APPLICABILITY OF AGILE PROJECT MANAGEMENT FOR CONSTRUCTION PROJECTS

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Degree of Master of Business Administration in Project Management

Department of Civil Engineering

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ABSTRACT

Project management is today a current and highly discussed area. Projects within the construction industry are managed has not changed significantly during the last decades. The construction industry, the number of different actors and the way that projects are procured today has however changed. This has led to a gap between the managerial view on how construction projects should be conducted today and how they actually are executed. This is reason enough to question this conservative industry and look into what possibilities there might be in the future. Using agile methodologies have numerous advantages over the classical methods used in project management in construction projects. However, their characteristics make them appropriate to be applied to projects in other areas.

Project management in the information systems industry has had a poor record of delivering value and has consequently seized upon the recent evolutional of agile project management. The meaning of the agile project management, from whence it originated and whether it has further applicability, are not widely understood. The construction industry also might benefit from the adoption of agile project management. A literature review has established that agile project management does indeed offer significant improvements and that the construction industry might also potentially benefit. In order to resolve to an agile theory, the underlying rationales for agile have been explored, leading to the identification of further promising research. The agile methodologies are suited for projects with high complexity and uncertainty. It is also suitable to work in agile ways when a project has unclear specifications, changing situations, complex project goals and results needs to be achieved continually or early in the project process.

In order to this study is focused on establishing the possibility of applying the scrum method in construction project management. The compatible scrum framework is identified for construction projects as a result of the literature review. A case study is conducted by following the model outputs, and then reviews the possibility of establishing the scrum roles, meetings and artifacts. An expertise review is referred to validate and generalize the case study output to construction project management. Even though the case study highlighted the positive possibilities to establish scrum methods in construction project management, the expertise review is not positively resulted.

Keywords: Construction Project Management, Agile Project Management, Scrum Method

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

PM	-	Project Management
TPM	-	Traditional Project Management
APM	-	Agile Project Management
CPM	-	Construction Project Management
DRR	-	Disaster Risk Reduction
XP	-	Extreme Project
WBS	-	Work Breakdown Structure
PBS	-	Project Breakdown Structure
IT	-	Information Technology
GDP	-	Gross Domestic Products
US	-	United State
DOE	-	Department Of Energy
FDA	-	Food and Drug Administration
ROI	-	Return on Investment
STOMC	-	Senior Technical Officer Municipal Council
CONS	-	Consultant
CONT	-	Contractor

CHAPTER 1.BACKGROUND OF THE STUDY

1.1.Introduction

1.1.1. Construction industry

The construction industry in Sri Lanka has witnessed many challenges and demands and increased competition. Maintaining a motivated workforce and getting them involved in the effective performance of organizations is vital. The major importance and value of this study derive from several reasons. Construction industries are meeting new challenges regularly. Hence, the impact of Project Management (PM) support for team performance in a construction industry is a key factor. Construction industries are relying more and more on team-based structures and designs. Empirical findings on PM support and the effect on the team and organizational effectiveness are limited in the construction industry in Sri Lanka.

The multiple dimensions of PM support and the impact on team performance lead to the following research problem. What is the applicability of agile PM for construction projects in Sri Lankan context? This project focuses on the impact of PM support as a mean enhancing performance. The study was carried out in a construction industry, belonging to a well-established in Sri Lanka. The study has focused on the importance of PM support and its impact on team performance. Findings of study provide empirical data taken from each relevant industry for team leaders, top management, and team members for effective team performance.

There are several models to achieve successful teams, with several factors fitting the step for getting the best outcome by developing appropriate project goals, empowering the team with decision-making power, assigning appropriate human resources, and creating a productive climate to foster team success. Identify the specific team behaviors, including teamwork, dedication to the project, ownership of the project, and respect and trust among team members have been posited to contribute to team success. Even though project managers and supervisors in achieving success. Team leadership is the most frequently mentioned enabler,

followed by PM support. In supporting teams, the PM's role to take out the maximum potential in employees has been mentioned in studies. A directive style when the employee has a low skill level, coaching for the tasks employee is having some skills but lacking experience or motivation, supportive style for the tasks employee knows what to do but is lacking confidence in his abilities and delegation when the employee is motivated and capable. Consistently ensuring the employee is progressively growing their skill by providing new responsibilities and a higher level of supervision, and mentoring him to absorb the organizational culture and the value of empowerment are vital. And it consists of a group leader responsible for product quality, monitoring yield, quality systems management, and environmental sustainment. PM is responsible for the results, which eventually are the organizational goals. Team members do the organizational value addition.

Also, the PM involvement is essential for effective implementation of strategy in the construction industries. Top management provides a role model for other managers in assessing the relevant environmental variables, their relationship to the organization, and the appropriateness of the organization's response to these variables. Top management shapes the perceived relationships among organization components. PM is largely responsible for the determination of coordination of projects within the organization structure (e.g. information flow, decision-making processes, and job assignments should include that). They must recognize the existing organization culture and learn to work within or change its parameters. PM is also responsible for the design and control of the organization's reward and incentive systems. Management is involved in the design of information systems for the organization. In this role, managers influence the key environmental variables to the organization. They must be certain that information concerning these key variables is available to the managers. Top-level managers must also provide accurate and timely feedback concerning the organization's performance and the performance of strategic business units of the organization.

Project managers need information to maintain a realistic view of their performance, the performance of the organization and the organization's relationship to the environment have defined team performance as the extent to which a team is capable

of meeting the established quality, cost and time objectives. They mentioned that the awareness of project success depends on the outlook of the measures evaluated, such as effectiveness, efficiency, learning, work satisfaction, team conflict, and team effort, the balance of member contribution, mutual support, unity, coordination, and cooperation.

1.1.2. Agile project management

Agile development framework is becoming popular in the industry and consequently, companies and practitioners are faced with the challenge of understanding and embracing this new paradigm. They are enthusiastic to know what it is, how it works, and what does it take to make it work. Companies or practitioners interested in adopting agile frameworks are faced with the challenge of making the transition. Traditional roles are challenged and processes are revamped to reflect the new development frameworks.

Agile frameworks follow the iterative and incremental style of development that dynamically adjusts to changing requirements and enables better risk management. The four basic principles of agile as defined by the agile policy are as follow.

- Individuals and interactions over process and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

There are differences between the traditional ways of software development and the agile style of working. Some of the important ones are highlighted in Table 5.3.

Table 1: Comparative chart – Traditional vs. Agile

Categories	Traditional	Agile
Development Model	Traditional	Iterative

Focus	Process	People
Management	Controlling	Facilitating
Customer involvement	Requirements gathering and delivery phases	On-site and constantly involved
Developers	Work individually within teams	Collaborative or in pairs
Technology	Any	Mostly Object Oriented
Product Features	All included	Most important first
Testing	End of development cycle	Iterative and/or Drives code
Documentation	Thorough	Only when needed

In real life development, it's common to experience frequent change requests in customer requirements. The traditional forms of development left the little scope of refactoring to address this need. They adopt the traditional model of development which unrealistically assumes that the customer requirements remain fixed over the entire length of the project. Agile frameworks, on the other hand, are focused towards customer satisfaction and therefore allow for changes through the iterative style of development where only needed functionalities are focused on. Since only hands full of tasks are achieved in the iteration, it's easier to modify functionalities as needed and manage the associated risks better.

1.1.3. Scrum method

The Scrum development involved in this process is Product Owner, Scrum Master, and the team. The Product owner is responsible for maintaining the correct business perspective. The Scrum master works with the product owner and facilitates the team. The team should contain seven (plus/minus two) members.

Activities include sprint planning, sprint review, and scrum meeting. A sprint is usually 2 to 4 weeks of development time where a set of selected stories are worked on. The sprint review reviews the previous sprint in terms of tasks achieved and the next sprint details are defined. The Scrum master leads a daily 15 minutes meeting where each member briefly describes their tasks and concerns.

The artifacts produced are named product backlog, sprint backlog, and burn down the chart. The product backlog is a list of product features prioritized by value delivered to the customer and is maintained by the product owner. The sprint backlog refers to the development tasks that are needed in order to implement a feature and is a subset of the product backlog. The burndown chart shows the total work remaining in a sprint.

1.2. Objective

Main objective

To establish the applicability of Agile Project Management in construction project management

Sub-Objectives

- To establish the applicability of scrum meeting in construction project management.
- To establish the applicability of scrum roles in construction project management
- To establish the applicability of scrum artifacts in construction project management.

1.3. Methodology

The literature review will be carried out focusing Residential construction management, agile management and scrum process in different industries and scrum application of agile in the construction industry.

After having a comprehensive literature review and the implemented case study, scrum characteristics are mapping with the attribute of the conventional construction process in order to develop the scrum structure for the construction process.

With the having data from the case study, the applicability of scrum structure (Meetings, roles, artifacts) is verified by expert review.

CHAPTER 2.LITERATURE REVIEW

2.1.Introduction

Finding the optimal way of managing, control and coordinate projects is a constant challenge. Adjusting working methods, clarifying roles, simplifying project reporting or visualizing the project status through new user-friendly management tools are examples of how this challenge can be met. Project management today often concerns the entire organization whether it is a small private company or a larger public business [13].

Managing a project in any organization is a challenged because there is no a complete uniqueness between project. On the other hand, the organizational setup also challenges in managing projects. Those challenges are fallen into nineteen major areas.

1. Scarce resources competition
2. Project management incompetence,
3. Issues related to organizational culture,
4. Lack of accountability,
5. Insufficient team skills,
6. Cross- functional teams,
7. Poor planning,
8. Poor quality,
9. Lack of tools,
10. Unclear scope or vision,
11. Lack of customer involvement,
12. Scheduling issues,
13. Scope changes,
14. Risk management,
15. Uncertain dependencies,
16. Technology issues,
17. Resistance to change,

18. Lack of proper processes, and

19. Lack of organizational support. [14]

These challenges obviously seem in construction projects too. As Young says it is because "today's construction industry operates in a climate of widespread economic fluctuations, population and migration growth, and the growing pressure from global economic instability." Further, he says "regions and economies of the world are increasingly interdependent and new challenges arise every day that leads to major shifts in the context of the marketplace" [15]. Therefore modern project management methods need to be evolved in order to overcome problems in construction management.

The Agile project management approach evolved from the software industry where it has grown and developed through empirical progress. It is suited for large complex projects where it is difficult to specify the product in advance. It is today used in different industries but mostly in the software business where the customer detects their needs through means of repeated tests and improvements to a prototype [13].

Over the past decade, agile methods have revolutionized IT and software development projects, resulting in impressive success, especially in volatile or uncertainty environments. However, software projects are only a small part of project management world. Can the success of agile be translated into these other types of projects? [16].

2.2. Construction Industry

The construction industry plays a major role in the development of many countries [17]. The construction industry is regarded as a competitive business with high risk, which operates differently from other industries [18].

Sorvala and Ka¨rna¨(2009) describes more about the construction industry. They note that the entire field of construction is becoming a service business. Further, they say this has been implied by various developments and change factors in the field. Sorvala and Ka¨rna¨ also found that companies have expanded their operations on the project's life cycle, on the one hand, towards project development by developing the project in cooperation with the customers and by offering the customers different

financing options, and, on the other hand, by offering real estate and user services and various management services.

Anyhow, globally, construction and engineering services industry are regarded as one of the largest fragmented industry accounting for 10-12% of GDP in many countries. Benefiting from both public and private investments, the construction industry is a prime source of employment generation offering job opportunities to millions of unskilled, semi-skilled and skilled workforce [19].

The total world spending on construction amounted to US$3.2 trillion in 1998 [19]. According to the Annual Survey of Construction Industries, the total estimated value of work done by all type of construction activities in Sri Lanka was Rs.78,320 million in 2010 [20]

In general, the industry is segmented as:

- Commercial building Constructions,
- Industrial Constructions,
- Infrastructure/heavy Constructions, and
- Residential Constructions. [21]

Activities within the construction industry are generally developed, designed, packaged, tendered, awarded, constructed, monitored and completed as single projects [22].

2.3. Construction Projects

2.3.1. Overview

A project is a temporary endeavor undertaken to create a unique product, service or result. The temporary nature of project indicates a definite beginning and end [23].

By its very nature, construction is a manufacturing process, but unlike manufacturing a product in the predictable environment of a factory, construction is performed outside and subject to the elements. Not until the structure encloses itself is there any reprieve from nature. Adding to the challenges of manufacturing outside, construction projects are one-time events. [24].

Construction projects usually include the design and build of a new structure [25]. Most activities in the construction industry are organized in projects: as temporary undertakings, including a vast number of different stakeholders and professions [26] Construction projects are highly complex collaborative events involving many different bodies and organizations, e.g. clients, designers, consultants, contractors, and inspectors [27].

Most construction projects are unique and fast moving, so work organizations are rather dynamic as they must be restructured again and again with different designs and designers, management, materials, equipment, and crews [18]. That means, the construction projects vary with the course of development, planning, realization and operating [28].

A construction project passes through several phases. It begins with a concept and continues through the preliminary studies, planning, the construction process, and on the start of operations [29].

2.3.2. Stakeholders in construction project

Project management is also becoming increasing complex not only because the projects are becoming larger (referred to as mega projects when investments amount to $1 billion or more), but also because of a large number of stakeholders involved [30].

In recent years it has become more common – however still a bit controversial – those construction project stakeholders such as property owners/clients, architects, engineers, contractors, and suppliers are working together in collaborative construction projects [26].

Lindahl & Ryd (2007) mentioned that construction clients have a key role as the initiators of projects. They also explain that clients are individuals or organizations that contract the construction of facilities either for their own use or for someone else's. Lindahl & Ryd also found that the construction client often also represents many different interests in terms of services required, functions, designs, and interpretation aspects.

In construction, the relationship between client and contractor constitutes a multilevel complex in which parties operate simultaneously and collaborate with in-groups of networks [31].

Project managers in today's construction industries are facing a situation whereby the fundamental roles and functions they perform witnesses a gradual shift in focus [18]. Another uniqueness of construction projects involves two specific positions which are not found in other sectors. These positions include project planners and estimators [25].

One of project performance criteria is stakeholders' satisfaction.

- Owner's satisfaction
- Project team's satisfaction
- End-user's satisfaction
- Suppliers' satisfaction
- Other stakeholders' satisfaction [32]

2.4. Problem in Construction Projects

The project is considered a success if the project meets the technical specification, and if there is a high level of satisfaction concerning the project outcome among clients, completed within a stated cost or budget and getting the project into use by a target date [33]

More than a third of major clients are dissatisfied with contractors' performance in keeping with the quoted price and to time, resolving defects, and delivering a final product of the required quality and more than a third of major clients are dissatisfied with consultants' performance in coordinating teams, in design and innovation, in providing a speedy and reliable service and in providing value for money [1].

