Sustainable Requirement Engineering Practices Model for Sustainable Software Development

by

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CANDIDATE DECLARATION

I declare that this thesis entitled "*Sustainable Requirement Engineering Practices Model for Sustainable Software Development*" is conducted by me and results produced in this research is the effort of this research and the references used in this research is cited accordingly. The thesis in hand has not been accepted and submitted for any other degree.

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ABSTRACT

Sustainability in requirement engineering (RE) has an emerging aspect in every fields, achieving sustainability during software development and as whole to get sustainable software is important. The survival of software is largely depending upon the selection of requirement practices that can leads software to sustain, and can evolve as environmentally friendly software is crucial. However, practicing sustainability during software development as sustainable software development, if ignored, it can lead to the disaster of sustainable society. In particular, this will ultimately lead towards less sustainable software which can only spread over shorter period of time affecting to the society with more resource utilization, heat emitting sources and others. Thus, study aims on identifying the sustainable RE practices, for each process of requirement engineering phase including the elicitation of requirements, specification, analysis, verification and validation, managing the requirements. This could eventually help to explore sustainable incorporating requirements. This research contributes to theory and practice by providing the sustainable requirement engineering practices model. Such research can help academician and industry to evaluate their practicing level of sustainable software development.

Keywords: Sustainability, Requirement Engineering, Practices Model, Sustainable Software Development.

DEDICATION

I dedicate my work to my beloved parents who have been supporting me throughout my life and education career with their wishes and love unconditionally.

ACKNOWLEGEMENT

First of all, I wish to offer my thanks and profound thankfulness to Almighty ALLAH, I would like to express my sincere thankfulness and appreciation. Yet, there were significant contributors for my attained success and I cannot forget their input, especially my research supervisors, Dr. Muhammad Noman Malik, during my research journey, he guided me consistently shall also thankful from the administrations of Department of Computer Sciences who supported me

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LIST OF ABBREVIATIONS

RE	Requirement Engineering
SDLC	Software-Development Life Cycle
SSD	Sustainable Software Development
ISO	International Standard Organization
ICT	Information and Computing Technology
SEO	Search Engine Optimization
SLR	Systematic Literature Review
QA	Quality Assurance
RQ	Research Question
PSC	Pakistan Software Community
PSEB	Pakistan Software Export Board (PSEB)
IEEE	Institute of Electrical and Electronic Engineer
DEF	Data Extraction Form.

CHAPTER # 1

INTRODUCTION

1.1 Overview

This chapter sets the illustration of the research background along with the problem statement and the goals of this research. Moreover, research questions address in this research is described with the research objectives subsequently. Besides, aim of the research, scope, contribution and significance of the study is described.

1.2 Background of Research

Sustainable is a not a new term as it has been used in various fields that describes "…..capable of being continued with minimal long-term effect on the environment" [1]. The sustainability has primarily associated with natural science and ecology system [2], however sustainability has emerged into varied fields industries well needed software fields. Sustainability in the information technology (IT) and software engineering (SE) has recently emerged as critical concern. Especially for the complex software systems indulge with environment, society and economy, requirement engineering for such system is even getting difficult to align with sustainable requirements. In this regard, sustainability generally refers to the "…. the quality of being sustained". Further to this, the term of sustained directs the "….capable of being endured and capable of being maintained" [2]. This describes the longevity and the maintenance are the crucial aspects to better understand and implement sustainability aspects.

Although sustainability concept has been involved in different fields, example environmental, social etc. [3] ., but this sustainability term is recently coined in the field of SE that shows two aspects of software sustainability and sustainable development. The Software which survives for the longer period of time is generally known as sustainable software [4]. Whereas the development process that focuses on those key practices to attain the software sustainability known as sustainable development.

Software sustainability and sustainability development focus to address the basic nurture of sustainability dimensions as contributing to the society. However, if

sustainable development of software is ignored, it can lead to the disaster of sustainable society. In particular, this will ultimately lead towards less sustainable software which can only spread over shorter period of time affecting to the society with more resource utilization, heat emitting sources and others.

In order to address such disastrous notion, there is need to focus on those requirement engineering practices, termed sustainable requirement engineering practices, which must be followed for each phase of requirement engineering.

Sustainability awareness is deep rooted towards individual's knowledge, attitudes and behaviors on each of four aspects of sustainability that includes the economic aspect, technical aspects and environment [2]. Software which is addressing one or more of these parameters lies under the umbrella of sustainable software.

1.3 Problem Statement

Despite of the theoretical importance of sustainability representing the complexities involved in software development, there is a lack of guidance in identifying the RE practiced indicators that can lead to the sustainable software development [2]. Considering the fact of unknown and diversified views on what to practice while performing RE, there is serious need for any drive towards integrating the sustainable development for software sustainability [2].

Thus, lack of sustainability in software development generates less environmentally friendly software's [2]. In the interests of avoiding future inconsistencies and making software successful and sustainable, this research focuses to develop a model by identifying the sustainable requirement engineering practices, for each phase of requirement engineering.

1.4 Research Questions

The two research questions are addressed in this research which are as follows.

(i) What are the sustainable requirement engineering practices essentially required for developing sustainable software?

(ii) How much industry is practicing to the identified sustainable requirement engineering practices for software development?

1.5 Research Objectives

This research has taken three research objectives with alignment of research questions. Following are the objectives of study research.

(i) To identify the relevant sustainable RE practices for software development.

(ii) To identify the industry practicing level of sustainable RE practices for software development.

(iii) To formulate a sustainable RE practices model for sustainable software development.

1.6 Aim of Study

Aim of this research is to focus on identifying relevant sustainable requirement engineering practices for each process of requirement engineering life cycle including the elicitation of requirements, specifying the detailed requirements, analyzing, verifying and validating, managing the requirements. Besides, Research also focused to provide comprehensive guideline to measure their current level of practices for sustainable software development for project.

1.7 Scope of Study

The research scope of this study is relevant to software engineering, especially towards requirement engineering and the integration of sustainability for software development. The details of scope of the study are as follows.

(i) Sustainable RE Practices for each process of requirement engineering be initially selected from the System Literature Review.

(ii) This study only focuses RE phases in the context of sustainable RE practices, ignoring SDLC other phases.

(iii) SLR followed by the expert review from academia and survey from industry is focused to get the answer of the research questions raised in this research.

(iv) To conduct a survey among companies' practitioners, companies listed in Pakistan Software Community (PSC) and Pakistan Software Export Board (PSEB) has been contracted.

1.8 Contribution and Significance of Study

This thesis introduces the identifying sustainable requirement engineering practices which are relevant and required.

This research significantly focused to measure the practicing level of requirement engineering practices. It can eventually contribute towards theoretical knowledge of software engineering as well as to contribute the industry practitioners' understanding of these practice states in the organization. This research can contribute to organizations to understand and communicate the software development strategies for achieving software sustainability.

1.9 Thesis Outline

The thesis in hand consists of five chapters. The 1st chapter sets the illustration of the research background along with the problem statement and the goals of this research. Moreover, research questions address in this research is described with the research objectives subsequently. Besides, aim of the research, scope, contribution and significance of the study is also described.

The 2nd Chapter describes the existing literature on and around the subject of sustainability and requirement engineering. Moreover, introduction of term 'sustainability' with 'requirement engineering' is described and both the term found in recent articles are also discussed along with the literature review about sustainable requirement. Basic identified practices and existing proposed models are also taken under discussion.

The Chapter 3 sets the research methodology employed to conduct this research. The overall research process carried in this study is explained and also the detail process of systematic literature review (SLR) adopted to investigate the sustainable practices. Secondly, expert review (ER) and survey is also conducted for evaluation purpose.

The 4th Chapter describes the research results collected in this study related to identify sustainable practices and sub-practices from existing studies. Moreover, survey results of identified practices and sub-practices are discussed and to develop sustainable practice model for software development.

5th Chapter consists of conclusion, future work, limitation and discussion of this research. Some recommendations to enhance the sustainable RE practices model for future studies are also described.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter describes the existing literature review on the subject matter. Introduction of term 'sustainable or sustainability' and Role of requirement engineering, and gap, challenges, exist practices and solution of requirement are discussed. Furthermore, at the end of chapter existing sustainable and requirements engineering studies compared and reported.

2.2 Introduction

Sustainable is a not a new term as it has been used in various fields that describes "…..capable of being continued with minimal long-term effect on the environment" [1]. Sustainability is deep rooted with the environment and initially with ecology concern [2]**.** Sustainability term has been defined in various ways and one of most common definition is presented by the Brundtland commission as "meeting the needs of the present without compromising the ability of future generations to meet their needs" [2]. In software field particularly, there is known institute of Software Sustainability has defined the term of sustainability as "….software you use today will be available - and continue to be improved and supported - in the future" [5]

In [4], authors has emphasized on the process of sustainable software engineering (SSE) that underlines the long term, reliable and sustained with requirements of users by considering not to impact on environment. Based on the reviewing of literature related to sustainability, it is observed that it is composite and have variation in different aspects while taken into account of software industry [6].

Naumann et. al., have referred sustainability as triple bottom line of sustainability into the software development [7]. A definition is given on this regard, "software, whose direct and indirect negative impacts on economy, society, human beings, and environment that result from development, deployment, and usage of the software are minimal and/or which has a positive effect on sustainable development". Literature is evident that achieving sustainable in software is primarily depends on organizations

understanding of sustainability. Moreover, its impact need to be foresee on sustainable development they way organizations practice it [8].

2.3 Sustainability Perspective of non-function Requirement:

As non-function requirement perspective, Sustainability should be rated as a non-functional first-class requirement were said by various observers. [2]. Refer to both desired qualities, such as observed qualities and the system developer 's internal features of non-functional requirements. [9]. In addition, they indicate criteria which will be utilized to evaluate the functioning of a framework, instead its of specific functional behavior [10]. Consequently, a number of contributions have focused on defining sustainability of software as a non-functional requirement.

In [11] The GREENSOFT model proposed by Naumann aims to combine three types of non-functional requirements Refer to the sustainability criteria and indicators section of the reference model. This division permits the assessment of the first-, second-, and third-order effects on the environment caused by supply effects, use effects, and system effects.

As defined author [12] Venters et. al., software sustainability as a complex, non-functional requirement that is “a measure of a systems extensibility, interoperability, maintainability, portability, reusability, scalability, and usability”

Author Calero and Moraga [11] as they recommend that sustainability from two viewpoints: energy efficiency and perdurability, has model named in the ISO/IEC 25010 quality reference model they propose that sustainability related to a various quality attributes and sub-characteristics In any case, may be taken into consideration specification standard has eight item quality characteristics and thirty one sub-characteristics.

One of the key difficulties in characterizing sustainability as a non-functional imperative is how to explain a quantifiable way for the quality variables. [12].

2.4 Sustainability perspective of reference model:

In the perspective of references model, many numbers of frameworks have proposed for defining sustainability.

In [13][14] Authors Penzenstadler and Femmer propose a reference model for sustainability that breaks down sustainability into five dimensions.

• *Environmental*: the purpose of this dimension by protecting natural resources;

• *Individual*: the aim of reference model regarding this dimension the Protection of individual human capital's private good;

• *Social*: In this dimension keeping up social capital and protecting the societal communities in their solidarity;

• *Economic*: In this dimension keeping up maintaining assets;

• *Technical*: the purpose of this dimension is long-time utilization of frameworks and their satisfactory advancement with changing encompassing conditions and respective requirements.

Author Naumann in [15] proposed A generic model which improves common software development processes towards sustainable software product design. It implements many artefacts and practices to achieve "Sustainable Software Development"

In [2] author duck as defined : Model of software systems in the domain of industrial automation is usually a long-lived system with a lifetime of more than 10 years. In arrange to encourage long-living software systems, they have created a catalog of “sustainability guidelines” this catalog model provides contracted method, information about characteristic on their validation of industrial, supporting tools each dimension, benefits potential, risks connected, checklists-based, and references literature.

2.5 Software Sustainability difficulties in adoption:

To understand why current good practices are frequently misunderstood and ignored, we reviewed the RE literature. It has been recognized that there is a general discrepancy between what should be practiced theory and actual practice [16]

- There is evidence suggests that poor adoption at an individual level is often caused by a lack of education and experience. [16] .
- Regev et. al., [17] defined as, A poor understading of these practices and their advantages hampers the use of good RE practices in software industry.
- In [10] the author Glass argues, researchers actually do not have the required experience to make theoritical solution that reason of good practices are not widely adopted in the industries.
- Ahmed et. al., [18] argue, It is the organizational culture which is believed to have a significant impact on the adoption of practices and, one of the big reasons for not implementing certain best practices in software development are the extra costs [16].
- In professional practices, It is not only necessary to understand the properties and behavior of the software,But also the behavior of team members such as software engineers, development teams and organizations [19]
- In [20] Several people have suggested that they cannot used sustainability practices in the organization because the methodologies used in their businesses do not support it.For occasion, they utilize in company a waterfall technique, but they cannot apply sustainability to them work as “the waterfall life- cycle does not contain any concepts of sustainability.”
- author Kim[21] said, A general assumption is there that sustainable practice requires additional work which inevitably leads to additional costs but IT professional think that sustainability itself is not a good reason for the extra work..
- *Need for Change of Mentality.* The author Pat. defined as the key challenge in adopting sustainability in the companies are to “convincing them and getting them to change their way of thinking”[22].
-

- *Little Company Concerns*:[25] customer satisfaction is carried out in small companies with less than 50 employees.. They emphasized that the key focus in work life is to maintain a good relationship with customers. That means the companies are very responsive to customer requests in terms of delivery time , customer viewpoints acceptance, and costs..
- *Limited resource availability:* another question raised by small companies that sustainable design "would require us to do extra things which we do not have resources for". so It is clear small companies don't have surplus manpower and skill availability [23].
- *Lack of Time in businesses*. A few individuals think that lack of time as a key factor to perventing them from making sustainable designs,These individuals say that when customers demand something that is not sustainable, The company cannot waste time on reasoning, but only implement it[24].
- *Lack of Management Support:* in [25] Each organization having difference structured of Organizations hierarchies, which may make people at lower levels feel powerless to make bigger changes without permission from the management..
- *Lack of awareness* :Sustainability can be used many cases through use of the present RE strategies ,techniques and methods,tools but RE practitioners have no knowledge of this. [26].
- In [27] Lack of education and experience in a related subject may have a negative impact on actual practice.

Following Table 2.1 showing literature papers describe Research focus, Limitation, Methodology Support, authors name.

