endeavor undertaken to create a unique product, service, or result and Projects are undertaken to fulfill objectives by producing deliverables. An objective is defined as an outcome toward which work is to be directed, a strategic position to be attained, a purpose to be achieved, a result to be obtained, a product to be produced, or a service to be performed. A deliverable is defined as any unique and verifiable product, result, or capability to perform a service that is required to be produced to complete a process, phase, or project. Deliverables may be tangible or intangible (Project Management Institute, 2017).

Projects come in many forms. There are traditional major projects from heavy engineering industries, (water, energy, transport, and telecommunications) to a small one. These are huge projects needing numerous supporting organizations to work together as well as large, devoted teams. However, there are also smaller tasks in the project. At work, projects may be maintenance on existing facilities, the deployment of new computer systems or technological advancements, the introduction of new products or programs for management training or development (Turner et al., 2014).

2.2. Project Management

Project management practiced as long as humanity lives on Earth. There are several instances in history of difficult projects that were finished successfully despite all obstacles, complexity, and uncertainty that may have led to the project's failure. Moreover, project management theories, tools, and techniques are now mainstream in many organizations and industries. It’s not clear exactly what the future holds for project management, but with challenges such as globalization, diminishing resources, and increasing population there is no more fitting vehicle for managing such issues than project management (Seymour & Hussein, 2014).

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. It is accomplished through the appropriate application and integration of the project management processes identified for the project (Project Management Institute, 2017).

Project management oversees defining and adhering to project goals and objectives, developing project plans, identifying various activities, quantifying necessary resources, setting budgets, and scheduling the project's completion. To produce a high-quality result, project management offers rules and guidelines to guarantee that the project is finished within the specified range, time, and budget (Uikey & Suman, 2012).

Projects are not considered as successful until they meet the set budget, timeline, and quality requirements. quality, time, and money have evolved into inseparable components of judging project management success during the past 50 years. this is perhaps not surprising, since over the same period these criteria have usually been included in the description of project management. these three factors remain in constant tension as can be seen in Figure 2.1. (El-Maaty et al., 2017).

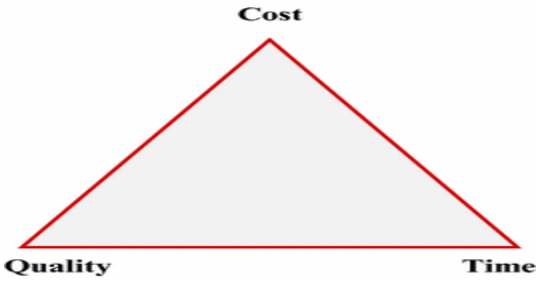

Figure 2.1 The iron triangle of projects management

Traditional project management has several disadvantages despite of its purpose which includes; the amendment does not allow deletion or addition at any completed stage, it does not allow to start more than one stage at a time, it is very difficult to estimate the time and budget of each stage, lack of monitoring tools in the project, it is exposed to many of the risks that adversely affect the progress of the project, insufficient risk management coverage, lacks the ability to adapt to changes that may occur during project phases with negative impacts on the project that affect time and quality, limited communication between project management and stakeholders, limited to the beginning and end of the project, there is no way to get feedback, makes the project team without work for long periods where each team is, responsible for the stage waiting for the role to come to work and therefore negatively affect the time and cost, not suitable for projects whose requirements are unclear or incomplete and subject to frequent changes, does not work well with large and complex projects (Project Management Institute, 2017).

Project passes through several stages organized by the project management team. According to (Project Management Institute, 2017), the stages begin with the planning and identification of the work, then the route of the implementation, monitoring and controlling of these actions and ultimately the transition and closure of those works. Traditional project management divided the stages of the project into five phases: initiating, planning, executing, monitoring, and controlling, and closing.

Construction project is also traditionally managed like a waterfall, with extensive pre-planning developed by the department and transferred to the project team for execution. No matter how well the plan is executed, numerous unknowns will still arise. To accomplish this, the project team must always have up-to-date knowledge of the project's state and be capable of taking the appropriate actions in a timely manner (Mohamed & Moselhi, 2019).

2.3. Construction Project Management

Engineering management, as one of the critical disciplines in construction engineering, directly impacts the life and property security in the environment. As society develops, construction projects naturally grow in scale, involving vast numbers of professionals, long life cycles, and complex interfaces. Therefore, the types and quantities of construction-related information have become quite large and complex, which has increased the complexity of construction operations processes. Nowadays, highly specialized knowledge and practical insight are needed for construction projects. In order to address these difficulties, project management was created, which makes it easier to implement and complete projects (Chou & Yang, 2012).

All construction projects aim to satisfy the client while staying within the allocated budget, timeframe, and range. The vast amount of data created during execution is seldom used in traditional construction management, which leads to missed deadlines and increased costs. Since there isn't constant feedback, issues might not be found until the final end. There's a chance the answer isn't properly documented. This makes it impossible to document lessons learned from these issues in future projects (Mohamed & Moselhi, 2019).

In the past few decades, little has changed in terms of how building projects are managed. The demands of users, competitors, and stakeholders, however, are continuously shifting. Due to this, there is a discrepancy between management's existing perceptions of how construction projects are carried out and their potential for efficiency gains (Streule et al., 2016).

Agile has many methods based on the principles mentioned in manifesto. These methods are based on an agile approach to project management, which is simplicity, repetition, and completion of tasks as soon as possible, adaptation to changes in the work environment, monitoring and feedback and it is concerned with the productivity and quality of the outputs at each stage of the work. It also focuses on the continuous interaction between the team and stakeholders (Project Management Institute, 2017).

2.4 Agility in Project Management

Agile project management is a technique for overseeing projects that aims to deliver customer value through flexible planning for change, quick feedback, ongoing improvement, and high levels of teamwork and involvement. Agile project management (APM) is a broad management style, to make the project management process more straightforward, flexible, and iterative in order to raise performance while requiring less management effort and to boost levels of innovation and value added for the client (Arefazar et al., 2022).

Companies have moved from a hierarchical approach of project management to a more collaborative approach for decades, with the increasing importance of knowledge labor at the heart of the evolution of globalization there is a need for project managers to flexibly adapt to the project system to be able to constantly adapt to new challenges and opportunities. the need to distribute responsibility and initiative in support of adaptation to change is familiar territory to "agile" approaches to projects (Paul & Rahman, 2018).

Agile project management originated in the software development sector and has grown because of empirical growth. There are applications for this methodology outside of that sector. It outlines values and standards that other industries can follow. It also provides a variety of project management tools and techniques that will help to adhere to its values and principles. In the software development sector, where the client recognizes his requirement and iteratively improves it, agile approaches are extensively utilized (Gopika Krishna. 2019).

Empowering teams to self-manage and self-organize, agile methodologies help businesses build engaged and cohesive teams. Regular team meetings give them a forum to exchange knowledge, work together, and consider the difficulties they are facing. Companies have strong focus on starting software construction earlier in the development process Regassa et al., (2017), provides empirical evidence of agile method adoption in smaller companies in Ethiopia. However, it was discovered that the companies in the study were conducting software projects for government clients that mandate substantial documentation with elaborate staged approval procedures, using fixed price contracts with predefined delivery schedules.

Feyissa, (2019), Also studied Adoption Level and Challenges of Implementing Agile Project Management Methodology at the Private Banking Industry in Ethiopia the findings show that among the 7 participating banks in the survey, only 2 of the development team managers (28%) indicated to have started using the Scrum agile project management methodology. The remaining 72% identify their methods to be the traditional waterfall method with either full release at the end of the SDLC or using the incremental delivery approach. This closely agrees with the development team members' response that shows 77% of developers identify their development methodology to be TSDM and 23% identifying their methodology as APM. Hence the adoption level can be said to be low as most of the banks have not started to adopt the agile methodology in the software development process.

Agile is an important tool for software development because it provides many benefits to the teams and project owners. The management style employed in the development process motivates the team members, which enable them to work effectively and accomplish the project tasks. The motivation increases their creativity and innovativeness, which contribute new ways of addressing the project problems effectively to deliver high quality software. The method provides different iterations, during which the developers can make appropriate changes based on the customer needs. The teams collaborate with the stakeholders during the process, thus enabling them to determine the successes and failures of the project to respond to them in good time. The control modes used by the leaders during the process enable the developers to cope with the changing needs of customers, thus leading to project success. Agile methodology enables the developers to detect and respond to the defects early enough (Moges, 2018).

According to Turner (2014), agile is an incremental, interactive technique of managing the building and designing activities of information technology, engineering as well as other business fields that aims at providing a new service or product in a highly interactive and flexible manner. Agile provides phases that are supposed to be followed in the process of developing and managing a given project, such as software development. Agile management usually requires people with appropriate skills and experience to successfully use it while managing. Turner also points out that agile management in most cases is viewed as broadening as well as generalization of principles that have in the past being successfully used in software development in other areas of project management in the world of business.

Agile project management is characterized by working in short iterative cycles with the delivery of some part of the project result at the end of every cycle. Before February 2001 there was no name under which all these new flexible and adapting methods (Agile methods) could be gathered, they had up until then called lightweight. However, in the small ski resort Snowbird in Utah, USA, seventeen method developers who represented different agile methods gathered because they felt they needed a common name and common values for all their methods. The name "Agile" was considered a more accurate description of these methods and was hence chosen. The common issues, which were discussed and agreed upon during the meeting in Snowbird, became the "Agile Manifesto" (Beck et al., 2001)**,** The Agile Manifesto was stated with four values and twelve principles, these would be explained in following paragraphs.

2.4.1 Agile Values

The following are four main values that agile methods are built upon

1. Individuals and interactions over processes and tools

The project team and its members are responsible for applying the best working processes and methods for a particular project, (Mohammed & Jasim, 2018). Communicate effectively with others, understand their requirements, and create the tools and actions that help work are essential to successful work. If you can't interact with others, your task will be delayed. The working group is working to apply the best working methods for existing projects. Every project has conditions to determine the right method and working team (Salem, 2019).

2. Working software over comprehensive documentation

The second statement in the agile manifesto is mainly considering software development projects. To make it more adapted to other kinds of projects, it could be changed into "Useful project outcome over comprehensive documentation",(Mohammed & Jasim, 2018). Moreover, these documents are rarely used beyond the initial deployment phase. Therefore, the documentation that matters in agile is the documentation that serves the working software and adds value to the process (Rodríguez et al., 2019).

3. Customer collaboration over contract negotiation

At the end of each cycle of an agile project, the customer is involved in presenting opinions and ideas about the project. This means that working with clients is the core of a successful project. Customers are involved in the entire agile project process by reviewing, discussing, and making decisions at the end of each cycle (Mohammed & Jasim, 2018).

4. Responding to change over following a plan

The Agile Manifest states that changes are welcomed in agile projects. This is because agile projects don't believe in pre-planning all the details and "predicting the future." Instead, planning needs to be dynamic, and agile teams need to be aware that projects tend to change (Mohammed & Jasim, 2018). Responding to changes and developments in the work environment is essential to project completion. Therefore, plans must be flexible and scalable. Thus, the stakeholders can change the project to the best and increase the quality of the final product. Agile does not believe in predicting the future by planning all the details at first (Salem, 2019).

2.4.2 Agile Principles

To further explain; the values of the Manifesto, it was also accompanied by twelve principles, which are presented below:

1. "Our highest priority is to satisfy the customer through the early and continuous delivery of valuable software" (Beck et al., 2001). Customer satisfaction is achieved through the project. Get results early, listen to their feedback, and discuss the results. This will move the work in the right direction and meet the needs of stakeholders. It also handles all bugs first, resulting in lower loss rates and no increased costs (Salem, 2019).

2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage (Beck et al., 2001). Agile Processes harness change for the customer's competitive advantage. The corresponding implication of the impact of any embracing any change in requirement must be minimized through practices like 'refactoring' (Alsaqqa et al., 2020).

3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale (Beck et al., 2001).

Agile efforts rely on completing projects in a short amount of time and delivering results as quickly as possible. This is done in collaboration between the team and stakeholders to test the results of each phase and add improvements to achieve the highest quality standards (Rodríguez et al., 2019). This principle emphasizes using an iterative approach to divide a project into very small steps called sprints or iterations. This is usually in the range of 2-4 weeks (Cobb, 2015).

4. Business people and developers must work together daily throughout the project (Beck et al., 2001). These frequent integrations are intended to provide feedback and answer questions from the development team (Alsaqqa et al., 2020). This principle underscores the partnership approach between the project team and the business sponsor. This is in line with the value of the Agile Manifesto of "Collaboration by Contract". To implement this principle, both the business sponsor and the project team must jointly take responsibility for the successful completion of the project (Cobb, 2015).

5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done. (Beck et al., 2001) Agile is interested in building a team that can work together, work together effectively, learn from each other, and respect each other. The availability of these features among team members needs to be coordinated by empowering everyone, motivating them to work, and supporting them in every possible way. Teams work together to make the project a success (Salem, 2019). This principle emphasizes the importance of properly motivated people for the project. In the past, some project managers frequently used high-pressure, command and control tactics to get project teams to deliver results faster. Many of us are involved in the "Death March" project in our career, giving people an absolute deadline to get things done and work at night and weekends, (Cobb, 2015).

6. The most efficient and effective method of conveying information to and within a development team is a face-to-face conversation (Beck et al., 2001)**.** This principle emphasizes direct human communication with agile teams, rather than the use of written specifications or written plans (Alsaqqa et al., 2020). The methods of transfer of knowledge between people, including writing documents, but it is not fast and does not work on the transfer of information correctly, it is more appropriate to connect people with each other.

Communication between team members is necessary and there are many ways of communication, but the best of these methods is to contact face to face so that each party can send his information to the other party directly(Rodríguez et al., 2019).

7. Working software is the primary measure of progress, (Beck et al., 2001)**.** The agile standard for software delivery is that the program meets the requirements of stakeholders already. The repetitive workflows provide a work program and thus are measures of progress. Measuring the progress of a software development project can be difficult and problematic. The traditional method is to divide the project into tasks, track the completion rate of those tasks, and measure their progress. However, this can be very misleading. This is because the to-do list is often incomplete, and the level of completion is often difficult to create and often requires inaccurate subjective evaluation (Cobb, 2015).

8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely (Beck et al., 2001)**.** Project team members need to have a high level of preparedness, vigilance, and constant creativity. Each phase of the iterative project has a schedule. Specific work hours, specifications, and these measures require teams to work with the same intensity, efficiency, and frequency in all project phases (Salem, 2019). Sponsors, developers, and users need to be able to maintain a stable pace indefinitely. Sustainable development means that the team needs to maintain a constant rhythm. In short, the ultimate perfect delivery is not the goal that needs to be achieved early by consuming all available resources, but also the availability to deliver high quality and appropriate work. It's better to get feedback until the final goal is finally achieved (Alsaqqa et al., 2020).

9. Continuous attention to technical excellence and good design enhances agility (Beck et al., 2001)**.** Even if you need to redesign your code as your requirements change, you should always provide the highest quality code to be agile (Alsaqqa et al., 2020).

Agile is committed to developing great, unique designs, recognizing and responding to changes, improving work performance and improving productivity (Salem, 2019).

10. Simplicity "the art of maximizing the amount of work not done" is essential (Beck et al., 2001). it aims to produce a product that is simple and capable of handling the sudden changes and at the same time fulfill the customer requirements (Alsaqqa et al.,2020).

This statement emphasizes simplicity. This is also related to the concept of "good enough" to avoid over-designing something. Keep it as simple as possible. In general, it is much more effective to take a step-by-step approach, starting with something simple and expanding as needed, rather than starting with something overly complex that can be overkill for your requirements (Cobb, 2015).

11. The best architectures, requirements, and designs emerge from self-organizing teams (Beck et al., 2001)**.** Any agile team is a self-organized team that shares the responsibilities of a project and determine the best way to handle them through the knowledge they gain throughout the development process to achieve the optimal structure (Alsaqqa et al., 2020). Agile methods are teams that have self-adjusting skills and there are no instructions to coordinate their behavior, but mutual communication is the basis for coping with a collective work culture. This has a positive effect on creativity and innovation in developing and creating the best designs without resorting to rigorous planning (Salem, 2019).

12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly (Beck et al., 2001). The project team has a guide to work on the project, giving them special time to estimate distances and discuss ideas and actions taken to motivate them to achieve the highest level of service improvements(Rodríguez et al., 2019). The team is expected to continuously improve and adapt the agile process as needed as the project progresses (Cobb, 2015).

2.5 Application of Agile Project Management in Construction

Agile project management is originated in the IT industry, but now it is moving into other businesses. Although there is extensive evidence of Agile project management used in software development, there is a lack of empirical studies in other types of industries and projects.

The complexity of construction projects is the main reason, why the construction industry is searching for better ways of managing construction projects. To enhance the challenging coordination, planning and control work of construction projects, it is important to have efficient methodologies called “agile methodologies” which take into consideration that the projects are often initiated under large uncertainties. In contrast to the traditional methodologies, the agile methodologies keep in mind that it is impossible to predict the future. Supporters of agile approach think that it possible be more suitable for managing projects because it includes approaches to managing changes (Neamah Ahmed & Rasheed Mohammed, 2018).

Yllén Johansson, (2012), also discussed some basic concepts of APM included in management of construction projects which are ;-customer collaboration & face to face meeting, definition of clear goals, breaks the project or challenge down into small bits to be completed so as of highest priority downwards, emphasizing learning and continuous improvement, responding to change, identifying weaknesses and issues as soon as they occur, implementing root cause analysis to work out the cause of problems, individuals and interactions.

Agile techniques and methods can effectively manage disruptive technologies. Agile project management (APM) is based on accepting change as an inevitable part of the project management process in the construction industry, thereby providing new management opportunities. In large-scale construction, completing the construction project on time seems to be a daunting task. Time is the main factor in construction, and completion on time will bring many benefits to the client, contractors and society. Agile project management is a method that can quickly adapt to changes in delivery or designs. The time between identification of a problem and resolving the problem get reduced (Dahmardeh & Pourshahabi, 2021).

Agile project management has many benefits in construction and real estate which includes;-improving understanding and implementation of project requirements, improving communication and cooperation between project stakeholders, improving team and project effectiveness, reducing omissions and reworks, reducing project time and costs, quickly switch between teams on one or more of construction sites (Ciric et al., 2018).

(Pope-Ruark, 2015), states that Agile is not only popular in software development; a quick Google search reveals its reach in design, marketing, publishing, energy management, financial services, and civil and mechanical engineering, to name a few.

To ensure the effectiveness of agile project management practices, an assessment of their performance must be done. it also considers decision-makers' behavior towards risk using an index of optimism in aggregations. Moreover, such an attempt should be accompanied with a sensitivity analysis to capture the impact of such specific variations on overall assessment of agility by using enablers, criterion and attributes (Mafakheri et al., 2008).

2.6 Agility Assessment

Agility is the ability of an organization to adapt to change and to seize opportunities that become available due to change. It can be understanding and meeting the needs of customers in the short term, adapting structures and services to address medium term trends, and shaping needs in the long term (Dahmardeh & Pourshahabi, 2021).

Zhang and Sharifi (2000), introduced their first tool to determine whether a company needs to implement Agile Manufacturing (AM) program or not, and the second tool assesses the agility level. Following this, they proposed the neural network to determine the required agile capabilities and the providers. Their work has prepared for the model to deal with vague and complex situations.

Agile Manufacturing paradigm is fast instilled in modern organizations. AM enables an organization to evolve products and services quickly and economically in response to the customers' dynamic demands. The effectiveness of AM is largely determined by the performance of Agile Supply Chains (ASC). To assess their performance, an ASC assessment model was reported. It encompassed with agile supply chain attributes whose performance levels need to be determined for assessing the overall ASC performance of the organization. The computation was performed using fuzzy logic approach. The working of the model was examined by conducting a case study in an Indian automotive component manufacturing organization. The experience gained by conducting the case study favored the use of a computerized system which will ensure accuracy of computations involving fuzzy logic (Vinodh et al., 2013).

Vinodh & Devadasan, (2011), carried out research to assess the agility level of an organization using fuzzy logic approach. During the study, an agility index measurement model containing 20 criteria incorporated with fuzzy logic approach was designed. Subsequently, the data gathered from a manufacturing organization were substituted in the model and the agility index has been determined. Using the model, the method of determining the obstacles for achieving agility in the organization was examined. It was found that the organization is required to concentrate on the activities leading to overcome obstacles to achieve agility. This method of agility evaluation will help the organization to accelerate the process of achieving agility.

Another research work has been conducted to assess the agility of the manufacturing organization using a scoring approach. The paper presents a 30-criteria agility assessment model which could be utilized to measure agility and to identify the agile characteristics of organization. Thus, weak factors were identified, and proposals are suggested to enhance the agility of the organization. The advanced agility assessment also based on fuzzy approaches could be developed for enhancing the effectiveness of agility assessment (Vinodh et al., 2012).

The agility evaluation has been done using a multi-grade fuzzy approach for a manufacturing organization using a multi-grade fuzzy approach; an agility index measurement model containing 20 criteria incorporated with the multi-grade fuzzy approach was designed. Subsequently, the data gathered from a manufacturing company was substituted in this model and the proposals for enhancing the agility level of this company were derived. The usage of the model contributed to indicate the actions required to enhance an organization's agility level. This process will accelerate the absorption of agility characteristics in modern organizations (Devadasan et al.,2013).

Lin, Chiu, & Chu, (2006), addressed the questions of how to measure and improve supply chain agility. Also, conventional evaluation approaches, which are inappropriate and ineffective for handling situations that, by nature, are characterized by complexity and uncertainty. To compensate these limitations of the conventional evaluation approaches, a fuzzy supply chain agility index which focuses on the application of linguistic approximation and fuzzy arithmetic was designed for addressing agility measurement, stressing the multiplicity of meaning and ambiguity of attribute measurement.

The model was developed from the concept of Manufacturing and adapted for an IT product supply chain, which served as an initial case study for validating the model and approach. Their work has potentially environments and has considered the uncertainty of each attribute for assuring realistic and informative assessment.

Another study also assesses the readiness level of healthcare utilizing fuzzy logic approach to implement agility. The conceptual readiness model is framed with enablers, criteria and attributes. The proposed model is applied into a case hospital to assess the readiness level. The Fuzzy readiness for the implementation of agility index and fuzzy performance importance index are computed to determine the readiness level of the case hospital and its weaker attributes in the implementation of agility. It constructs the conceptual model which analyses the current readiness of healthcare and weaker attributes are denoted and required corrective actions should be carried by the management of healthcare organization to improve the readiness. The continuation of assessment readiness model over a period of time would help to improve the readiness level of healthcare for agile implementation (Narayanamurthy et al., 2018).

Suresh & Patri, (2017), demonstrates a means to measure agility of a healthcare organization by assessing agility of a university dispensary. Its contribution to the knowledge base is twofold. First, it proposes a means to measure the agility of a healthcare organization and second, it identifies the attributes that prevent agile performance and outlines the suggestive measure to enhance its agile capabilities.

Mengistu, (2020), developed a conceptual model that would help to measure IT service management agility practice of CBE by extracting measurement variables from different literatures. the initial ITSM agility assessment model was analyzed using SEM techniques and adjustments were made to make it structurally fit. After making the necessary modification, validity and reliability was checked and the final ITSM agility assessment model for CBE were reported using structural equation modeling technique. research question has been successfully answered. after validating the assessment model and the hypotheses, the research has demonstrated the current agility level of the ITSM practice in CBE with sufficient analysis and explanations.

Project management agility is the ability of a project to respond to a changing environment effectively. This may include the capability of a project to be adapted to the dynamism that exists in the stakeholders' needs, technological changes, etc. To assure such a capability, it is necessary to assess the extent of projects' adaptability to change. This could be done by expressing the agility in terms of some quantifiable parameters such as size of the project's organization, levels of expertise, etc. However, there are uncertainties embedded in measurement of such parameters caused by imprecision and lack of well-defined information, which cannot be well treated by conventional assessment approaches. To address such complexity agility assessment of projects management has to be done (Mafakheri et al., 2008).

Agility appears as a composite concept beyond regular "flexibility" that incorporates the ideas of flexibility, responsiveness, adaptability, and coordination under one roof as shown in Figure 2.2 (Fei Han, 2013).

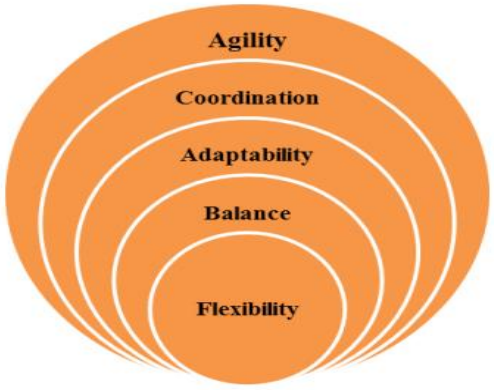

Figure 2.2 Conceptual layers of agility

When agility assessment is performed based upon structured assessment measurements, assessment findings would clearly indicate where projects stand in terms of agility and which areas of the adopted agile methods need improvement (Arefazar et al., 2022).

2.6.1 Enablers of Agility

One of the first attempts to provide a definition, as well as a comprehensive set, of agile enablers was made by Gunasekaran. According to the author, agile enablers are technologies which are critical to successfully accomplish agile manufacturing.

The author discusses seven agility enablers, namely virtual enterprise formation tools/metrics, physically distributed teams and manufacturing, rapid partnership formation tools/metrics, concurrent Engineering, integrated product/production/business information system, rapid prototyping tool and electronic commerce.

For agile manufacturing, six actions required for the implementation of agile strategies, including cross-functional team sharing, empowerment for decision making, technology integration, delayed design specification, product succession planning, and enterprise-wide integration of learning. Additionally, more agile methods were proposed, such as self-autonomous and integrated teams, concurrent engineering, partnership in supply chain management, learning organization, and virtual organization, to indicate agility is also desirable as a long-term strategy for enterprises (Vázquez-Bustelo, 2007).

Researchers have approached the management of agile manufacturing from a variety of perspectives, using a wide range of tools. The following enablers of agile manufacturing are discussed in Ezcan et al., (2020), virtual enterprise, formation tools/metrics, physically distributed teams and manufacturing, rapid partnership formation tools/metrics, Concurrent Engineering, integrated product/production/business information system, rapid prototyping tools and Electronic Commerce.

Management responsibility agility, manufacturing management agility, workforce agility, technology agility, manufacturing strategy agility also lists agility enablers (Aravind Raj et al., 2013).

Suresh & Patri, (2017), discussed agility can be gained through five main enablers which are; - agility through management driver, agility through technology driver, agility through competitive driver and agility through service strategy driver.

Bottani, (2009), suggests that agility can be achieved through the integration of organization, highly skilled and knowledgeable people and advanced technologies.

vázquez-bustelo et al., (2007), also illustrate many enablers those can bring agility in the manufacturing industries and according to the researchers the agility can be achieved through;- manufacturing top management support and employee involvement and empowerment, team working, self-directed teams, cross-functional teams, job rotation, multifunctional, workforce, job enrichment (responsibility on multiple tasks), training and education, higher average skill levels, workforce skill upgrade, continuous training and development, cross-functional training, knowledge workers, IT-skilled workers, decentralized decision making, reward schemes to encourage innovation and based on both financial and non-financial measures, enterprise resource planning, material requirement planning, robotics, automated guided vehicle systems, automated storage and retrieval systems, computer numerically controlled, machines, computer-aided design /computer-aided manufacturing, rapid prototyping tools, intranet, internet and world wide web, electronic data interchange, electronic commerce, visual inspection, manufacturing cells, virtual reality software, flexible manufacturing systems, computer-aided process planning, group technology, point-of-sales data collection, bar codes, automatic data collection, real-time communication/execution systems, design for manufacture/assembly, strategic alliances based on core/complementary competencies, virtual firm/organization, rapid-partnership formation, integration of functions from purchasing to sales, firm-wide integration of functions, global supply chain management, integrated supply chain, integrated and interactive partner relations, customer integrated processes for designing, manufacturing, marketing, and support, strategic relationship with customers, close relationship with suppliers; thrust-based relationship with customers/suppliers, internal and external cooperation, business process reengineering, formation of cross-functional product development teams, concurrent design of products and processes, multidisciplinary team working environment, intelligent engineering design support system; groupware collaborative work, customer and supplier integrated multidisciplinary teams, early involvement of different agents in the product development process and concurrent execution of functions/activities, organizational structure that promotes innovation and training and education; learning organization, team-to-team learning, firm-wide integration of learning, continuous learning, knowledge acquisition from internal and external sources and core-competence management.

Sherehiy et al., (2007), also lists some enablers of agility in manufacturing i.e management responsibility agility, manufacturing management agility, workforce agility technology agility and manufacturing strategy agility.

Integration, competence, team building, technology, quality, welfare, change, partnership market and education are the main enablers of agility as mentioned by (Lin, Chiu, & Tseng, 2006).

Management responsibility agility, manufacturing management agility, workforce agility technology agility and manufacturing strategy agility are some discussed enablers of agility in manufacturing (Vinodh et al., 2012).

Organizational structure type, multidisciplinary project teams (various competences), new product development process formalization level, customer/stakeholder involvement in the product development process, supplier or partner involvement in the product development process, project team members' experience in years, project manager experience in years, project team size, project team dedication (time dedicated exclusively for the project) and project team location are enablers of agility according to (Conforto et al., 2014).

Integration, competence, team building, technology, quality, welfare, change, partnership market and education are also used as agility enablers by (Yusuf et al., 1999).

Learning organization, strategy organizational culture, organizational structure, collaboration, communication, organization & methods, leadership, tools support and ICT are used as agility enablers by (Paterek, 2016).

Agility Enablers for construction management according to Han & Bogus, (2013), are resource and productivity monitoring, self-autonomous work team, short-term planning & concurrent execution of activities, continuous improvement & learning organization, information technology integration.

2.6.2 Criteria of Agility

Criteria is a principle or standard by which something may be judged or decided. agility assessment criteria are a standard which is used for agility measurement. several studies have been conducted regarding to agility assessment by using different criterions.