One of the key characteristics of the projects, especially construction projects, is executing the scope of work in a specific amount of time. As project time overrun may have bad consequences for the project performing organization such as cost overrun, damage of company's reputation, etc. [31].

To the dislike of owners, contractors, and consultants, many government projects experience extensive delays and thereby exceed the initial time and cost estimates

[34]. This problem is more evident in the traditional type of contracts in which the contract is awarded to the lowest bidder [35].

Usually, the vast majority of project delays occur during the 'construction' phase, where many unforeseen factors are always involved [36]. In construction, the delay could be defined as the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for the delivery of a project. It is a project slipping over its planned schedule and this is a common problem in construction projects. To the owner, delay means loss of revenue through the non-availability of production facilities and rentable space or a dependence on present facilities. In some cases, delay causes higher overhead costs to the contractor because of the longer work period, higher material costs through inflation, and due to labour cost increases [35].

Completing projects on time is an indicator of efficiency, but the construction process is subject to many variables and unpredictable factors, which result from many sources. The sources are the performance of parties, resources availability, environmental conditions, involvement of other parties, and contractual relations, and the completion of a project within the specified time is rare [37]

There are many important causes of delay related to owner involvement, contractor performance, and the early planning and design of the project. Important causes are financial problems, changes in the design and scope, delay in making decisions and approvals by owner, difficulties in obtaining a work permit, and coordination and communication problems [37].

2.5. Traditional/Waterfall Project Management

2.5.1. History

Project management is not a concept that has been pioneered in this century. Throughout the ages, there have been abundant large-scale construction projects, including such endeavors as the raising of the pyramids, the construction of Stonehenge, and the establishment of roads and aqueducts by the Romans [38]. Mankind has thus been involved with projects even before the formalization of project management. From approximately the 15th century, large construction projects saw the introduction of engineering aspects to ensure that these projects

were completed on time. Engineering was coming of age as a science and many of the advancements in this field were due to the continual research that was being undertaken [39].

The Term "Project Management" first appeared in the mid-twentieth century and it reflected a longer history of efforts in trying to rationalize discontinuous production practices that went back to Henry Gatt and Henry Fayol [40].

Project success is a core concept of project management but its definition remains elusive [41]. Early work into the success criteria assumed that the main criteria for success were the so-called golden triangle of time, budget and required quality [42].

2.5.2. Traditional Project Management- Iron Triangle

When implementing a project, a project manager will find that there are several constraints to be aware of and taken into consideration. Traditionally in project management, this is comprised of three constraints, namely time, cost and scope [43]. This triangle is known as either the iron triangle of project management constraints or the golden triangle of project management success [43]. Project management success encompasses meeting the iron/golden triangle time, cost and quality (technical) objectives and also the way in which the project is managed, i.e. the quality of the process [44].
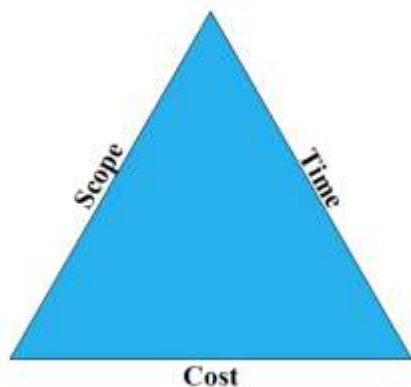
Figure 1 : Iron/Golden Triangle

2.5.3. Traditional/Waterfall Management-Theoretical Framework

In traditional project management, there are distinct phases throughout the project life cycle. In this approach, an important part is the disciplined planning and control methods. The activities are performed in planned and orderly series. In order to perform such extensive planning, the projects following this approach have the assumption that the project's future is predictable. Once a phase is completed it should not be revisited. There are of course both advantages and disadvantages to this approach as there are with any other approach. One advantage is that it is very structured and easy to follow. It also emphasizes the importance of the client's requirements. On the other hand, it is very seldom that a project can fully follow the series as planned since the conditions usually change over time and also it is difficult for the client to specify in detail all requirements at the start. This traditional approach is also referred to as the Waterfall approach [13].
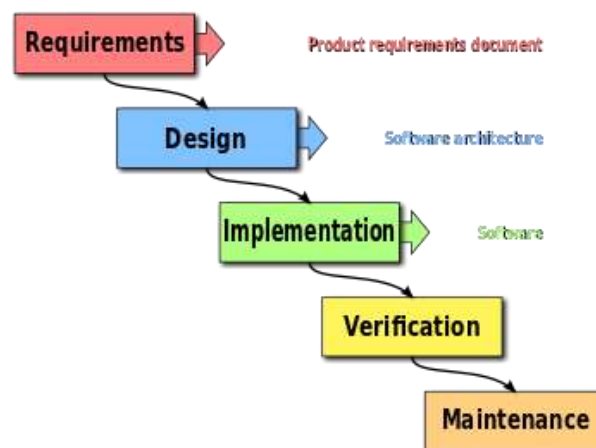
Figure 2 -Model of Waterfall Management **[45]**

2.6.Traditional Construction Project Management

Traditional construction project practice has been based on rigid and impermeable boundaries that have made communication, cooperation, and integration a major challenge [26]. Project management in the construction involves coordination of many tasks and stakeholders, affected by complexity and uncertainty, which

increases the need for efficient cooperation and multiple criteria decision making [46].

2.7.Residential Construction

Residential construction is a less-sophisticated but highly competitive segment of the industry, with multiple builders working in a particular region and typically, this industry segment includes single-family homes, multi-unit properties, and apartment buildings [21].

Residential construction addresses the housing needs of a society. Housing construction takes many forms: individual homes, apartments, condominiums, townhouses, and prefabricated units such as modular and manufactured homes [47].

The residential construction sector is diverse, including everything from design (including architecture, engineering, quantity surveys and project management); construction (including site works, building, roofing and concrete); installation (including plumbing, electrical, heating and ventilation) to completion services (including plastering, painting, glazing and fit out) [48].

2.8.Challenges for Traditional Construction Project Management

Project management is a vehicle of change. Unfortunately, many managers encounter problems in implementing projects. The efforts fail because they cost too much, take too long, are inadequately thought out and specified or simply don't deliver the expected benefits. [49]

Following project management challenges are identified by the Villanova University of United State in 2014.

Project Management Challenges within Corporate Projects

- Undefined Goals: When goals are not clearly identified, it is impossible for the team to meet them. And, since upper management cannot agree to or support undefined goals, the project in question has little chance of succeeding. The project manager must ask the right questions to establish and communicate clear goals from the outset.

- Scope Changes: Also known as "scope creep," this phenomenon occurs when project management allows the project's scope to extend beyond its original objectives. Certainly, clients and supervisors will ask for changes to a project - but a good project manager will evaluate each request and decide how and if to implement it while communicating the effects on budget and deadlines to all stakeholders.

Working with a Team: Challenges for Project Managers

- Inadequate Skills for the Project: A project sometimes requires skills that the project's contributors don't possess. Project management training can help a project leader determine the needed competencies, assess the available workers and recommend training, outsourcing or hiring additional staff.

- Lack of Accountability: A project manager's leadership qualities really shine when each member of the team takes responsibility for his or her role in achieving project success. Conversely, a lack of accountability can bring a project to a complete halt. Finger-pointing and avoiding blame are unproductive - but all-too-common - features of flawed project management. Learning to direct teams toward a common goal is an important aspect of project management training.

Another Project Management Challenge: Dealing With Risk

- Improper Risk Management: Learning to deal with and plan for risk is an essential piece of project management training. And risk tolerance is a desirable project manager trait - because projects rarely go exactly according to plan. Gathering input, developing trust and knowing which parts of a project are most likely to veer off course are all aspects of the project manager's job.

- Ambiguous Contingency Plans: It's important for project managers to know exactly what direction to take in pre-defined "what-if" scenarios. But if those contingencies are not identified, the entire project can become mired in an

unexpected set of problems. Asking others to identify potential problem areas can lead to a much smoother and more successful project.

Project Management and Communication Challenges

- Poor Communication: Project managers provide direction at every step of the project, so each team leader knows what's expected. Effective communication to everyone involved in the project is crucial to its successful completion.

Managing Expectations: An Important Project Manager Attribute

- Impossible Deadlines: A strong leader - and successful project manager - knows that repeatedly asking a team for the impossible will result in declining morale and productivity. The odds of successfully completing a project under unreasonable deadlines are not very good.

- Resource Deprivation: In order for a project to be run efficiently and effectively, management must provide sufficient resources - human, time and money. Project management training shows how to define needs and obtain approval up front, and helps project managers assign and prioritize resources throughout the duration of a project.

- Lack of Stakeholder Engagement: A disinterested team member, client, CEO or vendor can destroy a project quickly. It's like having a distracted paddler in a two-person canoe - you might get to the finish line, but not efficiently or on time. And you'll waste a lot of energy in the process! A skilled project manager communicates openly and encourages feedback at every step to create greater engagement among participants.

[50]

When it comes to special environments and conditions, one should move away from traditional project management approach and should look into modern methods that have been specifically developed for such environments and conditions.

2.9. Agile Project Management

Plan first, execute second--this is the paradigm of traditional project management. Adapt to change as you iterate--this is the paradigm of agile project management.

These competing methodologies represent two ends of a spectrum between linear (traditional) and non-linear (agile) project management processes [8].

There is no standard definition of agile project management. Alex Chin 2004 defined Agile Project Management as

"Practical and repeatable method for building sound, yet flexible project processes in environments exhibiting high internal and external uncertainty, need for unique expertise, and levels of urgency" [51]

Same year Doug DeCarlo defines it as,

"Art and science of facilitating and managing flow of thoughts, emotions, and interactions to produce value outcomes under turbulent and complex conditions (i.e., high speed, change, uncertainty, and stress)" [51]

Jim Heighsmith defined Agile Project Management in 2010 as,

"Industrial model designed for adaptive projects in order to deliver maximum business value to clients from every iteration cycle within limits of client imposed time and cost constraints." [51]

Agile project management has its roots in the system development industry and has developed and grown through empirical progress [52]. The main focus of the agile movement is to produce software quickly, without being constrained by the bureaucracy of the traditional methods [43].

2.10. History of Agile Project management

Agile methods were direct spinoffs of software methods from the 1980s, namely Joint Application Design (1986), Rapid Systems Development (1987), and Rapid Application Development (1991). However, they were rooted in earlier paradigms, such as Total Quality Management (1984), New Product Development Game (1986), Agile Leadership (1989), Agile Manufacturing (1994), and Agile Organizations (1996). The euphoria surrounding businesses as complex adaptive systems was also a major influence, namely Ecosystems (1995), Adaptive Learning (1996), Structured Chaos (1997), etc. Agile methods formally began in the 1990s with Crystal (1991), Scrum (1993), Dynamic Systems Development (1994), Synch-n-Stabilize (1995),

Feature Driven Development (1996), Judo Strategy (1997), and Internet Time (1998). Other agile methods included New Development Rhythm (1989), Adaptive Software Development (1999), Open Source Software Development (1999), Lean Development (2003), and Agile Unified Process (2005). However, the popularity of Extreme Programming (1999) was the singular event leading to the unprecedented success of agile methods by the early 2000s [51].

Agile methods appeared vastly different to the casual observer. However, they had more in common than anyone realized. The creators of agile methods gathered together in 2001 to explore these commonalities. They erected a website containing the Agile Manifesto, which still stands today [51]. Jim Highsmith in his article on history of agile manifesto is describing the beginning of Agile Manifesto concept as,

> "On February 11-13, 2001, at The Lodge at Snowbird ski resort in the Wasatch mountains of Utah, seventeen people met to talk, ski, relax, and try to find common ground and of course, to eat. What emerged was the Agile Software Development Manifesto. Representatives from Extreme Programming, SCRUM, DSDM, Adaptive Software Development, Crystal, Feature-Driven Development, Pragmatic Programming, and others sympathetic to the need for an alternative to documentation driven, heavyweight software development processes convened.
>
> Now, a bigger gathering of organizational anarchists would be hard to find, so what emerged from this meeting was symbolic a Manifesto for Agile Software Development signed by all participants. The only concern with the term agile came from Martin Fowler (a Brit for those who don't know him) who allowed that most Americans didn't know how to pronounce the word agile."
> [53]

Agile methodologies follow the iterative and incremental style of development that dynamically adjusts to changing requirements and enables better risk management. The four basic principles of agile as defined by the agile manifesto [10]are:

- Individuals and interactions over process and tools,
- Working software over comprehensive documentation,

- Customer collaboration over contract negotiation,
- Responding to change over following a plan.

To help people to gain a better understanding of what agile software development is all about, the members of the Agile Alliance refined the philosophies captured in their manifesto into a collection of twelve principles. These principles are:

- Our highest priority is to satisfy the customer through the early and continuous delivery of valuable software.
- Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
- Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
- Business people and developers must work together daily throughout the project.
- Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
- The most efficient and effective method of conveying information to and within a development team is a face-to-face conversation.
- Working software is the primary measure of progress.
- Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
- Continuous attention to technical excellence and good design enhances agility.
- Simplicity--the art of maximizing the amount of work not done--is essential.
- The best architectures and designs emerge from self-organizing teams.
- At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly. [10]

Early agile methods had their own built-in agile or adaptive project management frameworks, namely Scrum and Extreme Programming (XP) [51]. Table2 describes the recently speaking agile models.

Table 2: Different Agile Management Models **[51]**

Year	Model	Source	Major Agile Project Management Methods, Models, and Frameworks
2001	XP	Beck	Release planning (Stories, Scope, Velocity), Iteration Planning (Tasks, Schedule, Dev.).
2004	Scrum	Schwaber	Sprint Planning, Sprint (Dev.), Daily Scrum, Sprint Review, Sprint Retrospective.
2004	Flexible	DeCarlo	Visionate (Vision), Speculate (Plan), Innovate (Dev.), Reevaluate (Rev.), Disseminate (Dep.).
2005	Leadership	Augustine	Alignment (Teams, Vision), Emergence (Rules, Collaborate, Coach), Learning (Adaptation).
2010	Agile	Highsmith	Envision (Vision), Speculate (Release), Explore (Iterate), Launch (Deploy), Close (Doc.).
2010	Adaptive	Wysocki	Version Scope, Cycle Plan, Client Checkpoint, Post-Version Review.
2011	Scalable	Leffingwell	Portfolio (Vision, Architecture), Program (Product, Release), Team (Spikes, Iterations).

Today, agile methods are used by 80% to 90% of worldwide projects and have clearly "crossed the chasm." They are commonly used by big data firms (Google, Facebook, Yahoo, Amazon, etc.) and major global telecom giants (Nokia, Ericsson, British Tel., Siemens, etc.). They are also used by 60% to 70% of U.S. DoD projects (F-35, F-22, F-18, etc.), highly- regulated industries (DOE, FAA, VA, etc.), and medical device manufacturers (FDA Class III certified products).