Table 2.1 Existing Studies on Sustainable Software

Authors &Years	**Research Focus**	**Methodology**	**Limitation**
Venters (2014)	defined the definitions of sustainability perspective of various dimension.	Conceptual research and empirical findings	currently no absolute definition of the sustainability concept
Chitchyan (2016)	The term sustainability defined as perceptions and attitudes towards requirements engineering practitioners	Interview Conducted	The organization has limited knowledge and understanding of its potential opportunities and benefits of sustainability
Betz, Stefanie (2016)	finding the solutions of "sustainable" practices.	Conceptual research Model	Limited and lack of available solutions of sustainable practices for each phase of SDLC
Theresia Ratih Dewi(2019)	this study was considered to analyze the sustainability criteria and to approve software code based on the proposed sustainability measurements and estimations.	Conceptual research	The limits of the information retrieval methodology and techniques
Naumann (2011)	The author was proposed a reference model, the named of model is GREENSOFT for "Green and Sustainable Software"	Conceptual research	Lack of models, implementations in the field of software development.

Renzel (2017)	The researcher addresses the specify two longitudinal case studies in large-scale EU research projects for the example of sustainability	Empirical Study	limited example for the large scale (LS) and smaller scale (SC) projects
Venters (2016)	Sustainability design provides an opportunity for software companies	Conceptual research	Role in software society aspect
Theresia (2020)	A reference model that provide approach or technique for complex sustainability requirements	empirical study	In research, limited quantifiable methods that promoting sustainable design and analysis.
Kristin Roher (2011)	The solution proposed recommender system	Case Study	Evaluation of the suggested method is not yet a structured analysis, nor has it established a standardized metric.
Raturi (2014)	Proposed to NFR framework that is informed by sustainability reference model	Conceptual Model	It is theoretical framework for limited specific dimension achievable goal of the sustainability.
Mahaux (2013)	Provide GreenSoft Model	Conceptual Model	Specific purpose used.
Patricia (2015)	Provide a model of sustainability that identify environmental impact	Theory define	Few limited challenges explained.
Durdik (2012)	Provide a model namely “catalog of software sustainability guidelines”	Case Studies	limited information regarding phase

			of software architecture and design.
Naumann (2010)	solution of a generic model to which improves common software development processes towards sustainable software product design	Conceptual Model	Specific example explained.
Calero (2013)	Proposed a model namely (25010+S) an extension standard of the ISO/IEC 25010 Which are provide characteristics and sub-characteristics of sustainability	SLR	Multifaced information provide.
Asghar (2010)	customer-off-the-shelf components (COTS).	Theorical	Bugs in requirements are not identified during development rather they until system becomes operational
Huzooree (2015)	The aim of paper is Encountered the difficulties and the gap between theory and practice in the requirements engineering process	Systematic Study	These gap and practices only explained for the RE phase.
Albertao (2010)	Provide a set of software engineering indicators that can be used to evaluate the economic, social and environmental sustainability of software projects	theorical	Benchmarks not available for the metrics,
Betz, Stefanie (2014)	in a paper, describe holistic approach to support SDLC for the sustainability	Conceptual Model	General describe of the reference model.
Roher, Kristin (2013)	Recommender System	Theorical	Not implemented

Saputri, Theresia (2020)	functional decomposition to elicitation requirement	empirical study,	Not clearly define methodology.
….	….	…..	….

CHAPTER # 3

RESEARCH METHODOLOGY

3.1 Overview

Research methodology employed to conduct this research is descried in this chapter. The overall research process carried in this study is explained and also the detail process of systematic literature review (SLR) adopted to investigate the sustainable practices. Moreover, conduction of expert review (ER) and survey is also explained in detail.

3.2 Research Methodology

This chapter explains overall research methodology, tools and techniques adopted to achieve all the core objectives. In the study, several sustainable practices identified and process for requirement engineering methodologies have been presented, we propose to identify the essential required sustainable software development practices for each requirement engineering phase of lifecycle including elicitation, specification, Analysis, verification and validation of requirements and its management.

3.3 Overall Structure of Research Methodology

The methodology opted in this research to answer research questions entails three step process. The details of three step process of research methodology is shown in Figure 3.1. The first step is to conduct an SLR to identify the relevant sustainable practices for Requirement Engineering. Exert Review selection and conduction of reviews are explained in second step. The purpose of conducting expert review is to evaluate the identified RE Practices from literature. Lastly, a survey is conducted to industries measure their current level of practices for requirement engineering.

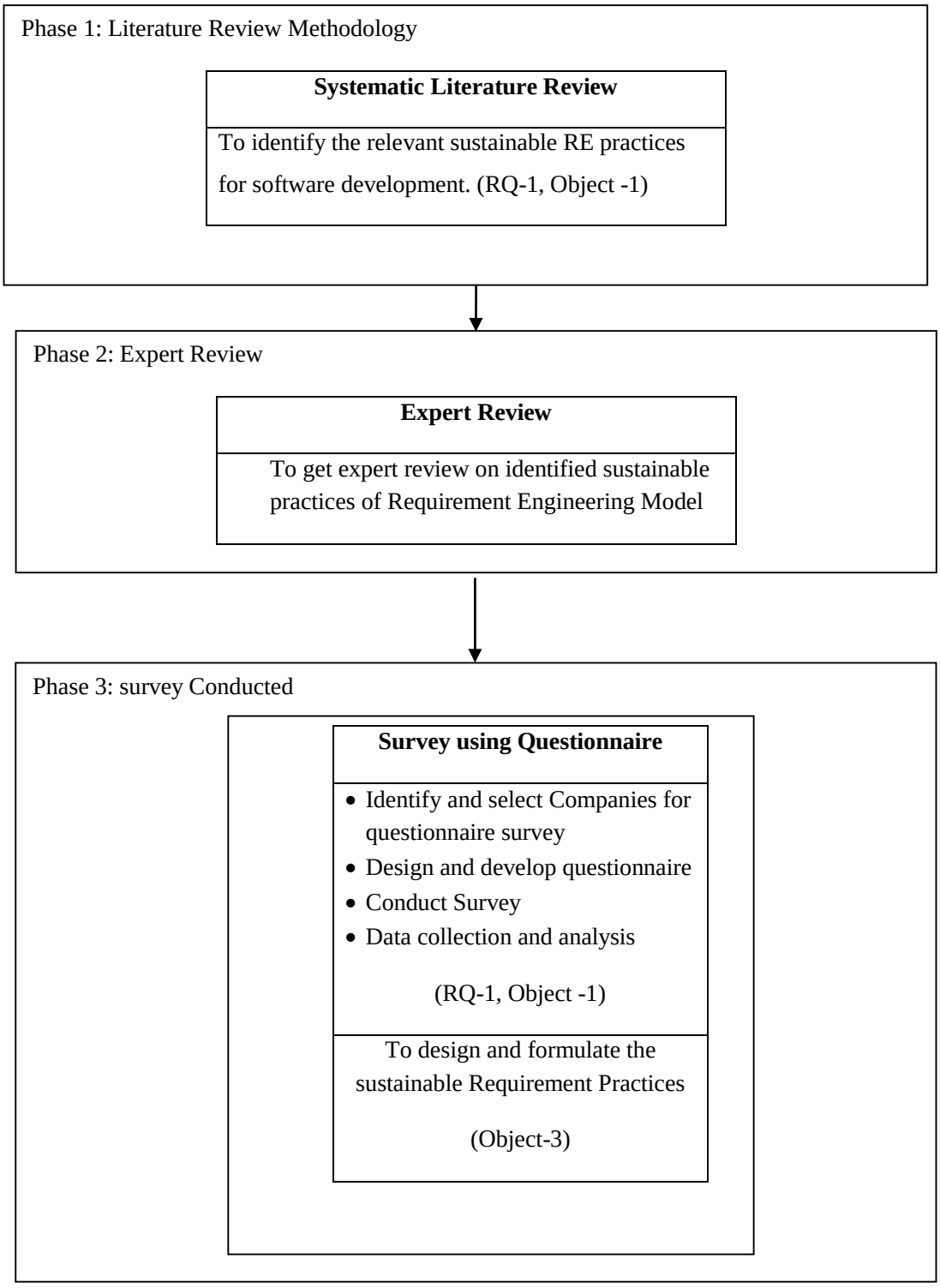


Figure 3.1 – Three step process of Research Methodology

3.4 Research Design and Procedure

In order to answer research questions, the following methodologies are opted in this study:

- SLR
    - Stages
    - Protocols
- Expert Review
    - Stages
    - Expert Reviews suggestion
- Industrial survey
    - Companies
    - Participant Profile.
    - Questionnaires.

The research methodology to conduct this research is as follows. First, we present the SLR approach we decided to use because we think it is the one that best fits our stated goals. Later, will have scale sustainable practices model from software expert for review these practices, A doctor level like a Professor/Assistant Professor of Computer or IT or any relevant fields having more than five year of experience after that select for data collection. the methodology for collecting empirical data from the software companies**,** participating in the research is explained, as well as what different kind of companies we find out there are when doing the research. Moreover, the overview of the inquiries that compose the questionnaire and the purpose of each of them is explained.

3.5 Research Approach

Research approach used in this research can be refer to two ways, one is related to the qualitative and another is related to quantitative approach. Subsequently, it aimed to give a deeper the identified essential required practices of requirement engineering and will have focus on validated to identify practices into IT industries, and the latter in the research select software related professionals to verify sustainable practices. As the purpose of our thesis is to identify sustainable practices in requirement engineering, investigation have conducted from software companies which use sustainable

development in real life and ask for their ideas. Thus, the qualitative approach is an appropriate approach for this thesis, and it will lead us to understand how to measure requirement engineering practices**.**

3.6 Systematic Literature Review

SLR is quite comprehensive and laydown the foundation for the subject investigated. This study has adopted the guideline of Kitchenham [28] and followed all steps specified in the guideline from initial selection of the papers to results reporting [28].

3.6.1 SLR Adopting Reasons

Following are the reasons of adopting SLR to conduct this study.

- Identifying the Sustainable Requirement Engineering Practices for Sustainable Software.
- Highlighting the research gap in the literature.
- Contribute by providing future avenues on the subject under investigation

3.6.2 The Process of SLR

For SLR, there are mainly into three steps such as planning, execution and Summarization. Kitchenham guided three step process of SLR which are showing in figure 3.2.

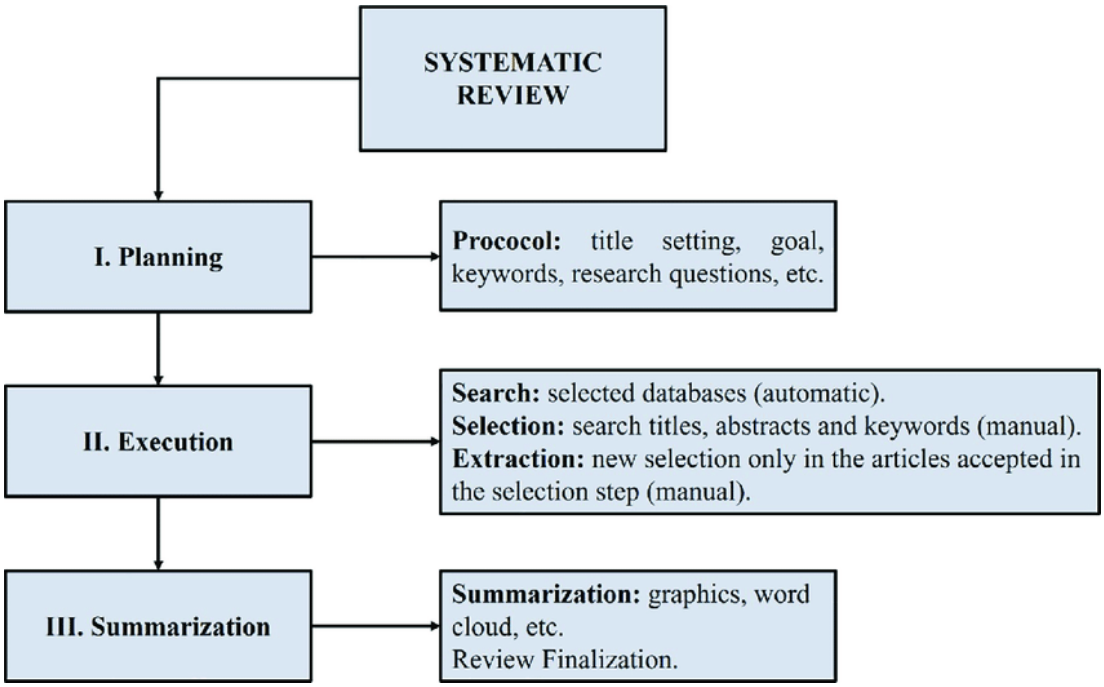


Figure: 3.2 Systematic Review Steps Adopted from the Work of [28]

In the planning step, the research carried out by considering the purpose of SLR, research questions, keywords selection, inclusion and exclusion criteria and the analysis and assessment of studies. Later, review execution is performed. Details of each steps is further explained in subsequent sections.

3.6.3 Planning of SLR

While performing SLR, planning is considered the core of review conduction. Initially the need of research conduction is identified with primary results of SLR. To extract the primary studies, the complete protocol is followed that includes research question and objective, selection of data sources, inclusion and exclusion criteria of studies, and finally assessing the quality of selected studies.

3.6.4 Research Question and Objective

SLR perform base on following research question and objective showing in Table-3.1 As in the table shown first research question with the objective of research.

Table: 3.1 - SLR Perform Based on RQ-1, Object-1

ID	Research Question	Research Objective
RQ1	what are the sustainable requirement engineering practices essentially required for developing sustainable software??	To identify the relevant sustainable RE practices for software development.

3.6.5 Data Sources and Search Strategies

Selection of data sources and search strategies are shown in Figure 3.3. The objective is to extract articles from the reliable and most authentic databases and conferences. The in figure state the overview of SLR in the step-1, specify research question as mention in step-2, review protocol describe all relevant information of strategies in step-3, finally step-4 is result and findings.

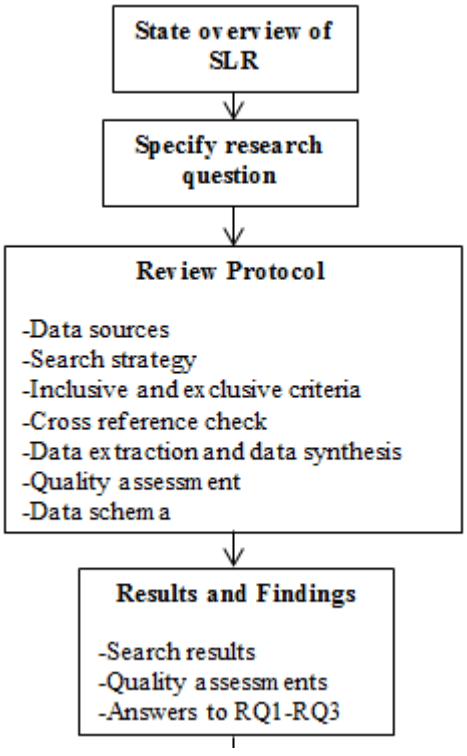


Figure: 3.3 - Flowchart of SLR

Table 3.2 describes the sources of studies selection in SLR. It consists of single column that represent the list of data sources. Further to this, snowballing technique is also used to extract more relevant articles in this step.