Management structure, autonomy of work force, top management support, IT integration, automation of equipment's, change in service and technical process, patient flow and time management, visual control, status of the caregivers, flexible work practices, patients' service quality, optimum treatment cost, patient and caregivers' safety and caregivers involvement illustrated criteria's of agility by (Suresh & Patri, 2017).

According to Aravind Raj et al., (2013), manufacturing planning, , nature of management, customer response adoption, change in business and technical process, outsourcing, resource optimization, agile customization, flexible business practices, knowledge management, business support system, product variety, rapid manufacturing system, inter organizational system, employee status, employee involvement, team work, devolution of authority, creativity, fast production and delivery, manufacturing set-ups, product life cycle, product service, design improvement, production methodology, automation type, information technology integration, advances in design, concurrent processing, new product development, data management, virtual enterprise, status of quality, status of productivity, cost management, organizational structure, time management, collaborative relationship, flexible volume production, seasonality, flexible delivery time and locations are criteria's of agility measurement.

Agility also can be measured by organizational structure, devolution of authority, nature of management, customer response adoption, change in business and technical processes, outsourcing, employee status, employee involvement, manufacturing setups, product life cycle, product service, design improvement, production methodology, manufacturing planning, automation type, IT integration, status of quality, status of productivity, cost management, time management as mentioned by (Sherehiy et al., 2007).

Agility assessment criteria should be simple as much as possible. Obviously, those criteria which are simple and understandable are more effective and are more acceptable in industrial environments. Good Agility assessment criteria should also reflect an organizational or behavioral change. Indeed, any improvement in achieving these criteria directly is the result of trying to achieve more Agility (Gandomani, 2014).

2.6.3 Attributes of Agility

Attribute is a specification that defines a property of an object, element, or file. It may also refer to or set the specific value for a given instance.

Reconfigurability, mass customization, physically distributed manufacturing environment, integrated value chain, learning organization, flexible organization and quick response manufacturing are attributes of agility which are mentioned in (Gunasekaran & Yusuf, 2002).

Flattened organizational structure, smooth information flow, team management for decision making, interchangeability of personnel, clear definition of personnel's responsibility and authority, education and training to create the self-managed teams, participative management style, clearly known management goal, management involvement, profit motivation coupled with humanitarian approach, transparency in information sharing, regular conduct of management–employees meetings, rapid evaluation and implementation of employee suggestions. prevalence of continuous improvement culture, communication media to collect the customer responses, incorporation of customer's feedback into products, empowerment of personnel to resolve customer problems, efficient information system, flexible business system, employee's attitude tuned to accept the changes, conduct of pilot study on new production/business processes, adoption of SCM concepts for enhancing the outsourcing efficiency, exploitation of IT utilities in managing the supply chain, involvement of suppliers in product development, working towards a smaller number of qualified suppliers, flexible workforce to accept the adoption of new technologies, multi-skilled personnel, implementation of job rotation system, education and cross-training imparted to all the existing and new employees, strong employee spirit and cooperation, employee empowerment, institution of employee suggestion schemes, flexible manufacturing setups, less time for changing the machine setups, up gradation and retrofitting of machines, usage of collapsible setups, jigs and fixtures, usage of automated tools used to enhance the production, active policy to help keep work areas clean, tidy and uncluttered, specification of product life to the customer, company encouragement to the customer for switching over to new product, products superior field performance for a stipulated period with least maintenance cost, products designed for easy serviceability, products incorporated with modular design, service centers well equipped with spares, minimum time required to restore the defective product to its original performance, management's interest towards evolving new models, training of design personnel

in all aspects of design, cross-functional teams towards running development, preparedness of the management to invest on latest design techniques like CAD/CAM, axioms and guidelines, Fully automated inspection systems, Management's interest towards investment on FMS concepts, application of lean manufacturing principles for waste elimination, development of products whose components are all outsourced and assembled in-house, IT application to exercise better vendor and supplier management, execution of short range planning, company's procurement policy based on time schedule, strategic network in SCM to exercise zero inventory system, company having automated systems, flexible automation, management's interest towards full automation , it utilities incorporated with reengineered pattern of working, it application to eliminate paper work, adoption of multimedia technology, products exceeding the customers' expectations, incorporation of new ideas into products, conduct of survey/studies to ensure quality status, usage of TQM tools, inculcation of innovation into product design, productivity improvement in all functions, productivity linked to the personnel prosperity, reduction of non-value-adding costs, quality is not infused at the cost of productivity, application of totality concepts in achieving productivity, activity-based method of product pricing, costing system focusing on the identification of value adding and non-value adding activities, costing system enabling the evaluation of future resource consumption, product cost fixed based on customer's pricing , scheduled activities, it-based communication system, training program on time management concepts, adoption of time compression technologies are attributes of agility mentioned in (Sherehiy et al., 2007).

Vinodh & Chintha, (2011), explains attributes as of agility concurrent execution of activities, culture of change, enterprise integration, continuous improvement information accessible to employees, rapid partnership formation, multi-venturing capabilities strategic relationship with customers, decentralized decision-making, close relationship with suppliers, empowered individuals working in teams market response to changing market requirements, cross-functional team, new product introduction, teams across company borders customer-driven, innovations, technology awareness, customer satisfaction, leadership in the use of current technology, continuous training and development, skill and knowledge enhancing technologies, learning organization, flexible production technology multi-skilled and flexible people, quality over product life, workforce, skill upgrade, products with substantial added value, employee satisfaction, first-time right design and short development cycle time.

Bottani, (2009), presents enriching the customer, co-operation, organizing to master change and uncertainty and leveraging the impact of people and information as the four main dimensions of agility. A comprehensive taxonomy of agile attributes was proposed by Yusuf et al. who identified 32 attributes characterizing an agile enterprise, ranging from concurrent execution of activities to employee satisfaction; attributes were grouped into 10 decision domains. The set of agile attributes defined by Yusuf et al. has been used in many subsequent studies.

Concurrent execution of activities, enterprise integration, information accessible to employees, multi-venturing capabilities, empowered individuals working in teams, cross functional teams, teams across company borders, decentralized decision making, technology awareness, leadership in the use of current technology, skill and knowledge enhancing technologies, flexible production technology, quality over product life, products with substantial value-addition, first-time right design, short development cycle times, continuous improvement, culture of change, partnership rapid partnership formation strategic relationship with customers, close relationship with suppliers, trust-based relationship with customers/suppliers, market new product introduction, customer-driven innovations, customer satisfaction, response to changing market requirements, learning organization, multi-skilled and flexible people, workforce skill upgrade, continuous training and development, employee satisfaction (Lin, Chiu, & Chu, 2006).

Vinodh et al., (2012), lists attributes of agility as flattened organizational structure, smooth information flow, team management for decision making, clear definition of personnel's responsibility and authority , education and training to create the self-managed teams, participative management style, clearly known management goal, management involvement, profit motivation coupled with humanitarian approach, transparency in information sharing, regular conduct of management employees meetings, prevalence of continuous improvement culture, communication media to collect the customer responses, incorporation of customer's feedback into products, empowerment of personnel to resolve customer problems, efficient information system, rapid evaluation and implementation of employee suggestions, flexible business system, application for reinventing and reengineering the organization, employee's attitude tuned to accept the changes, conduct of pilot study on new production/business processes, adoption of SCM concepts for enhancing the outsourcing efficiency, exploitation of it utilities in managing the supply chain, involvement of suppliers in product development, working towards a smaller number of qualified

suppliers, customized system development, integration of mass customization with agile manufacturing, global response adoption, product variant, enterprise wide integration, virtual knowledge sharing, knowledge management system and availability, knowledge derivation, development of support systems, effectiveness, decision derivation, flexible workforce to accept the adoption of new technologies, multi-skilled personnel, implementation of job rotation system, education and cross-training imparted to all the existing and new employees, strong employee spirit and cooperation, employee empowerment, institution of employee suggestion schemes, decision making, conduct of meetings, total workforce involvement, promoting creative thinking, innovation embedded culture, flexible manufacturing setups, less time for changing the machine setups, up-gradation and retrofitting of machines, usage of collapsible setups, jigs, and fixtures, usage of automated tools used to enhance the production, active policy to help keep work areas clean, tidy, and uncluttered, specification of product life to the customer, company encouragement to the customer for switching over to new product, product superior field performance for a stipulated period with least maintenance cost, products designed for easy serviceability, products incorporated with modular design, service centers well equipped with spares, minimum time required to restore the defective product to its original performance, management's interest towards evolving new models, training of design personnel in all aspects of design, cross-functional teams towards running development, preparedness of the management to invest on latest design techniques like CAD/CAM guidelines, fully automated inspection systems, management's interest towards investment on FMS concepts, application of lean manufacturing principles for waste elimination, development of products whose components are all outsourced and assembled in-house, it application to exercise better vendor and supplier management, Execution of short-range planning, company's procurement policy based on time schedule, strategic network in scm to exercise zero inventory system, company having automated systems, flexible automation, management's interest towards full automation, IT utilities incorporated with reengineered pattern of working, IT application to eliminate paper work, adoption of multimedia technology, robustness in design, application of axiomatic approaches, modularity in design, concurrent product development, concurrent process development, collaborative relationship, networking, customer relationship management, vendor relation, competitor relationship, products exceeding the customers' expectations, incorporation of new ideas into products, conduct of survey/studies to ensure quality status and usage of TQM tools.

Team managed organization, transparent information flow, autonomy of work force, empowered work force, autonomous decision making power, responsibility of work, work sharing culture, managing good relationship with caregivers, adequate meeting with caregivers and work facilitation, management involvement and transparent decisions, adequate salary and bonuses for caregivers, patient information and medical history/records storages, avoiding the medical descriptions reading error, paperless work , gradation of dispensary equipment's and facilities, change of patient pathway for minimizing patient movements, patient flow monitoring and queuing system, comfort system in the patient waiting place, minimization of patient throughput time, visual inspection of patient condition, visually recognize the patient urgency, agility through service strategy driver, patients' response adaptation, continuous quality improvement culture, analyze the patients feedback and consider for future service improvements, flexible caregivers to accept the advanced equipment implementation, proper training about the new technology or systems, multi-skilled and working on routine shifts, manage the work responsibility within the available workforce, mutual shift changes are allowed for caregivers, flexible weekly offs of the caregivers with the prior information, sharing the lessons learned from the day to day medical practices to their colleagues for better services, ensuring the patients' service quality, progressive improvements of the patient recovery from sick, maximum utilization of available equipment, activity based cost classification system, reduction of non-value added time and cost, adequate training program for safety practices, continuous maintenance of fire extinguishers in the dispensary, maintain the safe and clean environment in-and-around the dispensary, creative thinking, minimization of non-value added activities, strong involvement and co-operations are the proposed attributes of agility as (Suresh & Patri, 2017).

2.7. Summary and Research Gap

2.7.1. Summary of Reviewed Literatures

In this chapter papers related to agile project management and agility assessment were reviewed to create a complete understanding to support this research.

Traditional method of construction management is inflexible and fails to respond on customer requests and changes. According to different literature there seems to be considerable potential for gains to be made from the adoption of agility in construction management to eliminate the limitation of conventional project management limitations. However, assessment of agility has been predominantly done in manufacturing enterprises. Many studies demonstrate a means to measure agility of manufacturing organization by using fuzzy logic approach and there are few studies tries to assess healthcare and supply chain organizations using the manufacturing assessment model as a reference.

To sum up more complex environment needs a coping management scheme to deliver projects meeting their goals, where Agile project management might be the practice to help coping with the complex environment. And companies need to know their level of agility with different aspects and improve their weaker attributes.

Finally, ten enablers, twenty criterion, and fifty attributes were chosen to discuss with experts to use them as real state companies project management agility by using them as project management agility measures and are presented in Table 2.1,2.2 and 2.3 respectively.

Table 2.1. Collected enablers from literature

NO	Enabler	Reference
1	Agility through Management	(Suresh & Patri, 2017), (Vaishnavi & Suresh, 2020), (Vinodh & Devadasan, 2011), (Lin, Chiu, & Tseng, 2006).
2	Agility through Technology	(Vinodh & Devadasan, 2011), (Suresh & Patri, 2017), (Vinodh et al., 2012), (Yusuf et al., 1999).
3	Manufacturing Strategy agility.	(Sherehiy et al., 2007), (Vinodh & Devadasan, 2011), (Vinodh et al., 2012), (Vázquez-Bustelo et al., 2007).
4	Organizational structure type	(Conforto et al., 2014),(Paterek, 2016), (Lin, Chiu, & Tseng, 2006).
5	Agility through customer collaboration/communication	(Vázquez-Bustelo et al., 2007), (Lin, Chiu, & Tseng, 2006), (Paterek, 2016).
6	Agility through competitive driver	(Fei Han, 2013), (Vázquez-Bustelo et al., 2007), Paterek, 2016), (Suresh & Patri, 2017).
7	Agility through Workforce	(Vinodh et al., 2012), (Fei Han, 2013), (Vázquez-Bustelo et al., 2007).
8	Competence	(Paterek, 2016), (Vázquez-Bustelo et al., 2007), (Sherehiy et al., 2007).
9	Concurrent Engineering	(Sherehiy et al., 2007)(Yusuf et al., 1999), (Vázquez-Bustelo et al., 2007).
10	Change	(Yusuf et al., 1999), (Sherehiy et al., 2007) (Vázquez-Bustelo et al., 2007).

Table 2.2. Collected criterion from literature

NO	Criterion	Reference
1	Nature of management	(Aravind Raj et al., 2013),(Suresh & Patri, 2017) ,(Vinodh & Devadasan, 2011) , (Vinodh et al., 2012).
2	Teamwork	(Aravind Raj et al., 2013), (Sherehiy et al., 2007),(Vinodh & Devadasan, 2011), (Vinodh et al., 2012).
3	Management structure	(Suresh & Patri, 2017), (Aravind Raj et al., 2013), (Vinodh & Devadasan, 2011).
4	Change in business and technical processes	(Sherehiy et al., 2007), (Aravind Raj et al., 2013, (Vinodh & Devadasan, 2011).
5	Time management	(Suresh & Patri, 2017), , (Aravind Raj et al., 2013), (Sherehiy et al., 2007), (Vinodh et al., 2012).
6	Devolution of authority	(Aravind Raj et al., 2013), (Suresh & Patri, 2017), (Vinodh et al., 2012).
7	Creativity	(Aravind Raj et al., 2013), (Suresh & Patri, 2017), (Vinodh & Devadasan, 2011).
8	Constant customer Involvement	(Sherehiy et al., 2007), (Suresh & Patri, 2017), (Vinodh et al., 2012).
9	Strategic relationship with customer	(Aravind Raj et al., 2013), (Vázquez-Bustelo et al., 2007), (Gunasekaran & Yusuf, 2002).
10	Product life cycle	(Aravind Raj et al., 2013), (Sherehiy et al., 2007), (Vinodh et al., 2012).
11	Information technology integration	(Aravind Raj et al., 2013), (Suresh & Patri, 2017, (Gunasekaran & Yusuf, 2002) (Vázquez-Bustelo et al., 2007).
12	Status of productivity	(Sherehiy et al., 2007), (Vinodh & Devadasan, 2011), (Vinodh et al., 2012).
13	Team building	(Aravind Raj et al., 2013), (Vinodh & Devadasan, 2011), (Vázquez-Bustelo et al., 2007).
14	Cost management	(Aravind Raj et al., 2013), (Sherehiy et al., 2007), (Vinodh et al., 2012).
15	Status of quality	(Sherehiy et al., 2007), (Aravind Raj et al., 2013), (Vinodh & Devadasan, 2011).
16	Automation of equipment's	(Suresh & Patri, 2017) (Sherehiy et al., 2007) , (Aravind Raj et al., 2013), (Vinodh & Devadasan, 2011).
17	Training and development	(Sherehiy et al., 2007), , (Aravind Raj et al., 2013), (Vinodh et al., 2012).
18	Manufacturing planning	(Gunasekaran & Yusuf, 2002),
19	Customer response adoption	(Sherehiy et al., 2007), (Aravind Raj et al., 2013), (Suresh & Patri, 2017).
20	Production methodology	(Sherehiy et al., 2007), (Aravind Raj et al., 2013).

Table 2.3. Collected attributes from literature

NO	Attributes	Reference
1	Repeatability	(Fei Han, 2013), (Vinodh & Devadasan, 2011), (Vázquez-Bustelo et al., 2007), (Gunasekaran & Yusuf, 2002).
2	Flattened organizational structure	(Sherehiy et al., 2007), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vázquez-Bustelo et al., 2007).
3	Technology awareness	(Lin, Chiu, & Tseng, 2006), (Yusuf et al., 1999), (Vázquez-Bustelo et al., 2007), (Gunasekaran & Yusuf, 2002).
4	Cross-functional teams	(Sherehiy et al., 2007), (Gunasekaran & Yusuf, 2002),(Vinodh & Devadasan, 2011),(Lin, Chiu, & Tseng, 2006).
5	Customer satisfaction	(Lin, Chiu, & Tseng, 2006), (Gunasekaran & Yusuf, 2002), (Sherehiy et al., 2007).
6	Creativity	(Vinodh et al., 2012), (Sherehiy et al., 2007), (Vinodh & Devadasan, 2011).
7	Flexibility	(Fei Han, 2013),(Gunasekaran & Yusuf, 2002), (Lin, Chiu, & Tseng, 2006).
8	Participative management style	(Sherehiy et al., 2007), (Vinodh et al., 2012), (Gunasekaran & Yusuf, 2002).
9	Education and training	(Sherehiy et al., 2007), (Lin, Chiu, & Tseng, 2006), (Vinodh & Devadasan, 2011).
10	Skill and knowledge enhancing technologies	(Lin, Chiu, & Tseng, 2006), (Sherehiy et al., 2007), (Vázquez-Bustelo et al., 2007).
11	Information accessible to employees	(Lin, Chiu, & Tseng, 2006), (Vinodh & Devadasan, 2011), (Vázquez-Bustelo et al., 2007).
12	Transparency in information sharing	(Sherehiy et al., 2007), (Vinodh et al., 2012), (Suresh & Patri, 2017), (Stettina, 2014).
13	Financial management system	(Gunasekaran & Yusuf, 2002), (Vinodh et al., 2012), (Lin, Chiu, & Tseng, 2006).
14	Technology-based scheduling system	(Stettina, 2014), (Lin, Chiu, & Tseng, 2006), (Gunasekaran & Yusuf, 2002).
15	Transparency	(Fei Han, 2013), (Gunasekaran & Yusuf, 2002), (Suresh & Patri, 2017).
16	Survey study to check status of productivity regularly	(Vinodh & Devadasan, 2011), (Gunasekaran & Yusuf, 2002), (Lin, Chiu, & Tseng, 2006).
17	Productivity linked to every personnel prosperity	(Vinodh & Devadasan, 2011), (Vinodh et al., 2012), (Gunasekaran & Yusuf, 2002).
18	Productivity improvement in all functions	(Gunasekaran & Yusuf, 2002), (Vinodh et al., 2012), (Suresh & Patri, 2017).
19	Survey studies to ensure quality status constantly	(Stettina, 2014), (Vinodh et al., 2012),(Gunasekaran & Yusuf, 2002).
20	Stakeholders Satisfaction	(Fei Han, 2013), (Lin, Chiu, & Tseng, 2006), (Vinodh & Devadasan, 2011), (Stettina, 2014).
21	Usage of TQM tools	(Sherehiy et al., 2007), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011).
22	Specification of product life to the customer	(Vinodh & Devadasan, 2011), (Suresh & Patri, 2017), (Stettina, 2014) .
23	Proactive behavior	(Vinodh & Devadasan, 2011), (Stettina, 2014), (Fei Han, 2013).

24	Inculcation of innovation into product design	(Vinodh & Devadasan, 2011), (Vinodh et al., 2012), (Gunasekaran & Yusuf, 2002).
25	Smooth information flow	(Vinodh & Devadasan, 2011), (Gunasekaran & Yusuf, 2002), (Vaishnavi & Suresh, 2020).
26	Responsiveness to external change	(Vaishnavi & Suresh, 2020), (Vinodh & Devadasan, 2011), (Fei Han, 2013).
27	Decentralized organizational structure	(Vaishnavi & Suresh, 2020)(Gunasekaran & Yusuf, 2002), (Lin, Chiu, & Tseng, 2006).
28	Regular meetings with the client	(Vinodh et al., 2012), (Vaishnavi & Suresh, 2020).
29	Individual/team innovation	(Vinodh & Devadasan, 2011), (Lin, Chiu, & Tseng, 2006).
30	Adaptive behavior	(Vinodh et al., 2012), (Vinodh & Devadasan, 2011).
31	Self-managed teams	(Vinodh & Devadasan, 2011), (Vaishnavi & Suresh, 2020).
32	Regular conduct of management employees' meetings	(Vinodh & Devadasan, 2011), (Gunasekaran & Yusuf, 2002).
33	Training program on time management concepts	(Sherehiy et al., 2007), (Vinodh et al., 2012), (Vaishnavi & Suresh, 2020).
34	Project information and electronic records	(Gunasekaran & Yusuf, 2002),(Suresh & Patri, 2017).
35	Continuous learning	(Gunasekaran & Yusuf, 2002), (Vinodh et al., 2012).
36	Deliver the final product with little defect	(Vinodh et al., 2012),(Sherehiy et al., 2007).
37	Learn from each other	(Vinodh & Devadasan, 2011), (Sherehiy et al., 2007), (Yusuf et al., 1999).
38	Scheduled activities	(Sherehiy et al., 2007), (Stettina, 2014).
39	Employee satisfaction	(Vinodh & Chintha, 2011), (Lin, Chiu, & Chu, 2006).
40	Monitoring and evaluating work progress	(Vinodh & Devadasan, 2011), (Sherehiy et al., 2007).
41	Empowerment of personnel	(Sherehiy et al., 2007), (Suresh & Patri, 2017), (Lin, Chiu, & Tseng, 2006).
42	Paperless work	(Vinodh & Devadasan, 2011), (Stettina, 2014), (Vaishnavi & Suresh, 2020).
43	Work-breakdown and follow specification	(Vinodh & Devadasan, 2011), (Gunasekaran & Yusuf, 2002).
44	Having backup plan	(Vinodh et al., 2012),(Gunasekaran & Yusuf, 2002),(Stettina, 2014), (Sherehiy et al., 2007).
45	Teams across company borders	(Lin, Chiu, & Chu, 2006) ,(Vinodh et al., 2012).
46	Concurrent execution of activities,	(Vinodh & Chintha, 2011), (Vinodh & Devadasan, 2011),(Gunasekaran & Yusuf, 2002).
47	Customer-driven innovations	(Lin, Chiu, & Chu, 2006) ,(Vinodh et al., 2012), (Vinodh & Chintha, 2011).
48	New product introduction	(Vinodh et al., 2012), (Vinodh & Chintha, 2011), (Lin, Chiu, & Chu, 2006).
49	Enterprise integration	(Lin, Chiu, & Chu, 2006), (Vinodh & Chintha, 2011), (Vinodh et al., 2012).
50	Self-autonomous work team	(Lin, Chiu, & Chu, 2006) ,(Vinodh et al., 2012).

2.7.2. Research Gaps

A review on the traditional project management process has been conducted and stating the challenges that meet project managers while managing a project. Another focus on the agility project management was views in the literatures and by enhancing their project management agility companies can improve their overall success.

Traditional management under one plan for the entire project works only in exceptional circumstances. Managers involved in construction projects are supposed to lead as well as manage their respective projects in their entire life cycles. Since construction projects carry a lot of risks, and unpredictable in nature, it is not an easy task to manage them as a manager. According to Turner (2014), construction projects need flexible leadership and management for purposes of responding to different changes that occur during their execution.

Over the year's managers have been using traditional methods of project management as way of trying to deal with construction project management challenges. However, due to weaknesses associated with traditional approaches of project management, agile project management technique was designed for purposes of being used in the construction industry, but agility concepts are already embodied in any project separately. To understand the factors that determine agility dimensions assessment of their performance and importance must be done. Assessment of agility plays a crucial role because it helps to understand how flexible, accommodative, and responsive an organization at present is and what prevents it from being more flexible and accommodative.

Mengistu, (2020), developed a conceptual model that would help to measure the IT service management agility practice of CBE by extracting measurement variables from different literatures the research has demonstrated the current agility level of the ITSM practice in CBE with sufficient analysis and explanations from local context. Which would help conducting this research on the construction sector.

There is a shortage of literature about the agility assessment in Ethiopian context. Besides the research paper quoted above, the author was not able to find research articles on agility assessment or on attempts to assess agility of project management in Ethiopia.

3. RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes the research method adopted for this study. The main purpose of research methodology is to show that the research was conducted with the right and suitable methodology to properly answer the research questions. Hence, this chapter tries to clearly demonstrate how the research objective is achieved. This includes a detail description and justification of the methodological choices that are used to conduct this study.

3.2. Study Area

The study area for this research is Addis Ababa, which is the capital city of Ethiopia. One major activity in Addis Ababa is construction. Real estate is one of the classifications of housing development that are participating to solve the severe housing problem in Addis Ababa.

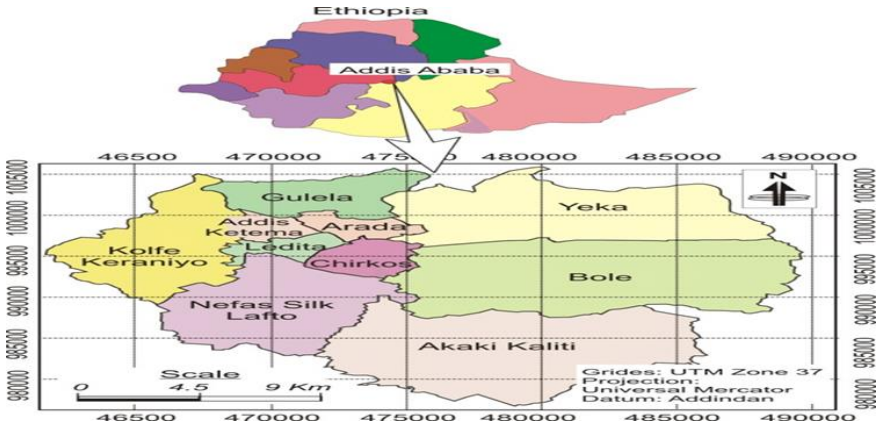

Figure 3.1 Map of Addis Ababa

3.3. Research Design

The research design refers to the overall strategy chosen to integrate the different components of the study in coherent and logical way. In the current study mixed method research approach using both qualitative and quantitative methods were employed to answer the research questions with descriptive nature. Survey questions were distributed to construction experts and responses were analyzed to assess project management agility of companies using fuzzy logic approach.

Descriptive type of research design is purely on a theoretical basis where the individual collects data, analyses, prepares and then presents it in an understandable manner. It is the most generalized form of research design. To explore one or more variables, a descriptive design might employ a wide range of research approaches.

3.4. Sample and Population of the Study

3.4.1 Target Population

Population is the total sum to be concerned for the study and sampling is the process of taking sample from a population and it should represent the total population. The population of the current study includes private real estate companies found in Addis Ababa. According to a field survey by the Ministry of housing and urban development, currently, there are twelve private real estate companies are actively involved in real estate investment in Addis Ababa city by targeting decision-makers like a construction manager, project manager, and engineers (both site and office) are selected as respondents.

3.4.2 Sampling frame

The process through which a sample is extracted from a population is called sampling. In investigation it is impossible to assess every single element of a population so a group (smaller in number than the population) is selected for the assessment by different sampling techniques for this research purposive sampling is used to pick the sample from population and forty-five experts were chosen who works in three case real estate companies by targeting construction manager, project manager, and engineers (both site and office) are selected.

3.4.3 Sampling Technique

As the research is a case-based study, the method used for sampling in the current study is a Purposive sampling. It is a widely used sampling method which allows a researcher to get information from a sample of the population that one thinks knows most about the subject matter. Purposive sampling techniques include hand picking of the subject cases that the researcher thinks that possesses rich information to accomplish the researchers' objective.

3.5. Types and Sources of Data

Data source is the vital component of any research, and which implies from where we access row data to answer the research questions and to fulfil the objectives of the study. For this study, the researcher used both primary and secondary source of data.

3.5.1. Primary Data Source

Primary data refers to the first-hand data gathered by the researcher himself. The primary data is obtained from decision makers of real estate companies through questionnaire from experienced experts.

3.5.2. Secondary Data Source

Secondary source of data is the data obtained not from the original source which is easily available from different literature, published and unpublished sources, books, and previous made research.

3.6. Data Collection Instruments

Data collection instruments are used to collect information on substantially identical items from a certain number of respondents. For this study, the researcher uses questionnaire to obtain data from the respondents. Questionnaire survey is the process of collecting data through an instrument consisting of a series of questions and prompts to receive a response from individuals. The researcher prepares questionnaires and distributes to the selected respondents which include the construction manager, project manager, site engineers and office engineers.

The first questionary was developed to identify project management agility measures (attributes, criterion and enablers). After the review of literature first survey questionary was distributed to various experts from real estate to formulate the enablers, criterion, and attributes. Since this study rises new insights in the area the researcher found out the importance of conducting first survey and oral discussion about the enablers, measurement criteria and agility attributes with experienced experts with real estate companies and other scholars in construction management field.

The second questionary was developed to measure the project management agility level of each case real estate company. After the identification of the measures and incorporating the comments from experts, final survey was distributed. The list comprised of five enablers, fifteen criteria and thirty-eight attributes where each enabler branched out to a number of criteria and each criterion branched out to a set of attributes. The enablers, criteria and attributes put together constituted the measures of real estate companies' project management agility.

3.7. Data Analysis Techniques

Data Analysis is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense, and recap, and evaluate data. In this study Relative Importance index (RII) and Fuzzy logic has been used to measure the current project management agility level of the private real estate companies and identify the attributes that pose a challenge to its more agile performance.