2.11. Agile over Traditional Project Management

There is a strong debate among advocates from both APM and TPM with regard to which path to follow. Therefore it is important to examine how these two can be

harnessed for the benefit of project managers, shareholders, stakeholders and the organization as a whole. A review of the literature shows that the two approaches mainly differ on the basis of the following assumptions and characteristics.

Table 3: Differing views on Project Management from Traditional and Agile approaches [54]

	Traditional Project Management	Agile Project Management
1	Focus on process and plan	Focus on people
2	Focus on developing all parts of the scope first	Focus on the most important part of the scope first and then proceed to the next
3	Regulation of changes is based on rigid procedures.	Regulation of changes depends on flexible and adaptable procedures.
4	Members work individually within teams i.e. less collaboration	Team members collaborate in all aspects
5	Order establishment is facilitated by hierarchical organizational structures	Order is established as a result of continuous and voluntary interaction in complex systems
6	Increased order is a result of increased control	Self-organization, interaction, and simple rules result in increased order.
7	Organizations must be rigid and static hierarchies	Organizations must be flexible and eliminate unnecessary bureaucracy.
8	Controlling type of management	Management role is to facilitate and give support
9	Employees are interchangeable 'parts' in the organizational 'machine'	Employees are an important part of the organization whose contribution is necessary
10	Customer is mainly involved during requirements gathering and delivery phases	Customer is continuously involved throughout the project lifecycle
11	The reductionist task breakdown and allocation is necessary for solving problems (e.g. Work Breakdown Structure (WBS) and the Project Breakdown Structure (PBS)).	Iterative approaches to selected tasks with continuous feedback from team members and stakeholders result in valuable incremental progress in a short time.
12	Projects and risks are adequately predictable and it is possible to manage them through detailed and complex advance planning.	It is impossible to control the future because projects and risks are unpredictable due to uncertainties; therefore there is no need for detailed

		advance planning.
13	Testing is done at the end of the project cycle	Testing is iterative and done more frequently
14	Documentation is thorough	Documentation is done only when needed

The conceptual difference between TPM and APM practices where the famous 'iron triangle' is turned upside-down. It can be seen that unlike traditional project management which stresses on fixing the scope, APM considers the functionality of the project environment that affects the scope to be variable while project resources (time and people) are fixed. Whilst TPM is suitable for stable conditions it is also necessary for project managers operating in unpredictable environments to consider the dynamic and iterative development based on agile methodologies where visionary leadership, continuous learning, and customer value are considered essential within the constraints of time and budget
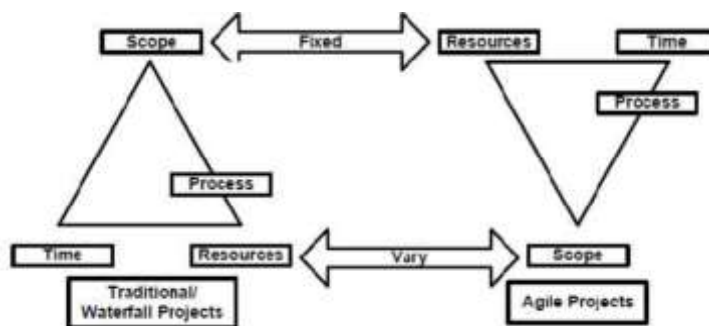
Figure 3: Conceptual differences between TPM and APM **[55]**

2.12. Scrum Method

2.12.1. Scrum Overview

The most popular agile method is Scrum. It was strongly influenced by a 1986 Harvard Business Review article on the practices associated with successful product development groups; in this paper, the term "Scrum" was introduced, relating successful development to the game of Rugby in which a self-organizing (self-managing) team moves together down the field of product development. The first

Scrum team was created at Easel Corporation in 1993 by Dr. Jeff Sutherland and the Scrum framework was formalized in 1995 by Ken Schwaber. Scrum is now used by companies large and small, including Yahoo!, Microsoft, Google, Lockheed Martin, Motorola, SAP, Cisco, GE, Capital One and the US Federal Reserve. Many teams using Scrum report significant improvements, and in some cases complete transformations, in both productivity and morale. For product developers – many of whom have been burned by the "management fad of the month club" – this is significant. Scrum is simple and powerful [56].

Scrum is an iterative, incremental framework for projects and product or application development [56]. Scrum consists of Scrum Teams and their associated roles, events, artifacts, and rules. Each component within the framework serves a specific purpose and is essential to Scrum's success and usage [57].

Scrum is a process that can manage and control software or product development. It is a project management process. Instead of promoting the traditional analysis, design, code, test and deploy approach; Scrum follows iterative and incremental practices. Scrum requires very few artifacts, unlike the usual "artifact-driven" projects, where large documentation on Requirements, Specifications, Design, etc. is needed. Scrum concentrates on what's important: "Managing a project that can produce business value" [58].

Scrum uses fixed length iterations, called **Sprints**, which are typically two weeks or 30 days long. Scrum teams attempt to build a potentially shippable (Properly tested) product increment after the every iteration [59].

2.12.2. Scrum framework

The Scrum framework consists of Scrum Teams and their associated **roles**, **events**, **artifacts**, and **rules**. Each component within the framework serves a specific purpose and is essential to Scrum's success and usage. The rules of Scrum bind together the events, roles, and artifacts, governing the relationships and interaction between them [57].

2.12.3. Scrum Roles.

In Scrum, there are three primary roles: The Product Owner, The Team, and The Scrum Master [56].

- Product Owner

The Product Owner is responsible for maximizing the value of the product and the work of the Development Team. How this is done may vary widely across organizations, Scrum Teams, and individuals [57]. In Scrum Reference Card the product owner's responsibility is scheduled as

- Single Person Responsible for Maximizing the Return on Investment(ROI) of the development effort
- Responsible for product version
- Constantly re-prioritizes the Product Backlog, adjusting any long-term expectations such as release plan
- Final arbiter for requirement questions
- Accepts or rejects each product increments
- Decides whether to continuous development
- Considers stakeholders interests
- May contributes as a team member
- Has a leadership role [59]

The Product Owner has profit and loss responsibility for the product, assuming it is a commercial product. In the case of an internal application, the Product Owner is not responsible for ROI in the sense of a commercial product (that will generate revenue), but they are still responsible for maximizing ROI in the sense of choosing – each Sprint – the highest business- value lowest-cost items. In some cases, the Product Owner and the customer are the same people; this is common for internal applications. In others, the customer might be millions of people with a variety of needs, in which case the Product Owner role is similar to the Product Manager or Product Marketing Manager Position in many product organizations. However, the Product Owner is somewhat different than a traditional Product Manager because they actively and frequently interact with the team, personally offering the priorities and reviewing the results each two- or four-week iteration, rather than delegating development decisions to a project

manager. It is important to note that in Scrum there is one and only one person who serves as – and has the final authority of – Product Owner [56].

- The Team/ The Development Team/ The Scrum Development Team

  The Development Team consists of professionals who do the work of delivering a potentially releasable Increment of "Done" product at the end of each Sprint. Only members of the Development Team create the Increment. Development Teams are structured and empowered by the organization to organize and manage their own work. The resulting synergy optimizes the Development Team's overall efficiency and effectiveness [57]. The team decides what to commit to, and how best to accomplish that commitment; in Scrum lore, the team are known as "Pigs" and everyone else in the organization are "Chickens" (which comes from a joke about a pig and a chicken deciding to open a restaurant called "Ham and Eggs," and the pig having second thoughts because "he would be truly committed, but the chicken would only be involved") [56]. Development Teams have the following characteristics,

  - Cross –functional
  - Self-Organizing/ Self-Managing, without externally assigned roles
  - Negotiates commitments with the product Owner; one Sprint at a time
  - Has autonomy regarding how to reach commitments
  - Intensely collaborative
  - Most successful when located in one team room, particularly for the first few sprints
  - Most successful when long-term, full-time membership. Scrum moves work to a flexible learning team and avoids moving people splitting them between teams
  - 7 ± 2 members
  - Has leadership roles [59]

- The Scrum Master

The Scrum Master is responsible for ensuring Scrum is understood and enacted. Scrum Masters do this by ensuring that the Scrum Team adheres to Scrum theory, practices, and rules. The Scrum Master is a servant-leader for the Scrum Team. The Scrum Master helps those outside the Scrum Team understand which of their interactions with the Scrum Team are helpful and which aren't. The Scrum Master helps everyone change these interactions to maximize the value created by the Scrum Team. [57]

The Scrum Master makes sure everyone on the team (including the Product Owner, and those in management) understands and follows the practices of Scrum, and they help lead the organization through the often difficult change required to achieve success with agile development. Since Scrum makes visible many impediments and threats to the team's and Product Owner's effectiveness, it is important to have an engaged Scrum Master working energetically to help resolve those issues, or the team or Product Owner will find it difficult to succeed. Scrum teams should have a dedicated full-time Scrum Master, although a smaller team might have a team member play this role (carrying a lighter load of regular work when they do so). Great Scrum Masters can come from any background or discipline: Engineering, Design, Testing, Product Management, Project Management, or Quality Management [56].

Scrum master characteristics and responsibilities can be formulated as below,

- Facilitate the Scrum Process
- Help Resolve impediments
- Creates an environmental conducive to team self-organization
- Capture empirical data to adjust forecast
- Shields the team from external interference and distractions to keep in group flow
- Enforce time boxes
- Keeps scrum artifacts visible
- Promotion improved engineering practices

- Has no management authority over the team (anyone with authority over the team is by definition not its Scrum master)
- Has a Leadership role [59].

The Scrum Master and the Product Owner cannot be the same individual; at times, the Scrum Master may be called upon to push back on the Product Owner (for example, if they try to introduce new deliverables in the middle of a Sprint). And unlike a project manager, the Scrum Master does not tell people what to do or assign tasks – they facilitate the process supporting the team as it organizes and manages itself. If the Scrum Master was previously in a position managing the team, they will need to significantly change their mindset and style of interaction for the team to be successful with Scrum. In the case that an ex-manager transitions to the role of Scrum Master, it is best to serve a team other than the one that previously reported to the manager, otherwise the social or power dynamics are in potential conflict [56].

2.12.4. Events

Prescribed events are used in Scrum to create regularity and to minimize the need for meetings not defined in Scrum. Scrum uses time-boxed events, such that every event has a maximum duration. This ensures an appropriate amount of time is spent planning without allowing waste in the planning process [46]

The heart of Scrum is a Sprint, a time-box of one month or less during which a "Done," usable, and potentially releasable product Increment is created. Sprints have consistent durations throughout a development effort. A new Sprint starts immediately after the conclusion of the previous Sprint. Sprints contain and consist of the Sprint Planning Meeting, Daily Scrums, the development work, the Sprint Review, and the Sprint Retrospective. [57].

- Sprint Planning meeting

  At the beginning of each Sprint, the Sprint Planning Meeting takes place [56].
  The Sprint Planning Meeting is time-boxed to eight hours for a one-month

Sprint. For shorter Sprints, the event is proportionately shorter. For example, two-week Sprints have four-hour Sprint Planning Meetings [57].

The Sprint Planning Meeting consists of two parts, each one being a time-box of one-half of the Sprint Planning Meeting duration. The two parts of the Sprint Planning Meeting answer the following questions, respectively:

- What will be delivered in the Increment resulting from the upcoming Sprint?
- How will the work need to deliver the Increment be achieved? [57]

In Sprint Planning **Part One**, the Product Owner and Team (with facilitation from the Scrum Master) review the high-priority items in the Product Backlog that the Product Owner is interested in implementing this Sprint [56]. After the Development Team forecasts the Product Backlog items it will deliver in the Sprint, the Scrum Team crafts a Sprint Goal. The Sprint Goal is an objective that will be met within the Sprint through the implementation of the Product Backlog, and it provides guidance to the Development Team on why it is building the Increment [57].

Sprint Planning Part Two focuses on detailed task planning for how to implement the items that the team decides to take on. The Team selects the items from the Product Backlog they commit to complete by the end of the Sprint, starting at the top of the Product Backlog (in others words, starting with the items that are the highest priority for the Product Owner) and working down the list in order. This is a key practice in Scrum: The team decides how much work they will commit to complete, rather than having it assigned to them by the Product Owner. Product Owner does not have control over how much the team commits to, he or she knows that the items the team is committing to are drawn from the top of the Product Backlog – in other words, the items that he or she has rated as most important [56].

- Daily Scrum

  The Daily Scrum is a 15-minute time-boxed event for the Development Team to synchronize activities and create a plan for the next 24 hours. This is done by inspecting the work since the last Daily Scrum and forecasting the work that could be done before the next one [57].

  In the Daily Scrum, one by one, each member of the team reports three (and only three) things to the other members of the team: (1) What they were able to get done since the last meeting; (2) what they are planning to finish by the next meeting; and (3) any blocks or impediments that are in their way [56].

  The Development Team uses the Daily Scrum to assess progress toward the Sprint Goal and to assess how progress is trending toward completing the work in the Sprint Backlog. The Daily Scrum optimizes the probability that the Development Team will meet the Sprint Goal. The Development Team often meets immediately after the Daily Scrum to re-plan the rest of the Sprint's work. Every day, the Development Team should be able to explain to the Product Owner and Scrum Master how it intends to work together as a self-organizing team to accomplish the goal and create the anticipated Increment in the remainder of the Sprint [60].

  The Daily Scrum is not a status meeting to report to a manager; it is a time for a self-organizing team to share with each other what is going on, to help them coordinate. Someone makes note of the blocks, and the Scrum Master is responsible for helping team members resolve them. There is no discussion during the Daily Scrum, only reporting answers to the three questions; if the discussion is required it takes place immediately after the Daily Scrum in a follow-up meeting, although in Scrum no one is required to attend this [56].

  The Daily Scrum is intended to disrupt old habits of working separately. Members should remain vigilant signs of old approach [59]. Further Daily Scrums improve communications, eliminate other meetings, identify and remove impediments to development, highlight and promote quick decision-making, and improve the Development Team's level of project knowledge. This is a key inspect and adapt meeting [57].

- Sprint Review Meeting

  A Sprint Review is held at the end of the Sprint to inspect the Increment and adapt the Product Backlog if needed. During the Sprint Review, the Scrum Team and stakeholders collaborate about what was done in the Sprint. Based on that and any changes to the Product Backlog during the Sprint, attendees collaborate on the next things that could be done. This is an informal meeting, and the presentation of the Increment is intended to elicit feedback and foster collaboration [57].

  The Sprint Review Meeting is appropriate meeting for external stakeholders (even end users) to attend. It is the opportunity to inspect and adapt the product as it emerges, and iteratively refine everyone's understanding of the requirements [59].