Table 3.2 – Shows List of Data source

Database
IEEE
ACM
Science direct
Elsevier
Springer

The keywords of this study are “Sustainability”, “Sustainable/Green”, “Requirement Engineering”, “Elicitation”,” Specification”, “Analysis”,” Validation”,” Management”, “Practices”. The keywords are analyzed in reference of synonyms to cover the compressive results. The synonyms of keywords are detailed in Table 3.3.

Table: 3.3 - Synonyms Regarding Keywords

Keyword	**Synonyms**
Sustainability	Sustainable, Continual /Green/ Continuous / Property / long-lasting
Requirement Engineering	Prerequisite, Qualification, Necessity, Demand, Technology.
Elicitation, Analysis, Specification, Validation, Management	Evocation, Induction Analysis, Investigation Identification, Definition Proof, Establishment Direction,
Practices	Patterns / Characteristic/ Exercises /Measure

After covering the keywords and their relative synonyms, search strings are formulated keeping in view of the research questions. Table 3.4 describes the details of search

strings used in this research. It consists of three columns named ‘keywords’ showing the list of keywords, ‘search strings’ using the Boolean AND / OR, and ‘strings ids.

Table: 3.4 - Each Keyword for Search Strings Grouping

Keywords	**Search Strings**	**String ID**
Sustainability RE Practice	(Sustainability OR Sustainable) AND RE AND (Practice)	Level-1
Sustainable Software Development	(Sustainable SE OR Sustainable Software) and (Practice OR Function OR Characteristic)	Level-2
Sustainable Requirement Engineering SE	(Sustainable OR RE OR Processes OR Practices) AND **(**“Quality Software” OR “Quality Attribute”))	Level-3
	(Sustainable OR RE OR Features OR Practices) AND **(**“Maintenance Software”)	Level-4

3.6.6 General Criteria

• All research should be published and peer-reviewed for more authentication.

• The research should be relevant to key terms of “Sustainable/Sustainability and RE”.

3.6.7 Inclusion/exclusion criteria

The detailed of inclusion and exclusion criteria is explained in table 3.5. Aim of these criteria is to cover the detailed studies on the subject.

Table: 3.5-A -An Inclusion Criteria

	Inclusion criteria
1	Articles relevant to RQs of this study will be considered.
2	Articles in RE context and green/ sustainable software in the general (Practices / Functions / Characteristic) will be considered.

3	The research papers/articles/books/review papers written in the English language only will be included.
4	Published articles will be included.
5	Articles that discusses sustainability and solutions/practices in sustain requirement engineering will be considered.
6	Papers including period 2010 to Present.
7	Research articles using keyword, Tag, Title of sustainable/Green

Table: 3.5-B Exclusion Criteria

	Exclusion criteria
1	Abovementioned criteria, if not fulfilled will not be considered for selection
2	Duplicate papers will be removed, if found.
3	Less than 2010 years
4	Only English written articles will be selected, rest will be excluded.

3.6.8 SLR Conduct

To conduct SLR, selection process, QA assessment, data extraction and analysis is discussed in this section.

3.6.9 Search and Selection of Primary Studies

The selection of primary studies is crucial and is explained in detail in Figure 3.4. It describes the details of number of studies in all steps.

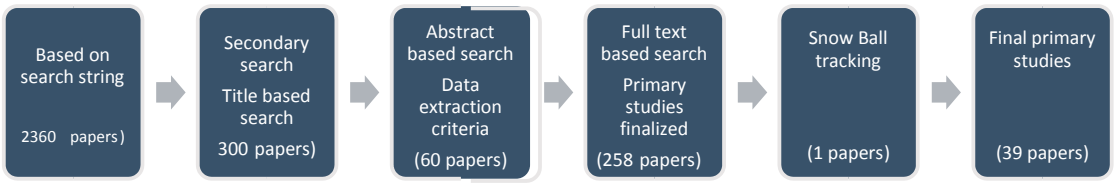


Figure: 3.4 Primary studies statistics in selection

Number of studies are described in Table 3.6 that consist of two column publisher and number of studies.

Table: 3.6 –studies selection

Data Sources	# of Potential Studies
Springer	02
Elsevier	03
Science Direct	07
IEEE	01
ACM	10
Google Scholar	15
Snowballing	01
Total	39

After following the searching protocol including snowballing, out of 2360 a total of 300 articles are selected in the first round on the basis of title and abstract via inclusion/exclusion criteria. After applying the secondary search, 258 articles and then carefully reading the complete articles, a total of 39 primary studies are selected.

3.6.10 Quality Assessment criteria

Ensuring quality in the selection of studies is always critical. To assess the quality of included studies, a checklist is prepared using Kitchenham work [28]. Table 3.7 describes the QA criteria.

Table: 3.7 – Shown Quality Assessment Checklists

SR No.	QA Questions	Respondent Response
1	In the paper researcher adequately described Title, key word, tag or issue About sustainability?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
2	Is the paper described sustainable context adequately?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
3	Are the aims of the study is clearly stated in reference of our research issue?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
4	Articles discussion and findings are trustworthy not?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
5	Does publications further the knowledge or understanding?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
6	Are the article selected are justified and aligned with the subject under investigation?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
7	Does articles are related to the context and have detailed discussion?	Yes/ Certainly =1 No/ Unreliable =0 Partially/Partly=.5
8	Does the article align in data, interpretation and conclusions?	Yes/ Certainly =1 No/ Unreliable =0

		Partially/Partly=.5

Criterion set for QA assessment is to give scoring described in Table 3.8. It shows that if questions are answered, the score will be 1, if it is not aligned then scoring would be 0 and if it is partial, then 0.5.

Table: 3.8 – Shown Quality Assessment Result

'YES' for score	'1'
'NO' for score	'0'
'Partially' for score	'0.5'

The QA procedure for the selected articles of this study is conducted through a careful coordination. Initially, several groups were devised consists of graduate or post graduate researchers from computer science and software engineering field. Each group consists of two members or individual. Based on the scoring, the detail result of QA is attached in Table 4.4.

3.6.11 Data Extraction

The extraction of data is performed and recorded in Excel Sheet against the research question of this study. Data Extraction form as an example is described in Table 3.9.

Table: 3.9 – Description of Data Extraction Form

Purpose	**Meta-Data**
DEF General Info	Article research title, authors name, date of pub, Year
DEF Specific Info	Researcher adequately described Title, keyword, tag or issue About sustainability, paper described sustainable context, aims clearly stated, findings credible and important, prediction techniques used clearly

The aim of designing such forms is to record the extracted information in a structured way that can tracked later conveniently. Table 3.10 is shown with the data extraction form details study by study.

3.6.12 Data Analysis and Synthesis

It is one of the core aspects of SLR where data is synthesized to examine the various aspects. In this regard, primarily studies with respect of years distribution is shown in Figure 3.5.

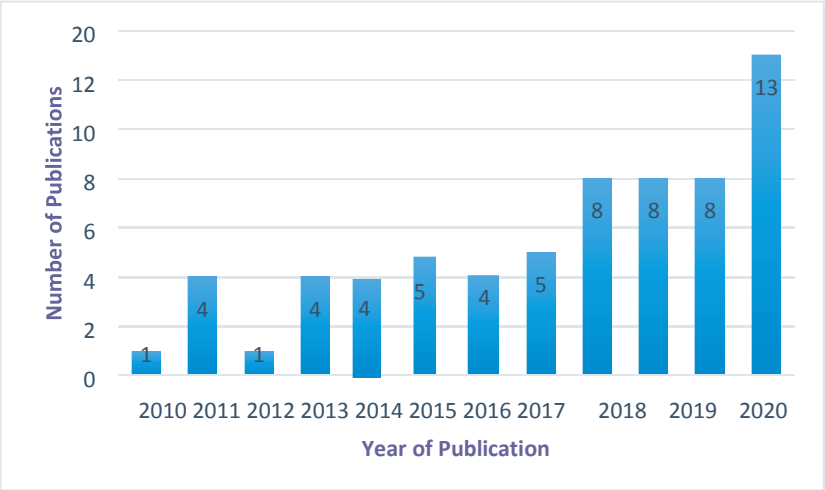


Figure: 3.5 – Studies with respect to publication years

3.6.13 Reporting of SLR

Reporting results of SLR is a critical activity that describes and compiles the results in comprehensive manner according to review protocol explained and defined. The key aspect of data extraction followed by data synthesis and finally report of identified practices from existing literature.

3.7.1 Expert Review

This review describes the basic practices of RE and opinion on the what is included in sustainable practices in context of requirements. The core advantage of reviewing from experts is to get insight from knowledgeable experts on the subject matter. Further to this, it also helps to be consistent and unique in using sustainability and RE terminologies. Thus, overall aim of this review is to get the review on identified practices of sustainable requirements.

3.7.2 Planning the Review method

Table: 3.11 - Expert Review Planning

Details for planning & executing the Review method	
Purpose of the review should be clearly defined and what subject must be considered	✓
Review integrity is ensured as reviewer give honest opinions	✓
Analytical skill is applied to infer some usable results	✓

3.7.3 Description of the Expert Reviews

A total of five experts were used in this study to review the identified sustainable practices for RE. Excerpts selection was made carefully who have knowledge and understanding sustainability. More importantly, academic qualification was same at least a PhD degree in Software Development, Computer science, Information technology, or related fields with understanding of sustainability and green software. Further to this, experience criteria was made more than 5 years. The details profiles of participants are described in Table 3.12.

Table: 3.12 - Professional profile of participants

Expert Participant	**Experience (Years)**	**Designation**
Exp A	More than 5	Assist. Professor
Exp B	More than 6	Assist. Professor
Exp C	More than 8	Assist. Professor
Exp D	More than 10	Professor
Exp E	More than 13	Professor

3.7.4 Changing Suggested by expert reviewer

Expert's recommended some changes and suggested few naming conventions. They have highlighted the placements of some of the practices and suggested some rephrasing of the identified practices. Overall, all they consolidated with the findings; however, their suggestions have polished the final list of identified practices.

3.7.5 Results of expert reviewer

The improvements according to recommendation and suggested each experts review are describe in following table. Table 3.13 display the results on based of expert review suggestion. first column name "Serial No" and Second Name display name of expert review names from (R1 to R6) and third column details of each expert review recommendation.

Table: 3.13 – Recommendation suggested by Expert review

No.	Reviewer	Suggestion
1	R1	Core checklist of basic design rules
2	R2	Recommendations on improvements within the design.
3	R3	Solutions to identified quality attribute in requirement engineering
4	R4	Suggest Maintenance quality.
5	R5	Some general changing recommendation.

3.8.1 Overview

This section describes the methodologies of the survey and complete details of survey employed in this research.

3.8.2 Survey

A survey is conducted in this research using the guideline of Mark Kasunic [29]. A survey is useful to get more detail from the industry practice that makes this research unique to get insight of how practitioners are practicing requirement engineering.

3.8.3 Survey Conduction / Methodology

A survey is conducted to gather all the possible initial sustainable practices in each phase of RE processes. All requirements about the sustainable development are explained in each phase of RE. In this survey, some significant questions related to sustainable importance, to identify the relevant sustainability practices and how to measure these practices. This survey was based on following questions. First some questions were about introduction and personal information. Other questions were related to development of sustainable requirement engineering practices. Informal has asked; which sustainable practices are the most preferable to be used in requirement engineering model. Few questions related to sustainable guideline and what are the possible solutions to those practices has been asked too. The outcome of this survey was used to design and develop an efficient practice.

3.8.4 The Survey Research Process

In this survey collection data is the using of a standardized questionnaire and the survey adapted in this study consist of seven-stage as shown in Figure 3.6.

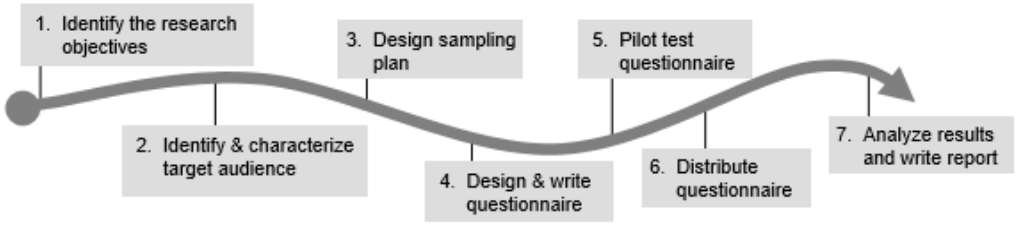


Figure 3.6 - Survey Seven-Stage Process

3.8.5 Objective of the survey

The survey is aimed to get practitioners insight of how they understand the RE practices and consider the integration of sustainability. Through survey, industry input can be yield to against some questions or given data [29]. Seven stages adapted in this study are as follows:

- Research objectives identification
- Target audience selection
- Sampling design
- Questionnaire development
- Pilot testing
- Reaching to audience with questionnaire
- Collect the data, analyze, and report the results

3.8.5.1 Research Objectives

Survey is conducted with objective of identify the industry practicing level of sustainable RE practices for software development. The research question and objective of this study is described in the Table 3.14.

Table: 3.14 - Survey Perform Based on RQ-2, Object-2

ID	Research Question	Research Objective
RQ	How much industry is practicing to the identified sustainable requirement engineering practices for software development?	To identify the industry practicing level of sustainable RE practices for software development.

3.8.5.2 Identify & Characterize the Target Audience

The first stage is to characterize the participant based on the background information, and acquiring how RE practitioners under the sustainability and to capture while taking requirements.

3.8.5.3 Design the Sampling Plan

In the survey, questionnaire we used consists of rating scale from 1 to 5. This survey was based on categorized ‘28’ questions. Out of those ‘28’ questions, Main heading are 5 that describes the main practices of sustainable RE. Another ‘23’ questions were related to sub practices of sustainability and the possibilities of insert new practices as provide by option. Researchers were asked, which sustainable practices are the most preferable to be used in requirement engineering phase. Few questions related to deeply sustainable dimension understanding and what are the possible solutions to those sustainable practices have been asked too. Survey data analysis and explanation is added, following are the Appendix-A used to complete sample form of research Questionnaire, in the table first part contain information of the respondent such as understand sustainable introduction, name, education, job and second part contain the questions with ranking scale from 1 to 5.

3.8.5.4 Design and Write the Questionnaire

In this thesis, we wrote the questionnaire from the perspective of placing the identified sustainable practices and sub-practices for RE. Respondents were also asked to suggest, if they think that they are practicing and it is not present here. The following likers scale is used in this survey.