3.7.1. Data Analysis Methods of First Questionary Survey

After the review of literature first survey questionary was distributed to various experts from real estate companies to identify enablers, criterion, and attributes. Since this study rises new insights in the area the researcher found out the importance of conducting first survey about the enablers, measurement criteria and agility attributes with experienced experts with real estate companies. And the number of enablers, criteria and attributes were decreased with reasonable manner by using their relative importance index value. RII value was calculated by using equation 3.1.

$$Relative\ importance\ Index = \frac{5N1+4N2+3N3+2N4+N5}{5(N1+N2+N3+N4+N5)} \quad (3.1)$$

Where: where N1 represents the number of respondents who answered, " Strongly agree ", N2 represents the number of respondents who answered " agree ", N3 represents the number of respondents who answered " Neutral ", N4 represents the number of respondents who answered " Disagree " and N5 represents the number of respondents who answered, " Strongly disagree".

3.7.2. Data Analysis Methods of Second Questionary Survey

Fuzzy logic is used to analyze the second survey to do the project management agility assessment of companies.

Fuzzy logic is preferred over other methods because it can take the linguistic data as input, analyze it, and then express the results back in linguistic terms. Linguistic expressions are vague to interpret and have very small difference in meaning; for instance, “Very bad” and “Worst”. Conversion of linguistic expressions into numerical values is difficult and poses a challenge in terms of consistency and reliability.

Fuzzy logic addresses these challenges by converting the linguistic variables into corresponding fuzzy intervals also known as membership function, perform fuzzy operation and then convert it back into linguistic terms with the help of Fuzzy Agility Measure Index (Suresh & Patri, 2017).

Fuzzy concepts also enable evaluators to use linguistic terms to measure indicators in natural language expressions, and each linguistic term can relate to a membership function. Fuzzy tools deliver a simplified and scientific route for the progress, analysis and testing of identified measures quantitatively compared to other approaches in a relatively lesser duration.

Fuzzy logic approach in the present study is acquired from Lin et al. (2006), Narayanamurthy et al. (2018), Sreedharan et al, (2019), (Suresh & Patri, 2017), (Narayanamurthy and Gurumurthy,2018), (Vinodh and Vimal 2012), and (Rajak and Vinodh, 2015) to evaluate the project management agility level of real estate companies.

Apart from this, fuzzy logic also identifies the obstacles of the phenomenon. Many studies have used fuzzy logic to assess several phenomena. One among them is agility assessment in manufacturing companies.

Fuzzy logic has been used to improve the performance of manufacturing sector by evaluating the leanness, agility, Lean Six Sigma, sustainability, and legality (Tseng and Lin 2011; Vinodh 2011; 21; Vinodh and Aravindraj 2013; Sreedharan et al. 2019). In this context, studies have developed an agility index and adopted multi-grade fuzzy to measure agility level of the manufacturing organization. Taking cues from these studies, this study adopts fuzzy logic to assess project management agility of private real estate companies.

The fuzzy logic project management agility assessment used in this study involves three major steps. First, a list of agile enablers, criterion and attributes that influence agile performance of a real estate companies project management are identified.

Second, the above measures (agile enablers, criteria and attributes) are assessed in the case of three experienced private real estate companies by collecting the observed importance weight and performance rating from decision makers and by using fuzzy mathematical calculations. Third, fuzzy mathematical calculations are also performed on the attributes to identify the weaker ones.

Step 1: Identification of agile enablers, criteria, and attributes the first step, "identification of agile enablers, criteria and attributes" has been accomplished in this study by identifying a list of agile enablers, criterion, and attributes from the literature, keeping the models for developed manufacturing, (Yusuf et al., 1999), (Gunasekaran, 1998), (Lin, Chiu, & Tseng, 2006), (Vinodh & Devadasan, 2011), (Gunasekaran & Yusuf, 2002), (Vinodh et al., 2012), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006) health care (Suresh & Patri, 2017), (Vaishnavi & Suresh, 2020) and supply chain (Vinodh et al., 2013), as reference.

After the review of literature first survey questionary was distributed to various experts from real estate to formulate the enablers, criterion, and attributes. The final survey was distributed after incorporating the comments from experts. The list comprised of five enablers, fifteen criteria and thirty-eight attributes where each enabler branched out to a number of criteria and each criterion branched out to a set of attributes. The enablers, criteria and attributes put together constituted the measures of real estate companies' project management agility.

Step 2; Following the identification of these measures, experts including construction manager, project manager, site engineers and office engineers were approached to capture the weightage of each enabler, criterion, and attribute.

The experts were asked to provide the weightage in terms of linguistic variables ranging from "Very low (VL)" to "Very High (VH)". For each of these linguistic variables from "Very low (VL)" to "Very High (VH)", a corresponding fuzzy interval or membership function was assigned.

Due to time and resource limitations the intervals have been adopted from (Vaishnavi & Suresh, 2020), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006), (Suresh & Patri, 2017), (Vaishnavi & Suresh, 2022) and presented below in Table 3.1.

Table 3.1 Linguistic variables and fuzzy numbers for rating importance weighting for agility

Importance Weighting	
Linguistic variable	Fuzzy number
Very Low (VL)	(0,0.05,0.15)
Low (L)	(0.1,0.2,0.3)
Fairly Low (FL)	(0.2,0.35,0.5)
Medium (M)	(0.3,0.5,0.7)
Fairly High (FH)	(0.5, 0.65,0.8)
High (H)	(0.7,0.8,0.9)
Very High (VH)	(0.85,0.95,1.0)

Step 3: Collection of observed performance rating on the measures in this step, a questionnaire was shared for participants to provide an observed performance rating indicating where the real estate's construction project management stands in terms of each attribute. Here, the performance rating is collected for attributes alone because during fuzzy analysis, the attribute ratings are aggregated to criteria rating and criteria rating to enablers rating. The attribute rating was captured in linguistic variables ranging from "Worst (W)" to "Excellent (E)". For each of these linguistic variables from "Worst (W)" to "Excellent (E)", a corresponding fuzzy interval or membership function was assigned. Due to time and resource limitations the intervals have been adopted from (Vaishnavi & Suresh, 2020), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006),(Vaishnavi & Suresh, 2022), (Suresh & Patri, 2017) and presented in Table 3.2.

Table 3.2 Linguistic variables and fuzzy numbers for rating performance for agility

Performance Rating	
Linguistic variable	Fuzzy number
Worst (W)	(0,0.5,1.5)
Very poor (VP)	(1,2,3)
Poor (P)	(2,3.5,5)
Fair (F)	(3,5,7)
Good (G)	(5,6.5,8)
Very Good (VG)	(7,8,9)
Excellent (E)	(8.5,9.5,10)

Step 4; The fuzzy intervals assigned to the expert weightage in step 2 and performance ratings in step 3 are aggregated using average operation method. Arithmetic mean, median, and mode are some methods that are being adopted to aggregate the assessments of multiple decision makers' inputs. The average operation is the most widespread aggregation method.

Because of its widespread usage, 'average' operation was adopted during this study to aggregate fuzzy rating and weights. The average importance ratings and average performance weights were denoted by R_j and W_j and calculated by using equation 3.2 and 3.3 respectively. The decision for adopting this method has been taken from (Vaishnavi & Suresh, 2020), (Suresh & Patri, 2017), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006a) and (Vaishnavi & Suresh, 2022).

Average fuzzy weight of the attribute $(R_j) = (a_j,b_j,c_j) = \frac{R_{j1}+R_{j2}+R_{j3}\ldots\ldots\ldots\ldots R_{jm}}{m}$ (3.2)

Average performance rating of the attribute $(W_{j)} = (a_j,b_j,c_j) = \frac{W_{j1}+W_{j2}+W_{j3}\ldots\ldots\ldots\ldots W_{jm}}{m}$ (3.3)

Where: R_j; Average importance ratings

W_j ; Average performance weights

aj,bj,cj ;Triangular fuzzy numbers

m; Number of observation/respondents

Step 5: In the next step, the aggregate performance ratings of the attributes is translated into criteria rating and the criteria rating is translated into enabler rating using equation 3.4 and 3.5 respectively. The decision for adopting this method has been taken following the literature (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006), (Suresh & Patri, 2017) and (Vaishnavi & Suresh, 2022).

$$O_{ij} = \frac{\sum_{k=1}^{k}(O_{ijk}*N_{ijk})}{\sum_{k=1}^{k} O_{ijk}} \quad (3.4)$$

Where O_{ijk}; Fuzzy observed rating for agility of k^{th} attribute of j^{th} criterion of i^{th} enabler

N_{ijk}; Fuzzy importance weight for agility of k^{th} attribute of j^{th} criterion in i^{th} enabler

$$O_i = \frac{\sum_{j=1}^{j}(O_{ij}*N_{ij})}{\sum_{j=1}^{j} O_{ij}} \quad (3.5)$$

Where O_{ij} ; Fuzzy performance rating for agility of j^{th} criterion in i^{th} enabler

N_{ij} ; Fuzzy importance weight for agility of j^{th} criterion in i^{th} enabler

Step 6; After obtaining the ratings for criteria and enablers, the Fuzzy Agility Measure Index (FAMI) of the real estate company's project management is calculated using equation 3.6. FAMI represents the overall agility of the real estate companies project management. The decision for adopting this method has been taken from (Vaishnavi & Suresh, 2020), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006), (Suresh & Patri, 2017) and (Vaishnavi & Suresh, 2022).

$$FAMI = \frac{\sum_{i=1}^{i}(O_i * N_i)}{\sum_{i=1}^{i} O_i} \quad (3.6)$$

Where, FAMI; Fuzzy Agility Measure Index

O_i; Fuzzy performance rating for agility of i^{th} enabler

Ni; Fuzzy importance weight for agility of i^{th} enabler

Step 7; Upon obtaining the FAMI, it is then converted back into linguistic terms using Euclidean distance method and agility of real estate can be determined. Euclidean distance method is considered as the most intuitive method for humans to calculate perceived proximity. In this method, there are five linguistic terms known as "natural language expression set of Agility Label (AL)" and for each agility label; the Euclidean distance (D) is calculated following equation 3.7. The minimum distance or D value is considered as the agility label of the organization in linguistic terms. Table 3.3 captures the linguistic agility labels and the corresponding fuzzy intervals. The calculation of Euclidean distance is shown below and this method is also adapted from (Vaishnavi & Suresh, 2020), (Suresh & Patri, 2017), (Vinodh et al., 2012), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006) and (Vaishnavi & Suresh, 2022)

The Euclidean distance method consists of calculating the Euclidean distance from the given fuzzy number to each of the fuzzy numbers representing the natural-language expressions set. Suppose the natural-language expression set is agility level (AL) then the distance between the fuzzy number fuzzy-agility-index (FAMI) and each fuzzy number member AL can be calculated as below:

$$\mathrm{DFAMI, AL}_i = \sqrt{\sum_x (fFAMI(X) - fAL_i(x))^2} \quad (3.7)$$

Where; Al_i ; Fuzzy number of agile level for natural-language expression

fFAMI(x); Triangular fuzzy number of FAMI

fALi(x); Triangular fuzzy number of AL

Table 3.3. Linguistic agility labels and the corresponding fuzzy intervals

Agility Label (AL)	Fuzzy determination
Extremely Agile (EA)	(7, 8.5, 10)
Very Agile (VA)	(5.5, 7, 8.5)
Agile (A)	(3.5 5, 6.5)
Fairly Agile (FA)	(1.5, 3, 4.5)
Slowly Agile (SA)	(0, 1.5, 3)

Step 8; Calculation of Fuzzy performance importance index (FPII); Fuzzy Performance Importance Index (FPII) calculation is performed to identify the attributes that pose a challenge to the phenomenon which in this study is project management agile capability. The FPII computation consists of two steps: first is the calculation of FPII following equation 3.8 and second is the development of a ranking score for each attribute following centroid method shown in equation 3.9. This method is adopted from (Vaishnavi & Suresh, 2020), (Vinodh et al., 2012), (Suresh & Patri, 2017), (Vinodh & Devadasan, 2011), (Vinodh & Vimal, 2012), (Sreedharan V. et al., 2019), (Lin, Chiu, & Tseng, 2006), (Vaishnavi & Suresh, 2022), (Rajak & Vinodh, 2015) and (Lin, Chiu, & Chu, 2006).

$$FPII_{ijk} = W_{ijk} * O_{ijk} \quad (3.8)$$

Where: $W_{ijk} = (1,1,1) - N_{ijk}$

$N_{ijk:}$ fuzzy importance weight for agility of k^{th} attribute of j^{th} criterion in i^{th} enabler

$FPII_{ijk;}$ Fuzzy performance importance index of k_{th} attribute of j^{th} criterion in i^{th} enabler

O_{ijk} ; fuzzy observed rating for agility of k_{th} attribute of j^{th} criterion of i^{th} enabler

Ranking score of each attribute = $\frac{a+4b+c}{6}$ (3.9)

Where; a,b and c are fuzzy triangular numbers of each calculated FPII.

Step 9; After obtaining the ranking scores the management threshold is fixed with the Pareto principle (20%) to acquire weaker attributes. Based on the Pareto principle, the researcher focused on the critical factors and set a scale of management threshold for identifying the factors requiring most urgent improvement for each company.

The Pareto Principle, named after economist Vilfredo Pareto, specifies that 80% of consequences come from 20% of the causes, asserting an unequal relationship between inputs and outputs. This principle serves as a general reminder that the relationship between inputs and outputs is not balanced. The Pareto Principle is also known as the Pareto Rule or the 80/20 Rule.

The Pareto Principle can be applied in a wide range of areas such as manufacturing, management, and human resources. In the current study Pareto principle used to identify the critically weak areas (20% of least ranked). This method is adopted from (Vaishnavi & Suresh, 2020), (Suresh & Patri, 2017), (Narayanamurthy et al., 2018) and (Lin, Chiu, & Chu, 2006).

3.9. Data Presentation Method

Data presentation is defined as the process of using various graphical formats to visually represent the relationship between two or more data sets so that an informed decision can be made based on them. In the current study, the collected, processed, and organized data was presented in the form of tables, graphs and in descriptive form and the interpretation were made from the analysed data.

3.10. Data Validity and Reliability

The accuracy and consistency of survey is a significant aspects of research methodology which are known as validity and reliability of data.

For this study, first face validity measure is conducted by having academicians who understand the topic to go through both questionnaires to evaluate the content and based on their evaluation and comment the questionnaire is modified. The first questionnaire items were tested for reliability by taking sample respondents using Cronbach Alpha test, which scored in 0.8, 0.83, and 0.78 for enablers, criterion and attributes respectively. Which is found in acceptable range for the data collected from respondents.

Checking statistical validation of fuzzy results was also done. Applicability of fuzzy logic approach in assessment of real estate companies' project management agility has been statistically validated. To do that, a feedback session was conducted with the experienced experts. The respondents were asked to rate the agile project management criteria of the companies in a Likert's scale ranging from 0–10. Following that, a t-test was performed on the mean rating to examine whether the project management agility assessment using fuzzy logic for real estate companies is accepted or not. And it is founded that project management agility assessment using fuzzy logic for the case companies is not less than 80%. This method is adapted from (Vaishnavi & Suresh, 2020), (Narayanamurthy et al., 2018), (Suresh & Patri, 2017) and (Lin, Chiu, & Chu, 2006).

4. RESULTS AND DISCUSSIONS

4.1. Introduction

The main objective of this research was to assess project management agility of private real estate companies. In this chapter, the results from the analysis were expressed and discussed. The analysis and interpretation of data is carried out in three phases. The first phase presents the respondents demography, then second phase is the presentation of result from the survey questionary and the third phase presents the result and discussion of the questioner survey. Based on the result, project management agility of real estate companies is determined, attribute which can influence project management agility are determined and the solutions are proposed.

4.2. Identification of Attributes, Criterions, and Enablers

Initially The researcher identified ten agile enablers, twenty agile criterion and fifty agile attributes. Since this study rises new insights in the area the researcher found out the importance of conducting first survey and oral discussion about the enablers, measurement criteria and agility attributes with experienced experts with real estate companies and other scholars in construction management field. Participants in this questionary have extensive experience in construction project management.

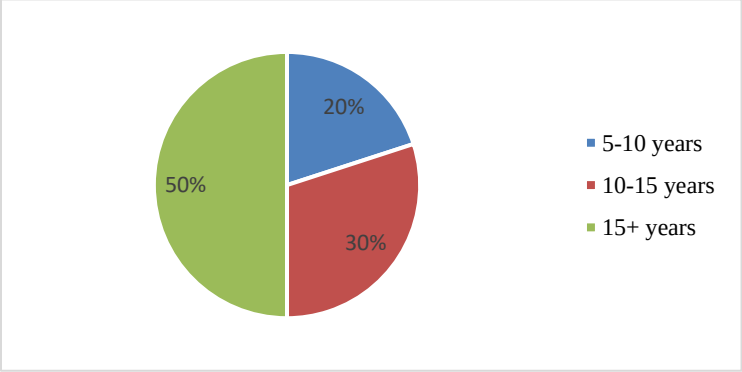

Figure 4.1 Work experience of respondents

Table 4.1. Enablers, criteria, and attributes project management agility assessment for real estate companies**.**

No.	Enabler	Criteria	Attributes
1	Agility through Management (AM_1)	Management structure (AM_{11})	Decentralized management structure (AM_{111})
			Team managed organization (AM_{112})
			Flexible management system (AM_{113})
		Nature of management (AM_{12})	Participative management style (AM_{121})
			Transparency in information sharing (AM_{122})
			Regular conduct of management employees' meetings (AM_{123})
		Project life-cycle management (AM_{13})	Having backup plan (AM_{131})
			Flat organizational structure (AM_{132})
			Work-breakdown and follow specification (AM_{133})
			Monitoring and evaluating work progress (AM_{134})
			Deliver the final product with little defect (AM_{135})
2	Agility through Technology (AM_2)	Information technology integration (AM_{21})	project information and electronic records (AM_{211})
			Paperless work (AM_{212})
		Leadership in the use of new technology (AM_{22})	Skill and knowledge enhancing ideas (AM_{221})
			Technology awareness (AM_{222})
3	Agility through Workforce (AM_3)	Team building (AM_{31})	Empowered individuals working in teams (AM_{311})
			Cross functional team (AM_{312})
			Employee satisfaction (AM_{313})
			Self-organized team (AM_{314})
		Training and development (AM_{32})	Continuous learning (AM_{321})
			Team training & education (AM_{322})
			Learn from each other (AM_{323})
		Creativity (AM_{33})	Individual/team innovation (AM_{331})
		Employee status (AM_{34})	Responsiveness to external change (AM_{341})
			Proactive behavior (AM_{342})
			Adaptive behavior (AM_{343})
4	Agility through customer collaboration/communication (AM_4)	Customer involvement on-site constantly (AM_{41})	Customer satisfaction (AM_{411})
			Transparency with the client (AM_{412})
		Strategic relationship with customer (AM_{42})	Regular meetings with the client (AM_{421})
5	Agility through Construction project constraint	Status of quality (AM_{51})	Survey studies to ensure quality status constantly (AM_{511})
			Usage of TQM tools (AM_{512})

	management strategies (AM_5)	Status of productivity (AM_{52})	Productivity improvement in all functions (AM_{521})
			Productivity linked to every personnel prosperity (AM_{522})
			Survey study to check status of productivity regularly (AM_{523})
		Cost management (AM_{53})	Financial management system (AM_{531})
		Time management (AM_{54})	Technology-based scheduling system (AM_{541})
			Scheduled and iterated activities (AM_{542})
			Training program on time management concepts (AM_{543})

The project management agility assessment measures were tested in three different private real estate companies found in Addis Ababa. Due to confidentiality agreements, the names of the companies are not disclosed in this paper, and they were referred as Company A, Company B and Company C. Educational background and work experience of responds for 36 respondents were presented below in figure 4.2 and 4.3.

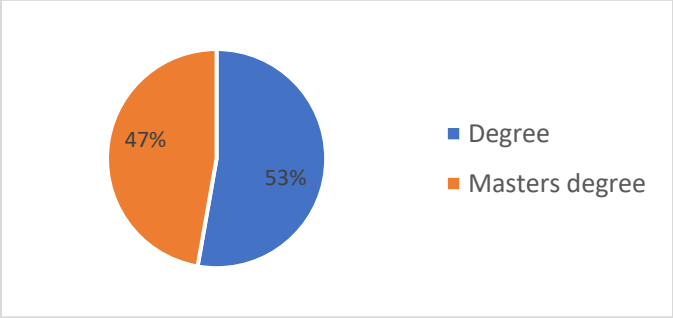

Figure 4.2 Educational background of respondents

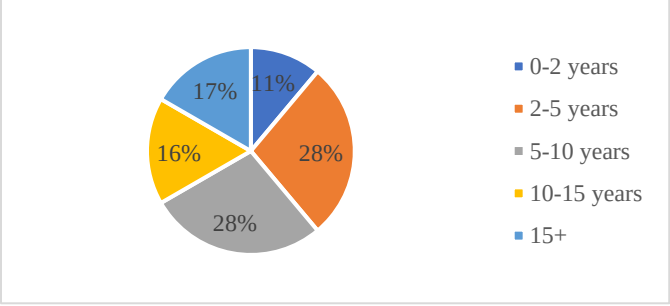

Figure 4.3 work experience of respondents

4.3. Identification of the Construction Project Management Agility Level of Case Companies

4.3.1. Identification of the Construction Project Management Agility Level of Company A

Profile of the company

Company A Real Estate is a private limited company that was created in 1997 and is one of the pioneering Ethiopian companies in this sector. It has managed to complete over 5,000 residential units, making it one of the most experienced in this sector. Company A real estate's history and background indeed makes it the largest construction company focused only on residential homes in Ethiopia. Company A real estate had a bumpy beginning when it were first building and selling the company a real estate villa houses in Addis Ababa area. Today, the company A villas which once sold for about 375,000 ETB are now being sold more than 20,000,000 ETB. Furthermore, to pass on the savings to its clients, company A Real Estate has bought and built factories for the purpose of producing the building materials they need, such as terrazzo tiles, concrete hollow blocks, marbles, prefabricated slabs, septic tanks, metal doors/windows, wooden doors/cabinets, and more. Now, one of their largest projects is in the Company A area of Addis Ababa with numerous apartment buildings being built and sold.

Observed importance and performance rating

Gathering the data for importance weights and performance rating from construction project managers, site engineers, office engineers. The experts were asked to provide the weightage in terms of linguistic variables ranging from “Very low (VL)” to “Very High (VH)”. For each of these linguistic variables from “Very low (VL)” to “Very High (VH)” a corresponding fuzzy interval or membership function was assigned. Questions were put forth to the experts to capture the weightage of enablers and criterion importance and their response is presented below in Table 4.2 and 4.3 respectively.

Table 4.2 Collected importance weights for enabler of construction project management agility of company A

AM_i	E_i											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_1	H	H	FH	FH	H	FH	VH	M	VH	H	VH	H
AM_2	H	VH	H	H	VH	H	VH	H	H	FH	VH	H
AM_3	VH	H	VH	H	H	FH	VH	FH	H	H	VH	H
AM_4	VH	H	H	FH	VH	H	VH	H	H	FH	VH	H
AM_5	H	VH	H	H	VH	H	VH	H	VH	FH	VH	H

Table 4.3 Collected importance weights for criteria of construction project management agility of company A

AM_{ij}	C_{ij}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{11}	H	VH	H	H	FH	H	VH	H	VH	H	VH	FH
AM_{12}	H	H	VH	H	VH	H	VH	FH	VH	H	VH	H
AM_{13}	H	H	VH	H	FH	FH	VH	H	VH	VH	VH	H
AM_{21}	H	VH	H	H	H	FH	VH	H	H	VH	H	VH
AM_{22}	H	FH	H	FH	H	H	VH	H	H	VH	H	VH
AM_{31}	H	VH	FH	H	VH	H	VH	H	H	VH	H	VH
AM_{32}	FH	H	VH	H	VH	H	VH	H	H	VH	VH	H
AM_{33}	H	H	VH	H	VH	FH	VH	VH	H	H	VH	H
AM_{34}	H	VH	FH	H	VH	H	VH	H	H	VH	H	VH
AM_{41}	H	VH	H	H	H	H	VH	VH	FH	H	VH	H
AM_{42}	FH	H	FH	H	VH	H	VH	H	H	VH	VH	H
AM_{51}	H	H	H	H	H	H	VH	H	H	VH	VH	VH
AM_{52}	FH	VH	H	H	VH	FH	VH	H	H	H	VH	VH
AM_{53}	H	FH	H	H	VH	H	VH	H	H	VH	VH	H
AM_{54}	FH	VH	H	H	FH	H	H	H	H	VH	FH	VH

Collection of observed performance rating on the measures, a questionnaire was shared for participants to provide an observed performance rating indicating where the real estate's construction project management stands in terms of each attribute. The attribute performance rating was captured in linguistic variables ranging from "Worst (W)" to "Excellent (E)".

Questions were put forth to the experts to capture the weightage of attributes importance weight and performance rate and their responses are presented below in Table 4.4 and 4.5 respectively.

Table 4.4 Collected importance weights for attributes of construction project management agility of company A

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	H	H	H	H	FH	H	VH	FH	H	VH	VH	FH
AM_{112}	FH	H	H	H	FH	H	H	FH	H	VH	VH	H
AM_{113}	H	H	H	H	H	H	VH	H	H	FH	FH	H
AM_{121}	FH	H	VH	H	H	FH	VH	H	H	VH	VH	VH
AM_{122}	H	H	H	H	VH	H	VH	FH	H	VH	VH	FH
AM_{123}	H	FH	H	H	VH	H	H	H	H	VH	VH	FH
AM_{131}	H	FH	H	H	VH	H	VH	H	H	VH	VH	H
AM_{132}	FH	H	H	FH	H	FH	VH	H	H	VH	H	H
AM_{133}	H	H	FH	H	VH	H	VH	H	VH	H	VH	H
AM_{134}	FH	H	VH	H	FH	H	H	H	VH	H	VH	FH
AM_{135}	FH	H	FH	H	H	H	FH	FH	VH	VH	VH	FH
AM_{211}	FH	H	H	H	FH	H	VH	H	H	VH	VH	VH
AM_{212}	FH	H	H	H	H	H	FH	H	H	FH	H	H
AM_{221}	FH	H	H	H	H	H	VH	H	H	FH	H	H
AM_{222}	H	H	FH	H	H	H	H	H	VH	VH	VH	FL
AM_{311}	FH	H	H	H	H	H	VH	H	H	VH	VH	H
AM_{312}	H	H	H	FH	H	H	H	H	VH	VH	H	H
AM_{313}	VH	H	FH	H	H	H	VH	H	H	VH	VH	H
AM_{314}	FH	FH	H	H	H	H	VH	H	H	VH	VH	VH
AM_{321}	FH	H	H	H	FH	VH	VH	H	H	VH	VH	FH
AM_{322}	H	FH	H	H	M	H	VH	FH	H	VH	VH	H
AM_{323}	FH	H	H	H	M	H	H	FH	H	VH	VH	H
AM_{331}	FH	FH	H	H	VH	H	H	M	H	VH	VH	VH
AM_{341}	H	FH	H	H	FH	H	VH	M	H	VH	VH	FH
AM_{342}	H	FH	FH	VH	VH	H	H	M	H	VH	VH	VH
AM_{343}	FH	VH	FL	H	H	FH	H	M	H	VH	H	M
AM_{411}	FH	H	FH	H	H	FH	VH	M	H	VH	VH	FH
AM_{412}	H	VH	FH	FH	H	H	FH	FL	H	VH	VH	H
AM_{421}	VH	VH	H	FH	VH	FH	FH	M	VH	FH	VH	H
AM_{511}	VH	VH	H	M	H	FH	VH	H	VH	H	VH	H
AM_{512}	VH	VH	FH	H	H	H	FH	FH	VH	H	VH	H
AM_{521}	VH	H	FH	FH	H	H	VH	M	VH	H	VH	FH
AM_{522}	VH	H	FH	FH	H	VH	VH	M	VH	H	VH	VH
AM_{523}	H	H	FH	H	H	VH	FH	M	FH	VH	VH	FH
AM_{531}	H	H	FL	H	VH	H	H	M	VH	H	FH	H
AM_{541}	H	FH	H	FH	H	H	VH	M	FH	VH	VH	H
AM_{542}	H	FH	FH	H	M	H	H	FH	VH	VH	H	M
AM_{543}	H	VH	H	H	FH	FH	M	FH	VH	VH	H	VH

Table 4.5 Collected performance rating for attributes of construction project management agility of company A

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	P	P	VP	VP	VG	VP	VG	F	VG	VG	E	VG
AM_{112}	F	F	F	VP	VG	VG	VG	G	VG	E	P	E
AM_{113}	F	P	P	VP	VG	F	VG	P	VG	VP	F	VG
AM_{121}	P	F	VG	VP	VG	F	VG	F	F	VG	P	F
AM_{122}	P	P	VP	W	P	F	F	F	VG	E	VP	P
AM_{123}	P	F	G	VP	E	VG	G	F	F	VG	F	F
AM_{131}	VP	P	G	VP	G	G	G	P	VG	G	F	E
AM_{132}	F	P	VP	VP	F	VG	G	G	F	VG	P	G
AM_{133}	P	F	G	VP	P	VG	G	P	G	VG	F	E
AM_{134}	P	F	G	VP	P	G	G	F	VG	P	F	F
AM_{135}	P	P	G	VP	E	G	VG	F	VG	F	P	VG
AM_{211}	F	P	P	VP	E	VG	G	F	VG	F	F	VG
AM_{212}	G	F	F	VP	VP	G	F	G	VG	P	E	G
AM_{221}	P	P	G	VP	E	G	G	F	VG	F	F	G
AM_{222}	P	F	G	VP	F	G	G	F	VG	E	F	VG
AM_{311}	P	P	G	VP	VG	G	G	F	VG	E	VG	G
AM_{312}	P	VP	G	VP	F	G	G	G	VG	F	E	VG
AM_{313}	P	F	VG	VP	VG	G	G	F	VG	E	F	VG
AM_{314}	P	P	P	VP	E	G	G	F	VG	E	E	VG
AM_{321}	VP	VP	VG	VP	VG	F	G	F	VG	VG	E	VG
AM_{322}	F	P	VP	VP	E	G	G	F	VG	VG	E	VG
AM_{323}	VP	F	VG	VP	E	P	G	G	VG	VG	E	F
AM_{331}	P	F	G	VP	E	VG	G	P	VG	F	F	VG
AM_{341}	F	P	G	VP	F	VG	G	F	VG	P	F	G
AM_{342}	P	P	VP	E	F	VG	G	F	G	E	G	G
AM_{343}	P	F	P	VP	E	G	G	G	VG	F	E	VG
AM_{411}	F	F	VG	VP	E	G	G	P	VG	VG	E	E
AM_{412}	P	F	VP	W	G	VG	F	G	VG	E	F	VG
AM_{421}	F	P	F	VP	E	VG	G	F	VG	F	E	VG
AM_{511}	P	VP	VP	VP	E	F	G	G	VG	VG	F	VG
AM_{512}	P	P	VG	VP	F	F	G	F	VG	F	P	F
AM_{521}	P	P	F	VP	G	VG	F	G	VG	F	F	E
AM_{522}	F	VP	VP	VP	G	VG	G	G	F	VG	P	VG
AM_{523}	P	F	VP	VP	F	VG	G	F	VG	F	G	VG
AM_{531}	P	P	VP	VP	F	G	F	G	VG	F	F	G
AM_{541}	P	F	F	VP	E	G	F	P	VG	F	F	G
AM_{542}	F	P	P	VP	E	VG	F	F	VG	F	F	G
AM_{543}	F	VP	W	VP	G	F	F	P	VG	F	F	P

Fuzzy mathematical calculations

Fuzzy mathematical calculations are performed on the above importance and performance rating and agility of the real estate company's project management is determined. The details regarding each of these steps are discussed below.