  This is a four-hour time-boxed meeting for one-month Sprints. Proportionately less time is allocated for shorter Sprints. For example, two-week Sprints have two-hour Sprint Reviews. The Sprint Review includes the following elements:

  - The Product Owner identifies what has been "Done" and what has not been "Done";
  - The Development Team discusses what went well during the Sprint, what problems it ran into, and how those problems were solved;
  - The Development Team demonstrates the work that it has "Done" and answers questions about the Increment;
  - The Product Owner discusses the Product Backlog as it stands. He or she projects likely completion dates based on progress to date; and,
  - The entire group collaborates on what to do next so that the Sprint Review provides valuable input to subsequent Sprint Planning Meetings.

  The result of the Sprint Review is a revised Product Backlog that defines the probable Product Backlog items for the next Sprint. The Product Backlog may also be adjusted overall to meet new opportunities [57].

- Sprint Retrospective Meeting

  Each sprint ends with a retrospective. At this meeting, the team reflects on its own process. They inspect their behavior and take actions to adapt it for future sprint [59]. The Team and Scrum Master will attend, and the Product Owner is welcome but not required to attend. Sometimes the Scrum Master can act as an effective facilitator for the retrospective, but it may be better to find a neutral outsider to facilitate the meeting; a good approach is for Scrum Masters to facilitate each other's' retrospectives, which enables cross-pollination among teams [56].

  The purpose of the Sprint Retrospective is to:
    - Inspect how the last Sprint went with regards to people, relationships, process, and tools;
    - Identify and order the major items that went well and potential improvements; and,
    - Create a plan for implementing improvements to the way the Scrum Team does its work [57].

  A simple way to structure the Sprint Retrospective is to draw two columns on a whiteboard, labeled "What's Working Well" and "What Could Work Better" – and then go around the room, with each person adding one or more items to either list. As items are repeated, check marks are added next to them, so the common items become clear. Then the team looks for underlying causes and agrees on a small number of changes to try in the upcoming Sprint, along with a commitment to review the results at the next Sprint Retrospective [56].

  By the end of the Sprint Retrospective, the Scrum Team should have identified improvements that it will implement in the next Sprint. Implementing these improvements in the next Sprint is the adaptation to the inspection of the Scrum Team itself. Although improvements may be implemented at any time, the Sprint Retrospective provides a formal opportunity to focus on inspection and adaptation [57].

- Backlog Refinement Meeting

Most product backlog items (PBI) initially need refinement because they are too large and poorly understood. Teams have found it useful to take a little time out of sprint execution – every sprint- to help prepare the product backlog for the next sprint planning meeting [59].

2.12.5. Artifacts

Scrum's artifacts represent work or value in various ways that are useful in providing transparency and opportunities for inspection and adaptation. Artifacts defined by Scrum are specifically designed to maximize transparency of key information needed to ensure Scrum Teams are successful in delivering a "Done" Increment [57].

- Product Backlog

  The Product Backlog is an ordered list of everything that might be needed in the product and is the single source of requirements for any changes to be made to the product. The Product Owner is responsible for the Product Backlog, including its content, availability, and ordering [57]. This backlog exists (and evolves) over the lifetime of the product; it is the product road map. At any point, the Product Backlog is the single, definitive view of "everything that could be done by the team ever, in order of priority." Only a single Product Backlog exists; this means the Product Owner is required to make prioritization decisions across the entire spectrum [56].

  A Product Backlog is never complete. The earliest development of it only lays out the initially known and best-understood requirements. The Product Backlog evolves as the product and the environment in which it will be used evolves. The Product Backlog is dynamic; it constantly changes to identify what the product needs to be appropriate, competitive, and useful. As long as a product exists, its Product Backlog also exists [60].

  The Product Backlog lists all features, functions, requirements, enhancements, and fixes that constitute the changes to be made to the product in future releases. Product Backlog items have the attributes of a description, order, and estimate. The Product Backlog is often ordered by

value, risk, priority, and necessity. Top-ordered Product Backlog items drive immediate development activities. The higher the order, the more a Product Backlog item has been considered, and the more consensuses exist regarding it and its value [57].

Higher ordered Product Backlog items are clearer and more detailed than lower ordered ones. More precise estimates are made based on the greater clarity and increased detail; the lower the order, the less detail. Product Backlog items that will occupy the Development Team for the upcoming Sprint are fine-grained, having been decomposed so that any one item can be "Done" within the Sprint time-box. Product Backlog items that can be "Done" by the Development Team within one Sprint are deemed "ready" or "actionable" for selection in a Sprint Planning Meeting.

As a product is used and gains value, and the marketplace provides feedback, the Product Backlog becomes a larger and more exhaustive list. Requirements never stop changing, so a Product Backlog is a living artifact. Changes in business requirements, market conditions, or technology may cause changes in the Product Backlog.

Multiple Scrum Teams often work together on the same product. One Product Backlog is used to describe the upcoming work on the product. A Product Backlog attribute that groups items is then employed [57].

Product Backlog grooming is the act of adding detail, estimates, and order to items in the Product Backlog. This is an ongoing process in which the Product Owner and the Development Team collaborate on the details of Product Backlog items. During Product Backlog grooming, items are reviewed and revised. However, they can be updated at any time by the Product Owner or at the Product Owner's discretion.

Grooming is a part-time activity during a Sprint between the Product Owner and the Development Team. Often the Development Team has the domain knowledge to perform grooming itself. How and when grooming is done is decided by the Scrum Team. Grooming usually consumes no more than 10% of the capacity of the Development Team.

The Development Team is responsible for all estimates. The Product Owner may influence the Development Team by helping understand and select trade-offs, but the people who will perform the work make the final estimate [57].

- Sprint Backlog

  The Sprint Backlog is the set of Product Backlog items selected for the Sprint plus a plan for delivering the product Increment and realizing the Sprint Goal. The Sprint Backlog is a forecast by the Development Team about what functionality will be in the next Increment and the work needed to deliver that functionality [57].

  The Sprint Backlog defines the work the Development Team will perform to turn Product Backlog items into a "Done" Increment. The Sprint Backlog makes visible all of the work that the Development Team identifies as necessary to meet the Sprint Goal. The Sprint Backlog is a plan with enough detail that changes in progress can be understood in the Daily Scrum. The Development Team modifies Sprint Backlog throughout the Sprint, and the Sprint Backlog emerges during the Sprint. This emergence occurs as the Development Team works through the plan and learns more about the work needed to achieve the Sprint Goal [57].

  As new work is required, the Development Team adds it to the Sprint Backlog. As work is performed or completed, the estimated remaining work is updated. When elements of the plan are deemed unnecessary, they are removed. Only the Development Team can change its Sprint Backlog during a Sprint. The Sprint Backlog is a highly visible, real-time picture of the work that the Development Team plans to accomplish during the Sprint, and it belongs solely to the Development Team [57].

2.12.6. Progress Monitoring

- Progress Monitoring - Product Backlog

  At any point in time, the total work remaining to reach a goal can be summed. The Product Owner tracks this total work remaining at least for every Sprint

Review. The Product Owner compares this amount with work remaining at previous Sprint Reviews to assess progress toward completing projected work by the desired time for the goal. This information is made transparent to all stakeholders. Various trend burns down, burn up and other projective practices have been used to forecast progress. These have proven useful. However, these do not replace the importance of empiricism. In complex environments, what will happen is unknown. Only what has happened may be used for forward-looking decision-making [57].

- Progress Monitoring - Sprint Backlog

  At any point in time in a Sprint, the total work remaining in the Sprint Backlog items can be summed. The Development Team tracks this total work remaining at least for every Daily Scrum. The Development Team tracks these sums daily and projects the likelihood of achieving the Sprint Goal. By tracking the remaining work throughout the Sprint, the Development Team can manage its progress. Scrum does not consider the time spent working on Sprint Backlog Items. The work remaining and date are the only variables of interest [57].

- Burndown Chart

  As Explained in progress monitoring the Burndown charts are one of the tools used for monitoring. It is used to monitor the progress of both Product Backlog and Sprint Backlog. Based on monitoring backlog the burndown charts named as
  a. Sprint Burndown Chart
  b. Product/ Release Burndown Chart

- Sprint Burndown Chart

  As per "Scrum Reference Card" developed by Michale James in 2012,

  Sprint burndown chart indicates the total remaining team task hours within one sprint. It can Re-estimated daily. As a result of Sprint

burndown chart initially go up before going down. It intended to facilitate team self –organization. It seemed like a good idea in the early days of the scrum. But in practice has often been misused as a management report, inviting interventions. The scrum master should discontinuous use of this chart if it becomes an impediment to team self-organization.

Figure 4- sample Sprint Burndown Chart **[59]**

- Product Burndown chart

    As per "Scrum Reference Card" developed by Michale James in 2012,

    Product/ Release Burndown chart tracks the remaining product backlog effort from one sprint to the next. It may use relative units for the Y axis. It depicts the historical trends to adjust the forecast.
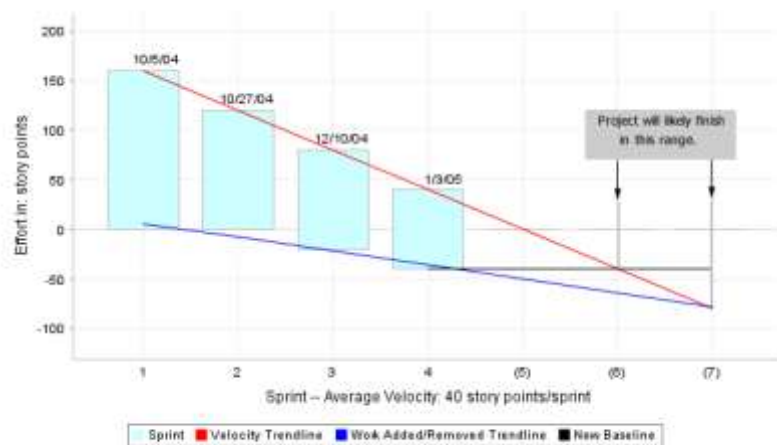
Figure 5-Sample of Product Burndown Chart **[61]**

2.13. Conclusion

The ultimate project goal shall be the satisfaction of all stakeholders of the project. Although the most numbers of clients in construction projects are dissatisfying about the project results because of either time delays or cost overruns. Most of the construction projects are managed by traditional project management method. The traditional project management is applicable to the projects where the scope is fixed. But the construction industry is experiencing the scope changes in many projects. The scopes changes are happening because of clients interesting are changing while the project is running, uncounted projects elements and etc. Almost all the construction projects are progressing towards the completion of entire scope and handing over to the clients or user. Therefore the client is sending the product at its final completion and may result in the deviating result from their initial expectation.

If the construction project is able to monitor time and cost at regular intervals and adjusts the project scope as per balance resources then the construction projects will satisfy all the stakeholders. Further if the clients or users able to experiencing the intermediate outputs of the projects then they would able to retrospect the scope to compatible with their expectations.

The scrum method in agile project management is developed to satisfy the client requirements in fixed cost and time. Therefore the scrum methods may be one of the better practice in the construction industry to address above mentioned requirement. But all methods in Agile Project Management are developed to deal with the software industry. Therefore the comprehensive study is required to identify the applicability of Agile Project Management to the construction projects.

CHAPTER 3.METHODOLOGY

3.1.Introduction

Research methodology involves the systematic procedure from identification of the problem to its conclusion. The methodology is helping to carry out research in a scientific and valid manner. The methodology consists of procedures, tools, and techniques for conducting the research study. The research study will not be meaningful and valuable until research procedure used properly. Therefore this chapter is aimed to study the different research method and used the proper method to conduct research meaningfully.

Research has a threefold objective: Theoretical, factual and application. These objectives are achieved by employing different methods and strategies of research. The method is a style of conducting a research work. It is determined according to the nature of the problem.

As Saunders et al introduced a "research onion" which explains the systematic approach from research question to conclusion. The researcher can peel

Figure 6 : The Research Onion [62]

away the layer by layer of research onion start from research philosophies to end at techniques and procedures.

3.1.2.   Research Philosophy

This over-arching term relates to the development of knowledge and the nature of that knowledge. At first reading, this sounds rather profound. But the point is that

this is precisely what you are doing when embarking on research – developing knowledge in a particular field. The knowledge development you are embarking upon may not be as dramatic as a new theory of human motivation. But even if the purpose has the relatively modest ambition of answering a specific problem in a particular organization it is, nonetheless, developing new knowledge. [62]

There are four philosophies can be identified in research approach named Positivism, Realism, Interpretivism, Pragmatism. The way of thinking on research philosophy either in ontology or epistemology is influencing on. [62]

3.1.3. Approach

Research can be approached in the following ways:

Table 4: Research Approach

Approach	Description
Quantitative/Qualitative	**Quantitative** research is on collecting and analyzing numerical data
	Qualitative research is more subjective in nature and examining and reflecting on the less tangible aspects of a research subject
Applied/Basic	**Basic Research** is to improve knowledge generally, without any particularly applied purpose in mind at the outset
	Applied Research is designed from the start to apply its findings to a particular situation
Deductive/Inductive	**Deductive research** moves from general ideas/theories to specific particular & situations:
	Inductive research moves from particular situations to make or infer broad general ideas/theories

3.1.4. Choice

When a researcher has an understanding of a philosophy then he moves to select the research strategy. A researcher can select one or more strategies out of following.

Table 5: Research Choice

Strategy	Description
Experiment	Experimental studies are done in carefully controlled and structured environments and enable the causal relationships of phenomena to be identified and analyzed. [63]
Survey	Surveys involve selecting a representative and unbiased sample of subjects drawn from the group you wish to study. The main methods of asking questions are by face-to-face or telephone interviews, by using questionnaires or a mixture of the two. [63]
Case study	A case study offers an opportunity to study a particular subject, e.g. one organization, in depth, or a group of people, and usually, involves gathering and analyzing information; information that may be both qualitative and quantitative. Case studies can be used to formulate theories, or be Descriptive, Illustrative, Experimental, Explanatory [63]
Action research	Action research involves an intervention by a researcher to influence change in any given situation and to monitor and evaluate the results. [63]
Grounded theory	Grounded theory reverses approaches in research that collected data in order to test the validity of theoretical propositions, in favor of an approach that emphasizes the generation of theory from data. [63]
Ethnography	More usually described as participant observation and this is where the researcher becomes a working member of the group or situation to be observed. The aim is to understand the situation from the inside: from the viewpoints of the people in the situation. [63]
Archival research.	Makes use of administrative records and documents as the principal source of data. [62]

A researcher can select either a mono method, Mixed method or Multi-method from above in order to achieve his/her objective.

3.2. Selection Of the Methodology

Application of agile management is rare or no in the construction industry. The word agile management is also an unfamiliar word to the construction industry. The stakeholders are not been able to share their point of view on scrum and agile. Therefore the direct data sourcing is not practical from construction industry regarding scrum method.

The Scrum method developed for software development industry need to be defined to comply with construction industry first. The roles, events, and artifacts of scrum framework shall be related to the stakeholders, meetings, and documents applying in the construction industry.