Example: Likert response scale

Liker Resp	Scale
Strongly disagree	1
Disagree	2
Undecided	3
Agree	4
Strongly Agree	5

Figure: 3.7 - Response Scale

Below are the just an example of showing how Likert scale is used in questionnaire. As shown in figure 3.8

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
Technical reviewers use proposal evaluation criteria during solicitation activities.	†	†	†	†	†

Figure: 3.8 – Likert response scale

3.8.5.5 Distribute the Questionnaire

We survey requirements practitioners from public and private companies. Questionnaire is distributed using email as well as by visiting different companies. As a result, total of 65 respondents responded for this distributed questionnaire.

3.8.5.6 Analyze Results and Write Report

After the collecting the data, analysis is critical. Results of the survey is compiled on behalf of data interpretation and discussion.

3.8.6 Conclusion Results

These conclusion results are based on survey one feedback from different respondents from IT companies. The reason of explaining these conclusions is to draw a clear picture of market perception and practice. The survey detail results are given into next chapter. Finally, complete methodologies of research have described in this chapter.

Chapter # 4

IDENTIFICATION OF SUSTAINABLE REQUIREMENT ENGINEERING PRACTICES

4.1 Overview

This chapter documents the findings and investigation of SLR and survey. Moreover, in this chapter compiled data in a list of sustainable practices that identified and analysis of as sustainable practices in requirement engineering.

4.2 SLR Execution

As performed SLR in the research, it aimed to give a deeper the identified essential required practices of requirement engineering SLR is quite comprehensive and laydown the foundation for the subject investigated and state of knowledge regarding any research domain is reviewed, in the previous chapter complete details of SLR protocols has described.

4.3 Data Analysis of Data Source, Publication Type and Methodology Adopted –

Sustainable practices are described in the SLR implementation process. Only ‘39’ articles met the requirement and have been chosen to be reviewed and included in this study is identified according to their distribution quantitative data representations of chosen ‘39’ articles. When search string was performed, the source database retrieved ‘2300’ research articles, and snowballing found some more papers. This increased to '2360' papers counting the total number of publications. In research, we adopted the Tollgate approach and selected ‘300’ afterwards on the basis of title and abstract by inclusion/exclusion criteria, the ‘60’ papers in the first round. a total of 39 primary studies are selected in the research papers authors have found a list of categorized and sub-categorized sustainable practices of requirement engineering in each phase these below results showing with base of database

Table: 4.1 – Display finding Statistics for Using Strings keyword

Strings	IEEE	SPRINGER	ELESVIER	ACM	SCIENCE DIRECT	Google Scholar	Snow balling	Total
Level 1 to 4	01	02	03	10	07	15	1	39

Figure 4.1 & Table 4.1 display the Distribution of those '39' research studies by source of data. There is a complete '6' database which discusses issues related to this research such as springer, Elsevier, ACM, Science Direct, google scholar, and IEEE. Following are the statistics showing finding

- Google Scholar has the most research, such as 15 of all 24 other data sources.
- ACM ranked second because it published 10 Papers.
- While Scient Direct has 07 studies and 07 other studies have been linked to this study

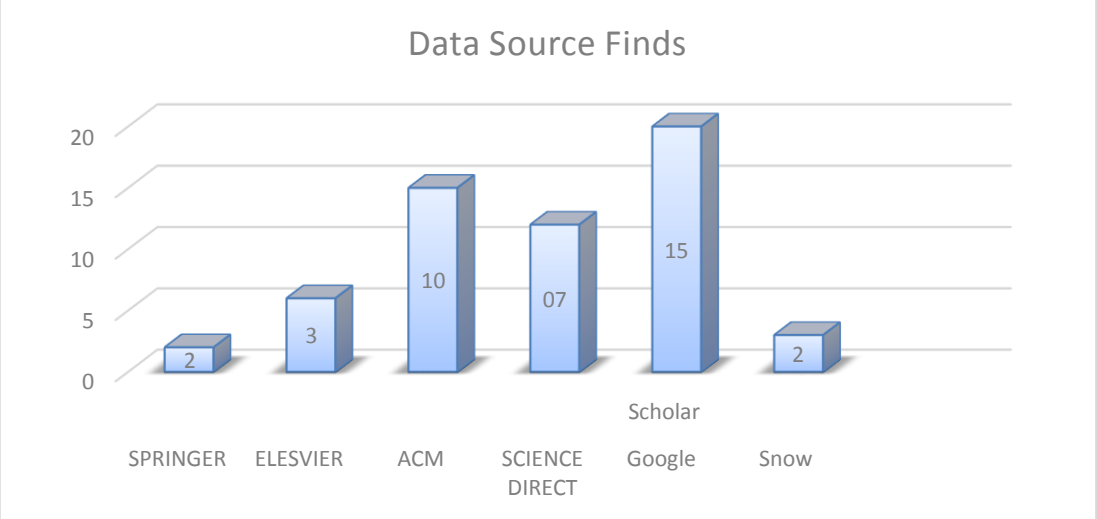


Figure: 4.1 – Data Source No. of Articles

Figure 4.2 Show a bar chart in which each bar appears a year of publication of the study. The duration of this research is selected from year is 2010 to 2020. The most important research related sustainable RE practices were published in 2010. Then from 2010 to 2020 add up to '39' papers were distributed relevant to term 'sustainability'

incorporating and ‘requirement engineering’. By examining the bar graph, it can be shown that in 2016, 2020 and 2019 the maximum number of studies, i.e. other studies collectively, is written. In addition, this work also analyses and discusses latest study from 2019.

Figure: 4.2 - Year of Publication Studies

It can be seen from Figure 4.3 that the '39' selected studies are distributed in different types of research methods, the details of figure describe following

Types of research methodology such as such as conceptual model, theorical, surveys, case studies, SLR, Expert Review, Interview etc. content analysis and industry experiment report. By analysing the statistics shown in the graph, it can be seen that 20 studies have been conducted using the conceptual model method. 10 studies using theoretical and while other 10 is case study methods; other studies used in the difference method

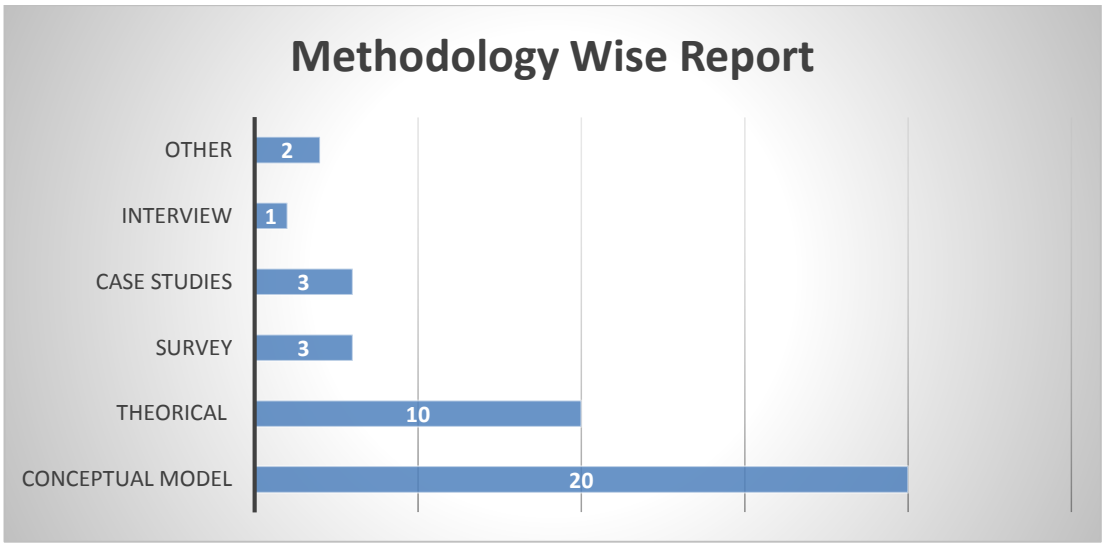


Figure: 4.3 – Methodology adopted in existing studies

The explanation of every SLR phase is illustrated in Chapter 3. The extraction form for the metadata of the all '39' studies are the explained. Each extract form showing information in the tabular form including such as ID, general info, type, author, approach etc. The extraction form of each of the studies is attached in Table 3.10

4.4 Description of the Sustainable RE Practices

For sustainable practices in requirement engineering a collection of studies related to this research area were selected, in a collection only '39' all most having studies have to do with this research 's exact statement of problems. The existing proposed work consists of various research methodologies, such as conceptual model, theoretical, case study, SLR, survey, empirical study and reporting of industry experience. Each study was reviewed by analyzing the study context, the research questions, and the findings empirically confirmed. These importance practices categorized below and each practice defined in Table 4.2 and each practice wise analysis report show in Table 4.4 & Table 4.6

Table: 4.2 – Sustainable Practices and Sub-practices List each RE Phase

Requirement Elicitation	
Main Practice	**Sub-Practices**

Explicit the Sustainability purpose of a system	• Elicit requirements that have overlay of lean understanding for resources. • Elicit requirements that is evolving in nature to foresee how software can cope these changes. • Elicit requirements that have impact on environment. • Elicit sustainability goals and constraints of the system requirements. • Help stakeholder to understand the impact of system on sustainability and vice versa. • Examine the requirements as usable requirements for social sustainability
Requirement Analysis	
Main Practice	**Sub-Practices**
Analyze requirements with sustainability aspects (social, economic, and environment)	• Analyze the economic aspect of requirements to be sustainable (for software and by software). • Evaluate the system technical components and requirements and foresee the quality attribute of sustainable design. • Analyze the consistency in requirements to rationalize the functional completeness. • Analyze quality of requirements as usable enough that can sustain over the longer period. • Ensure/Analyze the requirement for being feasible to be implemented in sustainability dimension. • Examine the requirements whether they adhere legislation related to social and environmental sustainability.
Requirement Specification	
Main Practice	**Sub-Practices**

Specified defines a set of requirements	• The requirement should be categorized on basis on economic, social. • The checklist-based template should include following consists (economic, social, technical). • Templates are tailor to acquire information about sustainability as a design concern. • The template will be sustainability goals.
Requirement Validation	
Main Practice	**Sub-Practices**
checking the requirements for realism, consistency and completeness	• Ensure the requirement is understandable by the broad community stakeholders with perspective of sustainability effects. • Ensure the system requirements are complying the sustainability goals. • Ensure the system requirements are considering risks related to sustainability aspects.
Requirement Management	
Need for Change of Mentality and Managing / changes to requirements with sustainability aspect	• Change in existing requirement should be ensured with sustainability dimension. • New requirement must be complied with sustainability development goals. • It is ensured that the changes should not impact on the existing requirement for the sustainability impact • Ensure that process, quality and deployment requirements are aligned with social, economic and environmental sustainability.

4.5 QA Profile Sample and Result QA Analysis

Table 4.3 display the statistics of QA results based on distribution papers in particular professional to evaluate these papers. First part contains the information of the QA studies and second part contain Tabular columns, In First column display "Serial No." second column display QA Questions and third column showing scope assign by respondent.

Table: 4.3 Shown QA Profile

Quality Assurance Paper Pattern/Sample		
Summary Checklist for quality assurance of the paper.		
Name: _____ Education: _____		
Job Designation: _____		
Title: _____		
Remarks:		
Table: Quality assessment checklist		
SR No.	**QA Questions**	**Respondent Response**
1	In the paper researcher adequately described Title, keyword, tag or issue About sustainability?	YES/ Certainly =1 NO/ Unreliable =0 Partially/Partly=.5
2	Is the paper described sustainable context adequately?	YES/ Certainly =1 NO=0 Partially/Partly =.5
3	Are the aims of the study is clearly stated in reference of our research issue?	YES/ Certainly =1 NO/ Unreliable =0 Partially/Partly =.5
4	Articles discussion and findings are trustworthy not?	YES/ Certainly =1 NO=0 Partially/Partly =.5
5	Does publications further the knowledge or understanding?	YES/ Certainly =1 NO/Unreliable =0 Partially/Partly =.5
6	Are the article selected are justified and aligned with the subject under investigation?	YES/ Certainly =1 NO/Unreliable =0 Partially/Partly =.5

7	Does articles are related to the context and have detailed discussion?	YES/ Certainly =1 NO/Unreliable =0 Partially/Partly =.5
8	Does the article align in data, interpretation and conclusions?	YES/ Certainly =1 NO/Unreliable =0 Partially/Partly =.5

Table 4.4 display the statistics of QA based on analysis. First column name "Paper ID" display Paper index, second column display respondent index, eight columns shown QA questions, finally last two columns for the scope of QA

Table 4.4: Display Results from Each Article of QA

Paper id	**Respond-ends ids**	**Q-1**	**Q-2**	**Q-3**	**Q-4**	**Q-5**	**Q-6**	**Q-7**	**Q-8**	**Score**	**Total scored**
P1	RSP1	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5+7/2 = 6.75
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P2	RSP 1	1	1	1	1	1	1	1	1	8	08+07/2 = 7.5
	RSP 2	1	1	0.5	1	1	0.5	1	1	7	
P3	RSP 1	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5+7+/2 =8.5
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P4	RSP 1	1	1	1	1	1	0.5	1	1	9.5	9.5+9.5/ =6.75
	RSP 2	1	1	1	1	1	0.5	1	1	9.5	
P5	RSP 1	0.5	0.5	0.5	0	1	0	0	1	5	5+6.5/2 =5.75
	RSP 2	0.5	0.5	0.5	1	0	1	1	0.5	6.5	
P6	RSP 1	1	1	1	1	1	0.5	1	1	7.5	7.5+6.5/2 =7.0
	RSP 2	1	0.5	0.5	1	1	1	1	0.5	6.5	
P7	RSP 1	1	1	1	1	1	0.5	1	1	7.5	7.5+7.0/2 = 7.25
	RSP 2	1	1	1	0	1	1	1	1	7.0	
P8	RSP 1	1	1	0.5	1	0	0.5	0.5	0.5	5	5+6.5/ = 5.75
	RSP 2	1	1	0.5	1	0	1	1	1	6.5	
P9	RSP 1	1	1	0.5	1	1	1	1	1	7.5	7.5+7.5/ = 7.5
	RSP 2	1	1	1	1	1	0.5	1	1	7.5	
P10	RSP 1	1	1	1	0	1	1	1	1	7	7+7/2 = 7
	RSP 2	1	1	1	0	1	1	1	1	7	
P11	RSP 1	1	1	0.5	1	0	0.5	0.5	0.5	5	5+7/2 = 6
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P12	RSP 1	1	1	1	1	1	0.5	1	1	7.5	7.5+7.5/ = 7.5
	RSP 2	1	1	1	1	1	0.5	1	1	7.5	