Step 1; Calculation of average fuzzy importance weights and average performance ratings; - Average importance weights and performance rating are calculated by using equation 3.2 and 3.3 respectively. The results of calculated average fuzzy importance weights and average performance ratings are presented below in Table 4.6.

For example, Average fuzzy importance weight of attribute Decentralized management structure=

(AM_{111}) = [(0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.85, 0.95, 1) + (0.5, 0.65, 0.8)]/12 = (0.69, 0.80, 0.90)

Average fuzzy performance rate of attribute Decentralized management structure =

(AM_{111}) = [(2, 3.5, 5) + (2, 3.5, 5) + (1, 2, 3) + (1, 2, 3) + (7, 8, 9) +(1, 2, 3) + (7, 8, 9) + (3,5,7) + (7, 8, 9) + (7, 8, 9) + (8.5, 9.5, 10) + (7, 8, 9)]/12 = (4.46, 5.63,6.75)

NB: Here, Average performance rating is calculated only for attributes because during fuzzy analysis, the attribute ratings are aggregated to criteria rating and criteria rating aggregated to enablers rating.

Average fuzzy importance weight of criteria Management structure

(AM_{11}) = [(0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) +(0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.5, 0.65, 0.8)]/12 = (0.69,0.83,0.92)

Average fuzzy importance weight of enabler Agility through management

(AM_{1}) = [(0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.5, 0.65, 0.8) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9)]/12 = (0.70, 0.81, 0.91)

Table 4.6 Calculated average fuzzy importance weights and average performance ratings of company A

Enabler	Importance average weight of enabler	Criteria	Importance average weight of Criteria	Attribute	Attributes importance average weight	Fuzzy performance average rating
AM_1	(0.70, 0.81, 0.91)	AM_{11}	(0.69, 0.83, 0.92)	AM_{111}	(0.69,0.80,0.90)	(4.46,5.63,6.75)
				AM_{112}	(0.64,0.76,0.88)	(5.17,6.50,7.75)
				AM_{113}	(0.67,0.78,0.88)	(3.75,5.13,6.50)
		AM_{12}	(0.75, 0.85, 0.93)	AM_{121}	(0.73,0.84,0.93)	(4.00,5.50,7.00)
				AM_{122}	(0.72,0.83,0.92)	(2.88,4.25,5.63)
				AM_{123}	(0.69,0.80,0.90)	(4.21,5.75,7.25)
		AM_{13}	(0.73, 0.84, 0.93)	AM_{131}	(0.73,0.84,0.93)	(4.13,5.50,6.83)
				AM_{132}	(0.68,0.79,0.89)	(3.67,5.13,6.58)
				AM_{133}	(0.73,0.84,0.93)	(4.21,5.63,7.00)
				AM_{134}	(0.69,0.80,0.90)	(3.88,5.38,6.83)
				AM_{135}	(0.65,0.78,0.88)	(4.38,5.75,7.08)
AM_2	(0.73,0.84, 0.93)	AM_{21}	(0.73, 0.84, 0.93)	AM_{211}	(0.72,0.83,0.92)	(4.29,5.75,7.17)
				AM_{212}	(0.68,0.79,0.89)	(4.04,5.50,6.92)
		AM_{22}	(0.70, 0.81, 0.91)	AM_{221}	(0.69,0.80,0.9)	(4.13,5.63,7.08)
				AM_{222}	(0.70,0.81,0.91)	(4.38,5.88,7.33)
AM_3	(0.72,0.75 0.92)	AM_{31}	(0.75, 0.85, 0.93)	AM_{311}	(0.72,0.83,0.92)	(4.79,6.13,7.42)
				AM_{312}	(0.69,0.80,0.90)	(4.38,5.75,7.08)
				AM_{313}	(0.73,0.84,0.93)	(4.88,6.25,7.58)
				AM_{314}	(0.72,0.83,0.92)	(4.96,6.25,7.42)
		AM_{32}	(0.75, 0.85, 0.93)	AM_{321}	(0.70,0.81,0.91)	(4.08,5.21,6.33)
				AM_{322}	(0.67,0.79,0.89)	(4.83,6.13,7.33)
				AM_{323}	(0.66,0.78,0.88)	(4.83,6.13,7.33)
		AM_{33}	(0.75, 0.85, 0.93)	AM_{331}	(0.70,0.81,0.91)	(4.46,5.88,7.25)
		AM_{34}	(0.73, 0.84, 0.93)	AM_{341}	(0.65,0.78,0.88)	(3.83,5.38,6.92)
				AM_{342}	(0.70, 0.81,0.9	(4.58,6.00,7.33)
				AM_{343}	(0.58,0.71,0.83)	(4.75,6.13,7.42)
AM_4	(0.72,0.83, 0.92)	AM_{41}	(0.72, 0.83, 0.92)	AM_{411}	(0.64,0.76,0.88)	(5.46,6.75,7.92)
				AM_{412}	(0.65,0.76,0.87)	(4.29,5.63,6.96)
		AM_{42}	(0.72, 0.83, 0.92)	AM_{421}	(0.66,0.79,0.89)	(4.83,6.25,7.58)
AM_5	(0.75,0.78, 0.93)	AM_{51}	(0.75, 0.85, 0.93)	AM_{511}	(0.71,0.83,0.92)	(4.33,5.63,6.8)
				AM_{512}	(0.70,0.81,0.91)	(3.42,5.00,6.58)
		AM_{52}	(0.73, 0.84, 0.93)	AM_{521}	(0.67,0.79,0.89)	(3.54,4.96,6.33)
				AM_{522}	(0.71,0.83,0.92)	(3.92,5.25,6.58)
				AM_{523}	(0.64,0.76,0.88)	(3.50,4.83,6.17)
		AM_{53}	(0.73, 0.84, 0.93)	AM_{531}	(0.63,0.75,0.86)	(3.33,4.88,6.42)
		AM_{54}	(0.69, 0.80, 0.90)	AM_{541}	(0.65,0.78,0.88)	(3.96,5.50,7.00)
				AM_{541}	(0.61,0.74,0.86)	(3.96,5.50,7.00)
				AM_{543}	(0.67,0.79,0.89)	(2.75,4.25,5.79)

Step 2; -In this step, the aggregate performance ratings of the attributes is translated into criteria rating and the criteria rating is translated into enabler rating using equation 3.4 and 3.5 respectively.

For example, the fuzzy index of performance rating of criteria O_{11} (AM_{11}) =

$$\frac{[(0.69,0.80,0.90) * (4.46,5.63,6.75) + (0.64,0.76,0.88) * (5.17,6.50,7.75) + (0.67,0.78,0.88) * (3.75,5.13,6.50)}{(0.69,0.80,0.90) + (0.64,0.76,0.88) + (0.67,0.78,0.88)}$$

= (4.45, 5.74, 7.00)

The aggregated performance ratings of the attributes are translated into criteria rating and the criteria rating is illustrated below in Table 4.7.

Equation (3.5) is employed to calculate the fuzzy index performance rating of the enablers the Fuzzy index of agility enablers rating is illustrated in Table 4.8.

For example, the fuzzy index of performance rating of enabler O_1(AM_{11})=

$$\frac{(4.45,5.74,7.00)*(0.69,0.83,0.92)+ (3.69,5.75,6.32)* (0.75,0.85,\&0.93)+(4.05,5.48,6.87)* (0.73,0.84,0.93)}{(0.69,0.83,0.92)+ (0.75,0.85,0.93)+(0.73,0.84,0.93)}$$

= (4.05, 5.46, 6.73)

Table 4.7 Fuzzy index of project management agility of criteria rating for company A

Criteria	Attribute	Attributes importance average weight	Fuzzy performance average rating	Criteria fuzzy rating
AM_{11}	AM_{111}	(0.69,0.80,0.90)	(4.46,5.63,6.75)	(4.45, 5.74, 7.00)
	AM_{112}	(0.64,0.76,0.88)	(5.17,6.50,7.75)	
	AM_{113}	(0.67,0.78,0.88)	(3.75,5.13,6.50)	
AM_{12}	AM_{121}	(0.73,0.84,0.93)	(4.00,5.50,7.00)	(3.69, 5.75, 6.32)
	AM_{122}	(0.72,0.83,0.92)	(2.88,4.25,5.63)	
	AM_{123}	(0.69,0.80,0.90)	(4.21,5.75,7.25)	
AM_{13}	AM_{131}	(0.73,0.84,0.93)	(4.13,5.50,6.83)	(4.05, 5.48, 6.87)
	AM_{132}	(0.68,0.79,0.89)	(3.67,5.13,6.58)	
	AM_{133}	(0.73,0.84,0.93)	(4.21,5.63,7.00)	
	AM_{134}	(0.69,0.80,0.90)	(3.88,5.38,6.83)	
	AM_{135}	(0.65,0.78,0.88)	(4.38,5.75,7.08)	
AM_{21}	AM_{211}	(0.72,0.83,0.92)	(4.29,5.75,7.17)	(4.17, 5.63, 7.04)
	AM_{212}	(0.68,0.79,0.89)	(4.04,5.50,6.92)	
AM_{22}	AM_{221}	(0.69,0.80,0.9)	(4.13,5.63,7.08)	(4.25, 5.75, 7.21)
	AM_{222}	(0.70,0.81,0.91)	(4.38,5.88,7.33)	
AM_{31}	AM_{311}	(0.72,0.83,0.92)	(4.79,6.13,7.42)	(4.75, 6.10, 7.38)
	AM_{312}	(0.69,0.80,0.90)	(4.38,5.75,7.08)	
	AM_{313}	(0.73,0.84,0.93)	(4.88,6.25,7.58)	
	AM_{314}	(0.72,0.83,0.92)	(4.96,6.25,7.42)	
AM_{32}	AM_{321}	(0.70,0.81,0.91)	(4.08,5.21,6.33)	(4.57, 5.81, 6.99)
	AM_{322}	(0.67,0.79,0.89)	(4.83,6.13,7.33)	
	AM_{323}	(0.66,0.78,0.88)	(4.83,6.13,7.33)	
AM_{33}	AM_{331}	(0.70,0.81,0.91)	(4.46,5.88,7.25)	(4.46, 5.88, 7.25)
AM_{34}	AM_{341}	(0.65,0.78,0.88)	(3.83,5.38,6.92)	(4.38, 5.83, 7.22)
	AM_{342}	(0.70,0.81,0.9)	(4.58,6.00,7.33)	
	AM_{343}	(0.58,0.71,0.83)	(4.75,6.13,7.42)	
AM_{41}	AM_{411}	(0.64,0.76,0.88)	(5.46,6.75,7.92)	(4.87, 6.19, 7.44)
	AM_{412}	(0.65,0.76,0.87)	(4.29,5.63,6.96)	
AM_{42}	AM_{421}	(0.66,0.79,0.89)	(4.83,6.25,7.58)	(4.83, 6.25, 7.58)
AM_{51}	AM_{511}	(0.71,0.83,0.92)	(4.33,5.63,6.8)	(3.66, 5.02, 6.36)
	AM_{512}	(0.70,0.81,0.91)	(3.42,5.00,6.58)	
AM_{52}	AM_{521}	(0.67,0.79,0.89)	(3.54,4.96,6.33)	(3.88, 5.31, 6.71)
	AM_{522}	(0.71,0.83,0.92)	(3.92,5.25,6.58)	
	AM_{523}	(0.64,0.76,0.88)	(3.50,4.83,6.17)	
AM_{53}	AM_{531}	(0.63,0.75,0.86)	(3.33,4.88,6.42)	(3.33,4.88, 6.42)
AM_{54}	AM_{541}	(0.65,0.78,0.88)	(3.96,5.50,7.00)	(3.54, 5.07, 6.59)
	AM_{542}	(0.61,0.74,0.86)	(3.96,5.50,7.00)	
	AM_{543}	(0.67,0.79,0.89)	(2.75,4.25,5.79)	

Table 4.8 Fuzzy index of project management agility of enablers rating for company A

Enabler	Criteria	Criteria Rating Calculated	Criteria Weights Average (collected)	Enabler Rating
AM_1	AM_{11}	(4.45, 5.74, 7.00)	(0.69, 0.83, 0.92)	(4.05, 5.46, 6.73)
	AM_{12}	(3.69, 5.75, 6.32)	(0.75,0.85, 0.93)	
	AM_{13}	(4.05, 5.48, 6.87)	(0.73, 0.84, 0.93)	
AM_2	AM_{21}	(4.17, 5.63, 7.04)	(0.73, 0.84, 0.93)	(4.2, 5.69, 7.13)
	AM_{22}	(4.25, 5.75, 7.21)	(0.70, 0.81, 0.91)	
AM_3	AM_{31}	(4.75, 6.10, 7.38)	(0.75, 0.85, 0.93)	(4.54, 5.90, 7.21)
	AM_{32}	(4.57, 5.81, 6.99)	(0.75, 0.85, 0.93)	
	AM_{33}	(4.46, 5.88, 7.25)	(0.75, 0.85, 0.93)	
	AM_{34}	(4.38, 5.83, 7.22)	(0.73, 0.84, 0.93)	
AM_4	AM_{41}	(4.87, 6.19, 7.44)	(0.72, 0.83, 0.92)	(4.85, 6.22 ,7.51)
	AM_{42}	(4.83, 6.25, 7.58)	(0.72, 0.83, 0.92)	
AM_5	AM_{51}	(3.66, 5.02, 6.36)	(0.75, 0.85, 0.93)	(3.61, 5.07, 6.52)
	AM_{52}	(3.88, 5.31, 6.71)	(0.73, 0.84, 0.93)	
	AM_{53}	(3.33,4.88, 6.42)	(0.73, 0.84, 0.93)	
	AM_{54}	(3.54, 5.07, 6.59)	(0.69, 0.80, 0.90)	

Step 3; - The next step is to compute the Fuzzy Agility Measure Index (FAMI) with equation 3.6. After determination of enabler rating the Fuzzy Agility Measure Index (FAMI) was calculated as; Fuzzy Agility Measure Index of real estate company A =

[(4.05, 5.46, 6.73) * (0.70, 0.81, 0.91) + (4.2, 5.69, 7.13) * (0.73,0.84, 0.93) + (4.54, 5.90, 7.21) * (0.72,0.75 0.92) + (4.85, 6.22 ,7.51) * (0.72,0.83, 0.92) + (3.61, 5.07, 6.52) * (0.75,0.78, 0.93)]/ (0.70, 0.81, 0.91) + (0.73,0.84, 0.93) + (0.72,0.75 0.92) + (0.72,0.83, 0.92) +(0.75,0.78, 0.93) = (4.26, 5.68, 7.02)

Final calculated Fuzzy Agility Measure Index (FAMI) of company A is presented in Table 4.9 below.

Table 4.9 Fuzzy agility measure index of company A

Enabler	Enabler Rating	Importance average weight of enabler	Fuzzy Agility Measure Index (FAMI)
AM_1	(4.05, 5.46, 6.73)	(0.70, 0.81, 0.91)	(4.26, 5.68, 7.02)
AM_2	(4.2, 5.69, 7.13)	(0.73,0.84, 0.93)	
AM_3	(4.54, 5.90, 7.21)	(0.72,0.75 0.92)	
AM_4	(4.85, 6.22 ,7.51)	(0.72,0.83, 0.92)	
AM_5	(3.61, 5.07, 6.52)	(0.75,0.78, 0.93)	

$FAMI$ of company A= (4.26, 5.68, 7.02)

Step 4; - The FAMI is evaluated by comparing Euclidean distance method to the linguistic general term. So, the distance between the fuzzy number fuzzy-agility-index (FAI) and each fuzzy number member can be calculated as below by using equation 3.7.

DFAMI (EA) = $\sqrt{(4.26-7)^2+(5.68-8.5)^2+(7.02-10)^2}$ = 4.94

DFAMI (VA) = $\sqrt{(4.26-5.5)^2+(5.68-7)^2+(7.02-8.5)^2}$ = 3.49

DFAMI (A) = $\sqrt{(4.26-3.5)^2+(5.68-5)^2+(7.02-6.5)^2}$ =1.14

DFAMI (FA) = $\sqrt{(4.26-1.5)^2+(5.68-3)^2+(7.02-4.5)^2}$ = 3.68

DFAMI (SA) = $\sqrt{(4.26-0)^2+(5.68-1.5)^2+(7.02-3)^2}$ = 7.18

Real estate construction project management agility of company A can be determined by minimum D value. Which is 1.14.

The current project management agility level of real estate company A is “Agile” which is average in relation to the Agility Labels. Figure 4.4 shows the Linguistic matches of fuzzy agility level of the company. The black and shaded line shows the current company’s project management fuzzy agility level.

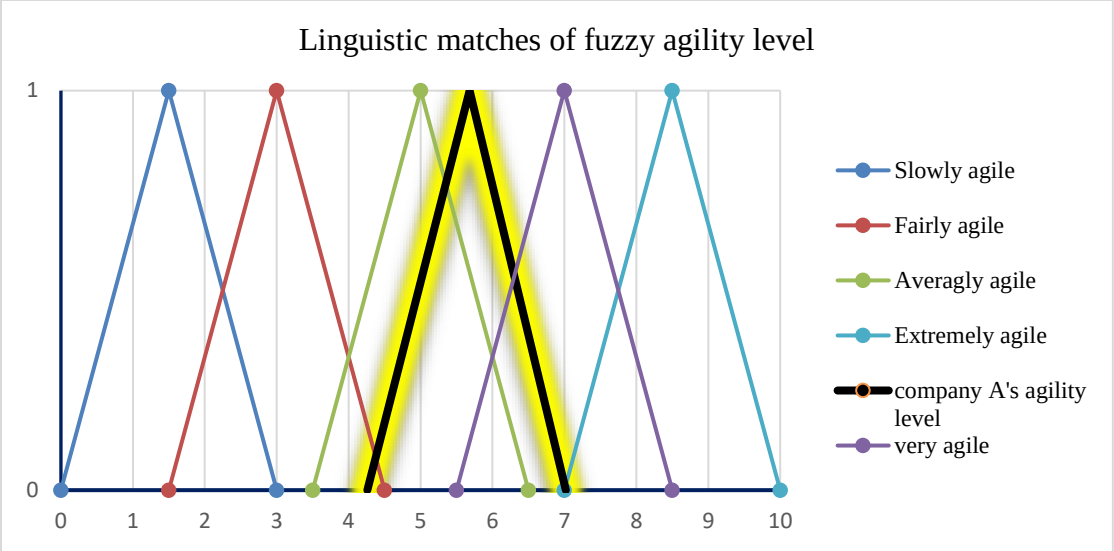

Figure 4.4 Linguistic matches of fuzzy project management agility level of Company A

4.3.2. Identification of the Construction Project Management Agility Level of Company B

Profile of the company

Company B Construction Plc was founded in 1984, as a sole proprietorship and later in 1993 transformed into a private limited company. In the early years of its establishment, the company had started to engage itself in minor construction and water proofing works with less than ten employees. Currently the company has over 3000 employees and the 34 years milestone career of the company enabled it to build a reliable capacity and exhibit practical excellence in the construction sector. Company B construction has attained a prestigious role position at the helm of the sector and become a bloodline to the establishment of other businesses and philanthropic entities under company B Investment Group.

Observed importance and performance rating

Gathering the data for importance weights and performance rating from construction project managers, site engineers, office engineers.

The experts were asked to provide the weightage in terms of linguistic variables ranging from “Very low (VL)” to “Very High (VH)”. For each of these linguistic variables from “Very low (VL)” to “Very High (VH)” a corresponding fuzzy interval or membership function was assigned.

Questions were put forth to the experts to capture the weightage of enablers and criterion importance and their response is presented below in Table 4.10 and 4.11 respectively.

Table 4.10 Collected importance weights for enabler of construction project management agility of company B

AM_i	E_i											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_1	VH	FH	H	H	VH	H	FH	FL	VH	FH	M	H
AM_2	VH	FH	H	H	VH	H	FH	M	VH	FH	M	H
AM_3	VH	H	H	VH	VH	H	H	H	H	FH	FH	FH
AM_4	H	M	H	H	H	H	VH	H	FH	M	H	H
AM_5	H	VH	H	FH	VH	H	H	H	VH	M	VH	FH

Table 4.11. Collected importance weights for criteria of construction project management agility of company B

AM_{ij}	C_{ij}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{11}	H	VH	H	H	VH	M	H	H	VH	FH	FH	FH
AM_{12}	FH	VH	FH	FH	H	H	VH	M	FH	FH	H	M
AM_{13}	FH	VH	VH	H	VH	H	VH	M	H	FH	FH	FH
AM_{21}	VH	VH	H	H	FH	FH	H	VH	FH	H	FH	H
AM_{22}	VH	VH	H	FH	H	FH	FH	VH	H	H	H	H
AM_{31}	FH	VH	VH	H	VH	H	H	VH	VH	H	VH	H
AM_{32}	VH	VH	H	H	VH	VH	FH	VH	H	FH	VH	H
AM_{33}	VH	VH	FH	H	H	VH	M	VH	FH	VH	H	VH
AM_{34}	M	FL	FH	VH	VH	M	M	M	H	FH	M	H
AM_{41}	FH	H	H	VH	H	H	FH	H	VH	M	FH	FH
AM_{42}	VH	VH	FH	VH	VH	VH	H	FH	VH	FH	VH	H
AM_{51}	VH	VH	H	VH	VH	VH	H	M	H	FH	VH	H
AM_{52}	H	VH	FH	VH	VH	H	H	M	FH	FH	VH	FH
AM_{53}	H	VH	H	VH	VH	H	H	FH	FH	FH	VH	M
AM_{54}	M	FH	H	FH	FH	H	M	FH	FH	FH	FH	M

Questions were put forth to the experts to capture the weightage of attributes importance and performance. The observed importance and performance rates are presented by using Table 4.12 and 4.13 respectively.

Table 4.12 Collected importance weights for attributes of construction project management agility of company B.

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	VH	VH	VH	H	H	H	H	M	VH	M	M	H
AM_{112}	H	VH	H	H	VH	FL	H	H	VH	FH	FH	VH
AM_{113}	VH	FH	H	VH	VH	H	FH	M	H	FL	FH	VH
AM_{121}	FH	H	H	VH	VH	VH	H	M	FH	M	FL	VH
AM_{122}	VH	VH	FH	VH	H	VH	H	VH	H	FH	FH	H
AM_{123}	H	FH	FH	VH	H	VH	FH	H	VH	M	FL	VH
AM_{131}	H	VH	H	H	VH	M	FH	FH	H	M	FH	H
AM_{132}	FH	FH	H	H	VH	FL	H	FH	H	M	M	VH
AM_{133}	FH	VH	VH	FH	FH	FH	FH	H	FH	M	M	VH
AM_{134}	VH	VH	H	H	H	H	H	H	H	FH	H	VH
AM_{135}	VH	VH	H	FH	VH	H	H	FH	H	M	M	VH
AM_{211}	VH	VH	VH	FH	H	H	FH	H	VH	FH	H	H
AM_{212}	FH	FL	VH	H	VH	M	FH	H	H	M	FH	H
AM_{221}	H	VH	VH	FH	VH	VH	H	H	VH	FH	FL	H
AM_{222}	VH	VH	H	FH	H	VH	FH	FH	H	M	M	H
AM_{311}	H	VH	H	H	H	H	FH	VH	H	M	VH	H
AM_{312}	FH	H	H	FH	H	FH	FH	H	VH	M	VH	H
AM_{313}	FL	H	VH	H	H	M	FH	M	H	M	VH	H
AM_{314}	M	H	VH	H	VH	FL	FH	FL	H	M	VH	H
AM_{321}	H	VH	VH	FH	VH	VH	FH	FH	VH	M	M	VH
AM_{322}	H	VH	H	H	VH	VH	FH	FH	H	M	FH	H
AM_{323}	VH	H	VH	FH	VH	VH	FH	FH	H	M	FH	VH
AM_{331}	H	H	H	H	FH	H	FH	FL	VH	M	M	H
AM_{341}	VH	H	H	H	VH	H	FH	H	VH	M	H	H
AM_{342}	VH	VH	H	H	H	H	FH	M	H	M	H	H
AM_{343}	VH	H	VH	FH	H	VH	H	FL	H	FL	VH	H
AM_{411}	FH	VH	VH	H	H	VH	FH	FH	H	M	FH	H
AM_{412}	H	VH	H	FH	VH	M	FH	FH	VH	M	FH	VH
AM_{421}	H	VH	H	H	VH	FH	H	VH	H	M	M	VH
AM_{511}	VH	VH	VH	H	H	VH	FH	FH	H	FL	M	H
AM_{512}	H	FH	VH	FH	VH	VH	H	H	H	M	M	H
AM_{521}	H	H	VH	H	VH	H	VH	FH	VH	M	H	H
AM_{522}	FH	FH	VH	H	H	VH	VH	FH	H	FL	FH	H
AM_{523}	H	H	VH	H	VH	VH	VH	FH	VH	FH	H	H
AM_{531}	H	VH	VH	H	VH	FH	H	H	H	M	FH	H
AM_{541}	H	VH	VH	H	H	FH	H	FH	VH	FL	M	VH
AM_{542}	FH	VH	H	FH	VH	FH	H	FH	H	FH	M	VH
AM_{543}	H	VH	VH	H	H	H	H	H	H	M	FH	H

Table 4.13 Collected performance rating for attributes of construction project management agility of company B

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	E	E	F	F	VP	G	F	F	E	P	P	G
AM_{112}	VG	E	G	F	VG	P	F	P	VG	P	P	VG
AM_{113}	F	VP	VG	G	F	F	VG	P	E	F	F	G
AM_{121}	VG	F	G	P	VG	F	VG	VP	E	VP	F	G
AM_{122}	VG	E	F	P	E	VG	G	P	VG	P	F	VG
AM_{123}	G	P	F	P	VG	G	VP	VP	G	P	P	VG
AM_{131}	VG	F	P	G	F	F	VG	F	G	F	P	F
AM_{132}	VG	E	F	F	VG	P	VG	VP	F	VP	P	F
AM_{133}	VG	F	G	F	P	F	E	P	F	G	F	VG
AM_{134}	VG	P	VG	F	P	VG	P	VP	E	P	F	VG
AM_{135}	VG	E	VG	F	VG	E	VG	VP	F	P	F	F
AM_{211}	F	F	G	E	F	VG	VP	VG	P	F	F	F
AM_{212}	G	VP	F	F	VG	F	P	P	G	P	F	G
AM_{221}	VG	E	F	F	E	VG	P	P	VG	G	F	VG
AM_{222}	G	G	F	G	VG	VG	VG	P	G	P	P	G
AM_{311}	G	E	F	G	VG	F	VG	VP	E	F	P	F
AM_{312}	VP	E	G	F	F	F	F	VG	P	F	P	P
AM_{313}	G	E	F	F	VG	P	VG	VP	VG	P	P	G
AM_{314}	G	E	F	F	VG	VP	VG	P	G	G	F	F
AM_{321}	VG	E	F	P	G	G	VG	VP	G	P	P	F
AM_{322}	E	E	F	P	VG	E	VG	P	VG	F	F	F
AM_{323}	VG	E	G	P	F	H	H	VP	P	F	P	F
AM_{331}	F	E	P	P	F	VG	VG	F	VG	F	F	F
AM_{341}	VG	E	F	F	VG	VG	VG	F	P	P	P	F
AM_{342}	VG	E	F	F	G	VG	G	P	G	P	P	F
AM_{343}	G	E	G	P	F	VG	G	P	E	VP	F	F
AM_{411}	G	E	F	G	VG	VG	VG	F	E	P	F	F
AM_{412}	VG	E	P	P	F	F	VG	P	P	G	P	F
AM_{421}	VG	G	P	G	P	F	G	P	G	P	VP	G
AM_{511}	G	VG	P	F	P	G	G	VP	G	P	F	F
AM_{512}	VG	P	F	G	F	F	VG	F	P	F	P	P
AM_{521}	F	F	VG	F	G	F	G	P	F	P	VP	G
AM_{522}	G	P	P	P	F	VG	G	F	G	P	F	P
AM_{523}	VG	G	F	F	G	VG	G	P	F	F	P	P
AM_{531}	F	F	F	P	P	VG	G	VG	G	F	G	F
AM_{541}	P	F	P	F	VG	F	G	P	G	P	F	P
AM_{542}	VG	G	P	F	VG	G	F	P	G	F	VP	P
AM_{543}	F	F	P	F	G	F	G	VP	P	P	P	F

Fuzzy mathematical calculations

Fuzzy mathematical calculations are performed on the above observed importance and performance rating and agility of the real estate company's project management is determined. The details regarding each of these steps are discussed below.