The case study is carried out to identify the compatibility of the scrum model.

This is a deductive approach with the choice of survey method.
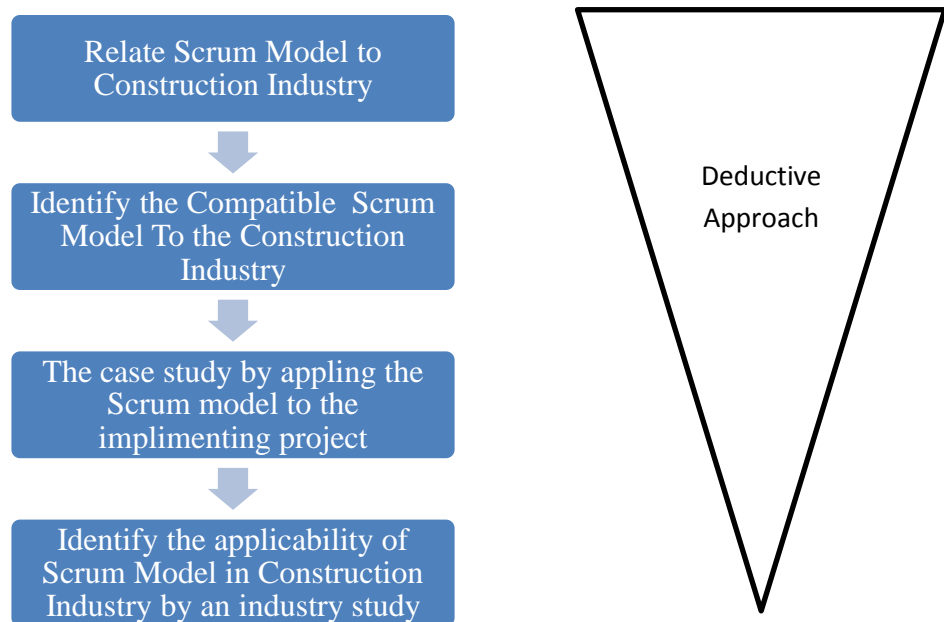
Figure 7- Research Methodology

CHAPTER 4.MODEL DEVELOPMENT

4.1.Traditional Scrum model

Incorporate scrum model to construction project management is processed along following steps.

a. Studied the attributes of traditional scrum model for software development and other applications

b. Studied the attributes of construction project management

c. Identified the demand improvements for construction project management

d. Map the scrum attributes and construction project management attributes and demand improvements.

4.2.Traditional Scrum model

The Scrum model is built on three major components: roles, process, and artifacts [11].
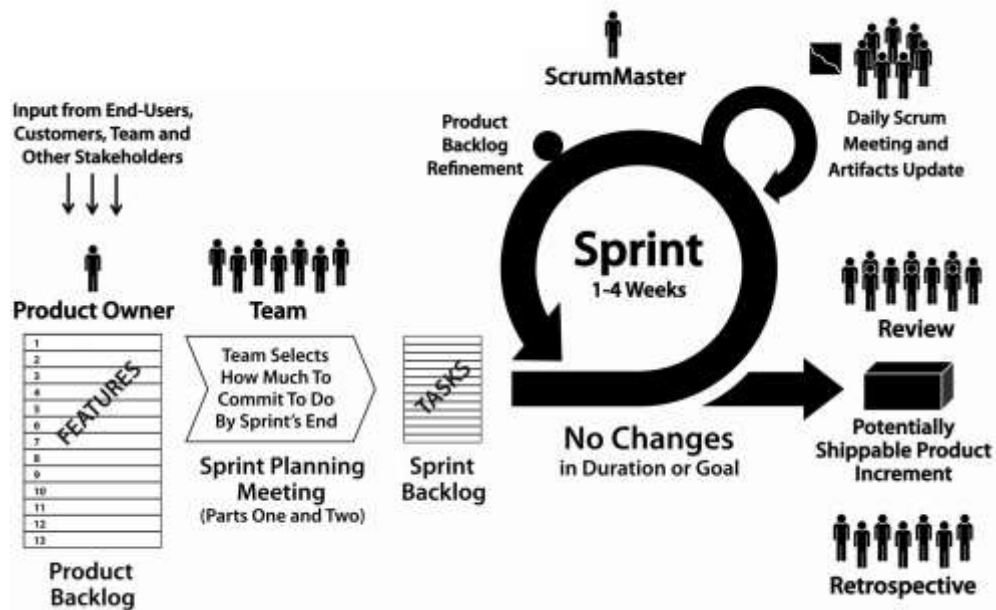
Figure 8: Typical Scrum Model **[56]**

4.2.1. Scrum Roles

Scrum process has three major roles called Product owner, Scrum Team and Scrum Master.

Table 6: Scrum Roles

Role	Attributes
Product Owner	• Single Person Responsible for Maximizing the Return on Investment(ROI) of the development effort • Responsible for product version • Constantly re-prioritizes the Product Backlog, adjusting any long-term expectations such as release plan • Final arbiter for requirement questions • Accepts or rejects each product increments • Decides whether to continuous development • Considers stakeholders interests • May contributes as a team member • Has a leadership role [59]
Scrum Team	• Cross –functional • Self-Organizing/ Self-Managing, without externally assigned roles • Negotiates commitments with the product Owner; one Sprint at a time • Has autonomy regarding how to reach commitments • Intensely collaborative • Most successful when located in one team room, particularly for the first few sprints • Most successful when long-term, full-time membership. Scrum moves work to a flexible learning team and avoids moving people splitting them between teams • 7±2 members

	• Has leadership roles [59]
Scrum Master	• Facilitate the Scrum Process
	• Help Resolve impediments
	• Creates an environmental conducive to team self-organization
	• Capture empirical data to adjust forecast
	• Shields the team from external interference and distractions to keep in group flow
	• Enforce time boxes
	• Keeps scrum artifacts visible
	• Promotion improved engineering practices
	• Has no management authority over the team (anyone with authority over the team is by definition not its Scrum master)
	• Has a Leadership role. [59]

4.2.2. Scrum Meetings

There are five meetings held in Scrum process. All five meetings are facilitated by Scrum master who has no decision making authority at these meetings. The order of meetings also named as scrum flow.
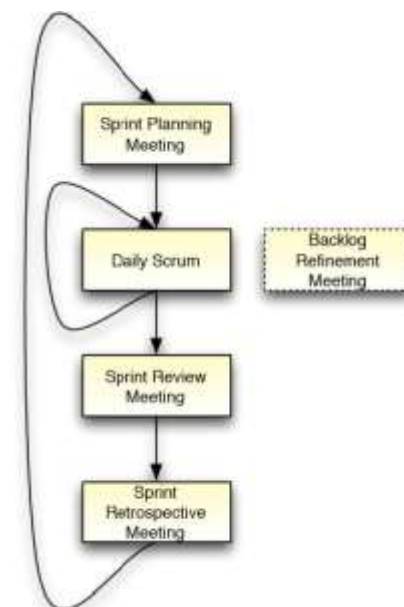
Figure 9: Scrum Flow **[59]**

Table 7: Scrum Meetings

Sprint Planning Meeting	Participant	• Product owner • Scrum master • Scrum Team
	Time	At Beginning of each Sprint
	Duration	A day with two parts.
	Discussion	<u>At first Part</u> The group defines the product backlog, which is basically a list of the project requirements. After this, the group determines the sprint goal, which is the formal outcome(s) from this particular sprint. [11] <u>At Second Part</u> In the second part of the meeting, the focus of work is on creating the sprint backlog. [11]
Daily Scrum meeting	Participant	• Scrum Master • Scrum Team
	Time	Every Day at set time
	Duration	15 minutes
	Discussion	• What did you do since the last Scrum? • What are you doing until the next Scrum? • What is stopping you getting on with your work? [11]
Sprint review Meetings	Participant	• Product Owner • Scrum Team • Scrum Master • Interest Stakeholders
	Time	At the end of each sprint

	Duration	As appropriate for demonstration
	Discussion	The functionality that was created during the sprint is demonstrated to the product owner [11]. Product owner reviews the commitments made at the sprint planning meeting and declares which items now he considered done [59].
Scrum Retrospective Meeting	Participant	• Scrum Master • Scrum Team
	Time	• At the End of each Sprint
	Duration	• Three Hour time boxed meeting for one month sprint [57]
	Discussion	• Inspect how the last Sprint went with regards to people, relationships, process, and tools; • Identify and order the major items that went well and potential improvements; • Create a plan for implementing improvements to the way the Scrum Team does its work. [57]
Backlog Refinement Meeting (Backlog Maintenance/Backlog Grooming/Story Time)	Participant	• Scrum Master • Scrum Team
	Time	• Prior to Next Sprint Planning Meeting
	Duration	• As appropriate for refinement
	Discussion	• The Team Estimates the amount of effort they would expend to complete items in the product Backlog. • Large vague items are split and clarified, considering both business and technical concerns. [59]

4.2.3. Scrum Artifacts

Scrum's artifacts represent work or value in various ways that are useful in providing transparency and opportunities for inspection and adaptation. Artifacts defined by Scrum are specifically designed to maximize transparency of key information needed to ensure Scrum Teams are successful in delivering a "Done" Increment [57].

Scrum Artifacts include

1. Product Backlog
2. Sprint Backlog
3. Sprint Task
4. Sprint Burndown Chart
5. Product/ Release Burndown chart

The process of scrum artifacts is explaining in Table 8: Scrum Artifacts.

Table 8: Scrum Artifacts

Artifact	Description	Process
Product Backlog	An ordered list of everything that might be needed in the product and is the single source of requirements for any changes to be made to the product. [57]	Planning (Product/Project Scope)
Sprint Backlog	The set of Product Backlog items selected for the Sprint plus a plan for delivering the product Increment and realizing the Sprint Goal. [57]	Planning
Sprint Task	A unit of work generally between four and sixteen hours. [64]	Execution
Sprint Burndown Chart	Indicates total remaining task within one sprint [59].	Monitoring
Product/ Release Burndown chart	Track the remaining Product Backlog effort from one sprint to the next [59].	Monitoring

4.2.4. Scrum Phases

The components of Roles, Meetings, and Artifacts of Scrum framework are arranged in scrum phases of scrum model. SCRUM has the following groups of phases:

1. Pregame

   This phase has further two sub-phases: Planning and Architecture [65]

   - Planning: Definition of a new release based on currently known backlog, along with an estimate of its schedule and cost. If a new system is being developed, this phase consists of both conceptualization and analysis. If an existing system is being enhanced, this phase consists of limited analysis.

   - Architecture: Design how the backlog items will be implemented. This phase includes system architecture modification and high-level design. [60]

2. Game

   - Development Sprints: Development of new release functionality, with constant respect to the variables of time, requirements, quality, cost, and competition. Interaction with these variables defines the end of this phase. There are multiple, iterative development sprints, or cycles, that are used to evolve the system. [60]

3. Postgame

   - The closure is actually the end of the release. This phase is started when an agreement has been completed that requirements are completed and now there will be no more welcome to the new requirements nor can any item be issued or invented. This actually the sign that system is now ready for release and all another task such as integration, testing, and documentation is completed. [65]

4.2.5. Traditional Scrum model

Phases, Sub-Phases, Roles, Meetings, and Artifacts of traditional scrum process are ordered and develop scrum model. Fig___ is representing the traditional scrum model.
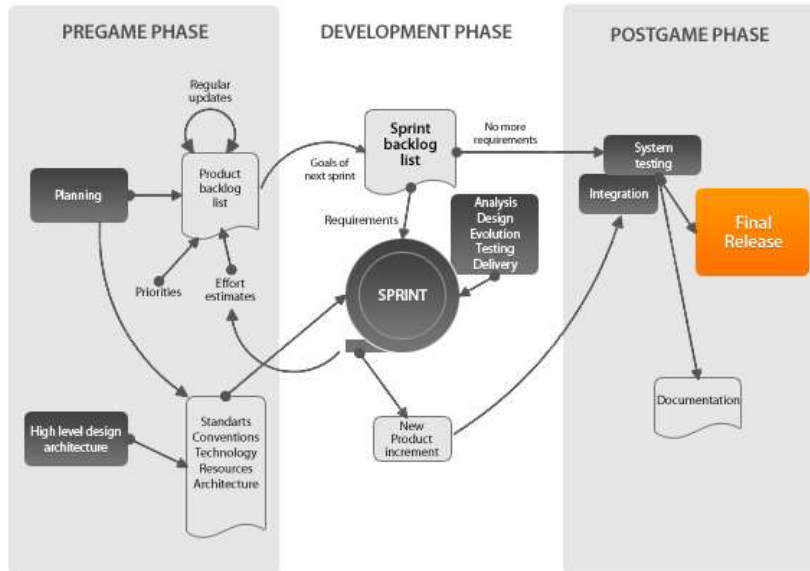
Figure 10: - Traditional Scrum Model **[66]**

4.3. Scrum Model And Traditional Construction Management

Based on facts finding by literature review the core elements of scrum model and Traditional project management can be compared as below.

Table 9: Relationship of elements between scrum Model and traditional project management

Scrum Model	Traditional Construction Management

Scrum Roles
 	
   1.   Product Owner
 	
   2.   Scrum Team
 	
   3.   Scrum Master
	Stakeholders
	
	   1. Client
	
	   2. Consultant
	
	   3. Contractor

Scrum Meetings	Project Meetings

1. Sprint Planning Meeting 2. Daily Scrum meeting 3. Sprint review Meetings 4. Scrum Retrospective Meeting 5. Backlog Refinement Meeting	1. Planning Meetings 2. Progress Meetings 3. Review Meetings 4. Project Closing Meetings
Scrum Artifacts 1. Product Backlog 2. Sprint Backlog 3. Sprint Task 4. Sprint Burndown Chart 5. Product/ Release Burndown chart	Project Documentation 1. Project Plan 2. Project Progress Monitoring Plan

Based on facts finding by literature review the phases/Process of scrum model and Traditional project management can be compared as below.

Table 10: Scrum Phases vs Traditional Construction Management process

Scrum Model	Traditional Construction Management
Pre-Game • Planning	Initiating
• Architecture	Planning
Game	Executing
	Monitoring and controlling
Post-Game	Closing

As per literature, the Pre-Game and Game phases of scrum model has iteration while the iteration of two process group of Executing and monitoring and controlling in traditional project management.

Therefore when adopting the scrum model to the traditional construction project management it shall need an iteration approach between planning and executing.

4.4.Proposed Scrum Model For Construction Project Management

The iteration between planning and implementing (Pre-Game and Game) is a core attribute of scrum method. If can associate an iteration between planning and implementing stage of construction project then all other components of scrum model can be applied to the proposed model.