P13	RSP 1	1	1	1	0	1	1	1	1	7	7+7/ = 7
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P14	RSP 1	1	1	0.5	1	0	1	1	1	6.5	6.5+7.5/ = 7
	RSP 2	1	1	0.5	1	1	1	1	1	7.5	
P15	RSP 1	1	1	1	1	1	1	1	1	8	8+7/2 =7.5
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P16	RSP 1	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5+7/2 = 6.75
	RSP 2	1	0.5	1	1	1	1	1	0.5	7	
P17	RSP 1	1	1	1	1	1	0.5	1	1	7.5	7.5+7.5/2 = 7.5
	RSP 2	1	1	1	1	1	0.5	1	1	7.5	
P18	RSP 1	1	1	1	0	1	1	1	1	7	7+5/2 = 6
	RSP 2	1	1	0.5	1	0	0.5	0.5	0.5	5	
P19	RSP 1	1	1	0.5	1	0	1	1	1	6.5	6.5+7.5/2 = 7
	RSP 2	1	1	0.5	1	1	1	1	1	7.5	
P20	RSP 1	1	1	1	1	1	1	1	1	8	8+6/2 = 7
	RSP 2	1	1	1	0	1	1	0	1	6	
P21	RSP 3	1	1	0.5	1	0	0.5	0.5	0.5	5	5
P22	RSP 3	1	1	0.5	1	0	1	1	1	6.5	6.5
P23	RSP 3	1	1	0.5	1	1	1	1	1	7.5	7.5
P24	RSP 3	1	1	1	1	1	1	1	1	8	8
P25	RSP 3	1	1	1	0	1	1	0	1	7.5	7.5
P26	RSP 3	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5
P27	RSP 3	1	0.5	1	1	1	1	1	0.5	7	7
P28	RSP 3	1	1	1	1	1	0.5	1	1	7.5	7.5
P29	RSP 3	1	1	1	1	1	0.5	1	1	7.5	7.5
P30	RSP 3	1	1	1	1	1	1	1	1	8	8
P31	RSP 3	1	1	0.5	1	1	1	1	1	7.5	7.5
P32	RSP 3	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5
P33	RSP 3	1	0	0	1	1	1	1	0.5	5.5	5.5
P34	RSP 3	1	0.5	1	1	1	1	1	0.5	7	7
P35	RSP 3	1	1	0.5	1	0.5	1	0	0.5	5.5	5.5
P36	RSP 3	1	0.5	0.5	1	1	1	1	0.5	6.5	6.5
P37	RSP 3	1	1	0.5	1	1	0.5	0	0.5	5.5	5.5
P38	RSP 3	1	0.5	0.5	1	0	1	1	0.5	5.5	5.5
P39	RSP 3	1	1	0.5	1	1	0.5	1	0.5	6.5	6.5
P40	RSP 3	1	1	0.5	1	1	1	1	0.5	7	7

4.6 Expert Review (ER) Discussion Process

Review describes the basic practices of RE and opinion on the what is included in sustainable practices in context of requirements. The core advantage of reviewing from experts is to get insight from knowledgeable experts on the subject matter. ER is in essence a kind of qualitative study. and review process is composed of three steps. The detail of each step is explained in chapter 3, section 3.7.4. Thus, overall aim of this review is to get the review on identified practices of sustainable requirements. addition, review suggestion and conclusion are explained below.

4.7 Data Analysis – Expert Review & Suggestion

Analysis of the ER data is carried out based on the suggestions, recommendations and opinions of experts. Metadata analysis collected from discussion questionnaires and represented in the table below. Some changes in sustainable practices and sub-practices were suggested by the experts. Table 4.5 shows the opinions and suggestions of Experts are analysed and reported as follows. As shown in table three columns first and second showing index, reviewer name, the third columns showing suggestion of expert review.

Table: 4.5 - Showing Suggestion of Expert Review

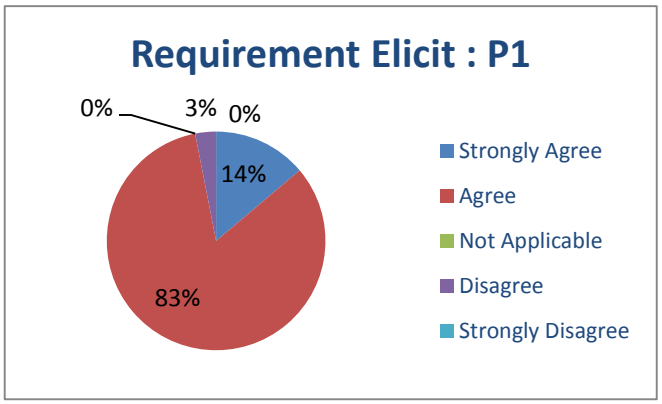
No.	Reviewer	Expert Review Suggestion
1	R1	Core checklist of basic design rules
2	R2	Recommendations on improvements within the design.
3	R3	Solutions to identified quality attribute in requirement engineering
4	R4	Suggest Maintenance quality.
5	R5	Some general changing recommendation.

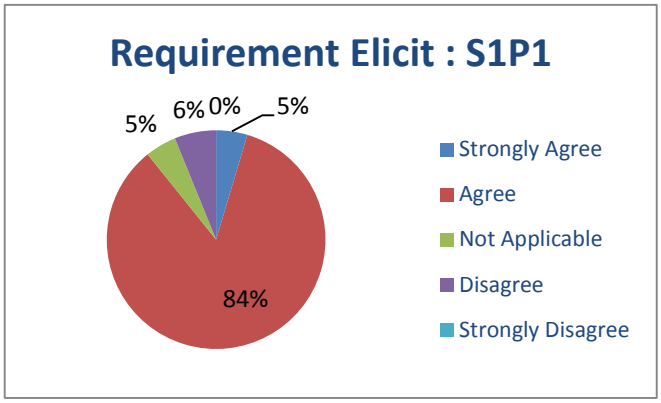
Table 4.5 - suggestions of expert review consists of three columns. First two columns name “No. & Reviewer” shows there are total 6 Reviewer (R1 to R6) and column third according to expert show suggestion.

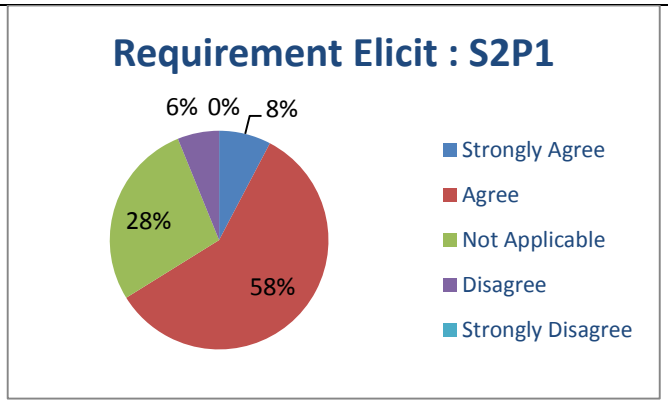
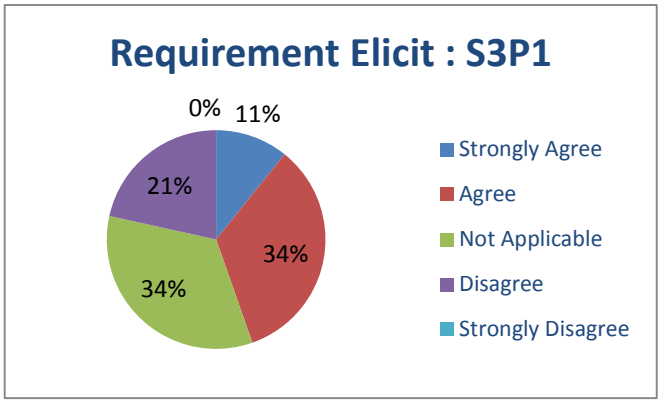
4.8 Survey Results and Analysis

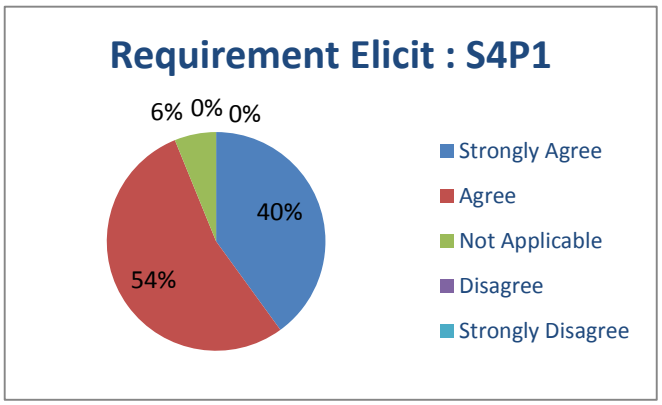
From the '65' respondents that participated in survey, the results and findings are discussed in this section. Table 4.6 Display the analysis reported of survey results on the base of IT industries. First column name describes the "Practices Name" and 2nd row columns split into 4 more columns which are shows "ID"," Respondent ID", "Practice-Details and type", after that 3rd rows to show analysis result for each practice with graph and description. The protocols with complete steps of survey are described in chapter 3, In the Table 4.6 Analysis result for each practice of sustainable including graphical presentation of describe here.

Table: 4.6 – Data Analysis Each Sustainable Practice and Sub-Practice

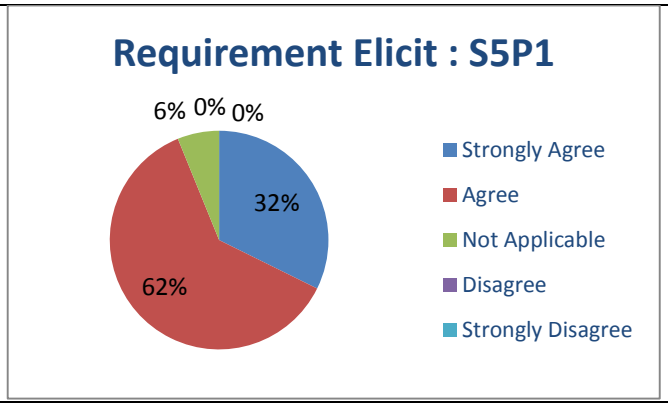
<table>
<tr><td colspan="4">I. Requirement Elicitation Sustainable Practices</td></tr>
<tr><td>1</td><td>Resp Id</td><td>Practice</td><td>Main / ~~Sub~~</td></tr>
<tr><td rowspan="3">Requirement Elicitation Process</td><td>P1</td><td colspan="2">Explicit the Sustainability purpose of a system.</td></tr>
<tr><td>Result</td><td colspan="2">As the query was posed to '65' respondents regrading requirement Elicitation practice (P1), the discoveries display a level of '14%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '83%' from the all-out number of respondents has admitted to 'agree' and of '0%' from the all-out number of respondents has 'Not Applicable' choice and '3%' from the all-out number of respondents has 'Disagree' '0%' from the all-out number of respondent has 'Strongly Disagree' in requirement engineering practice.</td></tr>
<tr><td>Graph 4.1</td><td colspan="2"> 
</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
</table>

2	**Resp Id**	**Practice**	~~**Main**~~ / Sub
Requirement Elicitation Process	**S1P1**	Elicit requirements that have overlay of lean understanding for resources.	
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S1P1), the discoveries display a level of '5%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '84%' from the all-out number of respondents has admitted to 'agree' and of '5%' from the all-out number of respondents has 'Not Applicable' choice and '6%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.	
	Graph 4.2		
3	**Resp Id**	**Practice**	~~**Main**~~ **/ Sub**
Requirement Elicitation Process	**S2P1**	Elicit requirements that is evolving in nature to foresee how software can cope these changes.	
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S2P1), the discoveries display a level of '8%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '58%' from the all-out number of respondents has admitted to 'agree' and of '28%' from the all-out number of respondents has 'Not Applicable' choice and '6%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.	
	Graph		

	4.3		
4	**Resp Id**	**Practice**	~~Main~~ / Sub
Requirement Elicitation **Process**	**S3P1**	Elicit requirements that have impact on environment.	
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S3P1), the discoveries display a level of '11%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '34%' from the all-out number of respondents has admitted to 'agree' and of '34%' from the all-out number of respondents has 'Not Applicable' choice and '21%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree 'in requirement engineering practice.	
	Graph 4.4		
5	**Resp Id**	**Practice**	~~Main~~ / Sub
Requirement	**S4P1**	Elicit sustainability goals and constraints of the system requirements.	
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S4P1), the discoveries display a level of '40%'	

		from the all-out number of respondents has admitted to 'Strongly Agree' and of '54%' from the all-out number of respondents has admitted to 'agree' and of '6%'s from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.5	
6	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Elicitation Process	**S5P1**	Help stakeholder to understand the impact of system on sustainability and vice versa.
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S5P1), the discoveries display a level of '32%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '62%' from the all-out number of respondents has admitted to 'agree' and of '6%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.6	

28	**Resp Id**	**Practice** ~~Main~~ / Sub
Re qui	**S4P5**	Ensure that process, quality and deployment requirements are aligned with social, economic and environmental sustainability.



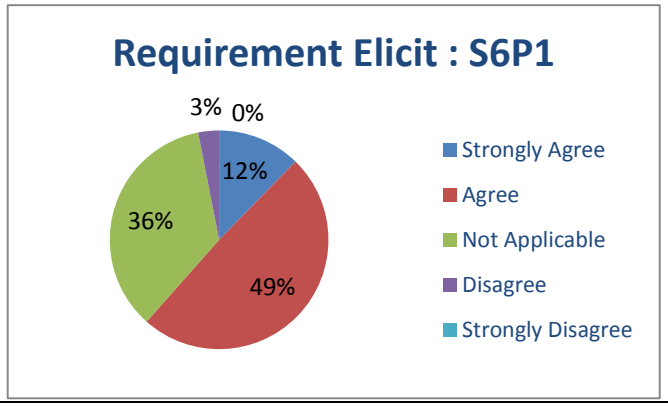
7	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Elicitation Process	**S6P1**	Examine the requirements as usable requirements for social sustainability
	Result	As the query was posed to '65' respondents regrading requirement Elicitation practice (S6P1), the discoveries display a level of '12%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '49%' from the all-out number of respondents has admitted to 'agree' and of '36%' from the all-out number of respondents has 'Not Applicable' choice and '3%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.7	

Table 4.1: Survey Results Statistics of Using Requirement Elicitation Sustainable Practices

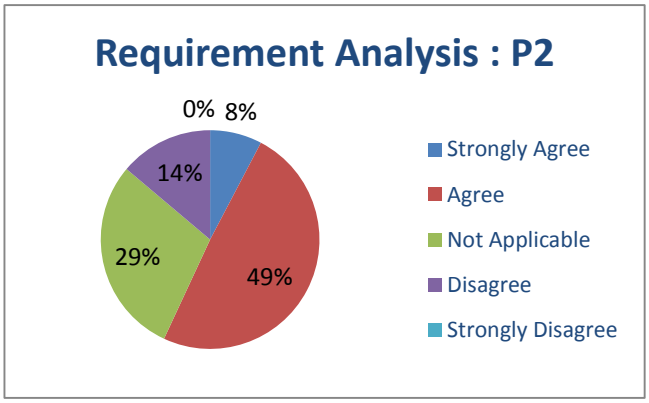
Table show statistic of Requirement Elicitation Survey Result.