Step 1; calculation of average fuzzy importance weights and average performance ratings; - Average importance weights and performance ratings were calculated by using equation 3.2 and 3.3 respectively. The result of calculated average fuzzy importance weights and average performance ratings are presented below in Table 4.14.

For example, - Average fuzzy importance weight of attribute Decentralized management structure

(AM_{111}) = [(0.85, 0.95, 1) + (0.85, 0.95, 1) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) +(0.7, 0.8, 0.9) +(0.7, 0.8, 0.9) +(0.7, 0.8, 0.9) + (0.3, 0.5, 0.7) + (0.85, 0.95, 1) +(0.3, 0.5, 0.7) + (0.3, 0.5, 0.7) + (0.7, 0.8, 0.9)]/12 = (0.65, 0.78, 0.88)

Average fuzzy performance rate of attribute Decentralized management structure

(AM_{111}) = (8.5, 9.5, 10) + (8.5, 9.5, 10) +(3, 5, 7) +(3, 5, 7) +(1, 2, 3) +(5, 6.5, 8) +(3, 5, 7) +(3, 5, 7) +(8.5, 9.5, 10) +(2, 3.5,5) + (2, 3.5, 5) + (5, 6.5, 8)]/12 = (4.38, 5.88 ,7.25)

Average fuzzy importance weight of criteria Management structure

(AM_{11}) = [(0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) +(0.3, 0.5, 0.7) + (0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.5, 0.65, 0.8) +(0.5, 0.65, 0.8) + (0.5, 0.65, 0.8)]/12 = (0.65, 0.78, 0.88)

Average fuzzy importance weight of enabler Agility through management

(AM_{1}) = [(0.7, 0.8, 0.9) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.7, 0.8, 0.9) + (0.85, 0.95, 1) + (0.85, 0.95, 1) +(0.5, 0.65, 0.8) + (0.3, 0.5, 0.7) + (0.85, 0.95, 1) +(0.3, 0.5, 0.7) + (0.7, 0.8, 0.9) +(0.85, 0.95, 1)]/12 = (0.68, 0.80, 0.90)

Table 4.14 Average importance weight of enablers, criteria, attributes, and performance average rating of company B

Enabler	Importance average weight of enabler	Criteria	Importance average weight of Criteria	Attribute	Attributes importance average weight	Fuzzy performance average rating
AM_1	(0.68, 0.80, 0.90)	AM_{11}	(0.65, 0.78, 0.88)	AM_{111}	(0.65, 0.78, 0.88)	(4.38, 5.88, 7.25)
				AM_{112}	(0.66, 0.78, 0.88)	(4.63, 6.00, 7.33)
				AM_{113}	(0.63, 0.75, 0.86)	(4.38, 5.88, 7.33)
		AM_{12}	(0.58, 0.71, 0.84)	AM_{121}	(0.61, 0.74, 0.85)	(4.54, 5.88, 7.17)
				AM_{122}	(0.68, 0.80, 0.90)	(5.17, 6.50, 7.75)
				AM_{123}	(0.62, 0.74, 0.84)	(3.50, 4.88, 6.25)
		AM_{13}	(0.65, 0.78, 0.88)	AM_{131}	(0.61, 0.74, 0.86)	(3.83, 5.50, 7.17)
				AM_{132}	(0.57,0.70, 0.83)	(3.96, 5.38, 6.75)
				AM_{133}	(0.57,0.71, 0.84)	(4.29, 5.88, 7.42)
				AM_{134}	(0.72, 0.83, 0.92)	(4.13, 5.50, 6.83)
				AM_{135}	(0.65, 0.78, 0.88)	(5.00, 6.38, 7.67)
AM_2	(0.61, 0.74, 0.85)	AM_{21}	(0.67, 0.79, 0.89)	AM_{211}	(0.70, 0.81, 0.91)	(4.04, 5.63, 7.17)
				AM_{212}	(0.54, 0.68, 0.80)	(3.42, 5.00, 6.58)
		AM_{22}	(0.69, 0.80, 0.90)	AM_{221}	(0.69 0.80, 0.89)	(5.17, 6.50, 7.75)
				AM_{222}	(0.62, 0.75, 0.87)	(4.58, 6.00, 7.42)
AM_3	(0.69, 0.72, 0.90)	AM_{31}	(0.76, 0.86, 0.94)	AM_{311}	(0.69, 0.80, 0.90)	(3.88, 5.21, 6.50)
				AM_{312}	(0.63, 0.75, 0.87)	(3.46, 5.00, 6.50)
				AM_{313}	(0.57, 0.70, 0.83)	(4.38, 5.75, 7.08)
				AM_{314}	(0.52, 0.65, 0.78)	(4.29, 5.75, 7.17)
		AM_{32}	(0.74, 0.85, 0.93)	AM_{321}	(0.66, 0.79,0.89)	(4.21, 5.63, 7.00)
				AM_{322}	(0.65, 0.78,0.88)	(4.79, 6.25, 7.58)
				AM_{323}	(0.66, 0.79, 0.89)	(4.13, 5.50, 6.83)
		AM_{33}	(0.71, 0.83, 0.92)	AM_{331}	(0.56, 0.69, 0.81)	(4.29, 5.88, 7.42)
		AM_{34}	(0.48, 0.64, 0.78)	AM_{341}	(0.69, 0.80, 0.90)	(4.38, 5.75, 7.08)
				AM_{342}	(0.64, 0.76, 0.88)	(4.71, 6.13, 7.50)
				AM_{343}	(0.65, 0.76, 0.86)	(4.58, 6.00, 7.33)
AM_4	(0.63, 0.75, 0.87)	AM_{41}	(0.63, 0.75, 0.87)	AM_{411}	(0.64, 0.76, 0.88)	(5.17, 6.63, 8.00)
				AM_{412}	(0.62, 0.75, 0.87)	(3.79, 5.25, 6.67)
		AM_{42}	(0.74, 0.85, 0.93)	AM_{421}	(0.67,0.79, 0.89)	(3.42, 4.88, 6.33)
AM_5	(0.68, 0.75, 0.90)	AM_{51}	(0.73, 0.84, 0.93)	AM_{511}	(0.64, 0.76, 0.87)	(4.00, 5.50, 7.00)
				AM_{512}	(0.63, 0.75, 0.86)	(3.33, 4.88, 6.42)
		AM_{52}	(0.65, 0.78, 0.88)	AM_{521}	(0.70, 0.81, 0.91)	(3.25, 4.88, 6.50)
				AM_{522}	(0.63, 0.75, 0.86)	(3.42, 5.00, 6.58)
				AM_{523}	(0.74, 0.85, 0.93)	(3.92, 5.50, 7.08)
		AM_{53}	(0.67, 0.79, 0.89)	AM_{531}	(0.67, 0.79, 0.89)	(3.33, 5.00, 6.67)
		AM_{54}	(0.45, 0.61, 0.72)	AM_{541}	(0.64, 0.76, 0.87)	(3.25, 4.88, 6.50)
				AM_{541}	(0.62, 0.75, 0.87)	(3.75, 5.25, 6.75)
				AM_{543}	(0.68, 0.79, 0.89)	(3.17, 4.75, 6.33)

Step 2; -In this step, the aggregate performance ratings of the attributes is translated into criteria rating and the criteria rating is translated into enabler rating using equation 3.4 and 3.5 respectively.

For example, the fuzzy index of performance rating of criteria O_{11} (AM_{11}) =

$$\frac{[(0.65, 0.78, 0.88) * (4.38, 5.88, 7.25) + (0.66, 0.78, 0.88) * (4.63, 6.00, 7.33) + (0.63, 0.75, 0.86) * (4.38, 5.88, 7.33)]}{(0.65, 0.78, 0.88)) + (0.66, 0.78, 0.88) + (0.63, 0.75, 0.86)}$$

= (4.46, 5.92,7.31)

The aggregated performance ratings of the attributes are translated into criteria rating and the criteria rating of company B is illustrated below in Table 4.15.

Equation (3.5) is employed to calculate the fuzzy index performance rating of the enablers and the Fuzzy index of agility of enablers rating is illustrated in Table 4.16.

For example, the fuzzy index of performance rating of enabler O_1(AM_{11})=

$$\frac{(4.46,5.92,7.31) * (0.65,0.78,0.88) + (4.43,5.49,7.04) * (0.58,0.71,0.84) + (4.25,5.73,7.17) * (0.65,0.78,0.88)}{(0.65,0.78,0.88) + (0.58,0.71,0.84) + (0.65,0.78,0.88)}$$

= (4.30, 5.72, 7.17)

Table 4.15 Fuzzy index of project management agility of criteria rating for company B

	Attribute	Attributes importance average weight	Fuzzy performance average rating	Criteria fuzzy rating
AM_{11}	AM_{111}	(0.65, 0.78, 0.88)	(4.38, 5.88, 7.25)	(4.46, 5.92,7.31
	AM_{112}	(0.66, 0.78, 0.88)	(4.63, 6.00, 7.33)	
	AM_{113}	(0.63, 0.75, 0.86)	(4.38, 5.88, 7.33)	
AM_{12}	AM_{121}	(0.61, 0.74, 0.85)	(4.54, 5.88, 7.17)	(4.43, 5.49, 7.04)
	AM_{122}	(0.68, 0.80, 0.90)	(5.17, 6.50, 7.75)	
	AM_{123}	(0.62, 0.74, 0.84)	(3.50, 4.88, 6.25)	
AM_{13}	AM_{131}	(0.61, 0.74, 0.86)	(3.83, 5.50, 7.17)	(4.25, 5.73, 7.17)
	AM_{132}	(0.57,0.70, 0.83)	(3.96, 5.38, 6.75)	
	AM_{133}	(0.57,0.71, 0.84)	(4.29, 5.88, 7.42)	
	AM_{134}	(0.72, 0.83, 0.92)	(4.13, 5.50, 6.83)	
	AM_{135}	(0.65, 0.78, 0.88)	(5.00, 6.38, 7.67)	
AM_{21}	AM_{211}	(0.70, 0.81, 0.91)	(4.04, 5.63, 7.17)	(3.79, 5.36, 6.91)
	AM_{212}	(0.54, 0.68, 0.80)	(3.42, 5.00, 6.58)	
AM_{22}	AM_{221}	(0.69 0.80, 0.89)	(5.17, 6.50, 7.75)	(4.88, 6.25, 7.58)
	AM_{222}	(0.62, 0.75, 0.87)	(4.58, 6.00, 7.42)	
AM_{31}	AM_{311}	(0.69, 0.80, 0.90)	(3.88, 5.21, 6.50)	(3.97, 5.41, 6.80)
	AM_{312}	(0.63, 0.75, 0.87)	(3.46, 5.00, 6.50)	
	AM_{313}	(0.57, 0.70, 0.83)	(4.38, 5.75, 7.08)	
	AM_{314}	(0.52, 0.65, 0.78)	(4.29, 5.75, 7.17)	
AM_{32}	AM_{321}	(0.66, 0.79,0.89)	(4.21, 5.63, 7.00)	(4.37, 5.79, 7.14)
	AM_{322}	(0.65, 0.78,0.88)	(4.79, 6.25, 7.58)	
	AM_{323}	(0.66, 0.79, 0.89)	(4.13, 5.50, 6.83)	
AM_{33}	AM_{331}	(0.56, 0.69, 0.81)	(4.29, 5.88, 7.42)	(4.29,5.88,7.42)
AM_{34}	AM_{341}	(0.69, 0.80, 0.90)	(4.38, 5.75, 7.08)	(4.55, 5.95, 7.30)
	AM_{342}	(0.64, 0.76, 0.88)	(4.71, 6.13, 7.50)	
	AM_{343}	(0.65, 0.76, 0.86)	(4.58, 6.00, 7.33)	
AM_{41}	AM_{411}	(0.64, 0.76, 0.88)	(5.17, 6.63, 8.00)	(4.49, 5.94, 7.34)
	AM_{412}	(0.62, 0.75, 0.87)	(3.79, 5.25, 6.67)	
AM_{42}	AM_{411}	(0.67, 0.79, 0.89)	(3.42, 4.88, 6.33)	(3.42, 4.88, 6.33)
AM_{51}	AM_{511}	(0.64, 0.76, 0.87)	(4.00, 5.50, 7.00)	(3.67, 5.19, 6.71)
	AM_{512}	(0.63, 0.75, 0.86)	(3.33, 4.88, 6.42)	
AM_{52}	AM_{521}	(0.70, 0.81, 0.91)	(3.25, 4.88, 6.50)	(3.54, 5.13, 6.73)
	AM_{522}	(0.63, 0.75, 0.86)	(3.42, 5.00, 6.58)	
	AM_{523}	(0.74, 0.85, 0.93)	(3.92, 5.50, 7.08)	
AM_{53}	AM_{531}	(0.67, 0.79, 0.89)	(3.33, 5.00, 6.67)	(3.33, 5.00, 6.67)
AM_{54}	AM_{541}	(0.64, 0.76, 0.87)	(3.25, 4.88, 6.50)	(3.38, 4.95, 6.53)
	AM_{542}	(0.62, 0.75, 0.87)	(3.75, 5.25, 6.75)	
	AM_{543}	(0.68, 0.79, 0.89)	(3.17, 4.75, 6.33)	

Table 4.16 Fuzzy index of project management agility of enablers rating for company B

Enabler	Criteria	Criteria Rating calculated	Criteria Weights Average (collected)	Enabler Rating
AM_1	AM_{11}	(4.46, 5.92,7.31)	(0.65, 0.78, 0.88)	(4.30, 5.72, 7.17)
	AM_{12}	(4.43, 5.49, 7.04)	(0.58, 0.71, 0.84)	
	AM_{13}	(4.25, 5.73, 7.17)	(0.65, 0.78, 0.88)	
AM_2	AM_{21}	(3.79, 5.36, 6.91)	(0.67, 0.79, 0.89)	(4.34, 5.81, 7.25)
	AM_{22}	(4.88, 6.25, 7.58)	(0.69, 0.80, 0.90)	
AM_3	AM_{31}	(3.97, 5.41, 6.80)	(0.76, 0.86, 0.94)	(4.27, 5.74, 7.16)
	AM_{32}	(4.37, 5.79, 7.14)	(0.74, 0.85, 0.93)	
	AM_{33}	(4.29,5.88,7.42)	(0.71, 0.83, 0.92)	
	AM_{34}	(4.55, 5.95, 7.30)	(0.48, 0.64, 0.78)	
AM_4	AM_{41}	(4.49, 5.94, 7.34)	(0.63, 0.75, 0.87)	(3.91, 5.38, 6.82)
	AM_{42}	(3.42, 4.88, 6.33)	(0.74, 0.85, 0.93)	
AM_5	AM_{51}	(3.67, 5.19, 6.71)	(0.73, 0.84, 0.93)	(3.49, 5.08, 6.66)
	AM_{52}	(3.54, 5.13, 6.73)	(0.65, 0.78, 0.88)	
	AM_{53}	(3.33, 5.00, 6.67)	(0.67, 0.79, 0.89)	
	AM_{54}	(3.38, 4.95, 6.53)	(0.45, 0.61, 0.72)	

Step 3; - The next step is to compute the Fuzzy Agility Measure Index (FAMI) with equation 3.6. After determination of enabler rating the Fuzzy Agility Measure Index (FAMI) is calculated as; -

Fuzzy Agility Measure Index of real estate company B =

[(4.30, 5.72, 7.17) *(0.68, 0.80, 0.90) + (4.34, 5.81, 7.25) * (0.61, 0.74, 0.85) + (4.27, 5.74, 7.16) * (0.69, 0.72, 0.90) + (3.91,5.38, 6.82) * (0.63, 0.75, 0.87) + (3.49, 5.08, 6.66)*(0.68, 0.75, 0.90)]/(0.68, 0.80, 0.90) + (0.61, 0.74, 0.85) + (0.69, 0.72, 0.90) + (0.63, 0.75, 0.87) + (0.68, 0.75, 0.90) = (4.07, 5.55, 7.01)

Final calculated Fuzzy Agility Measure Index (FAMI) of company B is presented in Table 4.17 below.

Table 4.17 Fuzzy agility measurement index of company B

Enabler	Enabler Rating	Importance average weight of enabler	Fuzzy Agility Measure Index (FAMI)
AM_1	(4.30, 5.72, 7.17)	(0.68, 0.80, 0.90)	(4.07, 5.55, 7.01)
AM_2	(4.34, 5.81, 7.25)	(0.61, 0.74, 0.85)	
AM_3	(4.27, 5.74, 7.16)	(0.69, 0.72, 0.90)	
AM_4	(3.91, 5.38, 6.82)	(0.63, 0.75, 0.87)	
AM_5	(3.49, 5.08, 6.66)	(0.68, 0.75, 0.90)	

$FAMI$ of company B = (4.07, 5.55, 7.01)

Step 4; - The FAMI is evaluated by comparing Euclidean distance method to the linguistic general term. So, the distance between the fuzzy number fuzzy-agility-index (FAI) and each fuzzy number member can be calculated by using equation 3.7.

DFAMI (EA) = $\sqrt{(4.07-7)^2+(5.55-8.5)^2+(7.01-10)^2}$ = 5.12

DFAMI (VA) = $\sqrt{(4.07-5.5)^2+(5.55-7)^2+(7.01-8.5)^2}$ = 2.52

DFAMI (A) = $\sqrt{(4.07-3.5)^2+(5.55-5)^2+(7.01-6.5)^2}$ = 0.95

DFAMI (FA) = $\sqrt{(4.07-1.5)^2+(5.55-3)^2+(7.01-4.5)^2}$ = 4.40

DFAMI (SA) = $\sqrt{(4.07-0)^2+(5.55-1.5)^2+(7.01-3)^2}$ = 7.00

Real estate construction project management agility of company B can be determined by minimum D value. Which is 0.95.

The current project management agility level of real estate company B is “Agile” which is average in relation to the Agility Labels. Figure 4.7. shows the Linguistic matches of fuzzy agility level of the company. The black and shaded line shows the current company’s project management fuzzy agility level.

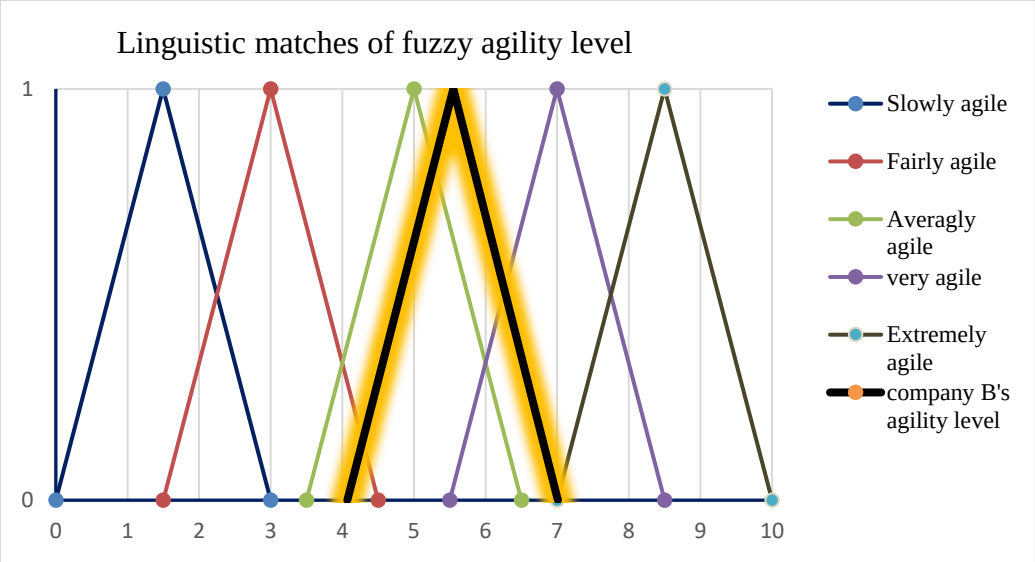

Figure 4.7 Linguistic matches of fuzzy project management agility level of company B

4.3.3. Identification of the Construction Project Management Agility Level of Company C

Company C

Profile of the company

Company C was engaged in real estate development business in Ethiopia as trading during the mixed economic era (early 1990s or 30 years ago) by its founder. Company C was established in 2005 as real estate company and since it has been engaged in the development of residential and commercial building and selling of Real Estate property. It was very difficult to start real estate business at that time because of limited experience in the government, no local customers, high failure rate of real estate companies, etc. thus, it took about 2 years for completing its establishment process and to secure plots of land. company C obtained 160,000 m^2 land plot from Addis Ababa city administration and it makes Company C one of the pioneers in the sector. The aim was to find solutions that compline high end technology, design and aesthetics and meet customer aspirations and expectations through superior standards performance and service. Now private real estate company C have over 1500 employees and is one of largest and most experience real estate company.

Observed importance and performance rating

Gathering the data for importance weights and performance rating from construction project managers, site engineers and office engineers.

The experts were asked to provide the weightage in terms of linguistic variables ranging from "Very low (VL)" to "Very High (VH)". For each of these linguistic variables from "Very low (VL)" to "Very High (VH)" a corresponding fuzzy interval or membership function was assigned. Questions were put forth to the experts to capture the weightage of enabler importance and the respondent's answer are illustrated in Table 4.18.

Table 4.18 Collected importance weights for enabler of construction project management agility of company C

AM_i	E_i											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_1	H	M	FH	M	FH	H	FH	FH	FH	H	FH	M
AM_2	H	FH	H	M	M	H	FH	H	H	FH	H	FH
AM_3	H	FH	H	FH	FH	M	H	FH	M	H	FH	H
AM_4	VH	H	VH	H	H	FH	H	H	H	FH	H	H
AM_5	H	H	FH	H	H	FH	H	FH	FH	H	H	H

Questions were put forth to the experts to capture the weightage of criteria importance and the expert's response is presented below in Table 4.19.

Table 4.19 Collected importance weights for criteria of construction project management agility of company C

AM_{ij}	C_{ij}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{11}	FH	M	VH	M	H	M	FH	FH	H	FH	FH	FH
AM_{12}	FH	H	FH	FH	H	M	FH	FH	FH	H	FH	H
AM_{13}	FH	FH	FH	M	FH	M	FH	FH	H	FH	H	H
AM_{21}	H	FH	H	M	FH	M	H	H	H	H	H	FH
AM_{22}	FH	FH	H	FH	H	FH	M	H	H	FH	FH	H
AM_{31}	FH	FH	H	FH	H	FH	FH	FH	VH	FH	H	H
AM_{32}	H	FH	FH	H	H	FH	FH	FH	H	FH	VH	FH
AM_{33}	FH	FH	FH	L	FH	FH	H	H	H	VH	H	H
AM_{34}	H	FH	FH	M	M	H	FH	H	H	FH	H	H
AM_{41}	H	FH	FH	M	FH	FH	FH	H	H	FH	FH	FH
AM_{42}	FH	FH	FH	M	FH	FH	M	H	H	H	H	H
AM_{51}	H	M	H	FL	H	FH	H	FH	FH	FH	FH	H
AM_{52}	H	FH	FH	FL	H	H	FH	FH	H	H	FH	H
AM_{53}	H	H	FH	M	FH	FH	FH	H	H	FH	H	H
AM_{54}	H	FH	H	M	H	FH	H	FH	M	H	FH	FH

Questions were put forth to the experts to capture the weightage of attributes importance and performance and their responses are presented below in Table 4.20 and 4.21 respectively.

Table 4.20 Collected importance weights for attributes of construction project management agility of C

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	H	M	H	M	FH	FH	FL	FH	H	VH	FH	FH
AM_{112}	H	M	H	FH	M	H	FH	H	FH	VH	FH	H
AM_{113}	H	M	VH	FH	FH	M	M	FH	H	VH	FH	H
AM_{121}	VH	M	H	FL	M	M	FH	FH	FH	VH	FH	VH
AM_{122}	VH	M	VH	M	FL	M	M	H	FH	H	FH	H
AM_{123}	VH	H	H	FL	FH	FH	M	H	FH	H	FH	H
AM_{131}	H	FH	FH	FH	M	FH	H	H	H	H	H	FH
AM_{132}	FH	M	H	FH	FH	M	H	H	H	H	H	M
AM_{133}	H	M	VH	M	FH	FH	FH	H	M	VH	H	H
AM_{134}	H	FH	M	FH	FH	FH	M	H	M	VH	M	VH
AM_{135}	H	H	H	M	FH	FH	FH	H	VH	M	VH	FH
AM_{211}	H	FH	H	FH	M	M	H	H	FH	VH	H	H
AM_{212}	VH	H	M	FH	M	FH	FH	H	FH	FH	H	FH
AM_{221}	VH	H	H	M	M	FH	FH	FH	H	FH	H	FH
AM_{222}	H	FH	FH	H	FH	M	M	H	H	FH	FH	VH
AM_{311}	VH	M	H	FH	H	M	FH	FH	H	H	FH	H
AM_{312}	VH	FH	FH	FH	FH	M	FH	H	H	FH	FH	VH
AM_{313}	VH	FH	FH	FH	FH	M	FL	H	FH	H	FH	H
AM_{314}	VH	FH	H	M	FH	H	M	FH	H	H	FH	FH
AM_{321}	H	FH	FH	FH	H	FH	FL	H	FH	VH	FH	H
AM_{322}	H	VH	FH	FH	FH	H	FL	FH	H	VH	H	FH
AM_{323}	H	H	FH	FH	M	FH	H	FH	H	VH	H	FH
AM_{331}	VH	FH	VH	M	FH	M	H	H	FH	VH	FH	H
AM_{341}	H	M	FH	FH	M	FH	H	VH	H	FH	FH	FH
AM_{342}	H	FH	H	H	FH	H	FH	H	H	FH	H	H
AM_{343}	FH	M	H	H	FH	M	M	H	FH	H	FH	H
AM_{411}	H	M	FH	H	FH	H	H	H	H	FH	H	H
AM_{412}	H	FH	FH	M	H	FH	FL	H	H	FH	FH	H
AM_{421}	H	FH	H	M	H	M	H	FH	H	FH	FH	FH
AM_{511}	H	VH	H	M	FH	FH	FH	FH	H	H	FH	H
AM_{512}	H	FH	H	FH	H	M	H	FH	H	FH	H	FH
AM_{521}	FH	FH	H	H	M	FH	FH	H	H	FH	H	H
AM_{522}	FH	M	H	H	FH	M	H	FH	FH	H	FH	FH
AM_{523}	FH	H	FH	FH	H	M	FH	H	H	FH	FH	H
AM_{531}	FH	H	M	FH	FH	FH	M	FH	H	FH	H	H
AM_{541}	H	H	H	H	M	FH	FH	H	H	FH	H	FH
AM_{542}	H	H	H	H	FH	FH	FH	H	H	H	FH	FH
AM_{543}	H	FH	H	FH	M	H	FH	FH	FH	H	H	H

Table 4.21 Collected performance rating for attributes of construction project management agility of company C

AM_{ijk}	O_{ijk}											
	PM_1	PM_2	PM_3	PM_4	PM_5	PM_6	PM_7	PM_8	PM_9	PM_{10}	PM_{11}	PM_{12}
AM_{111}	P	F	P	VP	P	P	P	F	P	VP	F	F
AM_{112}	P	VP	P	P	F	P	VP	F	P	F	F	P
AM_{113}	F	F	VP	P	P	VP	P	P	VP	F	P	F
AM_{121}	P	P	VP	P	P	P	F	G	P	VP	P	F
AM_{122}	P	F	VP	F	F	VP	P	F	P	P	VP	F
AM_{123}	P	F	P	VP	F	F	P	F	F	F	P	F
AM_{131}	F	P	P	VP	VP	F	P	P	VP	P	P	F
AM_{132}	P	P	P	P	P	P	P	P	P	F	P	F
AM_{133}	G	F	P	F	P	F	P	P	P	F	P	F
AM_{134}	F	P	P	F	VP	P	F	VP	F	F	P	P
AM_{135}	P	VP	P	P	F	P	P	VP	P	F	P	P
AM_{211}	F	P	VP	F	P	F	P	VP	F	F	VP	P
AM_{212}	F	F	P	VP	P	P	F	P	P	F	P	F
AM_{221}	VP	F	P	VP	P	VP	F	P	VP	P	VP	VP
AM_{222}	F	VP	VP	P	F	P	F	P	VP	P	P	F
AM_{311}	F	VP	VP	P	P	VP	P	P	VP	P	P	F
AM_{312}	P	VP	P	VP	P	P	P	F	P	P	G	F
AM_{313}	P	P	VP	P	P	P	P	P	P	VP	P	G
AM_{314}	F	P	F	P	P	P	F	P	P	F	P	F
AM_{321}	P	P	P	VP	P	P	P	F	P	VP	P	P
AM_{322}	F	VP	VP	P	P	P	P	P	P	P	VP	P
AM_{323}	VP	F	VP	F	P	P	VP	P	P	F	F	P
AM_{331}	F	VP	F	P	VP	F	P	P	P	F	P	F
AM_{341}	P	P	VP	P	P	F	VP	F	P	F	P	F
AM_{342}	P	F	F	P	VP	P	P	P	P	F	P	F
AM_{343}	P	F	VP	P	P	VP	F	P	P	F	P	F
AM_{411}	F	P	VP	F	P	F	VP	P	F	P	VP	F
AM_{412}	P	F	P	VP	P	P	F	P	F	VP	P	F
AM_{421}	P	VP	P	F	P	P	VP	P	P	F	VP	F
AM_{511}	P	VP	VP	F	VP	P	P	VP	P	F	P	F
AM_{512}	P	F	VP	F	P	VP	P	P	VP	P	P	F
AM_{521}	F	P	P	P	F	VP	P	P	P	VP	P	F
AM_{522}	F	P	F	P	P	VP	F	P	F	VP	P	F
AM_{523}	F	P	VP	P	VP	P	P	F	VP	F	P	P
AM_{531}	P	VP	P	P	P	VP	P	P	F	VP	P	P
AM_{541}	P	VP	P	F	P	P	P	F	P	F	P	F
AM_{542}	P	VP	P	P	VP	VP	P	F	P	F	P	F
AM_{543}	P	VP	P	W	F	VP	P	F	P	VP	P	F

Fuzzy mathematical calculations

Fuzzy mathematical calculations are performed on the above observed importance and performance rating and agility of the real estate company's project management is determined. The details regarding each of these steps are discussed below.