In the construction industry, the holistic planning is practicing. It's like a product backlog of scrum approach. Once planning done then executing start. There is no usual practicing in repetitive planning approaches after implementation begun. Only minor adjustments can be seen in planning for situational impacts. Also, there are no or fewer practices in part by part handing over the project.

In the proposed model the master project plan is documented first. The all possible project milestones are defined which can achieve in minimum time intervals. Those milestones are a list in order. This list is the product backlog. The client, consultant, and contractor then together select the milestone can achieve in defined time frame. The selected milestone/s for a defined time interval is/are the sprint backlog. The detail project plan for selected milestones is prepared by considering iron triangle (Time, Cost and Scope). The Selected milestones are divided to the multiple sprints can which can run parallel. Once selected milestones completed the client and consultants review the contractor team achievement. Then move to the next set of milestones which can complete in defined time period. There are two minor sprints in a defined sprint. Those identified as planning sprint and implementing sprint.

Table 11: Scrum Model for CPM

Scrum Phases	Pre-Game		Game			
Proposed Scrum Model for Construction	Plan the master project	Set Project Miles tones	Select Milestone/s to defined time period	Prepare Project Plan for selected milestones	Execute Project Plan	Review Intermediate output
TPM Phases	Initiating	Planning			Executing	Monitoring and controlling

Scrum Role		Proposed Model Role	
Product owner		Client and Consultant	
Scrum Master		Project Manager	Assistance Project Managers
Scrum Team		Assistance Project Managers	Implementing Team

→ Communication Link

Scrum Artifacts		Product Backlog	Sprint Backlog	Sprint Task	Sprint Burndown Chart	Product/ Release Burndown chart
Proposed Model Artifacts	Master Project Plan	Project Milestones	Selected Milestone/s to achieve in defined time period	Detailed Project plan for selected milestones	Milestone Progress monitoring chart	Project Progress monitoring chart

Table 12: Proposed Scrum model for CPM

Pre-Game		Game				Post-Game
Plan the master project	Set Project Milestones	Select Milestone/s to defined time period	Prepare Project Plan for selected milestones	Execute Project Plan	Review Intermediate output	Project Closing
				Multiple Sprint		
Master Project Plan	Project Milestones Project Progress monitoring chart	Selected Milestone/s to achieve in defined time period	Detailed Project plan for selected milestones	Milestone Progress monitoring chart		
Project Planning Meeting (Product owner)	Milestones Planning Meeting (Product owner and Project Manager) Backlog Refinement Meeting (Scrum Master & Scrum Team)	Sprint Planning Meeting (Product owner, Scrum master and Scrum Team)		Daily Scrum meeting (Scrum master and Scrum Team)	Sprint review Meetings (Product owner, Scrum master and Scrum Team) Scrum Retrospective Meeting (Scrum master and Scrum Team)	
		Sprint				

CHAPTER 5.CASE STUDY

5.1.Background

UN-Habitat in Sri Lanka in collaboration with the University of Moratuwa, the Urban Development Authority of Sri Lanka, the Disaster Management Center of Sri Lanka and the four local authorities of Sri Lanka started an initiative to focus on creating disaster resilient cities in Sri Lanka. Australian Aids through the UN Habitats was the funding source of the project. The primary goal of the project was to establish the sustainable, disaster-resilient and healthy cities and townships of disaster prone regions of Sri Lanka. The project was conducted with Balangoda Urban council, Rathnapura Municipal Council, Kalmune Municipal Council and Batticaloa Municipal Council. The project was structured in stepwise that began with planning to end with one selected implementation for answer an identified risk at the planning stage.

Balangoda urban council area had been identified as the disaster-prone city by the government and non-government agencies because it's physical, environmental and socioeconomic situation. Balangoda situates in hill area which faces seasonal heavy rains. Therefore the area is continuously facing a geological and hydro-meteorological disaster such as rock falling, floods, and Landslides.

The Strategic analysis team from the University of Moratuwa did the vulnerability assessment of the entire Balangoda Urban Council area in order to identify the disasters and their significance. As a result, they identified eight (8) disaster zones and seven out of them were Landslides zones and the other one was flooded zone.

The Balangoda town was among identified risk zone for the flood. The Dorawela oya which is flowing adjacent to the Bus stand and the fair land was overflowing and flood the nearby area. The functions of bus stand and the fair land were losing the time of flooding.

The UN-Habitat and the Local Authority (Balangoda Urban Council) decided to implement disaster risk reduction actions to mitigate overflowing of Dorawela oya

towards Bus stand and Fair Land. Therefore the implementation of the project of strengthening the river banks of Dorawela Oya was stated.

Figure 11: Along the Dorawela Oya **[67]**

5.2.Implementation

5.2.1. Introduction

The implementation project was also funded by Australian Aids through UN habitat Sri Lanka and set most clients were Balangoda Urban Council. The selected consultants were from Chamara Liyanage Architects.

The implementation was planned to construct the structures along the river banks to strengthen the river banks while widening the river to corporate the excess water flowing at the time of heavy rains by avoiding overflowing to nearby lands.

The consultants completed a master plan for the development. The developed master plan was evaluated by all stakeholders to ensure whether the identified risk can mitigate by it. The master plan included three numbers of key elements to carry out

and the project was planned to implement in phases. The first phase expected to complete strengthen the river banks and secondly the construction of leisure area and open air theater together with car park and finally the bridge over the Dorawela Oya. Then the consultants completed the design and Bill of Quantities for the first phase and the client call the competitive bidding under the standard tendering process directed by Sri Lanka government. A contractor was selected by evaluating the received bid documents and the contract was awarded. The tender awarded value was acknowledged to the funding agents and requested the funds. The funding agents granted the contract sum under the condition of the non-exceeding budget line under any circumstance. As per the UN-Habitat project constraints the project finish date also the freeze.

Figure 12: The Master Plan **[67]**

Table 13: Elements of the First phase

First Phase Elements
Demolish the existing RR masonry wall at right-hand side river bank
Construction of Retaining wall 1
Construction Of Retaining wall 2

Construction of Retaining wall 3
Construction of Retaining wall 4
Construction of Retaining wall 5
Turfing in left-hand Side river bank
Construction of toilets and sanitary facilities
Construction of foot bridge
Develop the leisure park along the flat terrain of right-hand side river bank
Construction of open air theater
Develop the car park

5.2.2. Managerial Approach

The Contractor was acknowledged the project scope and project budget. Therefore he produced the project plan to compatible the fixed time period. After the short period of construction commence, the contractor noticed that the scope is creeping because of an unexpected situation. The Rain began and the river was fully flowing and the certain initiative works like excavation etc were over costing. The expected quantities of some elements at the time of tendering were exceeding. Further certain new temporary measures were added which make considerable cost overrun to the project. As a result, the contractor requests the cost variation and the revision for Bill of Quantities. There for the stakeholders met again in February 2013 in order to discuss how to face the situation. At this forum, the consultants were permitted to find a solution to the default cost and time constraints.

As two constraints of the iron triangle (Cost and Time) fixed the consultants identified to vary scope by satisfying the project stakeholder's needs. Further, the consultants expected not to change the whole scope at once and planned to go through element by element while physically implementing at the site in order to mitigate the identified potential risk of the area. This method was especially accepted by the Urban Council at the meeting of members of the council.

Therefore the consultants prioritized the goals of the master plan at first as per the mitigation of identified risk. The first most element of the list was designed and then issued for the construction.

Table 14: Ranking the elements

Elements of First Phase	risk	Importance	Rank
Demolish the existing RR masonry wall at right-hand side river bank	Moderate	To assure the protection from unexpected failure of weakened wall	4
Construction of Retaining wall 1	High	Secure Bus stand from flood	1
Construction Of Retaining wall 2	High	Secure Bus stand from flood and stable the deeply unstable embankment	2
Construction of Retaining wall 3	Moderate	To stable the moderate slope river embankment	6
Construction of Retaining wall 4	High	to stable The deeply unstable river embankment	3
Construction of Retaining wall 5	Moderate	To stable the moderate slope river embankment	5
Turfing in left-hand Side river bank	Moderate	to stable the river embankment	7
Construction of toilets and sanitary facilities	Low	ensure the facility to people	8
Construction of foot bridge	Low	Ensure the extra rescue path	8
Develop the leisure park along the flat terrain of right-hand side river bank	none	Aesthetic purpose	10
Construction of open air theater	none	Aesthetic purpose	10
Develop the car park	low	Ensure the traffic reduction	9

Table 15: Prioritized List

Prioritized List	
Construction of Retaining wall 1	1
Construction Of Retaining wall 2	2
Construction of Retaining wall 4	3
Demolish the existing RR masonry wall at right-hand side river bank	4
Construction of Retaining wall 5	5
Construction of Retaining wall 3	6
Turfing in left-hand Side river bank	7
Construction of toilets and sanitary facilities	8
Construction of foot bridge	8
Develop the car park	9
Develop the leisure park along the flat terrain of right-hand side river bank	10
Construction of open air theater	10

The contractor, client participant, and the consultants set the possible time period and the particular cost calculation by using accepted rates for previous main bid document. The contractor completed the construction within the accepted time period and the all client consultant and contractor together with accepted the work done and completed the contractor's bill for payment.

Table 16: Summary of First Element Work Done

Set time duration	45 working days
Planned Cost	2,488,684.93
Bill Value	2,550,243.13
Cost Variation	61,558.20

The consultant's quantified the balanced budget and duration available and moved for the second element of prioritized list.

Table 17: Summary after implement of the first Element

Started Fixed Budget Value			13,312,346.21
First Element work Done	BOQ Cost	2,488,684.93	
	Bill Value	2,550,243.13	
	Cost Variation	61,558.20	
Balanced Fixed Budget Value			10,762,103.08

While doing the first element and existed Rubble work along the river bank was damaged. Even though the strengthen of the particular side is at 4th and 5th of prioritization, the client, consultants and contractor decided to complete that element as the second element. Therefore the new prioritized list was created.

Table 18: New Prioritized List

Demolish the existing RR masonry wall at right-hand side river bank Construction of Retaining wall 5	2
Construction Of Retaining wall3	3
Construction of Retaining wall 2	4
Construction of Retaining wall 4	5
Turfing in left hand Side river bank	6
Construction of toilets and sanitary facilities	7
Construction of foot bridge	8
Develop the car park	9
Develop the leisure park along the flat terrain of right-hand side river bank	10
Construction of open air theater	10

As per the new priority list, the demolishing of existing RR masonry wall at right-hand side river bank and construction of retaining wall 5 was carried out at the site. The three elements were separately inspected and accepted at the site. The contractor was able to complete the set targets within the agreed time period and client, consultant and contractor's representatives jointly inspect the site and accept the work done. The contractor work was done and cost variations were estimated and accepted at the same time.

Table 19: Summary of the Second Element

Set time duration 2nd element	28 working days
Planned Cost	788,524.60
Bill Value	812,876.97
Cost Variation	24,352.37

Then the balanced budget was estimated by the consultant prior to implementing the third element.

Table 20: Summary after implement of Second, Third and Fourth Element

Started Fixed Budget Value			10,762,103.08
Second Element work Done	BOQ Cost	788524.60	
	Bill Value	812876.97	
	Cost Variation	24,352.37	
Balanced Fixed Budget Value			9,949,226.11

The same procedure was followed and implemented for the next elements until the balanced budget retains impracticable.

Table 21: Summary of the third element

Set time duration 3rd element	30working days
Planned Cost	1,089,560.06
Bill Value	1,095,548.42
Cost Variation	5,988.36

Table 22: Summary after implement of the third element

Started Fixed Budget Value 3rd element			9,949,226.11
Third Element work Done	BOQ Cost	1,089,560.06	
	Bill Value	1,095,548.42	
	Cost Variation	5,988.36	
Balanced Fixed Budget Value			8,853,677.69

Table 23: Summary of the fourth element

Set time duration 4th element	30working days
Planned Cost	845,208.04
Bill Value	859,003.94
Cost Variation	13,795.90

Table 24: Summary after implement of the fourth element

Started Fixed Budget Value 4th element			8,853,677.69
Fourth Element work Done	BOQ Cost	845,208.04	
	Bill Value	859,003.94	
	Cost Variation	13,795.90	
Balanced Fixed Budget Value			7,994,673.75

Table 25: Summary of the fifth element

Set time duration 5th element	45working days
Planned Cost	7,908,741.00
Bill Value	7,276,710.70
Cost Variation	-632,030.30

Table 26: Summary after implement of the fifth element

Set time duration 6th element	14working days
Planned Cost	607,505.00
Bill Value	563,763.50
Cost Variation	-43,741.50

Table 27: Summary of the sixth element

Started Fixed Budget Value 6th element			717,963.05
Sixth Element work Done	BOQ Cost	607,505.00	
	Bill Value	563,763.50	
	Cost Variation	-43,741.50	
Balanced Fixed Budget Value			154,199.55

Table 28: Summary after implement of the sixth element

Started Fixed Budget Value 5th element			7,994,673.75
Second Element work Done	BOQ Cost	7,908,741.00	
	Bill Value	7,276,710.70	
	Cost Variation	-632,030.30	
Balanced Fixed Budget Value			717,963.05

The client, Consultant, and the Contractor together with identified that the balanced budget after the sixth element is impracticable.

The client, consultant and contractor together with add two days of buffer for the inspection and accepted the each element after the completion. The period of construction was planned by merging those buffers too.

5.2.3. Cost of Element

The cost of each element was estimated by preparing the Bill of Quantities for each element. The rates for each element was abstracted from the contractor's BOQ submitted for the initial scope. The cost of the element was estimated at the time of the previous element implementing.

The funding agent agreed and freeze the total cost of SL Rs. 13,312,346.21. The each element cost was calculated just after the element finished and available balance are estimated and compare with the BOQ of the forthcoming element to implement.

5.2.4. Set the time period

The project was planned to start 05/03/2013 by doing all revisions and the 210 days of the time period was fixed for the total implementation. Therefore the project was expected to finish on 08/10/2013.

But the project commencement day was slightly dragged and was started on 12/03/2013. The time duration for each element was fixed by consultant by analyzing available time period. Yet the contractor allowed negotiating the time period. For those initiation work, additional two days of buffer maintained. At the end of given time period, the representatives of all parties have inspected the site together and accepted the work done. Even though the contractor not able to complete hundred percent of work, he was allowed to start next element. Although the contractor was able to complete almost all at the set time period and few identified rectifications of the element done were complete while next element process.

The contractor negotiation for element's time period was experienced only by the first element because the traditional April new year was lapped with the element's set time. As a result additional eleven day's drag was allowed.