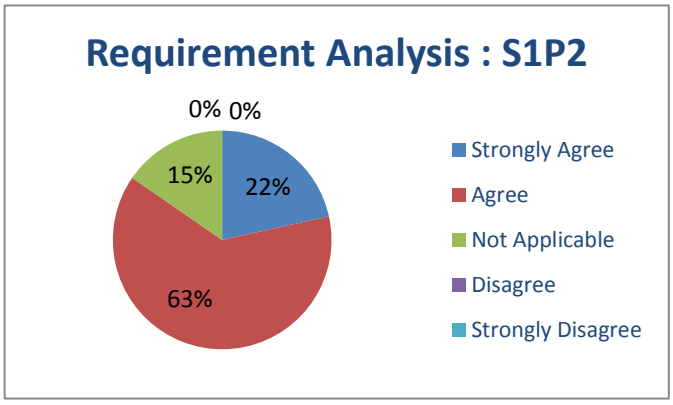
Requirement Elicitation	Strongly Agree	Agree	Not Applicable	Disagree	Strongly Disagree	*Total*
P1	*9*	*54*	*0*	*2*	*0*	*65*
S1P1	*3*	*55*	*3*	*4*	*0*	*65*

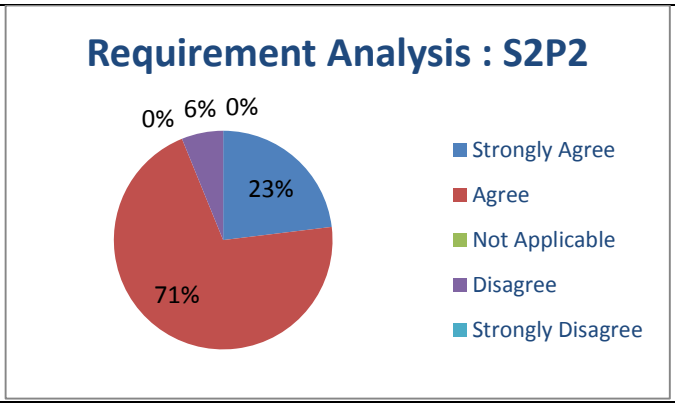
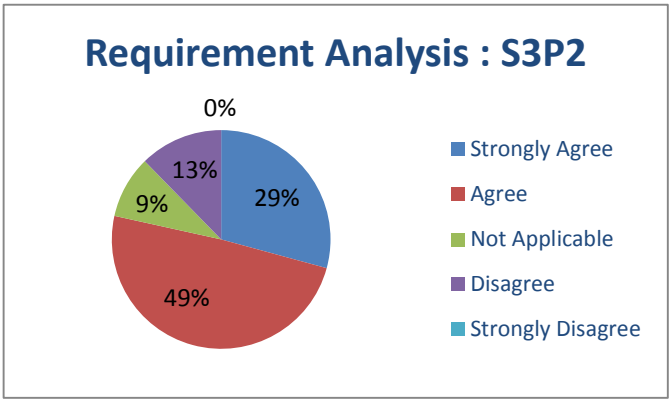
S2P1	*5*	*38*	*18*	*4*	*0*	*65*
S3P1	***7***	***22***	***22***	***14***	***0***	***65***
S4P1	*26*	*35*	*4*	*0*	*0*	*65*
S5P1	*21*	*40*	*4*	*0*	*0*	*65*
S6P1	*8*	*32*	*23*	*2*	*0*	*65*

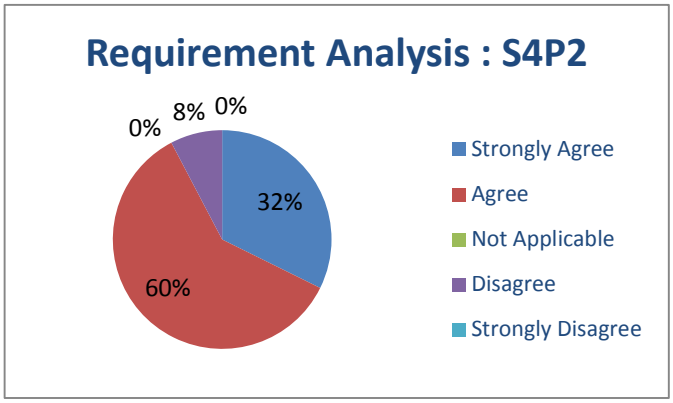
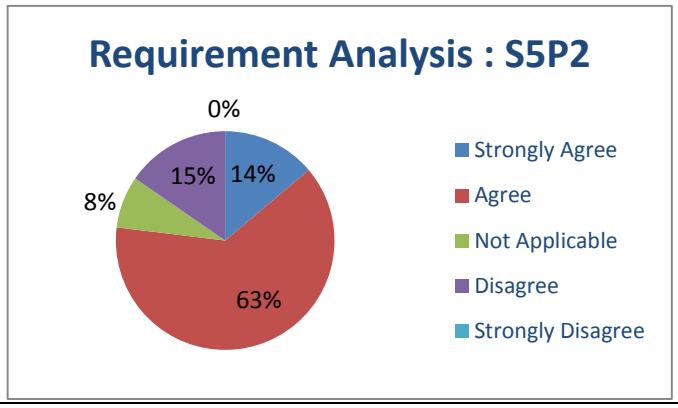
Table 4.1 display the statistics of survey results based on requirement elicitation practices. First column name "Practices Name" display there are complete 7 Practices (P1 to S6P1) that are found from performed SLR the related articles. From 2nd-7th column shows statistic result of all the elicitation requirement practices, as the question was asked to 65 respondents regrading requirement elicitation practices, the findings show a number of each practices in above table the practice of "**S3P1**" lower rate.

II. Requirement Analysis Sustainable Practices

8	**Resp Id**	**Practice**	Main / ~~Sub~~
Requirement Analysis Process	**P2**	Analyze requirements with sustainability aspects (social, economic, and environment)	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (P2), the discoveries display a level of '8%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '49%' from the all-out number of respondents has admitted to 'agree' and of '29%' from the all-out number of respondents has 'Not Applicable' choice and '14%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.	
	Graph 4.8		

9	Resp Id	Practice	~~Main~~ / Sub
Requirement Analysis Process	S1P2	Analyze the economic aspect of requirements to be sustainable (for software and by software).	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S1P2), the discoveries display a level of '22%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '63%' from the all-out number of respondents has admitted to 'agree' and of '15%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents has 'Disagree' or 'Strongly Disagree' in requirement engineering practice.	
	Graph 4.9		
10	Resp Id	Practice	~~Main~~ / Sub
Requirement Analysis Process	S2P2	Evaluate the system technical components and requirements and foresee the quality attribute of sustainable design.	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S2P2), the discoveries display a level of '23%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '71%' from the all-out number of respondents has admitted to 'agree' and of '0%' from the all-out number of respondents has 'Not Applicable' choice and '6%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice	
	Graph 4.10		

		
11	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Analysis Process	**S3P2**	Analyze the consistency in requirements to rationalize the functional completeness.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S3P2), the discoveries display a level of '29% from the all-out number of respondents has admitted to 'Strongly Agree' and of '49%' from the all-out number of respondents has admitted to 'agree' and of '9%' from the all-out number of respondents has 'Not Applicable' choice and '13%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.11	
12	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Analysis	**S4P2**	Analyze quality of requirements as usable enough that can sustain over the longer period.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S4P2), the discoveries display a level of '32%' from the all-out number of respondents has admitted to 'Strongly

		Agree' and of '60%' from the all-out number of respondents has admitted to 'agree' and of '0%' from the all-out number of respondents has 'Not Applicable' choice and '8%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.12	
13	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Analysis Process	**S5P2**	Ensure/Analyze the requirement for being feasible to be implemented in sustainability dimension.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S5P2), the discoveries display a level of '14%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '63%' from the all-out number of respondents has admitted to 'agree' and of '8%' from the all-out number of respondents has 'Not Applicable' choice and '15%' from all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.13	

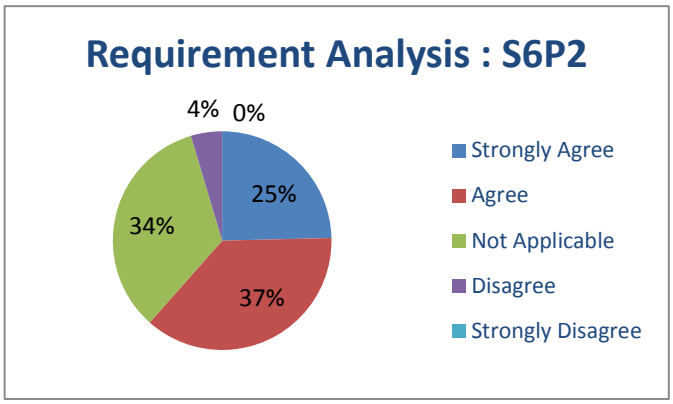
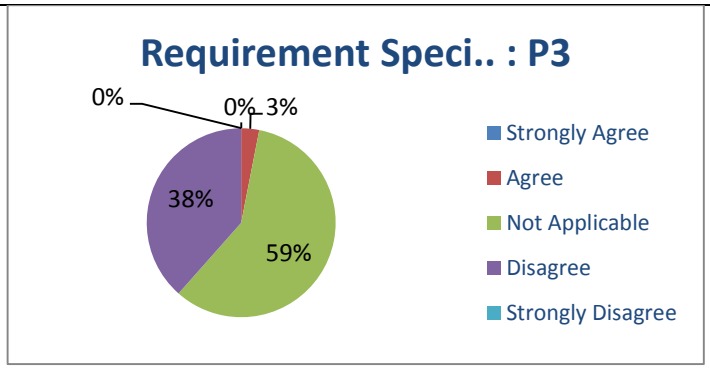
14	**Resp Id**	**Practice**	~~Main~~ / Sub
Requirement Analysis Process	**S6P2**	Examine the requirements whether they adhere legislation related to social and environmental sustainability.	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S6P2), the discoveries display a level of '25%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '37%' from the all-out number of respondents has admitted to 'agree' and of '34%' from the all-out number of respondents has 'Not Applicable' choice and '4%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.	
	Graph 4.14		

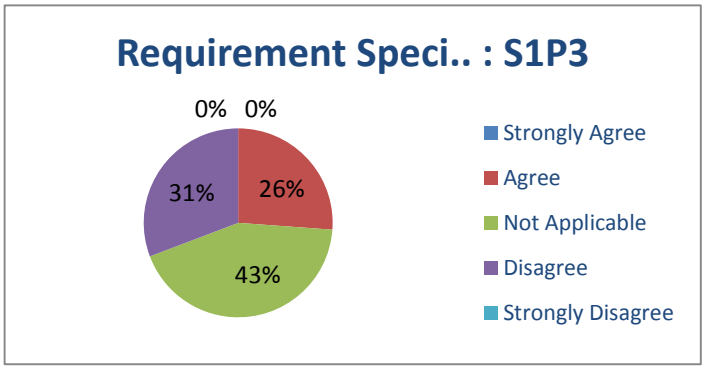
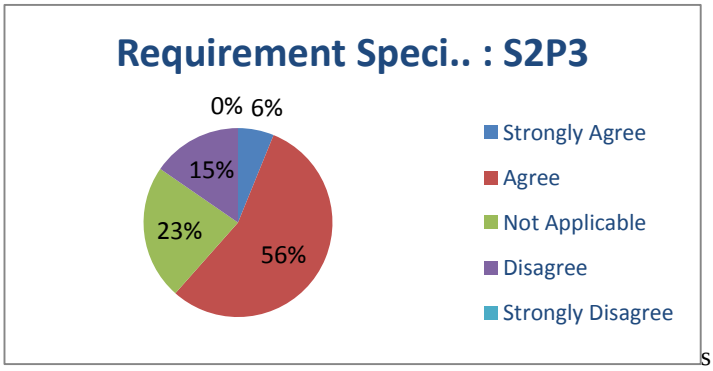
Table 4.2: Survey results statistics of using Requirement Analysis Practices

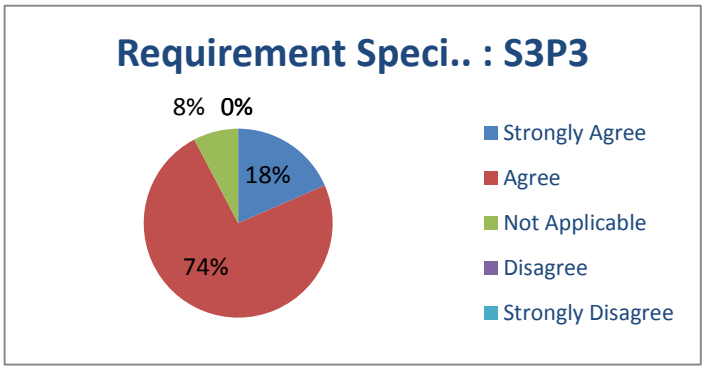
Table show statistic of Requirement Analysis Survey Result.

Requirement Analysis	Strongly Agree	Agree	Not Applicable	Disagree	Strongly Disagree	*Total*
P2	*5*	*32*	*19*	*9*	*0*	*65*
S1P2	*14*	*41*	*10*	*0*	*0*	*65*
S2P2	*15*	*46*	*0*	*4*	*0*	*65*
S3P2	*19*	*32*	*6*	*8*	*0*	*65*
S4P2	*21*	*39*	*0*	*5*	*0*	*65*
S5P2	*9*	*41*	*5*	*10*	*0*	*65*
S6P2	*16*	*24*	*22*	*3*	*0*	*65*

Table 4.2 display the statistics of survey results based on requirement analysis practices. First column name "Practices Name" display there are complete 7 Practices (P2 to S6P2) that are found from performed SLR the related articles. From 2nd-7th column shows statistic result

of all the analysis requirement practices, as the question was asked to '65' respondents regrading requirement analysis practices, the findings show a number of each practices in above tables.			
III. Requirement Specification Sustainable Practices			
15	**Resp Id**	**Practice**	Main / ~~Sub~~
Requirement Specification Process	**P3**	Specified defines a set of requirements	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (P3), the discoveries display a level of '0%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '3%' from the all-out number of respondents has admitted to 'agree' and of '59%' from the all-out number of respondents has 'Not Applicable' choice and '38%' from the total number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice. So as a result, statistics show, this practice survey result show lowest rate for sustainable	
	Graph 4.15		
16	**Resp Id**	**Practice**	~~Main~~ / Sub
Requirement Analysis Process	**S1P3**	The requirement should be categorized on basis on economic, social.	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S1P3), the discoveries display a level of '0%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '26%' from the all-out number of respondents has admitted to 'agree' and of 43% from the all-out number of respondents has 'Not Applicable' choice and '31%' from the all-out number of respondents has 'Disagree' or 'Strongly Disagree' in requirement engineering	

		practice. So as a result, statistics show, this practice survey result show lowest rate for sustainable.	
	Graph 4.16		
17	**Resp Id**	**Practice**	~~Main~~ / Sub
Requirement Analysis Process	**S2P3**	The checklist-based template should include following consists (economic, social, technical).	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S2P2), the discoveries display a level of '6%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '56%' from the all-out number of respondents has admitted to 'agree' and of '23%' from the all-out number of respondents has 'Not Applicable' choice and '15%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice	
	Graph 4.17		
18	**Resp Id**	**Practice**	~~Main~~ / Sub
Re qui	**S3P3**	Templates are tailor to acquire information about sustainability as a design concern.	