Step 1; Calculation of average fuzzy importance weights and average performance ratings; - Average importance weights and performance ratings were calculated by using equation 3.2 and 3.3 respectively. The results of calculated average fuzzy importance weights and performance ratings of company C are presented below in Table 4.22.

For example, - Average fuzzy importance weight of attribute Decentralized management structure

(AM_{111}) = [(0.7, 0.8, 0.9) + (0.3, 0.5, 0.7) + (0.7, 0.8, 0.9) +(0.3, 0.5, 0.7) + (0.5, 0.65, 0.8) + (0.5, 0.65, 0.8) +(0.2, 0.35, 0.5) + (0.5, 0.65, 0.8) + (0.7, 0.8, 1) +(0.85, 0.95, 1) + (0.5, 0.65, 0.8) + (0.5, 0.65, 0.8)/12] = (0.52, 0.66,0.81)

Average fuzzy performance rate of attribute Decentralized management structure =

(AM_{111}) = [(2, 3.5, 5) + (3, 5, 7) + (2, 3.5, 5) +(1, 2, 3) + (2, 3.5, 5) + (2, 3.5, 5) + (2, 3.5, 5) + (3, 5, 7) + (2, 3.5, 5) + (1, 2, 3) + (3, 5, 7) + (3, 5, 7)]/12 = (2.17, 3.75, 5.33)

Average fuzzy importance weight of criteria Management structure =

(AM_{11}) = [(0.5, 0.65, 0.8) + (0.3, 0.5, 0.7) + (0.85, 0.95, 1) + (0.3, 0.5, 0.7) + (0.7, 0.8, 0.9) + (0.3, 0.5, 0.7) +(0.5, 0.65, 0.8) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) + (0.5, 0.65, 0.8) +(0.5, 0.65, 0.8) + (0.5, 0.65, 0.8)/12] = (0.51, 0.66, 0.81)

Average fuzzy importance weight of enabler Agility through management =

(AM_{1}) = [(0.7,0.8,0.9) + (0.3,0.5,0.7) + (0.5,0.65,0.8) + (0.2,0.35,0.5) +(0.3, 0.5, 0.7) + (0.7, 0.8, 0.9) +(0.5, 0.65, 0.8) + (0.5, 0.65, 0.8) + (0.5, 0.65, 0.8) + (0.7, 0.8, 0.9) +(0.5, 0.65, 0.8) + (0.7,0.8, 0.9)]/12 = (0.51,0.65,0.79)

Table 4.22 Average importance weight of enablers, criteria, attributes, and performance average Rating of attributes of company C

Enabler	Importance average weight of enabler	Criteria	Importance average weight of Criteria	Attribute	Attributes importance average weight	Fuzzy performance average rating
AM_1	(0.51,0.65,0.79)	AM_{11}	(0.51, 0.66, 0.81)	AM_{111}	(0.52, 0.66,0.81)	(2.17, 3.75, 5.33)
				AM_{112}	(0.55, 0.69, 0.83)	(2.08, 3.63, 5.17)
				AM_{113}	(0.56, 0.70, 0.83)	(2.08, 3.63, 5.17)
		AM_{12}	(0.50, 0.65, 0.80)	AM_{121}	(0.50, 0.64, 0.77)	(2.17, 3.63, 5.08)
				AM_{122}	(0.51, 0.65, 0.78)	(2.17, 3.75, 5.33)
				AM_{123}	(0.57, 0.70, 0.83)	(2.17, 3.75, 5.33)
		AM_{13}	(0.49, 0.64, 0.78)	AM_{131}	(0.47, 0.63, 0.78)	(2.00, 3.50, 5.00)
				AM_{132}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)
				AM_{133}	(0.54, 0.69, 0.83)	(2.67, 4.38, 6.08)
				AM_{134}	(0.56, 0.70, 0.83)	(2.25, 3.88, 5.50)
				AM_{135}	(0.58, 0.71, 0.84)	(2.00, 3.50, 5.00)
AM_2	(0.57, 0.70, 0.83)	AM_{21}	(0.58, 0.71, 0.84)	AM_{211}	(0.60, 0.73, 0.85)	(2.17, 3.75, 5.33)
				AM_{212}	(0.55, 0.69, 0.83)	(2.33, 4.00, 5.67)
		AM_{22}	(0.57, 0.70, 0.83)	AM_{221}	(0.56, 0.70, 0.83)	(1.75, 3.13, 4.50)
				AM_{222}	(0.56, 0.70, 0.83)	(2.00, 3.50, 5.00)
AM_3	(0.55, 0.62, 0.83)	AM_{31}	(0.60, 0.73, 0.85)	AM_{311}	(0.58, 0.71, 0.84)	(1.75, 3.13, 4.50)
				AM_{312}	(0.58, 0.71,0.84)	(1.92, 3.25, 4.58)
				AM_{313}	(0.54, 0.68, 0.81)	(1.83, 3.25, 4.67)
				AM_{314}	(0.56, 0.70, 0.83)	(2.42, 4.13, 5.83)
		AM_{32}	(0.60, 0.73, 0.85)	AM_{321}	(0.57,0.70, 0.83)	(1.92, 3.38, 4.83)
				AM_{322}	(0.60, 0.73, 0.84)	(1.75, 3.13, 4.50)
				AM_{323}	(0.59, 0.71, 0.83)	(2.08, 3.63, 5.17)
		AM_{33}	(0.58, 0.70, 0.82)	AM_{331}	(0.60, 0.74, 0.86)	(2.25, 3.88, 5.500
		AM_{34}	(0.57, 0.70, 0.83)	AM_{341}	(0.53, 0.68, 0.82)	(2.08, 3.63, 5.17)
				AM_{342}	(0.63, 0.75, 0.87)	(2.25, 3.88, 5.50)
				AM_{343}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)
AM_4	(0.69, 0.80, 0.90)	AM_{41}	(0.53, 0.68, 0.82)	AM_{411}	(0.62, 0.74, 0.86)	(2.17, 3.75, 5.33)
				AM_{412}	(0.58, 0.70, 0.83)	(2.00, 3.50, 5.00)
		AM_{42}	(0.53, 0.68, 0.82)	AM_{421}	(0.50, 0.65, 0.80)	(2.00, 3.50, 5.00)
AM_5	(0.63, 0.68, 0.87)	AM_{51}	(0.54, 0.68, 0.81)	AM_{511}	(0.60, 0.73, 0.85)	(1.92, 3.38, 4.83)
				AM_{512}	(0.58, 0.71, 0.84)	(2.17, 3.75, 5.33)
		AM_{52}	(0.58, 0.70, 0.83)	AM_{521}	(0.58, 0.71, 0.84)	(2.08, 3.63, 5.17)
				AM_{522}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)
				AM_{523}	(0.57, 0.70, 0.83)	(2.00, 3.50, 5.00)
		AM_{53}	(0.58, 0.71, 0.84)	AM_{531}	(0.53, 0.68, 0.82)	(1.83, 3.25, 4.67)
		AM_{54}	(0.55, 0.69, 0.83)	AM_{541}	(0.60, 0.73, 0.85)	(2.17, 3.75, 5.33)
				AM_{541}	(0.63, 0.75, 0.87)	(1.92, 3.38, 4.83)
				AM_{543}	(0.58, 0.71, 0.84)	(1.83, 3.25, 4.68)

Step 2; -In this step, the aggregate performance ratings of the attributes is translated into criteria rating and the criteria rating is translated into enabler rating using equation 3.4 and 3.5. respectively.

For example, the fuzzy index of performance rating of criteria O_{11} (AM_{11}) =

$$\frac{[(0.52, 0.66,0.81) * (2.17, 3.75, 5.33) + (0.55, 0.69, 0.83) * (2.08, 3.63, 5.17) + (0.56, 0.70, 0.83) * (2.08, 3.63, 5.17)]}{(0.52, 0.66,0.81) + (0.55, 0.69, 0.83) + (0.56, 0.70, 0.83)}$$

= (2.11, 3.67, 5.22)

The aggregated performance ratings of the attributes are translated into criteria rating and the criteria rating company C is illustrated below in Table 4.23.

Equation (3.5) is employed to calculate the fuzzy index performance rating of the enablers the Fuzzy index of project management agility of enablers rating of company C is illustrated in Table 4.24.

For example, the fuzzy index of performance rating of enabler O_1(AM_{11}) =

$$\frac{(2.11, 3.67, 5.22) * (0.51, 0.66, 0.81) + (2.17, 3.71, 5.21) * (0.50, 0.65, 0.80) + (2.22,3.80, 5.39) * (0.49, 0.64, 0.78)}{(0.51, 0.66, 0.81) + (0.50, 0.65, 0.80) + (0.49, 0.64, 0.78)}$$

= (2.16, 3.73, 5.27)

Table 4.23 Fuzzy index of project management agility of criteria rating of company C

Criteria	Attribute	Attributes importance average weight	Fuzzy performance average rating	Criteria fuzzy rating
AM_{11}	AM_{111}	(0.52, 0.66,0.81)	(2.17, 3.75, 5.33)	(2.11, 3.67, 5.22)
	AM_{112}	(0.55, 0.69, 0.83)	(2.08, 3.63, 5.17)	
	AM_{113}	(0.56, 0.70, 0.83)	(2.08, 3.63, 5.17)	
AM_{12}	AM_{121}	(0.50, 0.64, 0.77)	(2.17, 3.63, 5.08)	(2.17, 3.71, 5.21)
	AM_{122}	(0.51, 0.65, 0.78)	(2.17, 3.75, 5.33)	
	AM_{123}	(0.57, 0.70, 0.83)	(2.17, 3.75, 5.33)	
AM_{13}	AM_{131}	(0.47, 0.63, 0.78)	(2.00, 3.50, 5.00)	(2.22,3.80, 5.39)
	AM_{132}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)	
	AM_{133}	(0.54, 0.69, 0.83)	(2.67, 4.38, 6.08)	
	AM_{134}	(0.56, 0.70, 0.83)	(2.25, 3.88, 5.50)	
	AM_{135}	(0.58, 0.71, 0.84)	(2.00, 3.50, 5.00)	
AM_{21}	AM_{211}	(0.60, 0.73, 0.85)	(2.17, 3.75, 5.33)	(2.25, 3.87, 5.50)
	AM_{212}	(0.55, 0.69, 0.83)	(2.33, 4.00, 5.67)	
AM_{22}	AM_{221}	(0.56, 0.70, 0.83)	(1.75, 3.13, 4.50)	(1.88, 2.44, 4.75)
	AM_{222}	(0.56, 0.70, 0.83)	(2.00, 3.50, 5.00)	
AM_{31}	AM_{311}	(0.58, 0.71, 0.84)	(1.75, 3.13, 4.50)	(1.98,3.4, 4.90)
	AM_{312}	(0.58, 0.71,0.84)	(1.92, 3.25, 4.58)	
	AM_{313}	(0.54, 0.68, 0.81)	(1.83, 3.25, 4.67)	
	AM_{314}	(0.56, 0.70, 0.83)	(2.42, 4.13, 5.83)	
AM_{32}	AM_{321}	(0.57,0.70, 0.83)	(1.92, 3.38, 4.83)	(1.92, 3.37, 4.83)
	AM_{322}	(0.60, 0.73, 0.84)	(1.75, 3.13, 4.50)	
	AM_{323}	(0.59, 0.71, 0.83)	(2.08, 3.63, 5.17)	
AM_{33}	AM_{331}	(0.60, 0.74, 0.86)	(2.25, 3.88, 5.500	(2.25, 3.79, 5.50)
AM_{34}	AM_{341}	(0.53, 0.68, 0.82)	(2.08, 3.63, 5.17)	(2.17, 3.75, 5.34)
	AM_{342}	(0.63, 0.75, 0.87)	(2.25, 3.88, 5.50)	
	AM_{343}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)	
AM_{41}	AM_{411}	(0.62, 0.74, 0.86)	(2.17, 3.75, 5.33)	(2.09, 3.63, 5.17)
	AM_{412}	(0.58, 0.70, 0.83)	(2.00, 3.50, 5.00)	
AM_{42}	AM_{421}	(0.50, 0.65, 0.80)	(2.00, 3.50, 5.00)	(2.00, 3.50, 5.00)
AM_{51}	AM_{511}	(0.60, 0.73, 0.85)	(1.92, 3.38, 4.83)	(2.04, 3.56, 5.08)
	AM_{512}	(0.58, 0.71, 0.84)	(2.17, 3.75, 5.33)	
AM_{52}	AM_{521}	(0.58, 0.71, 0.84)	(2.08, 3.63, 5.17)	(2.08, 3.62, 5.17)
	AM_{522}	(0.53, 0.68, 0.82)	(2.17, 3.75, 5.33)	
	AM_{523}	(0.57, 0.70, 0.83)	(2.00, 3.50, 5.00)	
AM_{53}	AM_{531}	(0.53, 0.68, 0.82)	(1.83, 3.25, 4.67)	(1.83, 3.25, 4.67)
AM_{54}	AM_{541}	(0.60, 0.73, 0.85)	(2.17, 3.75, 5.33)	(1.97, 3.46, 4.95)
	AM_{542}	(0.63, 0.75, 0.87)	(1.92, 3.38, 4.83)	
	AM_{543}	(0.58, 0.71, 0.84)	(1.83, 3.25, 4.68)	

Table 4.24 Fuzzy index of project management agility of enablers rating of company C

Enabler	Criteria	Criteria Rating calculated	Criteria Weights Average (collected)	Enabler Rating
AM_1	AM_{11}	(2.11, 3.67, 5.22)	(0.51, 0.66, 0.81)	(2.16, 3.73, 5.27)
	AM_{12}	(2.17, 3.71, 5.21)	(0.50, 0.65, 0.80)	
	AM_{13}	(2.22,3.80, 5.39)	(0.49, 0.64, 0.78)	
AM_2	AM_{21}	(2.25, 3.87, 5.50)	(0.58, 0.71, 0.84)	(2.30, 3.45, 5.46)
	AM_{22}	(1.88, 2.44, 4.75)	(0.57, 0.70, 0.83)	
AM_3	AM_{31}	(1.98,3.4, 4.90)	(0.60, 0.73, 0.85)	(2.82, 3.58, 5.82)
	AM_{32}	(1.92, 3.37, 4.83)	(0.60, 0.73, 0.85)	
	AM_{33}	(2.25, 3.79, 5.50)	(0.58, 0.70, 0.82)	
	AM_{34}	(2.17, 3.75, 5.34)	(0.57, 0.70, 0.83)	
AM_4	AM_{41}	(2.09, 3.63, 5.17)	(0.53, 0.68, 0.82)	(2.04, 3.56, 5.08)
	AM_{42}	(2.00, 3.50, 5.00)	(0.53, 0.68, 0.82)	
AM_5	AM_{51}	(2.04, 3.56, 5.08)	(0.54, 0.68, 0.81)	(2.67, 3.47, 4.96)
	AM_{52}	(2.08, 3.62, 5.17)	(0.58, 0.70, 0.83)	
	AM_{53}	(1.83, 3.25, 4.67)	(0.58, 0.71, 0.84)	
	AM_{54}	(1.97, 3.46, 4.95)	(0.55, 0.69, 0.83)	

Step 3; - The next step is to compute the Fuzzy Agility Measure Index (FAMI) with equation 3.6. After determination of enabler rating the Fuzzy Agility Measure Index (FAMI) is calculated as; -

Fuzzy Agility Measure Index of real estate company C =

(2.16, 3.73, 5.27) * (0.51,0.65,0.79) + (2.30, 3.45, 5.46) * (0.57, 0.70, 0.83) + (2.82, 3.58, 5.82) * (0.55, 0.62, 0.83)+(2.04, 3.56, 5.08)*(0.69, 0.80, 0.90) + (2.67, 3.47, 4.96) * (0.68, 0.75, 0.90)]/(0.51,0.65,0.79)+ (0.57, 0.70, 0.83) + (0.55, 0.62, 0.83) + (0.69, 0.80, 0.90) + (0.63, 0.68, 0.87) = (2.39, 2.86, 5.31)

Final calculated Fuzzy Agility Measure Index (FAMI) of company C is presented in Table 4.25 below.

Table 4.25 Fuzzy project management agility measurement index of company C

Enabler	Enabler Rating	Importance average weight of enabler (collected)	Fuzzy Agility Measure Index (FAMI)
AM_1	(2.16, 3.73, 5.27)	(0.51,0.65,0.79)	(2.39, 2.86, 5.31)
AM_2	(2.30, 3.45, 5.46)	(0.57, 0.70, 0.83)	
AM_3	(2.82, 3.58, 5.82)	(0.55, 0.62, 0.83)	
AM_4	(2.04, 3.56, 5.08)	(0.69, 0.80, 0.90)	
AM_5	(2.67, 3.47, 4.96)	(0.63, 0.68, 0.87)	

$FAMI$ of company C = (2.39, 2.86, 5.31)

Step 4; - The FAMI is evaluated by comparing Euclidean distance method to the linguistic general term. So, the distance between the fuzzy number fuzzy-agility-index (FAI) and each fuzzy number member can be calculated as below by using equation 3.7.

DFAMI (EA) = $\sqrt{(2.39-7)^2+(2.86-8.5)^2+(7.01-10)^2}$ = 7.87

DFAMI (VA) = $\sqrt{(2.39-5.5)^2+(2.86-7)^2+(5.31-8.5)^2}$ = 10.82

DFAMI (A) = $\sqrt{(2.39-3.5)^2+(2.86-5)^2+(5.31-6.5)^2}$ = 3.96

DFAMI (FA) = $\sqrt{(2.39-1.5)^2+(2.86-3)^2+(5.31-4.5)^2}$ = 1.21

DFAMI (SA) = $\sqrt{(2.39-0)^2+(2.86-1.5)^2+(5.31-3)^2}$ = 3.6

Real estate construction project management agility of company can be determined by minimum D value. Which is 1.21.

The current project management agility level of real estate company C is “Fairly Agile” which is below average in relation to the Agility Labels. Figure 4.10 shows the Linguistic matches of fuzzy agility level of company. The black and shaded line shows the current company’s project management fuzzy agility level.

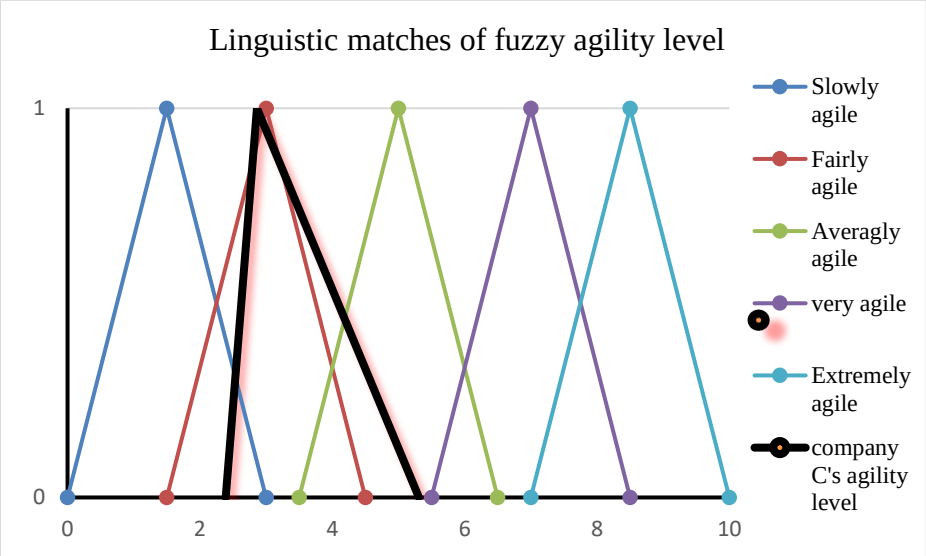

Figure 4.10 Linguistic matches of fuzzy project management agility level of company C

4.4. Identification of Attributes that Influence Agility of Project Management in Real Estate Construction Companies.

4.4.1. Identification of Attributes That Influence Agility of Project Management in Company A.

Step 1; - Fuzzy performance importance index (FPII) is calculated to categorize weaker attributes by using equation 3.8 and the ranking scores of each attribute can be calculated by using equation 3.9. The calculated FPII and ranking scores are illustrated in Table 4.26.

The sample calculation of FPII for (AM_{111})

W_{111}= (1, 1, 1) - (0.69,0.80,0.90) = (0.31, 0.20, 0.10)

FPII for (AM_{111}) = (0.31, 0.20, 0.10) * (4.46, 5.63, 6.75) = (1.39, 1.13, 0.68)

The sample calculation of ranking score for (AM_{111}) = $\frac{1.39+4*1.13+0.68}{6} = 1.1$

Step 2; After obtaining the ranking scores the management threshold is fixed with the Pareto principle least 20% to acquire weaker attributes as shown in Figure 4.11.

Based on the pareto principle, the researcher focused on the critical factors and set a scale of one as the management threshold for identifying the factors requiring most urgent improvement it is found out these ten attributes; - transparency in information sharing, participative management style, having backup plan, work-breakdown and follow specification, productivity linked to every personnel prosperity, usage of TQM tools, continuous learning, survey studies to ensure quality status constantly, project information and electronic records, employee satisfaction are weaker attributes that affect project management agility of company A.

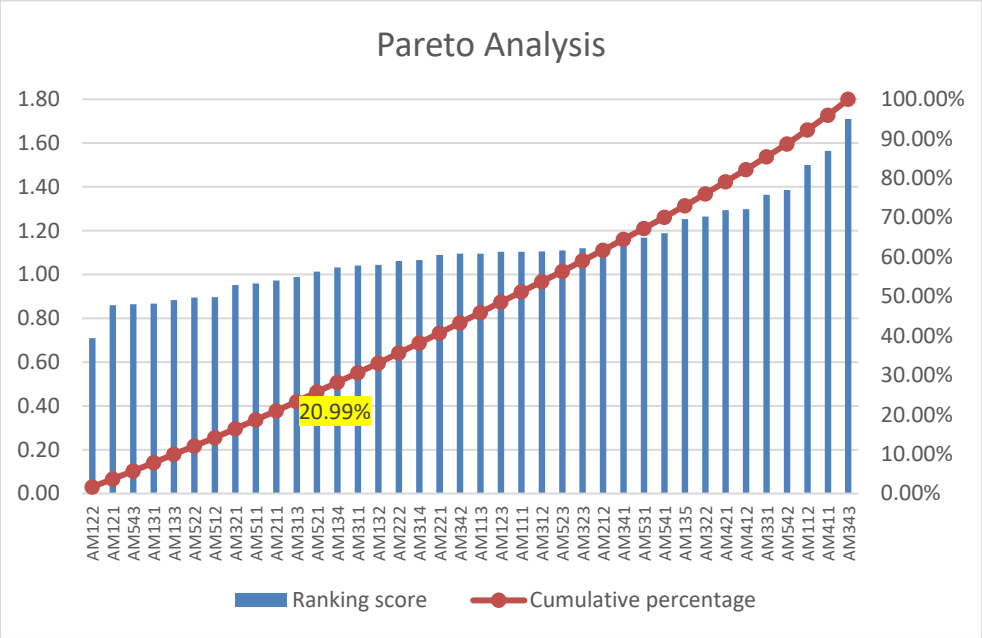

Figure 4.11 Pareto analysis chart for company A

Table 4.26 FPII and the ranking score of project management agility attributes in current level of company A

	Fuzzy performance average rating	Wijk = (1, 1, 1)-Oijk	FPII	Ranking score
AM_{111}	(4.46, 5.63, 6.75)	(0.31, 0.20, 0.10)	(1.39, 1.13, 0.68)	1.1
AM_{112}	(5.17, 6.50, 7.75)	(0.36, 0.24, 0.13)	(1.85, 1.54, 0.97)	1.50
AM_{113}	(3.75, 5.13, 6.50)	(0.33, 0.23, 0.12)	(1.25, 1.15, 0.76)	1.10
AM_{121}	(4.00, 5.50, 7.00)	(0.27, 0.16, 0.08)	(1.08, 0.89, 0.53)	0.86
AM_{122}	(2.88,4.25,5.63)	(0.28, 0.18, 0.08)	(0.81, 0.74, 0.47)	0.71
AM_{123}	(4.21, 5.75 ,7.25)	(0.31, 0.20, 0.10)	(1.30, 1.15, 0.72)	1.10
AM_{131}	(4.13, 5.50, 6.83)	(0.27, 0.16, 0.08)	(1.12, 0.89, 0.51)	0.87
AM_{132}	(3.67, 5.13, 6.58)	(0.33, 0.21, 0.11)	(1.19, 1.09, 0.71)	1.04
AM_{133}	(4.21, 5.63, 7.00)	(0.27, 0.16, 0.07)	(1.12, 0.91, 0.52)	0.88
AM_{134}	(3.88,5.38, 6.83)	(0.31, 0.20, 0.10)	(1.21, 1.08, 0.68)	1.03
AM_{135}	(4.38, 5.75, 7.08)	(0.35, 0.23, 0.12)	(1.51, 1.29, 0.83)	1.25
AM_{211}	(4.29, 5.75, 7.17)	(0.28, 0.18, 0.08)	(1.22, 1.01, 0.60)	0.97
AM_{212}	(4.04, 5.50, 6.92)	(0.32, 0.21, 0.11)	(1.30, 1.17, 0.75)	1.12
AM_{221}	(4.13, 5.63, 7.08)	(0.31, 0.20, 0.11)	(1.27, 1.13, 0.77)	1.09
AM_{222}	(4.38, 5.88, 7.33)	(0.30, 0.19, 0.09)	(1.29, 1.10, 0.67)	1.06
AM_{311}	(4.79, 6.13, 7.42)	(0.28, 0.18, 0.08)	(1.34, 1.07, 0.62)	1.04
AM_{312}	(4.38, 5.75, 7.08)	(0.31, 0.20, 0.10)	(1.35, 1.15, 0.71)	1.11
AM_{313}	(4.88, 6.25, 7.58)	(0.27, 0.16, 0.07)	(1.30, 1.02, 0.57)	1.18
AM_{314}	(4.96, 6.25,7.42)	(0.28, 0.18, 0.08)	(1.40, 1.09, 0.62)	1.07
AM_{321}	(4.08, 5.21, 6.33)	(0.30, 0.19, 0.09)	(1.23, 0.98, 0.58)	0.95
AM_{322}	(4.83, 6.13, 7.33)	(0.33, 0.21, 0.11)	(1.59, 1.30, 0.79)	1.27
AM_{323}	(4.83, 6.13, 7.33)	(0.30, 0.19, 0.09)	(1.47, 1.15, 0.67)	1.12
AM_{331}	(4.46,5.88, 7.25)	(0.35, 0.24, 0.14)	(1.58, 1.40, 1.03)	1.36
AM_{341}	(3.83, 5.38, 6.92)	(0.35, 0.23, 0.12)	(1.33, 1.21, 0.81)	1.16
AM_{342}	(4.58, 6.00, 7.33)	(0.30, 0.19, 0.09)	(1.39, 1.13, 0.67)	1.09
AM_{343}	(4.75, 6.13 ,7.42)	(0.42, 0.29, 0.17)	(1.98, 1.76, 1.24)	1.78
AM_{411}	(5.46,6.75,7.92)	(0.36, 0.24, 0.13)	(1.98, 1.60, 0.99)	1.56
AM_{412}	(4.29, 5.63, 6.96)	(0.35, 0.24, 0.13)	(1.52, 1.34, 0.93)	1.30
AM_{421}	(4.83, 6.25 ,7.58)	(0.34, 0.21, 0.11)	(1.63, 1.33, 0.82)	1.29
AM_{511}	(4.33, 5.63, 6.8)	(0.29, 0.18, 0.08)	(1.25, 0.98, 0.57)	0.96
AM_{512}	(3.42, 5.00 ,6.58)	(0.30, 0.19, 0.09)	(1.03, 0.94, 0.60)	0.90
AM_{521}	(3.54, 4.96, 6.33)	(0.33, 0.21, 0.11)	(1.18, 1.05, 0.69)	1.18
AM_{522}	(3.92, 5.25 ,6.58)	(0.29, 0.18, 0.08)	(1.14, 0.92, 0.55)	0.89
AM_{523}	(3.50, 4.83, 6.17)	(0.36, 0.24, 0.13)	(1.27, 1.15, 0.77)	1.11
AM_{531}	(3.33, 4.88, 6.42)	(0.37, 0.25, 0.14)	(1.22, 1.22, 0.91)	1.17
AM_{541}	(3.96, 5.50, 7.00)	(0.35, 0.23, 0.12)	(1.37, 1.24, 0.82)	1.19
AM_{542}	(3.96, 5.50, 7.00)	(0.39, 0.26, 0.14)	(1.55, 1.44, 0.99)	1.39
AM_{543}	(2.75, 4.25, 5.79)	(0.33, 0.21, 0.11)	(0.92, 0.90, 0.63)	0.86

4.4.2. Identification of Attributes that Influence Agility of Project Management in Company B.

Step 1; - Fuzzy performance importance index (FPII) is calculated to categorize weaker attributes by using equation 3.8 and ranking scores of each attribute was calculated by using equation 3.9. The calculated FPII and ranking scores are illustrated in Table 4.27.

The sample calculation of FPII for (AM_{111})

W_{111}= (1, 1, 1) - (0.65, 0.78, 0.88) = (0.35, 0.22, 0.12)

FPII for (AM_{111}) = (0.35, 0.22, 0.12) * (4.38, 5.88, 7.25) = (1.53, 1.32, 0.85)

The sample calculation of ranking score for (AM_{111}) = $\frac{1.53+4*1.32+0.85}{6}$ = 1.28

Step 2; - After obtaining the ranking scores the management threshold is fixed with the Pareto principle least 20% to acquire weaker attributes as shown in Figure 4.12. Based on the pareto principle, the researcher focused on the critical factors and set a scale of 1.11 as the management threshold for identifying the factors requiring most urgent improvement it is found out these eleven attributes; survey study to check status of productivity regularly, productivity improvement in all functions, monitoring and evaluating work progress, training program on time management concepts, regular meetings with the client project, information and electronic records, empowered individuals working in teams, responsiveness to external change, financial management system, technology-based scheduling system, transparency in information sharing are weaker areas for improvement and needs managerial attention.