Table 29: The time flow of the project

Element	Consultant set duration	Negotiated duration	Buffer duration	Start date	Planned End date	Actually finished date
First	34	45	2	12/03/2013	06/05/2013	12/05/2013
Second	28	28	2	08/05/2013	04/06/2013	08/06/2013
Third	30	30	2	06/06/2013	05/07/2013	15/07/2013
Fourth	30	30	2	07/07/2013	05/08/2013	10/08/2013
Fifth	45	52	2	08/08/2013	29/09/2013	07/10/2013
Sixth	14	14	2	23/9/2013	06/10/2013	13/10/2013

The contractor work was seven days dragged from expected project end date set by funding agents. Yet the contractor has to carry out only a few minor works and rectifications as directed by a consultant at the visit. Therefore the funding agent was acknowledged as project finished by all parties.

5.2.5. Scrum framework

The intended expectation of this section is to identify the relationship between scrum method's components and the case study's activity. As literature explained the scrum model has three components called Roles, Events and Artifacts. The stakeholders, meetings, and documents referred in the case study are almost similar to those scrum components as describe in following paragraphs.

5.2.5.1. Artifacts

As per literature scrum has five major Artifacts called Product Backlog, Sprint Backlog, Sprint task, Sprint burndown chart and Product burndown chart. The case study project was able to manage three major similar artifacts as shown in Table 26.

Table 30: Relationship between Project Artifacts and Scrum Artifacts

Scrum Artifact	Project Artifact
Product Backlog	Construction prioritized list
Sprint Backlog	Element to implement
Sprint Task	BOQ Element to complete

5.2.5.2.Roles

As described in the scrum roles there are the product owner, Scrum team and Scrum Master. The client, Consultant, and contractor were the major three parties of the case study project. The contractor appointed a project manager to represent him. The senior technical officer from the urban council was appointed as a client representative and consultant team was there. The appointed stakeholders are compatible with scrum roles but the role of appointed stakeholder seems to be changed at the different situation of the project. The table 27 explained the relationship between project stakeholders and scrum roles.

Table 31: Scrum Role and Stakeholder Relationship

Role	Stakeholder		
	At planning	At Implementing	At Accepting
Product owner	STOMC	STOMC	STOMC & CONS
Scrum Master	CONS	CONTPM	CONTPM
Scrum Team	CONS Team	CONT Team	CONT Team
Abbreviation: **STOMC** – Senior Technical Officer Municipal Council			
CONS - Consultant			
CONTPM- Contractor's Project Manager			
CONT Team – Contractor's Team			
CONS Team – Consultant's Team			

5.2.5.3.Events

Scrum process has five defined events called Sprint Planning Meeting, Daily Scrum meeting, Sprint review Meetings, Scrum Retrospective Meeting and Backlog Refinement Meeting. The case study project also held meetings at several stages in order to achieve the set time cost targets. The Relationship between project meetings and Scrum Events are shown in table 28.

Table 32: Relationship with scrum Events and Project meeting

Scrum Event	Project Meeting
Sprint Planning Meeting	Client's, Consultant's and Contractor's Representative together discuss the elements to implement and negotiated the time period to complete the selected element
Daily Scrum Meeting	The Contractor's Project manager inform the BOQ elements to proceed to his subordinates in regular intervals
Sprint Review Meeting	Client's, Consultant's and Contractor's representatives jointly inspect the site and accept the contractors work after completion of each element's construction
Scrum Retrospective Meeting	Contractor's Project Manager convey the rectifications has to be carried out for completed element to his subordinate
Backlog Refinement Meeting	Client's, Consultant's and Contractor's representatives together discuss whether any change of prioritizing list has to be done as per available budget and occurred risk.

The case study project's artifacts, roles, and meetings are having a slightly closed relationship with the Scrum artifacts, roles, and events. Although some artifacts not

applied in case study project, there is a possibility to apply those artifacts in similar projects.

5.3. Expert Review

5.3.1. Introduction

The similarities between the case study approach and the scrum method needed to be operationalizing by having the Expert Review. The construction industry is almost based on projects which are having uniqueness. Even the case study project support to develop similarity with scrum method there may have or not positive similarity with other construction projects. Therefore the study of the applicability of case study results in the present construction industry is the prior objective of this subsection.

5.3.2. The Methodology for Expert Review

The Expert Review is based on the questionnaire (Appendix A) developed by using the case study output. The questionnaire is referred the four major areas named General, Project Documents, Team members and Project Meetings.

1. General

The general section of the questionnaire is covered the respondent's view of the traditional construction project management approach which is practicing in present day industry. The project scope and its behavior throughout the project, the time and cost behavior and client satisfaction is the core identification of this area of the questionnaire. The task of this area is to identify the possibility to work with the core principle of scrum method.

2. Project documents

This section of the questionnaire is covered the respondent's weight and interest on project documentation in traditional project management. The task

of this section is to identify the possibility of work in no or less documentation environment in construction projects.

3. Project team Members

    The stakeholders in construction projects and the level of importance of them are studying in this section. The present day stakeholder behavior, their classification, the importance of stakeholder's interactions are perceived from respondent while identifying the possibilities of work with smaller groups having cleared defined roles is the task of this section of the questionnaire.

4. Project Meetings.

    The respondents perceived on traditional constructions project meetings is the aim of this section of the questionnaire. The relevance of project meetings, the relevance of participants, and the value of meeting durations are extruded from respondents while identifying the possibility to incorporate a predefined set of meetings used in scrum method is the prior task of this section.

5.3.3. Selection of Expert Review sample

The prior task of this questionnaire is to validate of case study outputs in the construction industry. The construction industry is a project-based industry. A construction project is an effort of major three parties called client consultant and contractor. Therefore the stakeholders in construction projects are the focused group of Expert Review. But the above mentioned three parties are having different levels of professional involvements. As the prior objective of the questionnaire is to studying on project management approach and validation of new project management method in a construction project; the core respondents for the questionnaire survey are managerial level experts in construction projects.

5.3.4. Data Analysis
5.3.4.1.Introduction

This subsection is focused on analyzing the data collected from a questionnaire survey and discuss the results obtained.

There is 17 respondents reply to the questionnaire via three responding way of online survey monkey web facility, emails and on table discussion. The first sections of the questionnaire are presenting the participant's personal data to validate the appropriateness to perceive their ideas to this survey. The analysis is not required for those data.

The second section of the questionnaire is presenting the pre-knowledge of respondents regarding the agile project management. The data received for the third section have mostly perceived the value of respondents. The data of the second and third section of the questionnaire is used to analyze because these are the based questions areas for this study.

5.3.4.2.Raw Data

The sixty-nine numbers of requests were made for the questionnaire survey and nineteen respondents were found. Although the two incomplete receives were omitted for the analysis. The raw data of the balanced seventeen participants are referred to the analysis.

5.3.4.3.Data Analysis
5.3.4.3.1. Respondents Summary

All the respondents presented their professional and academic qualification as per the following table.

Table 33: The Respondents summary

Academic Qualification	Diploma	Bachelor Degree	Master Degree	Doctoral Degree	Other
Professional Qualification					
Charted Engineer		2	5		

Engineer			1	3		
Charted Architect				4	1
Architect					
Charted Quantity Surveyor				1	
Quantity Surveyor					
Other					

Table 34: Respondents representing party

Representing party	
Client's Party	2
Consultant's Party	6
Contractor's Party	9

5.3.4.3.2. Awareness of Agile Project Management (APM)

The awareness on agile project management of the participants to the survey is analyzed and found that five out of seventeen participants heard the term agile project management before. Although three out of this five say the Agile Project Management (APM) can be applied to the Construction industry.
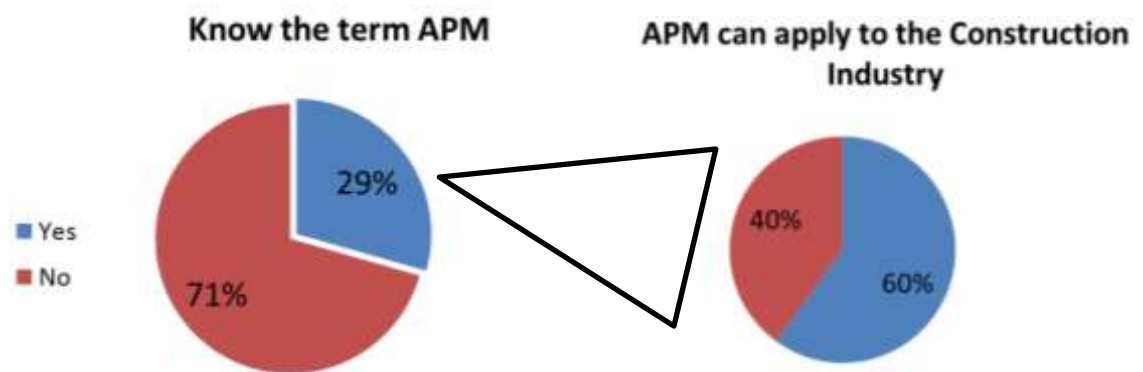

Figure 13: Respondent perceive on APM to the Construction Industry

5.3.4.3.3. Analysis on PM Practice In Construction Industry

The all seventeen participants knew that the plan first and implementing second is the traditional project management practice in construction projects. Further, they all say that the project scope needs to be fixed prior implementation. Nine out of these seventeen agree that in most construction projects the project scope is changing while implementing. Further, the sixteen respondents say that if any changes of scope are significantly influenced by the project cost and project time. Also, all seventeen respondents agree that the clients are worried about exceeding project budget and time.

Table 35: Participant Responds on Project Scope and Client interest on Project Cost and Project time

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
	General						
1	Plan first and implementing second is the general practice in construction industry	17					
3	The scope of the construction project is needed to be fixed prior implementing	17					
5	Although the scope of most construction project **is changed** while implementing		9		5	3	
6	The scope change significantly influence to change the construction time	11	5	1			
7	The scope change is significantly influenced to change cost of construction project	11	5	1			
8	The clients are mostly worrying about the exceeding project cost and project time	13	4				

As per the above responds the construction industry is facing the scope changes in some circumstance and it may affect the construction time and cost which is a mostly worrying factor of clients. Therefore it seems that there is a possibility to incorporate fixed project cost and time and change the project scope. In other words, there is a possibility to turn iron triangle upside down in some projects.

Although the most important facts to incorporate scrum method to the construction industry is the possibility of prioritization of the client needs. But the most of the expertise disagree about the description "client requirements in the construction industry can be prioritized."
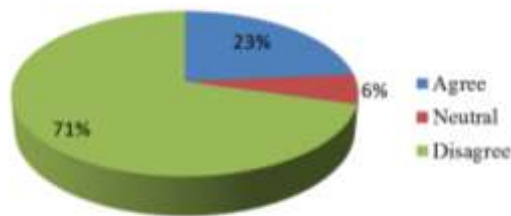
Figure 14: Participants responds to possibility of prioritizing the client needs in construction industry

This means even though there is a possibility to work with fixed project cost and time with varying project scope; the client needs is difficult to prioritize. In other words, it implies the development of product backlog is difficult in construction projects.

5.3.4.3.4. Participant responds on Project Documents

The participant responds regarding the present practice of project documents is tabulated as below table.

Table 36: Participant responds about Present practice of project documents

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Project documents					
13	The documents of construction projects work is not difficult	3	12	2		
14	the type of documents of projects are not varying project to project /manager to manager	2	8	1	6	
15	The documents are supporting to the achievements of the projects (Time and cost)	6	8		3	
17	The documents are important to the construction project's progress monitoring	10	7			
18	Simplify the project documentation is required	17				

This data present that the expertise view is more positive about existing project documentation in point of project cost and time achievements and its progress monitoring. But there are some different thoughts about the consistency of documents type in a project to projects. Some participants say there is not a variation of the document in the different project but some say there is variation. This may happen because of their different experiences. Also, all participants agree to simplify the project documentation. This is a positive point to penetrate the simplified documentation process in scrum method.

But the scrum method's documents/ Artifacts are focused on client prior needs, implementing needs and implementing tasks. Therefore it may have the possibility to incorporate these three defendants to the construction industry.

Table 37: Participant perception about Project Documents behavior of APM

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Project documents					
20	Project documents shall represent client prior needs.		5	12		
21	Project document shall clearly state the forthcoming element to implement	14	3			
22	The project documents shall clearly state the task completed to finish the implemented element	7	3	7		

As per the response, the task-oriented documentation is possible but most of the participants not having a clear idea about the possibility of incorporate prior needs to project documentation. This may because the difficulty of identifying the prior needs of the project. Therefore the incorporate the product backlog of scrum method documentation is difficult in construction projects.

5.3.4.3.5. Team members of construction project

The team of construction projects is an important factor. The size of the project team, their relationships, the defined boundaries between each other are important. The participants respond to their experience about construction project teams as below.

Table 38: Participant responds about the construction project team

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Team members					
23	the construction project's stakeholders are clearly classified	15	2			
24	The team members of the construction project has good relationship between each other	3	7	2	5	

25	the project team members know the limitations and constrain to the interaction with different stakeholders	9	2	2	4	
26	the irrelevant interactions from different parties of the project generally happens	13	3	1		
27	The smaller size project teams are more effective		3	2	4	8

As per the participant responds there is no similar perception about project teams. It may because of the different experiences with project stakeholders. It can be happened because of human feelings and thoughts differ person to person. Most of the respondents face irrelevant interaction, improper relationships, and unclear limitations and restraint of the project team members. This is better opportunity to incorporate well and pre-defined roles in scrum methods to construction projects. But most expertises are not expecting to work with smaller teams which are core characteristics of scrum method.

5.3.4.3.6. Participants responds about project meetings

The project meetings are importance in the construction industry. The expertises perceive about the present practice of project meetings is requested and they responded as below.

Table 39: Participants responds of Project meetings

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Project meetings					
28	the construction project meetings are necessary	17				
29	the construction project meetings are effective in present practice	1	3	2	11	
30	Duration of the project meetings are pre-decide		3	1	7	6

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
31	There are irrelevant participants also attends to the meetings	1	7	2	2	5
32	Project meetings are held in order to pre-prepared agenda.	2	7	6	2	

The participated expertises seem not passively thinking about the present day project meetings. Even all of them strongly agree with the description of "the construction project meetings are necessary"; most of them are worrying about effectiveness, meeting durations and the participants. It makes the better opportunity to incorporate scrum events (meetings) to the construction projects. Therefore the applicability of platform of scrum events to construction projects is perceived with participants and they respond as below.

Table 40: Participants expectation about Project meetings

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Project meetings					
33	project meetings duration needed to be fixed	14	3			
34	The scope of the project meeting needed to be defined	8	9			
35	the relevant Participants to the project meeting needed to be identified prior to the meetings	12	5			
36	the daily 5minutes standup meeting with project members is effective	1	6	5	5	

As per expertises responds they expect to have fixed duration, scope and relevant participants to the project meetings. The scrum events (meetings) also having these characteristics. Therefore it seems to have the possibility to incorporate scrum events to the project meetings. But the participants say it's impractical to have daily five minutes standup meetings. The core driven events of scrum method are daily five

minutes meeting of scrum team (Daily scrum meeting). Therefore the stability of daily scrum meetings is doubtful in construction projects.