	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S3P2), the discoveries display a level of '18%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '74%' from the all-out number of respondents has admitted to 'agree' and of '8%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.18	
19	**Resp Id**	**Practice** | ~~Main~~ / Sub
Requirement Analysis Process	**S4P3**	The template will be sustainability goals.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S4P3), the discoveries show a level of '28%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '65%' from the all-out number of respondents has admitted to 'agree' and of '1%' from the all-out number of respondents has 'Not Applicable' choice and '6%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.19	
	Result	As the query was asked to '65' respondents regrading requirement Analysis practice (S4P5), the discoveries display a level of '12%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '52%' from the all-out number of respondents has admitted to

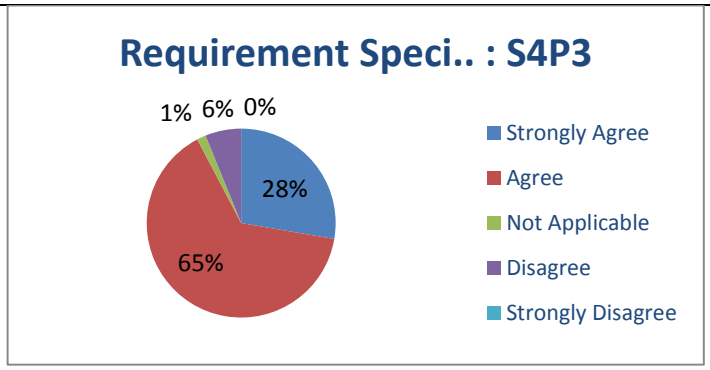


Table 4.3: Survey results statistics of using Requirement Specification Practices

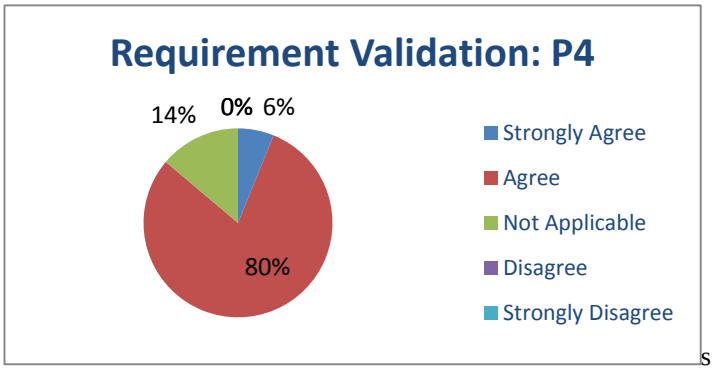
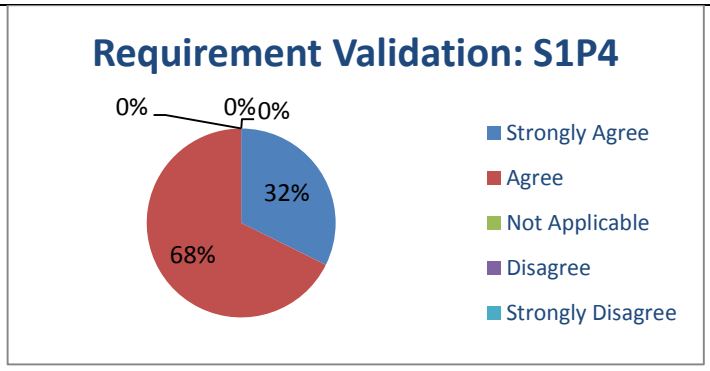
Table show statistic of Requirement Specification Survey Result.

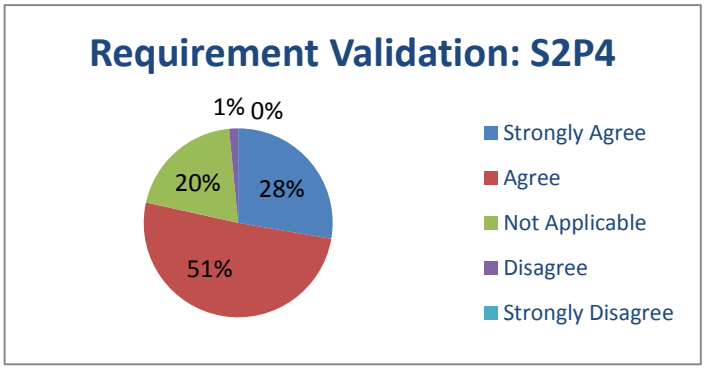
Requirement Specification	Strongly Agree	Agree	Not Applicable	Disagree	Strongly Disagree	*Total*
P3	***0***	***2***	***38***	***25***	***0***	***65***
S1P3	***0***	***17***	***28***	***20***	***0***	***65***
S2P3	*4*	*36*	*15*	*10*	*0*	*65*
S3P3	*12*	*48*	*5*	*0*	*0*	*65*
S4P3	*18*	*42*	*1*	*4*	*0*	*65*

Table 4.3 display the statistics of survey results based on requirement specification practices. First column name "Practices Name" display there are complete '5' Practices (P3 to S4P3) that are found from performed SLR the related articles. From 2nd-7th column shows statistic result of all the specification requirement practices, as the question was asked to '65' respondents regrading requirement specification practices , the findings show a number of each practices in above table, the practice of "P3 & S1P3" is lower rate so as a result, statistics showing, these practice observe not result for sustainable from IT industries.

IV. Requirement Validations Sustainable Practices

20	**Resp Id**	**Practice**	Main / ~~Sub~~
Requirement Validation process	**P4**	checking the requirements for realism, consistency and completeness	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (P4), the discoveries display a level of '6%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '80%' from the all-out number of respondents has admitted to 'agree' and of '14%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents	

		has ‘Disagree’ OR ‘Strongly Disagree’ in requirement engineering practice.
	Graph 4.20	
21	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Validation Process	**S1P4**	Ensure the requirement is understandable by the broad community stakeholders with perspective of sustainability effects.
	Result	As the query was posed to ‘65’ respondents regrading requirement Analysis practice (S1P4), the discoveries display a level of ‘32%’ from the all-out number of respondents has admitted to ‘Strongly Agree’ and of ‘68%’ from the all-out number of respondents has admitted to ‘agree’ and of ‘0%’ from the all-out number of respondents has ‘Not Applicable’ choice and ‘0%’ from the all-out number of respondents has ‘Disagree’ or ‘Strongly Disagree’ in requirement engineering practice.
	Graph 4.21	
22	**Resp Id**	**Practice** ~~Main~~ / Sub
Re qui	**S2P4**	Ensure the system requirements are complying the sustainability goals.

	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S2P2), the discoveries display a level of '28%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '51%' from the all-out number of respondents has admitted to 'agree' and of '20%' from the all-out number of respondents has 'Not Applicable' choice and '1%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice
	Graph 4.22	
23	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Validation Process	**S3P4**	Ensure the system requirements are considering risks related to sustainability aspects.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S3P4), the discoveries display a level of '34%' from the all-out number of respondents has admitted to 'Strongly Agree' and of 62% from the all-out number of respondents has admitted to 'agree' and of '3%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.23	
		'agree' and of '25%' from the all-out number of respondents has 'Not Applicable' choice and '11%' from the all-out number of respondents

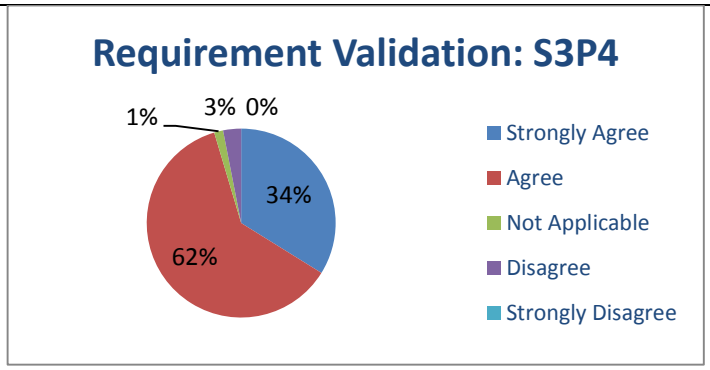


Table 4.4: Survey results statistics of using Requirement Validation Practices

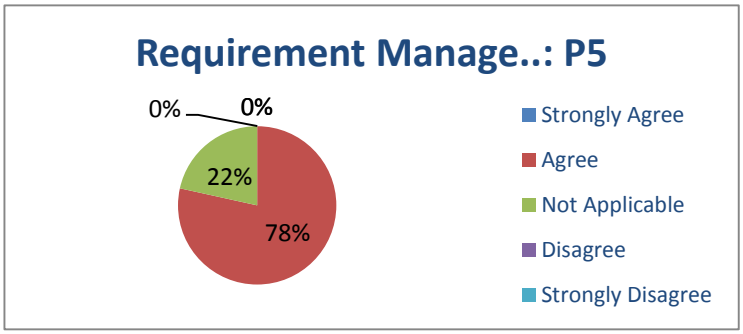
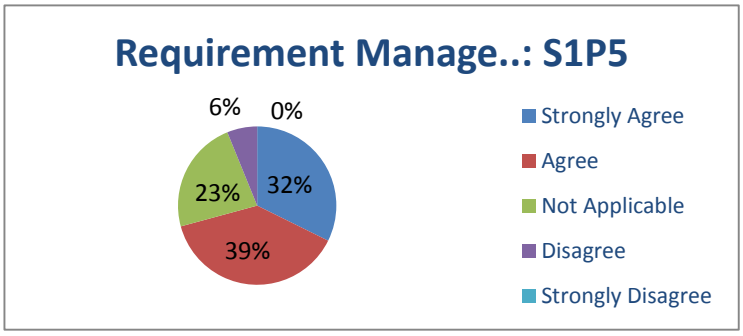
Table show statistic of Requirement Validation Survey Result.

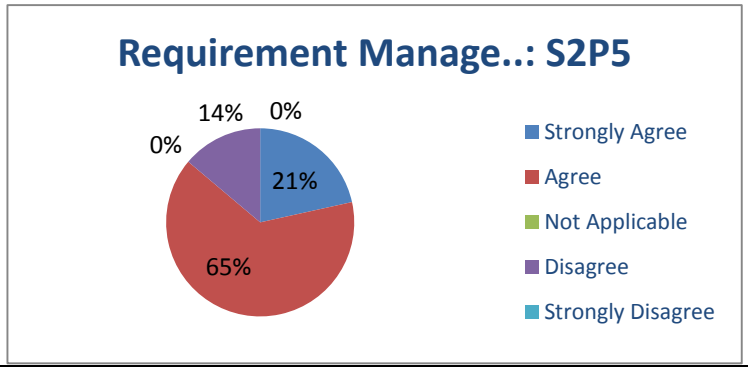
Requirement Validation	Strongly Agree	Agree	Not Applicable	Disagree	Strongly Disagree	*Total*
P4	*4*	*52*	*9*	*0*	*0*	*65*
S1P4	*21*	*44*	*0*	*0*	*0*	*65*
S2P4	*18*	*33*	*13*	*1*	*0*	*65*
S3P4	*22*	*40*	*1*	*2*	*0*	*65*

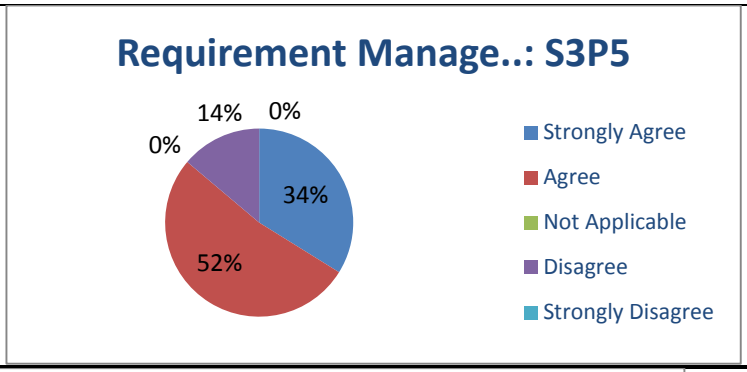
Table 4.4 display the statistics of survey results based on requirement specification practices. First column name "Practices Name" display there are complete '4' Practices (P4 to S3P4) that are found from performed SLR the related articles. From 2nd-7th column shows statistic result of all the validation requirement practices, as the question was asked to '65' respondents regrading requirement validation practices, the findings show a number of each practices in above table.

V. Requirement Management Sustainable Practices

24	**Resp Id**	**Practice**	Main / ~~Sub~~
Requirement Validation **Process**	**P5**	Need for Change of Mentality and Managing / changes to requirements with sustainability aspect	
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (P5), the discoveries display a level of 0% from the all-out number of respondents has admitted to 'Strongly Agree' and of '78%' from the all-out number of respondents has admitted to 'agree' and of '22%' from the all-out number of respondents has 'Not Applicable' choice and '0%' from the all-out number of respondents	

		has ‘Disagree’ OR ‘Strongly Disagree’ in requirement engineering practice.
	Graph 4.24	
25	**Resp Id**	**Practice** | ~~Main~~ / Sub
Requirement Management Process	**S1P5**	Change in existing requirement should be ensured with sustainability dimension.
	Result	As the query was posed to ‘65’ respondents regrading requirement Analysis practice (S1P5), the discoveries display a level of ‘32%’ from the all-out number of respondents has admitted to ‘Strongly Agree’ and of ‘39%’ from the all-out number of respondents has admitted to ‘agree’ and of ‘23%’ from the all-out number of respondents has ‘Not Applicable’ choice and ‘6%’ from the all-out number of respondents has ‘Disagree’ and “0%” from the all-out number of respondents has ‘Strongly Disagree’ in requirement engineering practice.
	Graph 4.25	
26	**Resp Id**	**Practice** | ~~Main~~ / Sub
Re qui	**S2P5**	New requirement must be complied with sustainability development goals.