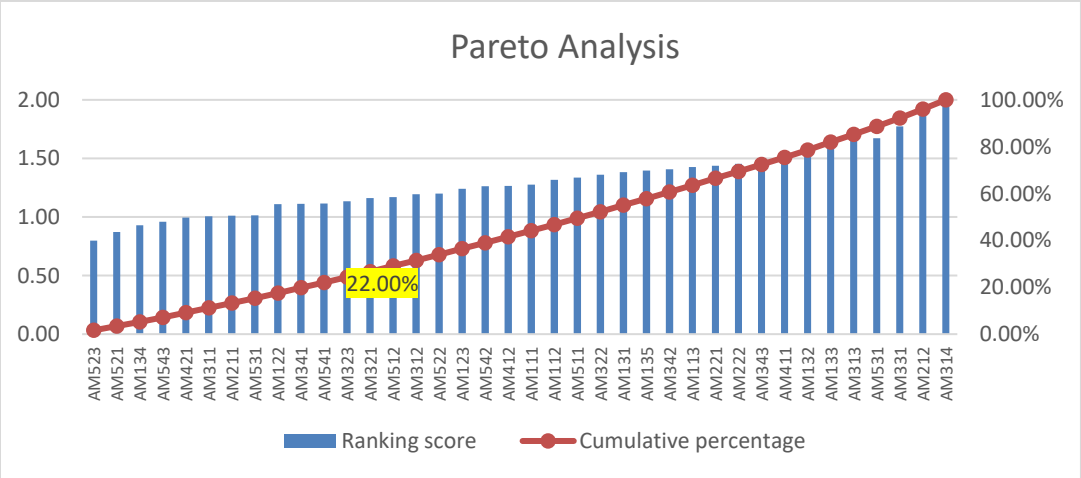

Figure 4.12 Pareto analysis chart for company B

Table 4.27 FPII and the ranking score of project management agility attributes in current level of company B

	Fuzzy performance average rating	W_{ijk} = (1, 1, 1)-O_{ijk}	FPII	Ranking score
AM_{111}	(4.38, 5.88, 7.25)	(0.35, 0.23, 0.12)	(1.53, 1.32, 0.85)	1.28
AM_{112}	(4.63, 6.00, 7.33)	(0.34, 0.23, 0.13)	(1.58, 1.35, 0.92)	1.32
AM_{113}	(4.38, 5.88, 7.33)	(0.38, 0.25, 0.14)	(1.64, 1.47, 1.04)	1.43
AM_{121}	(4.54, 5.88, 7.17)	(0.39, 0.26, 0.15)	(1.78, 1.54, 1.08)	1.67
AM_{122}	(5.17, 6.50, 7.75)	(0.32, 0.20, 0.10)	(1.43, 1.14 0.69)	1.11
AM_{123}	(3.50, 4.88, 6.25)	(0.38, 0.26, 0.16)	(1.34, 1.28, 0.99)	1.24
AM_{131}	(3.83, 5.50, 7.17)	(0.39, 0.26, 0.14)	(1.50, 1.44, 1.02)	1.38
AM_{132}	(3.96, 5.38, 6.75)	(0.43, 0.30, 0.18)	(1.72, 1.61, 1.18)	1.56
AM_{133}	(4.29, 5.88, 7.42)	(0.43, 0.29, 0.16)	(1.84, 1.69, 1.17)	1.63
AM_{134}	(4.13, 5.50, 6.83)	(0.28, 0.18, 0.08)	(1.15, 0.96, 0.57)	0.93
AM_{135}	(5.00, 6.38, 7.67)	(0.35, 0.23, 0.12)	(1.75, 1.43, 0.89)	1.40
AM_{211}	(4.04, 5.63, 7.17)	(0.30, 0.19, 0.09)	(1.21, 1.05, 0.66)	1.01
AM_{212}	(3.42, 5.00, 6.58)	(0.52, 0.39, 0.26)	(1.77, 1.94, 1.73)	1.87
AM_{221}	(5.17, 6.50, 7.75)	(0.34, 0.23, 0.13)	(1.74, 1.46, 1.03)	1.44
AM_{222}	(4.58, 6.00, 7.42)	(0.38, 0.25, 0.13)	(1.74, 1.50, 0.99)	1.45
AM_{311}	(3.88, 5.21, 6.50)	(0.31, 0.20, 0.10)	(1.21, 1.04, 0.65)	1.00
AM_{312}	(3.46, 5.00, 6.50)	(0.38, 0.25, 0.13)	(1.30, 1.25, 0.87)	1.19
AM_{313}	(4.38, 5.75, 7.08)	(0.43, 0.30, 0.18)	(1.90, 1.73, 1.24)	1.67
AM_{314}	(4.29, 5.75, 7.17)	(0.48, 0.35, 0.23)	(2.07, 2.01, 1.61)	1.98
AM_{321}	(4.21, 5.63, 7.00)	(0.34, 0.21, 0.11)	(1.44, 1.20, 0.76)	1.16
AM_{322}	(4.79, 6.25, 7.58)	(0.35, 0.23, 0.12)	(1.66, 1.41, 0.88)	1.36
AM_{323}	(4.13, 5.50, 6.83)	(0.34, 0.21, 0.11)	(1.39, 1.17, 0.74)	1.13
AM_{331}	(4.29, 5.88, 7.42)	(0.44, 0.31, 0.19)	(1.88, 1.84, 1.42)	1.77
AM_{341}	(4.38, 5.75, 7.08)	(0.31, 0.20, 0.10)	(1.37, 1.15, 0.71)	1.11
AM_{342}	(4.71, 6.13, 7.50)	(0.36, 0.24, 0.13)	(2.19, 1.45, 0.77)	1.41
AM_{343}	(4.58, 6.00, 7.33)	(0.36, 0.25, 0.16)	(1.64, 1.50, 1.16)	1.47
AM_{411}	(5.17, 6.63, 8.00)	(0.36, 0.24, 0.13)	(1.87, 1.57, 1.00)	1.53
AM_{412}	(3.79, 5.25, 6.67)	(0.38, 0.25, 0.13)	(1.45, 1.31, 0.89)	1.27
AM_{421}	(3.42, 4.88, 6.33)	(0.33, 0.20, 0.11)	(1.14, 1.04, 0.69)	0.99
AM_{511}	(4.00, 5.50, 7.00)	(0.37, 0.25, 0.15)	(1.47, 1.38, 1.05)	1.34
AM_{512}	(3.33, 4.88, 6.42)	(0.37, 0.25, 0.14)	(1.24, 1.22, 0.91)	1.17
AM_{521}	(3.25, 4.88, 6.50)	(0.30, 0.19, 0.09)	(0.98, 0.91, 0.60)	0.87
AM_{522}	(3.42, 5.00, 6.58)	(0.37, 0.25, 0.14)	(1.27, 1.25, 0.93)	1.20
AM_{523}	(3.92, 5.50, 7.08)	(0.26, 0.15, 0.07)	(1.01, 0.83, 0.47)	0.80
AM_{531}	(3.33, 5.00, 6.67)	(0.33, 0.21, 0.11)	(1.10, 1.06, 0.72)	1.01
AM_{541}	(3.25, 4.88, 6.50)	(0.36, 0.24, 0.13)	(1.16, 1.16, 0.87)	1.11
AM_{542}	(3.75, 5.25, 6.75)	(0.38, 0.25, 0.13)	(1.42, 1.31, 0.90)	1.26
AM_{543}	(3.17, 4.75, 6.33)	(0.33, 0.21, 0.11)	(1.03, 1.01, 0.69)	0.96

4.4.3. Identification of Attributes that Influence Agility of Project Management in Company C.

Step 1; - Fuzzy performance importance index (FPII) was calculated to categorize weaker attributes by using equation 3.8 and ranking scores of each attribute by using equation 3.9. The calculated FPII and ranking scores are illustrated in Table 4.28.

The sample calculation of FPII for (AM_{111})

W_{111}= (1, 1, 1) - (0.52, 0.66, 0.81) = (0.48, 0.34, 0.19)

FPII for (AM_{111}) = (0.48, 0.34, 0.19) * (2.17, 3.75, 5.33) = (1.04, 1.27, 1.02)

The sample calculation of ranking score for (AM_{111}) = $\frac{1.04+4*1.27+1.02}{6} = 1.19$

Step 2; - After obtaining the ranking scores the management threshold is fixed with the Pareto principle least 20% to acquire weaker attributes as shown in Figure 4.13. Based on the pareto principle, the researcher focused on the critical factors and set a scale of one as the management threshold for identifying the factors requiring most urgent improvement. according to findings of this research scheduled and iterated activities, team training & education, empowered individuals working in teams, survey studies to ensure quality status constantly, training program on time management concepts, skill and knowledge enhancing ideas, cross functional team, proactive behavior, customer satisfaction, deliver the final project with little defect, continuous learning, individual/team innovation, project information and electronic records, technology-based scheduling system, technology awareness, learn from each other, productivity improvement in all functions and survey study to check status of productivity regularly are imperatives for project management agility of company C.

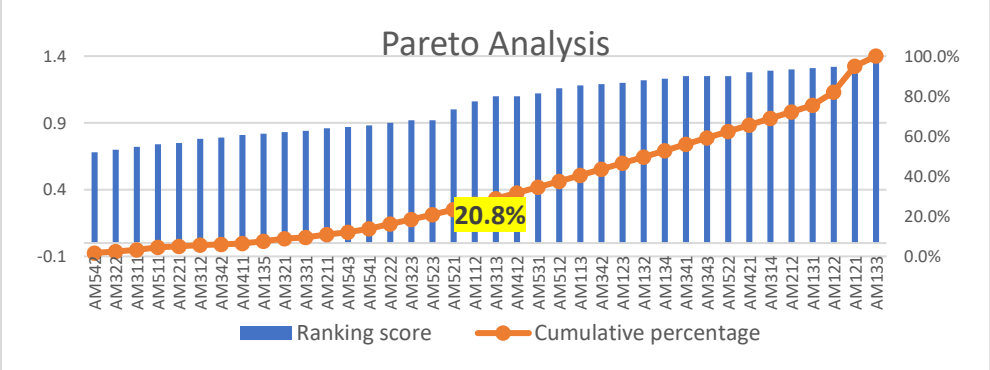

Figure 4.13 Pareto analysis for company C

Table 4.28 FPII and the ranking score of project management agility attributes in current level of company C

	Fuzzy performance average rating	W_{ijk} = (1, 1, 1)-O_{ijk}	FPII	Ranking score
AM_{111}	(2.17, 3.75, 5.33)	(0.48, 0.34, 0.19)	(1.04, 1.27, 1.02)	1.19
AM_{112}	(2.08, 3.63, 5.17)	(0.45, 0.31, 0.18)	(0.95, 1.13, 0.90)	1.06
AM_{113}	(2.08, 3.63, 5.17)	(0.44, 0.30, 0.17)	(0.92, 1.09, 0.86)	1.18
AM_{121}	(2.17, 3.63, 5.08)	(0.50, 0.36, 0.23)	(1.09, 1.31, 1.19)	1.33
AM_{122}	(2.17, 3.75, 5.33)	(0.49, 0.35, 0.22)	(1.07, 1.31, 1.16)	1.32
AM_{123}	(2.17, 3.75, 5.33)	(0.43, 0.30, 0.18)	(0.93, 1.13, 0.93)	1.2
AM_{131}	(2.00, 3.50, 5.00)	(0.53, 0.38, 0.22)	(1.07, 1.31, 1.08)	1.31
AM_{132}	(2.17, 3.75, 5.33)	(0.43, 0.30, 0.18)	(0.94, 1.13, 0.93)	1.22
AM_{133}	(2.67, 4.38, 6.08)	(0.46, 0.31, 0.18)	(1.22, 1.37, 1.06)	1.40
AM_{134}	(2.25, 3.88, 5.50)	(0.44, 0.30, 0.17)	(0.99, 1.16, 0.92)	1.23
AM_{135}	(2.00, 3.50, 5.00)	(0.43, 0.29, 0.16)	(0.85, 1.01, 0.79)	0.82
AM_{211}	(2.17, 3.75, 5.33)	(0.40, 0.28, 0.15)	(0.88, 1.03, 0.80)	0.86
AM_{212}	(2.33, 4.00, 5.67)	(0.45, 0.31, 0.18)	(1.06, 1.25, 0.99)	1.3
AM_{221}	(1.75, 3.13, 4.50)	(0.44, 0.30, 0.17)	(0.77, 0.94, 0.75)	0.75
AM_{222}	(2.00, 3.50, 5.00)	(0.44, 0.30, 0.17)	(0.88, 1.05, 0.83)	0.9
AM_{311}	(1.75, 3.13, 4.50)	(0.42, 0.29, 0.16)	(0.74, 0.90, 0.71)	0.72
AM_{312}	(1.92, 3.25, 4.58)	(0.43, 0.29, 0.16)	(0.81, 0.93, 0.73)	0.78
AM_{313}	(1.83, 3.25, 4.67)	(0.46, 0.33, 0.19)	(0.85, 1.06, 0.89)	1.1
AM_{314}	(2.42, 4.13, 5.83)	(0.44, 0.30, 0.17)	(1.06, 1.24, 0.97)	1.29
AM_{321}	(1.92, 3.38, 4.83)	(0.43, 0.30, 0.18)	(0.82, 1.01, 0.85)	0.83
AM_{322}	(1.75, 3.13, 4.50)	(0.40, 0.28, 0.16)	(0.70, 0.86, 0.71)	0.7
AM_{323}	(2.08, 3.63, 5.17)	(0.41, 0.29, 0.17)	(0.86, 1.04, 0.86)	0.92
AM_{331}	(2.25, 3.88, 5.500	(0.40, 0.26, 0.14)	(0.89, 1.02, 0.78)	0.84
AM_{341}	(2.08, 3.63, 5.17)	(0.47, 0.33, 0.18)	(0.98, 1.18, 0.95)	1.25
AM_{342}	(2.25, 3.88, 5.50)	(0.37, 0.25, 0.13)	(0.83, 0.97, 0.73)	0.79
AM_{343}	(2.17, 3.75, 5.33)	(0.47, 0.33, 0.18)	(1.01, 1.22, 0.98)	1.25
AM_{411}	(2.17, 3.75, 5.33)	(0.38, 0.26, 0.14)	(0.83, 0.98, 0.76)	0.81
AM_{412}	(2.00, 3.50, 5.00)	(0.43, 0.30, 0.18)	(0.85, 1.05, 0.87)	1.1
AM_{421}	(2.00, 3.50, 5.00)	(0.50, 0.35, 0.20)	(1.00, 1.23, 1.00)	1.28
AM_{511}	(1.92, 3.38, 4.83)	(0.40, 0.28, 0.15)	(0.77, 0.93, 0.73)	0.74
AM_{512}	(2.17, 3.75, 5.33)	(0.42, 0.29, 0.16)	(0.90, 1.08, 0.84)	1.16
AM_{521}	(2.08, 3.63, 5.17)	(0.42, 0.29, 0.16)	(0.87, 1.04, 0.82)	1.00
AM_{522}	(2.17, 3.75, 5.33)	(0.47, 0.33, 0.18)	(1.01, 1.22, 0.98)	1.25
AM_{523}	(2.00, 3.50, 5.00)	(0.43, 0.30, 0.17)	(0.87, 1.05, 0.83)	0.92
AM_{531}	(1.83, 3.25, 4.67)	(0.47, 0.33, 0.18)	(0.86, 1.06, 0.86)	1.12
AM_{541}	(2.17, 3.75, 5.33)	(0.40, 0.28, 0.15)	(0.87, 1.03, 0.80)	0.88
AM_{542}	(1.92, 3.38, 4.83)	(0.37, 0.25, 0.13)	(0.70, 0.84, 0.64)	0.68
AM_{543}	(1.83, 3.25, 4.68)	(0.42, 0.29, 0.16)	(0.76, 0.93, 0.74)	0.87

From the analysis we can see that the first two companies have averagely agile project management, and third company has fairly agile project management. From the calculation of FPII company A has ten weak attributes, company B has eleven weak attributes whereas company C has eighteen weak attributes. From this it can be concluded that as the project management agility decreases company's weak attribute increase, and a lot of work needs to do to overcome those weak attributes. All the companies have to work hard to improve all the attributes, but the weaker ones require immediate action of the management in order to improve their project management agility level.

4.5. Proposed Solutions for Weak Attributes to Project Management Agility.

4.5.1. Proposed Solutions for Company A's Weak Attributes

The management needs to develop and encourage a good relationship with its stakeholders including customers, suppliers, and other allied partnership from external environment. The good inter-relationship can be created by a proper communication with all the employees and capability to show them to be transparent with all staffs (Suresh & Patri, 2017).

The management needs to be delegating power, motivating teams, foster collaboration, teams need to communicate and collaborate as much as possible to be more effective, by promoting listening and understanding of the issues, teammates will build reciprocal trust, thus benefiting the company's operations and internal development of the teams, such, an effective collaboration, with collective intelligence platform build around peer learning can create participative management style (Rolková & Farkašová, 2015).

Backup plan is a set of alternative actions as well as tasks that are available if the main plan needs to be abandoned due to some issues, risks as well as other causes. managers should have this plan to protect failure of the project (Ling et al., 2018).

The management must create work-breakdown and follow specification diagram for project managers because it allows them to break down their project scope and visualize all the tasks required to complete their projects. it is a helpful integrates scope, cost and schedule baselines ensuring that project plans are in alignment (Cerezo-Narváez et al., 2020).

Managers have to use goals, incentives, development, and communication strategies to enhance employee performance and help them increase their productivity linked to every personnel prosperity (Miller, 2016).

Continuous learning culture can be created by focusing on upskilling managers, training initiatives by senior managers and leaders, implement by management and learning through different mechanisms (Armenia et al., 2019).

Management idea must aim at increasing an organization's ability to consistently deliver high-quality to its customers by using TQM tools. Managers have to use principles of TQM like; customer focused, total employee involvement, process oriented, integrated system, strategic and systemic approach, continual improvement, fact-based decision making and communications. In the construction industry, total quality management ensures both quality and productivity. (Mbazor & Okoh, 2015).

The following methods can be helpful survey studies to ensure quality status constantly according to Chin-Keng, (2018), create the acceptance criteria, create an inspection plan, use checklists to conduct inspections, correct deficiencies and verify acceptance criteria, prevent future deficiencies in terms of quality management companies should have tools and techniques that can improve status of quality.

Project records include all hardcopy and electronic documents that are significant to the project. Project should have all updated documents relating to business cases, approvals, project briefs and project plans, project reports, risk and issues registers closure, post-implementation reviews and 'lessons learned' documents and documentation of proposed projects which are not ultimately approved are still considered records and must be retained (Björk, 2003).

Offer a competitive salary, ask for employees' suggestions, being transparent, get creative with benefits, listen to employee concerns, celebrate successes, prioritize mental and physical well-being, invest in employees' future are best suited to increase employee satisfaction (Roper & Phillips, 2007).

4.5.2. Proposed Solutions for Company B's Weak Attributes

Here some proposed solutions for company B's weak attributes which are not addressed in company's A solutions.

The productivity measurement provides specific direction and guides the worker toward productive activities. Monitor performance and provide feedback diagnose problems, productivity analysis, facilitate planning and control and support innovation are some methods to survey study to check status of productivity regularly (Mbazor & Okoh, 2015).

To automate a project manager's work, construction project management software is a crucial communication tool. To improve their time management, people can employ a variety of technology-based scheduling tools and techniques (Cerezo-Narváez et al., 2020).

It is recommended that time management, application of project management tools, research and development, provision of new equipment, plant and machinery to replace the old ones, simplifying the product variety, increasing the overall effectiveness of the workforce through motivation and paying attention to details of the current best practices in the industry will no doubt lead to productivity improvement in all functions (Mbazor & Okoh, 2015).

The management can use the following steps to develop/improve procedure for project monitoring and evaluation and put it in project cycle, create a record for monitoring and evaluation, create a balance project base organization with mix project team between experience personnel and new personnel, mix organization structure between functional and matrix organization, knowledge sharing for how to performing project monitoring and evaluation and appropriate monitoring tools should be put in place and use accordingly (Fransisko, 2019).

Here are some of the best practices that the company can use to effectively improve its Training program on time management concepts i.e., teach employees prioritization techniques, coach employees who need extra time management help, model effective time management skills and encourage time management training courses (Dhir et al., 2019).

Planning well and set objectives, create an agenda, include the right attendees, start and finish on time, encourage participation and take good notes, will assist the company to conduct regular meetings with the client project which helps to create and run meetings that are organized, efficient, and effective in facilitating project progression (Noguera et al., 2018).

It is recommended that managers need to create clear guidelines for empowerment, like change management roles from supervisory to coaching, delegate to empower employees, communicate and set goals, training and development of team members, recognition/ rewards and select right mix (Okechukwu & Nnamani, 2015).

According to Cooper & Sommer, (2018), the following five cultural principles can to lead to create responsiveness to external change are align: engage stakeholders, act and adjust: communicate and put the plan in action, adopt: training for change and adapt: prepare for long-term adjustments.

One way to develop the finest financial management system in a construction company is to pay in advance, effectively manage materials, have a good contract management system, deliver materials on time and monitor workers' activities (Kiani Mavi & Standing, 2018).

4.5.3. Proposed Solutions for Company C's Weak Attributes.

Here are some solutions that are suggested for company C's weak attributes that are not covered in company A's and B's solutions.

In the context of company's agility, it is recommended that the managers should plan schedule management, define the project activities, determine dependencies, sequence activities, estimate resources, estimate durations, develop the project schedule and monitor and control in order to have good schedule and iterated activities (Koi-Akrofi et al., 2019).

It is formulated that there are three main areas which education the project team have these are;- developing critical thinking for dealing with complexity, developing softer parameters of managing projects, especially interpersonal skills and leadership as opposed to just technical skills, and preparing team to be engaged within the context of problem solving practice and the companies should give such kind of team training and education for their team. (Ramazani & Jergeas, 2015).

Proactive managers spend time with team members identifying anything which could go wrong on the project, thoroughly analyze the risks and identify mitigating actions (Hoda et al., 2010).

The management should focus on communication, take risks into account, transfer knowledge across the projects, use the right tools, encourage individual learning and knowledge sharing to create skill and knowledge enhancing ideas (Oyemomi et al., 2019).

As stated in Buvik & Rolfsen, (2015), the establishment of a cross-functional team depends on the early adoption of integrative work practices, the emergence of a shared philosophy, open communication, and early and explicit role expectations.

The findings of surveys are organized and evaluated by excellent project managers based on the responses given by their clients. Project managers can track procedures and strategies that help achieve customer satisfaction and set them for fine tuning by using customer tracking through helpdesks, tracking repeat purchases, social network involvement, and even regular meetings (Ciric et al., 2018).

Before errors become more difficult to correct, project managers must process, analyze, document, and validate project requirements. deliver a finished project with few flaws Pre-test evaluations are necessary because front-end flaws in the design and requirements cannot be found during routine testing (Williams, 2016).

A Guide to the Project Management Body of Knowledge (PMBOK) Guide 4th Edition (Project Management Institute, 2008), states that "effective project managers acquire a balance of technical, interpersonal, and conceptual skills that help them analyze situations and interact appropriately". Project manager can improve the application of technical procedures, direct the project team to successfully complete the project's objectives, and address difficulties by applying creative solutions. This can be done by effectively using creativity and innovative approaches.

The organization should plan training programs on new technology. Project management should processes control and coordinate the awareness of technology usage through the continuous information chain management in a disciplined and structured approach on a regular basis (Abd El Halim, 2020).

Employees can get to know one another through aspects like progressive leadership, cooperative teams, openness at work, a realistic workload, staff recognition programs, and participation in decision-making (Gil & Mataveli, 2018).

4.6 Statical Validity

4.6.1. Statical Validity of Applicability of Fuzzy Logic Approach in Assessment of Company A's Project Management Agility

Applicability of fuzzy logic approach with the identified measures for assessment of company A's project management agility has been statistically validated.

To accomplish that, a feedback session was conducted with the experienced experts. The respondents were asked to rate the project management agility criterion of the companies in a Likert's scale ranging from 0 –10. The maximum and minimum mean rating was found to be 8.92 and 7.5 respectively. Table 4.29 shows the rating of the respondents and the mean scores. Following this, a t-test was performed on the mean rating to examine whether the project management agility assessment using fuzzy logic for company A is accepted or not.

At first, the test value was assigned as '10' which indicates that the null Hypothesis (H0) is "H0: 100% of the feedback opinions favored the assessment results of agility" at 95% confidence interval". The significance of two tailed t-test (p-value) was found to be less than 0.05 and as a result, the null hypothesis was rejected at 95% level of confidence. Then, the test value was lowered to 9, 8 and 7 in subsequent attempts and the significance p-value converged towards 0.05 between 8.4 and 8.5. This indicated that the null hypothesis can't be rejected for test value between 8.4 and 8.5. Statistically, this result translated into "84% of the feedback opinions favored the assessment results of project management agility" at 95% confidence interval.

In summary, it was concluded that project management agility assessment by using fuzzy logic can be adopted with a success rate of 84% for company A.

Table 4.29 Mean responses of experts for company A

Criterion	Rating in Likert's scale of range 0-10												Mean score
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	
AM_{11}	9	6	8	9	10	8	10	9	9	10	10	9	8.92
AM_{12}	7	8	6	9	9	7	10	8	8	9	9	8	8.17
AM_{13}	7	7	3	9	9	7	10	9	7	9	6	9	7.67
AM_{21}	7	7	6	9	7	7	10	8	6	9	5	9	7.50
AM_{22}	6	9	8	8	10	6	10	9	7	9	4	8	7.83
AM_{31}	6	9	6	9	10	9	10	9	7	9	8	8	8.33
AM_{32}	6	8	6	7	10	8	10	9	7	9	7	9	8.00
AM_{33}	7	7	8	9	10	9	10	9	7	9	5	9	8.25
AM_{34}	8	9	6	7	8	5	10	8	7	8	6	9	7.58
AM_{41}	9	6	8	8	9	6	10	9	8	9	9	10	8.42
AM_{42}	8	7	8	8	9	7	10	9	8	10	9	9	8.50
AM_{51}	9	8	8	9	10	8	10	8	8	9	9	10	8.83
AM_{52}	8	7	5	7	9	7	10	9	7	9	8	10	8.00
AM_{53}	9	8	8	8	10	6	10	9	8	10	8	10	8.67
AM_{54}	6	6	6	9	9	8	10	9	7	9	7	8	7.83

4.6.2. Statical Validity of Applicability of Fuzzy Logic Approach in Assessment of Company B's Project Management Agility

Applicability of fuzzy logic approach in assessment of company B's project management agility has been statistically validated. To accomplish this, a feedback session was conducted with the experienced experts. The respondents were asked to rate the project management agility criterion of the companies in a Likert's scale ranging from 0–10. The maximum and minimum mean rating was found to be 8.83 and 7.08 respectively.

Table 4.30 shows the rating of the respondents and the mean scores. Next, a t-test was performed on the mean rating to examine whether the project management agility assessment using fuzzy logic for company B is accepted or not. First, the test value was assigned as '10' which indicates that the null Hypothesis (H0) is "H0: 100% of the feedback opinions favored the assessment results of agility" at 95% confidence interval". The significance of two tailed t-test (p-value) was found to be less than 0.05 and as a result, the null hypothesis was rejected at 95% level of confidence.

Then, the test value was lowered to 9, 8 and 7 in subsequent attempts and the significance p-value converged towards 0.05 between 8.16 and 8.17. This indicated that the null hypothesis can't be rejected for test value between 8.16 and 8. 17. Statistically, this result translated into "81.6% of the feedback opinions favored the assessment results of project management agility" at 95% confidence interval. In summary, it was recognized that project management agility assessment by using fuzzy logic can be adopted with a success rate of 81.6% for company B.

Table 4.30 Mean responses of experts for company B

criteria	Rating in Likert's scale of range 0-10												Mean score
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	
AM_{11}	9	10	8	8	6	6	9	6	9	4	5	9	7.42
AM_{12}	8	9	9	8	7	9	7	7	10	5	7	7	7.75
AM_{13}	9	9	6	8	9	8	7	6	9	4	6	8	7.42
AM_{21}	10	10	9	9	9	7	8	7	8	5	8	9	8.25
AM_{22}	10	10	9	9	10	7	8	7	7	5	9	9	8.33
AM_{31}	9	9	7	8	9	9	7	8	8	5	7	10	8.00
AM_{32}	10	9	5	9	10	9	8	7	9	5	9	10	8.33
AM_{33}	9	10	4	9	8	10	8	6	10	4	5	10	7.75
AM_{34}	8	5	8	8	10	5	8	6	9	4	6	8	7.08
AM_{41}	9	9	7	8	10	7	7	8	8	4	7	8	7.67
AM_{42}	10	10	6	9	8	10	7	6	7	4	8	8	7.75
AM_{51}	10	10	8	8	9	10	7	6	8	3	6	9	7.83
AM_{52}	10	10	9	10	10	8	7	6	9	4	7	10	8.33
AM_{53}	10	10	9	10	10	9	7	9	10	4	8	10	8.83
AM_{54}	9	8	9	9	7	9	9	8	8	9	8	8	8.42

4.6.3. Statical Validity of Applicability of Fuzzy Logic Approach in Assessment of Company C's Project Management Agility

Applicability of fuzzy logic approach in assessment of company C's project management agility has been statistically validated. To accomplish this, a feedback session was conducted with the experienced experts. The respondents were asked to rate the project management agility criterion of the company in a Likert's scale ranging from 0–10. The maximum and minimum mean rating was found to be 8.83 and 7.75 respectively.

Table 4.31 shows the rating of the respondents and the mean scores. Following this, a t-test was performed on the mean rating to examine whether project management agility assessment using fuzzy logic for company C is accepted or not.