5.3.4.3.7. Comparison of Participant response

This section is analyzing the participate response on APM related questions in the questionnaire. The section 2 of the questionnaire is regarding the participant awareness on APM and there are five participants say they know the term APM and three out of five say they think APM can apply to the construction industry. The following analysis is regarding the respond of those five participants about the questions relevant to APM in section 3 of the questionnaire.

Table 41: APM aware participant responds on APM relevant descriptions

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	General					
5	Although the scope of most construction project **is changed** while implementing		5			
11	Client requirements of the construction projects can be prioritized (Most required one to lesser)		4	1		
12	Client will satisfy if his prior requirements are fulfilled within available project budgeted and expected project time period	3	2			
	Project documents					
18	Simplify the project documentation is required	5				
20	Project documents shall represent client prior needs.		3	2		
21	Project document shall clearly state the forthcoming element to implement	5				

No	Statement						
22	The project documents shall clearly state the task completed to finish the implemented element	3	2				
	Team members						
27	The smaller size project teams are more effective		3	2			
	Project meetings						
33	project meetings duration needed to be fixed	5					
34	The scope of the project meeting needed to be defined	5					
35	the relevant Participants to the project meeting needed to be identified prior to the meetings	5					
36	the daily 5minutes standup meeting with project members is effective	1	3	1			

The participant response on APM related questions is positive as in Table 38. It says the pre-study study or awareness on the APM may be effective to incorporate the APM to the construction project.

5.4. Summary of the chapter

The main objective of this chapter is to implement the case study regarding APM and conduct the expert review with the experience from conducted case study. The implemented case study makes positive and successful output to establish the APM to the construction project. It is donor-funded construction project and the time and cost constraint also made a platform to incorporate APM (scrum method). Although the time and cost behavior and client expectations of the construction projects differ from project to project as literature explained. Therefore the expertise review also conducted by referring the experience having with the case study and it says the awareness on APM is less in the construction industry and identifies some possibilities and difficulties to incorporate APM in construction projects.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1. Introduction

This concluding chapter brings out conclusions drawn by the research based on the findings. Limitations of the study are also discussed, and implications and recommendations are presented for practitioners. Finally, future research areas are discussed.

6.2. Conclusions and implications

For the construction project management, the APM is a strange word to most stakeholders. Almost all construction projects practice the TPM (waterfall management). Therefore they familiar the approach of the plan first and implementation second; in other words the sequential approach. Therefore the iterative approach like scrum methods in APM is a challenge to incorporate in construction projects.

As per the literature review, there are certain dissatisfactions and failures are experiencing in TPM approach. The literature says that the cost overruns and time overruns are the prime challenges with TPM. The client who is the ultimate owner of the project is overviewed the output at the end of the whole project. Therefore it is hard to revise or alter the project even the client may need to add or omit his needs to or from the project.

The scrum method in APM is an iterative approach which is possible to review outputs within the predefined time interval to the product owner (Client). Also, the product owner and the team are able to review and make refinement to the client needs and order of needs at predefined intervals. Therefore it seems more user supportive approach.

After having the literature review about scrum method and construction traditional project management the scrum model able to develop. The three phases of scrum

methods called pre-game, game, and post-game are satisfied by the elements of traditional construction project management. The compatible sprint also identified for the construction project management and the artifacts, meetings, and roles incorporated to the model.

The developed model then supported to the conduct the case study. The case study was conducted to the donor-funded project which is sealed the time and project budget with its upper limit.

Establish Product Backlog- the client of the project had multiple needs from the project and those all seems not possible to answer within given time period and available budget (project cost). Therefore the all client needs were prioritized as per his interest and the let them act sequentially. Therefore the product backlog was able to establish at the case study project.

Establish the Sprint Backlog- The top prior need of the ordered product backlog selected and project team allowed implementing it. The detailed instructions were pre-planned for the selected item and expected budget and time also set. The team was able to complete the selected client need and the available balance time and cost were calculated. Therefore the sprint backlog also established for the case study project.

Establish the Roles- the incorporations of scrum roles and its limitations was hard because; the client party has several stakeholders having different thoughts and establishment of their involvement was difficult to pre-planned. Also, the client authorization process was not readjusted to suit the scrum method and process as traditional way. On the other hand contractor team which is the core component of scrum team also not established well. When a sprint is processing the team members are altering. But the contractor able to maintain four members supervision team until the end of the project which is almost same as scrum team and the project manager of the contractor is acting as a scrum master. Therefore the establishment of roles was not success in case study project.

Establish the Sprint Planning Meeting- the client, consultant and contractor representative able to agree the set cost, time and the scope of selected sprint (prior need) of the project be it implemented at the on-desk meeting. Therefore the expectations of the sprint planning meeting almost established at the case study project.

Establish the Daily Scrum Meeting- the contractor was advised to implement the daily five minutes standup meeting to discuss what they completed so far and what has to be completed today. But it seems the project manager still hold the instructing and advising role rather than discussion role. He is passing the daily scope to cover but not having the share thoughts like the scope of daily scrum meeting. It may be happening because the completion of the works is physically seen and then the project manager not required discussing the completion effort again. Therefore the daily scrum meetings are seems established in case study projects with minor deviations of its predefined scope.

Establish the Sprint Review Meeting- the all-party representatives together with accepted the contractor work done to complete selected client needs (sprint). At this meeting, contractor advised for rectifications to carry out (if available). The construction value is jointly calculated and balanced budget and time also estimated. The pre-notified variations also calculated and the contractor payments also approved at the same meeting with any required holdings up to rectifications and retentions. Therefore the sprint review meetings are almost established in conducted case study project.

Establish Sprint Retrospective Meeting- the contractor party not seems to have a discussion about their effort in completed client needs (sprint). But the irregular discussion is having between consultant and contractor to share their thoughts about completed sprint. Therefore the sprint retrospective meetings are not strongly established in case study project.

Establish the Backlog Refinement Meeting- the scope of this meeting is happened not in a face to the meeting. After client informed about available budgets and the project situations at the sprint review meeting then the client express interest of his

needs and all party then readjust the balance product backlog if required. But the client spends two or three days to authority approval for such changes if it is major. Therefore it seems not had separate backlog refinement meeting in case study project but the scope of backlog refinement meeting is almost covered at the time of sprint review meeting.

Therefore at the case study project; the major scrum artifacts are strongly established. The scrum roles are not well established. The scrum events like sprint planning meetings and sprint review meetings are well established and daily scrum meetings and backlog refinement meetings are established but not covered its whole scope. Further, the sprint retrospective meetings seem not established. Therefore the scrum meetings are established up to a certain extent at the case study project.

After conducting the case study the expertise review was carried out to identify the expert thoughts to incorporate scrum method in construction projects.

The hard challenge identified while the expertise review is the lack of or no knowledge about APM in stakeholders in the construction industry. Only five participants of review out of nineteen responds say they heard the term APM before. The most answers from expertise say that the client needs hard to be prioritized. It says the establishment of product backlog is difficult in a construction project. Although the five APM known participant responds is positive to prioritize the client needs.

The majority of participants are willing to work with simplified project documentation. Although they believe the project documentation is a must for project progress monitoring and to the achievement of the project. The responding behaviors of APM known and unknown participants are not much differed regarding project documentations.

The possibility of establishing the daily scrum meeting is difficult because most of the participant comments that they have not agreed to possible of conduct daily five minutes meetings at the sites. Although they are worried about the present meeting standards and they positively comments about predefined meeting package to the

construction projects such as predefined time duration, predefined scope, predefined participants etc.

The participants also not agreeing to work with smaller teams which are the core of scrum model, but they are agreeing that the clear classifications need to establish for the role responsibilities in the construction industry. Although the APM known participants slightly differ about small teams and they agree to work with smaller teams.

The overall expert review is not positive to establish the scrum method in PM to the construction industry although the APM known participants are showing some green lights about the incorporation of some facts in scrum methods to construction project management.

The ultimate conclusion of the study says; even though the case study positively responds to establish the scrum method the expertise review is not positive. But the APM known participants in expertise review are flash green lights in a certain extent to establish the scrum method for construction projects.

6.3. Recommendations and Limitations for future research

The case study conducted for the study is a donor funded project. The donor-funded projects are almost sealed budget projects. It may be the reason to incorporate the scrum method. But the construction projects are differing from project to project. Therefore the applicability of scrum method or APM needed to subjectively study for different project conditions to identify the compatibility of APM to CPM.

The client need prioritization is the principle requirement for driven the scrum method. Therefore identify whether the projects having the possibilities to prioritize client needs may comply to incorporate scrum method. Further, it says scrum method or APM may be more practical to introduce as a substitute for TPM wherever possible instead of trying replacing TPM by APM.

The lack of industry data to study the scrum method or APM in the construction industry is the challenge to make more effective outputs to the research studies. Therefore the industry should be encouraged to practice scrum methods or APM wherever possible to substitute for TPM in construction projects.

The pre-knowledge about APM needed to be penetrating among the stakeholders in construction projects because this pre-knowledge may change the stakeholder's perceptions on CPM and it will be open the stakeholders out of the box thinking from TPM.

The Scrum methods and other APM approaches are developed to compatible with software industries which more do not physically view until established. But construction project progress physically views. Therefore some scrum methods rolls, events, and artifacts are good to be recaptured to a suite with construction project activity. But it should be a deep study approach because the changes may be damaged to the concepts of Scrum or other APM methods.

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APPENDIX A- QUESTIONNAIRE FOR EXPERT REVIEW

AGILE PROJECT MANAGEMENT FOR SRI LANKAN CONSTRUCTION INDUSTRY

1. Professional Information

1.1 Your highest educational level
   a. Diploma (……………………………)
   b. Bachelor Degree
   c. Master Degree
   d. Doctoral Degree
   e. Other (…………………………….)

1.2 Your Profession
   a. Charted Engineer
   b. Engineer
   c. Charted Architect
   d. Architect
   e. Charted Quantity Surveyor
   f. Quantity Surveyor
   g. Other ……………………………………….

1.3 Current/Last Project   (If you are not engaging a project recently then refer your last project for following 1.3.1, 1.3.2 and 1.3.3)

1.3.1   Name of Current/Last project you have been experienced.
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………

1.3.2   Your Representing Party of the Current/Last Project
   a. Client's Party   ☐
   b. Consultant's Party   ☐
   c. Contractor's Party   ☐

1.3.3   Your level of management in the Current/Last Project

Project Director

Project Manager

Project Engineer

Site Engineer

Design Engineer

Project Architect

Project Quantity Surveyor

Other   ……………………………………

1.4 Your highest level of management in professional life

Management Level	Years of Experience (Approximately)
Project Director	
Project Manager	
Project Engineer	
Site Engineer	
Design Engineer	
Project Architect	
Project Quantity Surveyor	
Other (……………………………………)	

1.5 Have you experienced on Residential construction project/s? (Size/cost of project is not a matter for your answer)

Yes ☐   No ☐

2. **Awareness on Agile Project Management (APM)**

2.1 Do you know the term Agile Project Management (APM)?

Yes ☐   No ☐

2.2 If Yes then

    2.2.1 How did you get known?
- a. By reading
- b. By listening to a lecture
- c. As a partner of an application of APM
- d. Other (…………………………..)

    2.2.2 Which can Industry APM be applied as you known?
- a. Information Technology (IT) ☐
- b. Manufacturing ☐
- c. Construction ☐
- d. Agriculture ☐
- e. Apparel ☐
- f. Other (………………………………..)

    2.2.3 Do you have any experience of APM application in Sri Lankan Construction Industry?

Yes ☐   No ☐

  2.3 Do you think APM is adapting to Sri Lankan Construction Industry?

Yes ☐   No ☐   Not Having Exact idea ☐

3.   Construction project management practice in Sri Lanka

Please select your perceive value for following questions.

Question No	Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	General					
1	Plan first and implementing second is the general practice in construction industry					
2	The project scope is covered the client requirements of the project					
3	The scope of the construction project is needed to be fixed prior implementing					

4	The construction time and construction cost are planned to achieve the fixed project scope					
5	Although the scope of most construction project **is changed** while implementing					
6	The scope change significantly influence to change the construction time					
7	The scope change is significantly influenced to change cost of construction project					
8	The clients are mostly worrying about the exceeding project cost and project time					
9	The client may happy if the construction project close within available budget and expected time					
10	Varying the project scope without influencing to the available project cost and project time is the best option					
11	Client requirements of the construction projects can be prioritized (Most required one to lesser)					
12	Client will satisfy if his prior requirements are fulfilled within available project budgeted and expected project time period					
	Project documents					
13	The documents of construction projects work is not difficult					
14	the type of documents of projects are not varying project to project /manager to manager					
15	The documents are supporting to the achievements of the projects (Time and cost)					

16	The document process make drawbacks to the project-driven					
17	The documents are important to the construction project's progress monitoring					
18	Simplify the project documentation is required					
19	The project documentation is time wasting fact					
20	Project documents shall represent client prior needs.					
21	Project document shall clearly state the forthcoming element to implement					
22	The project documents shall clearly state the task completed to finish the implemented element					
	Team members					
23	the construction project's stakeholders are clearly classified					
24	The team members of the construction project has good relationship between each other's					
25	the project team members know the limitations and constrain to the interaction with different stakeholders					
26	the irrelevant interactions from different parties of the project generally happens					
27	The smaller size project teams are more effective					
	Project meetings					
28	the construction project meetings are necessary					
29	the construction project meetings are effective in present practice					
30	Duration of the project meetings are pre-decide					

31	There are irrelevant participants also attends to the meetings					
32	Project meetings are held in order to pre-prepared agenda.					
33	project meetings duration needed to be fixed					
34	The scope of the project meeting needed to be defined					
35	the relevant Participants to the project meeting needed to be identified prior to the meetings					
36	the daily 5minutes standup meeting with project members is effective					

APPENDIX B: PHOTOGRAPHIC EVIDENCE OF CASE STUDY
SITE CONDITION & CONSTRUCTION PROGRESS

AUGUST - 2012 (2012/08/06) (Design phase)

AUGUST - 2012 (2012/08/15) (Design phase)

AUGUST - 2012 (2012/08/26) (Design phase)

FEBRUARY - 2013 (2013/03/12) (Implementing)

MARCH - 2013 (2013/04/26)

APRIL - 2013 (2013/05/06)

MAY - 2013 (2013/06/04)

JUNE - 2013 (2013/06/26)

JULY - 2013 (2013/07/08)

JULY - 2013 (2013/07/20)

AUGUST - 2013 (2013/08/05)

SEPTEMBER - 2013 (2013/08/10)

OCTOBER - 2013 (2013/09/12)

OCTOBER - 2013 (2013/09/29)

NOVEMBER - 2013 (2013/10/06)