Initially, the test value was assigned as '10' which indicates that the null Hypothesis (H0) is "H0: 100% of the feedback opinions favored the assessment results of agility" at 95% confidence interval". The significance of two tailed t-test (p-value) was found to be less than 0.05 and as a result, the null hypothesis was rejected at 95% level of confidence.

Then, the test value was lowered to 9, 8 and 7 in subsequent attempts and the significance p-value converged towards 0.05 between 8 and 8.2. This indicated that the null hypothesis can't be rejected for test value between 8 and 8.2. Statistically, this result translated into "80% of the feedback opinions favored the assessment results of project management agility" at 95% confidence interval. In summary, it was concluded that project management agility assessment by using fuzzy logic can be adopted with a success rate of 80% for company C.

Table 4.31 Mean responses of experts for company C

Criterion	Rating in Likert's scale of range 0-10												Mean score
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	
AM_{11}	10	8	8	10	9	8	7	10	8	8	9	8	8.58
AM_{12}	10	7	9	9	9	5	6	6	9	8	8	8	7.83
AM_{13}	9	7	10	9	8	7	7	5	9	9	8	7	7.92
AM_{21}	9	7	8	10	8	8	6	6	8	8	7	8	7.75
AM_{22}	10	8	9	10	9	9	6	7	6	8	7	7	8.00
AM_{31}	9	7	8	10	9	7	6	8	8	9	8	7	8.00
AM_{32}	10	6	10	9	7	6	7	9	8	10	8	8	8.17
AM_{33}	8	8	8	9	7	8	7	10	6	10	7	9	8.08
AM_{34}	9	6	8	8	9	7	7	9	8	8	7	9	7.92
AM_{41}	9	6	8	10	8	7	6	8	9	8	10	9	8.17
AM_{42}	9	8	8	10	8	9	6	7	8	10	10	8	8.42
AM_{51}	10	9	9	10	7	8	8	7	9	10	9	10	8.83
AM_{52}	8	8	10	10	8	7	5	7	8	10	10	9	8.33
AM_{53}	9	8	10	10	8	8	6	8	8	9	10	10	8.67
AM_{54}	8	7	8	9	7	8	9	8	7	8	8	8	7.92

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The current study addresses all four research questions. First, measures for the assessment of project management agility were identified with the literature and the experts. Second, the identified, measures were tested with the case companies and their current agility level is determined, third the weaker attributes that influence project management of companies identified and lastly some solutions for the weaker attributes are proposed.

The study develops project management assessment measures with the enablers, criteria, and attributes. The identified measures were prepared after conducting survey study with construction experts, and the approval was obtained to assess the project management agility level of companies. Then the questionnaire was circulated among the construction managers, site engineers and office engineers to collect the ratings which are converted into linguistic terms. Then the linguistic variables use fuzzy set number to calculate FAMI and FPII to know the current level of project management agility and to identify the weaker attributes.

The agility index has been computed based on Euclidean distance computation, company A and B found to be averagely agile, and company C found to be fairly agile. Besides computing agility index, the weaker attributes have low performance and less than the value of FPII value based on Pareto principle least (20%) ranked also have been identified and some solutions are proposed.

The identified measures can bring insights for the management to assess their project management agility and to overcome the resistance of project management agility by identifying the obstacles. Fuzzy logic that uses the triangular can provide the project management agility level of the companies. The results of the assessment are strong enough for the management to understand issues and implement the strategy to overcome the weaker attributes. Implement agility successfully in project management of real estate companies is directly related to the success of company. So, it is necessary to know the level of agility in order to know and approve their weakness. This kind of exercise would enable the companies to identify the competitive strengths and weaknesses which is vital in today’s competitive scenario.

Generally, the evaluation of project management agility of real estate companies' gains extreme importance as it is an indicator of the company's excellence. The companies can apply agile project management values, principles, and methodologies to become more agile.

5.2. Recommendations

The project management agility assessment technique could be used as a test kit for periodically evaluating the project management agility level of the companies. This kind of exercise would enable the companies to identify the competitive strengths and weaknesses which is vital in today's competitive scenario. The researcher recommends the following points to the companies:

- Companies should use standard and updated project management methodologies to enhance their agility performance of projects.
- Companies need to work hard to improve weaker attributes that are identified in this study.
- Companies must check their level of project management agility regularly.
- Provide training to their teams and client members on agile values, principles, tools, and techniques.

The study can be extended in future by applying longitudinal study with different construction sectors and many stakeholders because comparison and contrast would give further insights. Also, the researcher suggests future research to explore the cause-and-effect paradigm for each of the attributes discussed in the study. This would help extend the current study and enrich the body of knowledge with new insights. The measures for project management agility evaluation could also be extended beyond fifteen criteria.

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APPENDIXES

Appendix A; Questionnaire survey

My name is Kemeriya Geremew and currently, I am a final year student studying Masters of Science in Construction Engineering Management at Adama Science and Technology University. I really appreciate that you are giving me your precious time to complete this questionnaire.

The main purpose of this questionnaire is to identify the measures that helps to assess project management agility of real estate companies. the following questions are designed from collected enablers, criterion and attributes from the literatures.

To keep participant responses anonymous, please do not write your name on this questionnaire. In addition, I kindly request your cooperation and sincere response to the questions included in this questionnaire so that the results of the research will be realistic and useful.

Thank you for your time and kind cooperation!

Agile Project Management (APM) is a method for managing projects to achieve customer value through adaptable planning to change, rapid feedback, continuous improvement, and high collaboration and engagement of project members. To ensure the effectiveness of agile project management practices, an assessment of their performance must be done by using aggregated enablers, criteria and attributes. In this study the list comprised of ten enablers, twenty criterion and fifty attributes are selected from the literatures that has been in different sectors. please indicate your level of agreement on which one of them can measure construction project management agility of real estate companies.

Personal information

1. Where do you work?

_____

2. What is your position?

_____

3. What is your current level of education?

A. Diploma (2 years)

B. Degree

C. Master's degree

D. Ph.D.

E. Other: _____

4. How many years of experience do you have in this profession?

A. 0 – 2 years

B. 2 – 5 years

C. 5 – 10 years

D. 10 – 15 years

E. 15+ years

Agility enablers literally refer to a series of methods which can bring agile performance during the project management process.

The following questions are about Enablers that can help to bring project management agility. please indicate your level of agreement with the following statements by using the following scale 1) Strongly agree 2) Agree 3) Neutral 4) Disagree 5) Strongly disagree

Agility Enablers	5	4	3	2	1
Do you agree that construction project management agility can be gained through management					
Do you agree that construction project management agility can be gained through technology					
Do you agree that construction project management agility can be gained through construction project constraint management strategies?					
Do you agree that construction project management agility can be gained through organizational structure type?					
Do you agree that construction project management agility can be gained through customer collaboration/communication?					
Do you agree that construction project management agility can be gained through competitive driver?					
Do you agree that construction project management agility can be gained through competence?					
Do you agree that construction project management agility can be gained through Workforce?					
Do you agree that change can help to gain construction project management agility?					
Do you agree that concurrent engineering can help to gain construction project management agility					

Criteria is a principle or standard by which something may be judged or decided. Agility assessment criteria is a standard which is used for agility measurement. The following questions are about the criterion that can measure of construction project management agility. please indicate your level of agreement with the following statements by using the following scale 1) Strongly agree 2) Agree 3) Neutral 4) Disagree 5) Strongly disagree

Criterion to measure agility	5	4	3	2	1
Do you agree that nature of management can measure agility of construction project management?					
Do you agree that teamwork can measure agility of construction project management?					
Do you agree that management structure can measure agility of construction project management?					
Do you agree that change in business and technical processes can measure agility of construction project management?					
Do you agree that time management can measure agility of construction project management?					
Do you agree that devolution of authority can measure agility of construction project management?					
Do you agree that creativity can measure agility of construction project management?					
Do you agree that constant customer involvement can measure agility of construction project management?					
Do you agree that strategic relationship with customer can measure agility of construction project management?					
Do you agree that product life cycle can measure agility of construction project management?					
Do you agree that information technology integration can measure agility of construction project management?					
Do you agree that status of productivity can measure agility of construction project management?					
Do you agree that team building can measure agility of construction project management?					
Do you agree that cost management can measure agility of construction project management?					
Do you agree that status of quality can measure agility of construction project management?					
Do you agree that automation of equipment's can measure agility of construction project management?					
Do you agree that training and development can measure agility of construction project management?					
Do you agree that manufacturing planning can measure agility of construction project management?					
Do you agree that customer response adoption can measure agility of construction project management?					
Do you agree that production methodology can measure agility of construction project management?					

Attribute is a quality, or characteristic ascribed to someone or something.

The following questions are about the attributes of project management agility. please indicate your level of agreement with the following statements by using the following scale.

1) Strongly agree 2) Agree 3) Neutral 4) Disagree 5) Strongly disagree

Attributes	5	4	3	2	1
Do you agree that that repeatability can be one attribute of agility in construction project management?					
Do you agree that flattened organizational structure can be one attribute of agility in construction project management?					
Do you agree that technology awareness can be one attribute of agility in construction project management?					
Do you agree that cross-functional teams can be one attribute of agility in construction project management?					
Do you agree that customer satisfaction can be one attribute of agility in construction project management?					
Do you agree that creativity can be one attribute of agility in construction project management?					
Do you agree that flexibility can be one attribute of agility in construction project management?					
Do you agree that participative management style can be one attribute of agility in construction project management?					
Do you agree that education and training can be one attribute of agility in construction project management?					
Do you agree that skill and knowledge enhancing technologies can be one attribute of agility in construction project management?					
Do you agree that team managed organization can be one attribute of agility in construction project management?					
Do you agree that transparency in information sharing can be one attribute of agility in construction project management?					
Do you agree that financial management system can be one attribute of agility in construction project management?					
Do you agree that technology-based scheduling system can be one attribute of agility in construction project management?					
Do you agree that transparency with the client can be one attribute of agility in construction project management?					
Do you agree that survey study to check status of productivity regularly can be one attribute of agility in construction project management?					
Do you agree that productivity linked to every personnel prosperity can be one attribute of agility in construction project management?					
Do you agree that productivity improvement in all functions can be one attribute of agility in construction project management?					

Do you agree that Survey studies to ensure quality status constantly can be one attribute of agility in construction project management?					
Do you agree that stakeholders' satisfaction can be one attribute of agility in construction project management?					
Do you agree that usage of TQM tools can be one attribute of agility in construction project management?					
Do you agree that specification of product life to the customer can be one attribute of agility in construction project management?					
Do you agree that proactive behavior can be one attribute of agility in construction project management?					
Do you agree that inculcation of innovation into product design can be one attribute of agility in construction project management?					
Do you agree that smooth information flow can be one attribute of agility in construction project management?					
Do you agree that responsiveness to external change can be one attribute of agility in construction project management?					
Do you agree that decentralized organizational structure can be one attribute of agility in construction project management?					
Do you agree that regular meetings with the client can be one attribute of agility in construction project management?					
Do you agree that individual/team innovation can be one attribute of agility in construction project management?					
Do you agree that adaptive behavior can be one attribute of agility in construction project management?					
Do you agree that self-managed teams can be one attribute of agility in construction project management?					
Do you agree that regular conduct of management in employees' meetings can be one attribute of agility in construction project management?					
Do you agree that training program on time management concepts can be one attribute of agility in construction project management?					
Do you agree that construction project information and electronic records can be one attribute of agility in construction project management?					
Do you agree that continuous learning can be one attribute of agility in construction project management?					
Do you agree that deliver the final product with little defect can be one attribute of agility in construction project management?					
Do you agree that learn from each other can be one attribute of agility in construction project management?					
Do you agree that scheduled activities can be one attribute of agility in construction project management?					
Do you agree that employees job satisfaction can be one attribute of agility in construction project management?					

Do you agree that monitoring and evaluating work progress can be one attribute of agility in construction project management?					
Do you agree that empowerment of personnel can be one attribute of agility in construction project management?					
Do you agree that paperless work can be one attribute of agility in construction project management?					
Do you agree that work-breakdown and follow specification can be one attribute of agility in construction project management?					
Do you agree that having backup plan can be one attribute of agility in construction project management?					
Do you agree that teams across company borders can be one attribute of agility in construction project management?					
Do you agree that concurrent execution of activities can be one attribute of agility in construction project management?					
Do you agree that customer-driven innovations can be one attribute of agility in construction project management?					
Do you agree that new product introduction can be one attribute of agility in construction project management?					
Do you agree that enterprise integration can be one attribute of agility in construction project management?					
Do you agree that self-autonomous work team can be one attribute of agility in construction project management?					

NB: If you have any comments and suggestions, please write your comment about any of the above questions.

Results of RII for the above questions are resented below the tables

Results of RII for enablers.

NO	Enabler	Relative importance index
1	Agility through management	0.98
2	Agility through technology	0.96
3	Agility through workforce	0.94
4	Agility through customer collaboration/communication	0.9
5	Agility through project constraint management strategies	0.82
6	Organizational structure type	0.48
7	Agility through competitive driver	0.4
8	Agility through change	0.38
9	Agility through concurrent engineering	0.34
10	Agility through competence	0.32

Results of RII for criterion.

NO	criterion	Relative importance index
1	Nature of management	0.9
2	Strategic relationship with customer	0.9
3	Information technology integration	0.88
4	Management structure	0.86
5	Teamwork	0.84
6	Status of productivity	0.82
7	Constant customer Involvement	0.8
8	Cost management	0.8
9	Product life cycle management	0.8
10	Time management	0.78
11	Team building	0.76
12	Training and development	0.72
13	Status of quality	0.66
14	creativity	0.6
15	Leadership in the use of new technology	0.58
16	Production methodology	0.4
17	Manufacturing planning	0.4
18	Automation of equipment's	0.4
19	Customer response adoption	0.38
20	Devolution of authority	0.38

Results of RII for attributes

NO	Attributes	Relative importance index
1	Decentralized organizational structure	0.92
2	Work-breakdown and follow specification	0.9
3	Technology awareness	0.9
4	Proactive behavior	0.88
5	Participative management style	0.86
6	Cross-functional teams	0.86
7	Stakeholders Satisfaction	0.86
8	Having backup plan	0.84
9	Learn from each other	0.82
10	Customer satisfaction	0.82
11	Monitoring and evaluating work progress	0.82
12	Flexible management system	0.82
13	Empowerment of personnel	0.8
14	Transparency in information sharing	0.8
15	Education and training	0.78
16	Self-managed teams	0.78
17	Flattened organizational structure	0.76
18	Survey studies to ensure quality status constantly	0.72
19	Usage of TQM tools	0.72
20	Skill and knowledge enhancing technologies	0.72
21	Financial management system	0.72
22	Technology-based scheduling system	0.7
23	Adaptive behavior	0.7
24	Paperless work	0.66
25	Transparency	0.66
26	Scheduled activities	0.64
27	Team managed organization	0.64
28	Individual/team innovation	0.64
29	Training program on time management concepts	0.62
30	Productivity improvement in all functions	0.62
31	Regular conduct of management employee's meetings	0.62
32	Project information and electronic records	0.6
33	Continuous learning	0.6
34	Deliver the final product with little defect	0.6
35	Survey study to check status of productivity regularly	0.58
36	Employee satisfaction	0.58
37	Productivity linked to every personnel prosperity	0.58
38	Responsiveness to external change	0.58
39	Stakeholders Satisfaction	0.44
40	Teams across company borders	0.44
41	Concurrent execution of activities	0.42
42	Specification of product life to the customer	0.42
43	Customer-driven innovations	0.4
44	Self-autonomous work team	0.4
45	New product introduction	0.4
46	Regular meetings with the client	0.4
47	Responsiveness to external change	0.4
48	Smooth information flow	0.38
49	Repeatability	0.36
50	Enterprise integration	0.36

Alpha Cronbach calculation of enablers, criterion and attributes

$\boldsymbol{\alpha} = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum S_y^2}{S_{yx}^2}\right)$

Where ; K, Number of items

$\sum S_y^2$ sum of the item variance

S_{yx}^2 variance of total score

$\boldsymbol{\alpha}$ Alpha cronbach

For enablers; Number of items =10

Sum of the item variance = 9.33

Variance of total score = 33.32

$\boldsymbol{\alpha} = \left(\frac{10}{10-1}\right)$ (1-9.33/33.32) = 0.8

For criterion; Number of items =20

Sum of the item variance =3.44

Variance of total score =16.38

$\boldsymbol{\alpha} = \left(\frac{20}{20-1}\right)$ (1-3.44/16.38) = 0.83

For attributes; Number of items = 50

Sum of the item variance = 5.92

Variance of total score = 24.63

$\boldsymbol{\alpha} = \left(\frac{50}{50-1}\right)$ (1-5.91/24.63) = 0.78

Appendix B; Questionnaire survey

Dear Sir / Madam,

My name is Kemeriya Geremew and currently, I am a final year student studying Masters of Science in Construction Engineering Management at Adama Science and Technology University. I really appreciate that you are giving me your precious time to complete this questionnaire.

The main purpose of this questionnaire is to collect data for research that attempts to assess Project Management Agility in Ethiopian real estate construction companies.

The specific objectives of the research are:

- To identify attributes, criterions, and enablers those will enable real estate construction professionals to assess their project management agility comprising of all major aspects.
- To identify the construction project management agility level of private real estate companies.
- To identify the attributes that influence agility of project management in real estate construction companies.
- To propose solutions for weak attributes to project management agility.

To keep participant responses anonymous, please do not write your name on this questionnaire. In addition, I kindly request your cooperation and sincere response to the questions included in this questionnaire so that the results of the research will be realistic and useful.

Thank you for your time and kind cooperation!

1. Where do you work?

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2. What is your position?

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3. What is your current level of education?

A. Diploma (2 years)

B. Degree

C. Master’s degree

D. Ph.D.

E. Other: _____

4. How many years of experience do you have in this profession?

A. 0 – 2 years

B. 2 – 5 years

C. 5 – 10 years

D. 10 – 15 years

E. 15+ years

Agility is the ability to remain flexible in facing new developments, to continuously adjust the company's strategic direction, and to develop innovative ways to create value.

Agile Project Management (APM) is a method for managing projects to achieve customer value through adaptable planning to change, rapid feedback, continuous improvement, and high collaboration and engagement of project members. To ensure the effectiveness of agile project management practices, an assessment of their performance has to be done by using aggregated enablers, criteria and attributes. In this study the list comprised of five enablers, fifteen criterion and thirty-eight attributes where each enabler branched out to a number of criteria and each criterion branched out to a set of attributes. The enablers, criteria and attributes put together constituted the measures of construction projects management agility assessment.

Agility enablers literally refer to a series of methods which can bring agile performance during the project life cycle. Please mention how important is the following enabler for real estate construction project management agility. The description of each Enabler is attached below the table.

	Enabler	Very-low	low	Fairly-low	medium	Fairly-high	high	Very-high
1	Agility through Management							
2	Agility through Technology							
3	Agility through Workforce							
4	Agility through customer collaboration/communication							
5	Agility through Construction project constraint management strategies							

Agility through Management; Means agility through ongoing development and for individual employees or managers, agility involves anticipating what might happen, decision-making capability under changing circumstance, managing the unexpected, and adapting to new situations.

Agility through Technology; is Agility through the ability of quickly and smoothly adapt to or integrate current technologies with newer, different, disruptive, expansive or convergent technologies.

Agility through Workforce; Agility through Workforce refers to an organization's ability to move people to support changes in the environment.

Agility through customer collaboration/communication; Agility through encouraging customers and development team to collaborate to chart the best way forward together, rather than to view each other as adversaries.

Agility through Construction project constraint management strategies; Agility through implementing different strategies that are helpful for project constraint management.

Criteria are a standard or principle for judging, evaluating, or selecting something. The following criteria listed in the table below are used to evaluate/assess how much the criterion are important to measure project management agility with respect to its respected branched enablers. Please mention how important the following criteria for real-estate construction project management agility. The description of each Criterion is attached below the table.

No.	Enabler	Criteria	Very-low	low	Fairly-low	medium	Fairly-high	high	Very-high
1	Agility through Management	Management structure							
		Nature of management							
		Project life cycle management							
2	Agility through Technology	Information technology integration							
		Using project management software							
3	Agility through Workforce	Team building							
		Training and development							
		Creativity							
		Employee status							
4	Agility through customer collaboration	Customer involvement on-site regularly							
		Strategic relationship with customer							
5	Agility through Construction project constraint management strategies	Status of quality							
		Status of productivity							
		Cost management							
		Time management							

Management structure: Describes how a company organizes its management hierarchy**.**

Nature of management; Is a set of activities (including planning and decision making, organizing, leading, and controlling) directed at an organization's resources (human, financial, physical, and information) with the aim of achieving organizational goals in an efficient and effective manner.

Project life cycle management: Handling of a project or portfolio of projects as they progress through the typical stages of the project life cycle.

Information technology integration; Is the use of technology resources, Computers, mobile devices like smartphones and tablets, digital cameras, social media platforms and networks, software applications, the Internet, etc.

Using project management software; Using different Project management software to plan, organize, and allocate resources for managing projects.

Team building: Creating a team that is cohesively working together towards a common goal.

Training and development; Formal, ongoing efforts that are made within organizations to improve the performance and self-fulfillment of their employees through a variety of educational methods and programs.

Creativity: Creativity encompasses the ability to discover new and original ideas, connections, and solutions to problems.

Customer involvement on-site regularly; Ongoing interactions with the customer regularly.

Strategic relationship with customer; Knowing customer expectations, measures performance against those expectations, identifies biggest challenges and opportunities lie and pinpoints exactly where customers want to improve.

Employee status; Is behavior or ability of employee for different perspectives.

Status of productivity; Position of Productivity in project work is determined by observing the relationship between final results and cost or time.

Cost management; Is the process of estimating, allocating, and controlling project costs.

Time management: Management of the time spent and the progress made over the project.

Attributes are a quality or features regarded as a characteristic or inherent part of something. The following attributes listed in the table below are used to characterize how much the attributes are important to measure project management agility with respect to its respect branched criterion's. Please mention how important is the following attribute for real estate construction project management agility. The description of each attribute is attached below the table.

No.	Enabler	Criteria	Attributes	Very-low	low	Fairly-low	medium	Fairly-high	high	Very-high
1	Agility through Management	Management structure	Decentralized management structure							
			Team managed organization							
			Flexible management system							
		Nature of management	Participative management style							
			Transparency in information sharing							
			Regular conduct of management employees' meetings							
		Project life-cycle management	Having backup plan							
			Flat organizational structure							
			Work-breakdown and follow specification							
			Monitoring and evaluating work progress							
			Deliver the final product with little defect							
2	Agility through Technology	Information technology integration	project information and electronic records							
			Paperless work							
		Leadership in the use of new technology	Skill and knowledge enhancing ideas							
			Technology awareness							
3	Agility through Workforce	Team building	Empowered individuals working in teams							
			Cross functional team							
			Employee satisfaction							
			Self-organized team							
		Training and development	Continuous learning							
			Team training & education.							
			Learn from each other							
		Creativity	Individual/team innovation							
		Employee status	Responsiveness to external change							

			Proactive behavior							
			Adaptive behavior							
4	Agility through customer collaboration/communication	Customer involvement on-site constantly	Customer satisfaction							
			Transparency with the client							
		Strategic relationship with customer	Regular meetings with the client							
5	Agility through Construction project constraint management strategies	Status of quality	Survey studies to ensure quality status constantly							
			Usage of TQM tools							
		Status of productivity	Productivity improvement in all functions							
			Productivity linked to every personnel prosperity							
			Survey study to check status of productivity regularly							
		Cost management	Financial management system							
		Time management	Technology-based scheduling system							
			Scheduled and iterated activities							
			Training program on time management concepts							

Decentralized management structure: Management structure which empower team members to use their knowledge, experience, and expertise to make meaningful contributions at work.

Team managed organization; Is the ability of an individual or an organization to administer and coordinate a group of individuals to perform a task.

Flexible management system: Type of characteristics in management that facilitates the work without having any interruption in the project due to changeovers. It is the capacity to adjust to range of possible environment.

Participative management style: Is a management style that requires the cooperation of personnel. It aims to build commitment and develop initiatives within work teams.

Transparency in information sharing; Creating a project management system in which all team members can access all relevant information about a project easily and efficiently.

Regular conduct of management employees' meetings; Regularly welcome employees to the meeting, Share the agenda and accept their ideas.

Having backup plan; Making backup plans with multiple project views in order to react with changes properly.

Flat organizational structure: Is the method by which workflows through an organization. It allows groups to work together within their individual functions to manage tasks.

Work-breakdown and follow specification; The total scope of the project is broken down into smaller manageable pieces and follow according to the specification.

Monitoring and evaluating work progress; Evaluate, re-evaluate and monitor the work and adjust in given increments to make sure that as the work and customer landscape.

Deliver the final product with little defect; Deliver the final product when all the client requirements are met appropriately without any loopholes.

Project information and electronic records; Digital records management helps ensure that information is captured, older versions are removed, and people can find the right information.

Paperless work: Is a work environment which uses minimal physical paper and instead uses primarily digital documents.

Skill and knowledge enhancing ideas; Build a knowledge developing & learning culture.

Technology awareness; Is the skill of an individual to be aware and mindful of new and popular technology.

Empowered individuals working in teams; Have the corporate authority, experience, responsibility and skills to enact their own decisions for the organization.

Cross functional team: Cross functional teams are groups of people with different viewpoints and expertise who collaborate to achieve a common objective.

Employee satisfaction: Is the extent to which employees are happy or content with their jobs and work environment.

Self-organized team: Choose how best to accomplish their work, rather than being directed by others outside the team.

Continuous learning; Ongoing expansion of knowledge and skill sets.

Team training & education; Invest in your team by providing them next level courses to strengthen and enhance their skills.

Learn from each other; Peer-to-peer learning taps into the expertise that already exists in organization.

Individual/team innovation; Advancing and discovering new ideas or ways of doing things that will improve the company's output.

Responsiveness to external changes; Is ability to identify and effectively adapt to the continuous change in their industry and in their customers' preferences.

Proactive behavior: Is self-initiated behavior that endeavors to solve a problem before it has occurred.

Adaptive behavior: Enables a person to cope in their environment with greatest success and least conflict with others.

Customer satisfaction: Is a measurement that determines how happy customers are with a company's products, services, and capabilities.

Transparency with the client; Allows the client to see all aspects and decisions of a project that might affect or interest them.

Regular meetings with the client; Constantly discuss with stakeholders and clients discuss how the project progresses.

Survey studies to ensure quality status constantly; Measuring the work progress according to the required quality regularly.

Usage of TQM tools; Are tools for project management or strategy that is implemented to assure that an awareness of quality is embedded in all phases of the project from conception to completion.

Productivity improvement in all functions; Process of achieving more output in all functions by implementing a continuous improvement approach.

Productivity linked to every personnel prosperity; Productivity which assures every one's prosperity.

Survey study to check status of productivity regularly; Various productivity measurement strategies involve monitoring productivity progress regularly.

Financial management system; Involves recording and analysis of large number and wide variety of transactions and take actions in order to keep the budget.

Technology-based scheduling system; - Involves using time management software.

Scheduled and iterated activities; - Iterate each activity and control the schedule as the plan.

Training program on time management concepts; Giving training on how to manage time for employees.

Please rate the project management indicating where your company stands with respect to the attributes listed given below.

No	Attributes	Worst	Very-poor	Poor	Fair	Good	Very-good	Excellent
1	Decentralized management structure							
2	Team managed organization							
3	Flexible management system							
4	Participative management style							
5	Transparency in information sharing							
6	Regular conduct of management employees' meetings							
7	Having backup plan							
8	Flat organizational structure							
9	Work-breakdown and follow specification							
10	Monitoring and evaluating work progress							
11	Deliver the final product with little defect							
12	project information and electronic records							
13	Paperless work							
14	Skill and knowledge enhancing ideas							
15	Technology awareness							
16	Empowered individuals working in teams							
17	Cross functional team							
18	Employee satisfaction							
19	Self-organized team							
20	Continuous learning							
21	Team training & education.							
22	Learn from each other							
23	Individual/team innovation							
23	Responsiveness to external change							
24	Proactive behavior							
26	Adaptive behavior							
27	Customer satisfaction							
28	Transparency with the client							
29	Regular meetings with the client							
30	Survey studies to ensure quality status constantly							
31	Usage of TQM tools							
32	Productivity improvement in all functions							
33	Productivity linked to every personnel prosperity							
34	Survey study to check status of productivity regularly							
35	Financial management system							
36	Technology-based scheduling system							
37	Scheduled and iterated activities							
38	Training program on time management							

Please, rate the following criterions for assessment of construction project management agility by using Likert's scale ranging from (1-10) for achieving better agility in construction project management.

No	Criteria	1	2	3	4	5	6	7	8	9	10
1	Management structure										
2	Nature of management										
3	Project life cycle management										
4	Information technology integration										
5	Using project management software										
6	Team building										
7	Training and development										
8	Creativity										
9	Employee status										
10	Customer involvement on-site regularly										
11	Strategic relationship with customer										
12	Status of quality										
13	Status of productivity										
14	Cost management										
15	Time management										

Thank you for your time and kind cooperation!

Results of t test for statistical validity

For company A

	A	*Dummy*
Mean	8.166666667	0
Variance	0.198412698	0
Observations	12	4
Hypothesized Mean Difference	8.4	
df	11	
	-	
t Stat	2.028792744	
P(T<=t) one-tail	0.030971135	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.061942269	
t Critical two-tail	2.144786688	

For company B

t-Test: Two-Sample Assuming Unequal Variances

	B	*Dummy*
Mean	7.910714	0
Variance	0.217376	0
Observations	12	4
Hypothesized Mean Difference	8.16	
df	11	
t Stat	2.08083	
P(T<=t) one-tail	0.028893	
t Critical one-tail	1.770933	
P(T<=t) two-tail	0.057786	
t Critical two-tail	2.160369	

For company C	*C*	*Dummy*
Mean	8.190476	0
Variance	0.109432	0
Observations	12	4
Hypothesized Mean Difference	8	
df	11	
t Stat	2.154428	
P(T<=t) one-tail	0.025273	
t Critical one-tail	1.770933	
P(T<=t) two-tail	0.050546	
t Critical two-tail	2.160369	