	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S2P5), the discoveries display a level of '21%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '65%' from the all-out number of respondents has admitted to 'agree' and of '0%' from the all-out number of respondents has 'Not Applicable' choice and '14%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice
	Graph 4.26	
27	**Resp Id**	**Practice** ~~Main~~ / Sub
Requirement Management Process	**S3P5**	It is ensured that the changes should not impact on the existing requirement for the sustainability impact.
	Result	As the query was posed to '65' respondents regrading requirement Analysis practice (S2P5), the discoveries display a level of '34%' from the all-out number of respondents has admitted to 'Strongly Agree' and of '52%' from the all-out number of respondents has admitted to 'agree' and of '0%' from the all-out number of respondents has 'Not Applicable' choice and '14%' from the all-out number of respondents has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice
	Graph 4.26	
		has 'Disagree' and '0%' has 'Strongly Disagree' in requirement engineering practice.
	Graph 4.28	



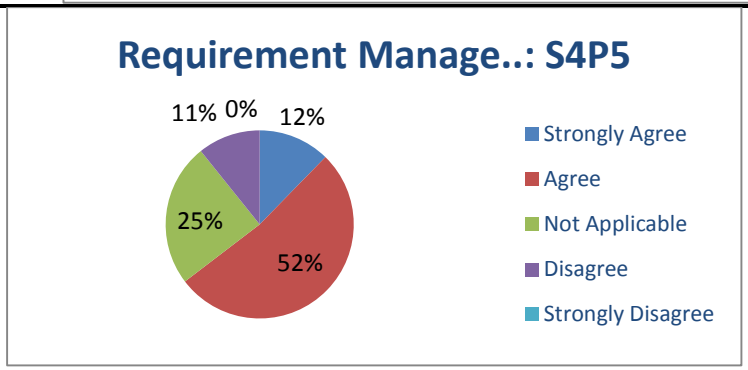


Table 4.5: Survey results statistics of using Requirement Management Practices

Table show statistic of Requirement Management Survey Result.

Requirement Management	Strongly Agree	Agree	Not Applicable	Disagree	Strongly Disagree	*Total*
P5	*0*	*51*	*14*	*0*	*0*	*65*
S1P5	*21*	*25*	*15*	*4*	*0*	*65*
S2P5	*14*	*42*	*0*	*9*	*0*	*65*
S3P5	*22*	*34*	*0*	*9*	*0*	*65*
S4P5	*8*	*34*	*16*	*7*	*0*	*65*

Table 4.5 display the statistics of survey results based on requirement Management practices. First column name "Practices Name" display there are complete '5' Practices (P5 to S4P5) that are found from performed SLR the related articles. From 2nd-7th column shows statistic result of all the management requirement practices, as the question was asked to '65' respondents regrading requirement management practices, the findings show a number of each practices in above table.

4.9 Analysis Practices Suggested by IT Industries

Analysis of data is done on the basis of survey. Table 4.7 shown the final conclude of survey in which can be improvements according to respondent's suggestion are

performed. Based upon analysis and results of survey details about sustainable practices are reported in Table 4.3 of chapter 4.

The Respondent's opinions are analyzed and described as follows.

According to respondent 'R-5' suggested a new sub-practice, he reported that practice in requirement elicitation phase, the description of practice is "convey customer about sustainability". The purpose of this practice is that convey customer about sustainability feature and methodology

According to respondent 'R-12' suggested a new sub-practice, he reported that practice in requirement analysis phase, the description of practice is "achieving scalability with sustainability". It is a characteristic of the software

Likewise, respondent 'R-13' shared his opinion about requirement specification phase of RE, He described a new sub practice is, "The template shall also include functional i.e. business requirement apart from sustainability". respondent suggestion depends upon two-part first template base design and second business requirement consider apart from the sustainability.

Similarly, Respondent 'R-15 share his opinion about sustainable practices from IT industries, and informed "Some software development projects special have limited time and resource; it is difficult to include sustainability aspect in each requirement". It is observation of the respondent in the form of limitation.

According to respondent, 'R-19 share his opinion about sustainable practices, He recommended a new sub practice in the requirement analysis phase in requirement engineering. The description of practice is "Critical Systems thinking and Design thinking". The purpose of mention is that design critical thinking.

According to respondent, 'R-25 suggested a new sub-practice, he reported that practice in requirement specification phase. The description of practice is "Checklist base template, match features of sustainability". the respondent suggests, checklist base template made, to evaluate sustainability pre-requisition in the system.

Similarity According to respondent, 'R-36 suggested a new sub-practice, he reported that practice in requirement validation phase. The description of practice is

“Sustainable Development Goals”. the respondent suggests, explain clearly sustainable goals in this phase.

According to respondent, ‘R-41 suggested a new sub-practice, he reported that practice in requirement management phase. The description of practice is “Management should be check sustainability in Triple button perspective”. Means respondent suggest to us management should be discuss and check sustainability feature in the project/product perspectives of (Economical, social, environmental, technical) dimensions.

Likewise, according to respondent, ‘R-49 suggested a new sub-practice, he reported that practice in requirement management phase. The description of practice is “Management adaptation sustainability methodology in organization”. He suggests that management should be implementation sustainability as methodology in the business organization.

According to respondent, ‘R-52’ suggested a new sub-practice, he reported that practice in requirement analysis phase. The description of practice is “sustainability as Change of mind”. He is suggested to us sustainability as a changing as mind set.

According to respondent, ‘R-60’ suggested a new sub-practice, he reported that practice in requirement analysis phase. The description of practice is “sustainability is basic principle of software development as example object-oriented programming”. He suggested to us sustainability as a principal of software development.

According to respondent, ‘R-62’ suggested a new sub-practice, he reported that practice in requirement management phase. The description of practice is “All Stakeholders involvement for the sustainable feature”. Respondent suggested to us all stakeholders discuss regarding sustainable software development in the business.

According to respondent, ‘R-64’ suggested a new sub-practice, he reported that practice in requirement specification phase. The description of practice is “Include sustainability part as a requirement each document”. Respondent suggested to us that include sustainability feature in the requirement documentation.

As the question was asked to 65 respondents regrading requirement engineering sustainable practices, the findings show only 13 of 65 respondent to replies for new practices. Below table is shows respondent replies for sustainable practice.

Table: 4.7 –Respondent Suggested Practices from IT Industries

No.	Requirement Phase	Respondent	Suggested Practices
1	Elicitation	R-5	convey customer about sustainability
2	Analysis	R-12 R-19 R-52 R-60	1. Achieving scalability with sustainability 2. Critical Systems thinking and Design thinking. 3.sustainability as Change of mind 4. sustainability is basic principle of software development as example object-oriented programming
3	Specification	R-13 R-25 R-64	The template shall also include functional i-e business requirement apart from sustainability Checklist base template, match features of sustainability. Include sustainability part as a requirement each document
4	Validation	R-36	Sustainable Development Goals
5	Management	R-15 R-41 R-49 R-62	1. Some software development projects special have limited time and resource; it is difficult to include sustainability aspect in each requirement 2. Management should be check sustainability in Triple button perspective. 3. Management adaptation sustainability methodology in organization. 4. All Stakeholders involvement for the sustainable feature

4.10 RE Sustainable Practices Model

Following Table 3.8 objective has achieved and provide comprehensive guideline to measure their current level of practices for sustainable software development. It can eventually contribute towards theoretical knowledge of software engineering as well as to contribute the industry practitioners' understanding of these practice states in the organization. This research can contribute to organizations to understand and communicate the software development strategies for achieving software sustainability.

Table: 4.8 – Objective to provide RE Sustainable Practices Model

ID	Research Objective
3	formulate a sustainable RE practices model for sustainable software development

Figure: 4.5 formulate a sustainable RE practices model for sustainable software development Thus, as discussed our research has taken three research objective with alignment of research question, study aims on identifying the sustainable RE practices, for each process of requirement engineering phase including the elicitation of requirements, specification, analysis, verification and validation, managing the requirements. This could eventually help to explore sustainable incorporating requirements. This research contributes to theory and practice by providing the sustainable requirement engineering practices model. Such research can help academician and industry to evaluate their practicing level of sustainable software development. research has taken three research objectives with alignment of research questions

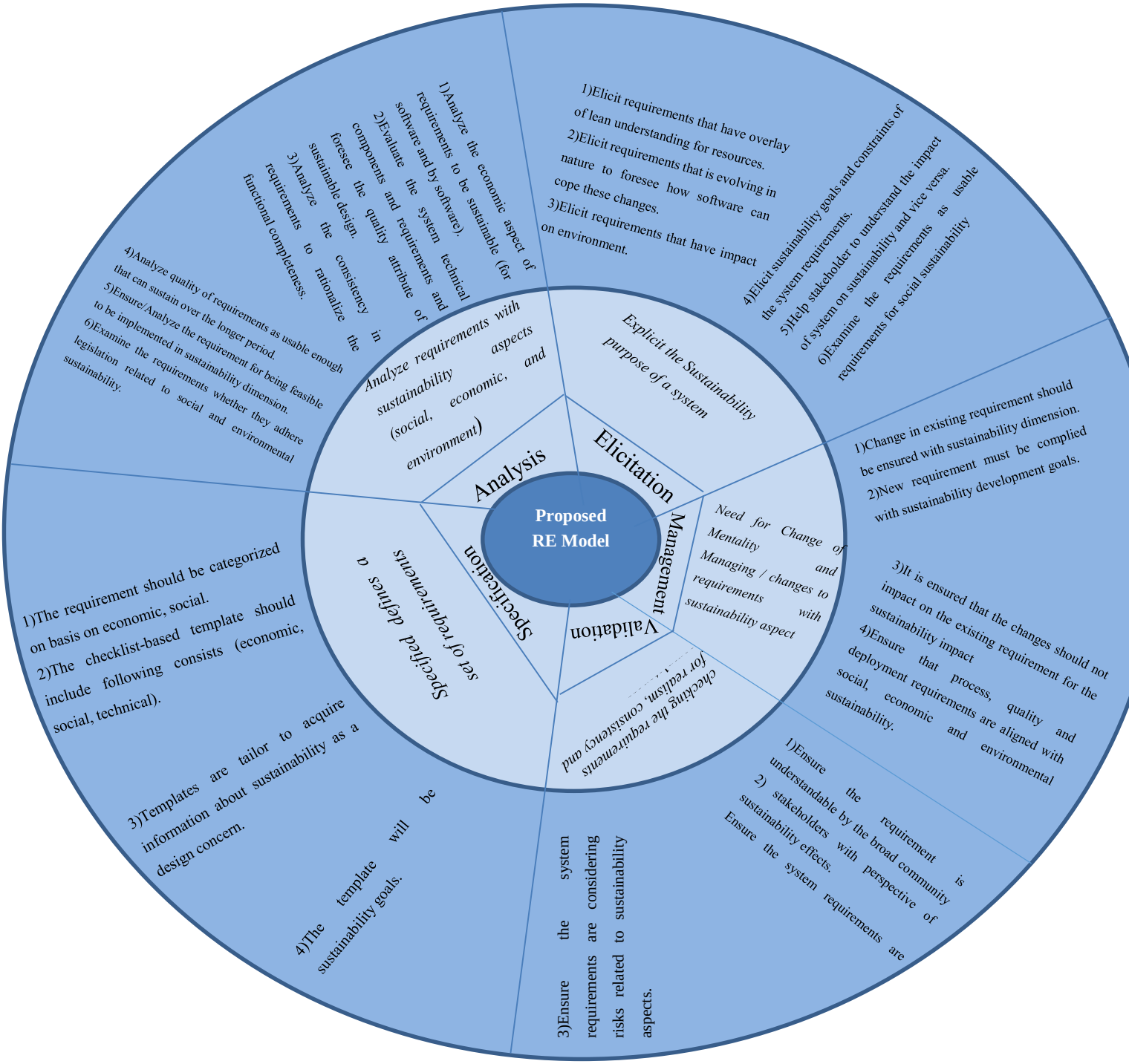


Figure: 4.5 – Sustainable RE Practices Model

CHAPTER # 5

DISCUSSION AND CONCLUSION

5.1 Overview

In previous chapter, the data collection and analysis of the SLR technique, Expert review, and conducted survey is reported. This chapter explain the discussion about RQ, objectives achievement, limitation, future work and conclusion of the research

5.2 Fulfillment of Research Questions

Considering the research questions of this research, sustainable requirement engineering practices are identified for the software development. Moreover, a sustainable practices model for requirement engineering is formulated. The research questions of this study are as follows.

- What are the sustainable requirement engineering practices essentially required for developing sustainable software?
- How much industry is practicing to the identified sustainable requirement engineering practices for software development?

SLR was conducted to answer the first research question in which sustainable RE practices were identified for each phase of RE. Later, evaluation process was conducted for these identified practices from expert review. A total of 28 practices and sub-practices found in RE.

A survey was conducted to get the answer of second research question. Furthermore, to evaluate these sustainable practices and its importance from IT industry, based on the feedback of survey sustainable RE practices model was developed for software development.

5.3 Fulfillment of Research Objectives

This research has taken three research objectives with alignment of research questions. The following are the research objectives taken in this study.

I. To identify the relevant sustainable RE practices for software development.
II. To identify the industry practicing level of sustainable RE practices for software development.
III. To formulate a sustainable RE practices model for sustainable software development.

The contribution of the research is providing the sustainable requirement engineering practices model that could aid theoretical and practical grounds. Such research can help academician and industry to evaluate their practicing level of sustainable software development.

The first objective archived by SLR and expert review to identified sustainable RE practices details in section (4.3,4.4 & 4.6) and the second objective achieved by industries survey details in section (4.7 & 4.8) finally third objectives formed into Sustainable RE practices model for software development is details in chapter four and section figure 4.5

5.4 Contributions and Significance of the Study

Study contributes in various ways such as highlighting the importance of sustainability in RE phase and by providing list of sustainable RE practices for software development. Further to this, an industry approved sustainable RE practices model is developed for industry that could eventually help them for sustainable software development. This research is significant in terms of addressing the much-needed aspect of sustainability into software field to get more environmental, social and economic software.

To contribution made by this study is in two folds. First, by identifying and reporting the sustainable RE practices which can help to develop sustainable software development. A thorough SLR is used to contribute toward the body of knowledge that resulted in a list of 28 sustainable practices and sub-practices in RE phases.

The research contributes in second fold is to identifying industry practicing level of sustainable RE practices for software development by conducting the survey. Industry practitioners were contacted to explore the most sustainable practices. By ranking the most sustainable practices, were presented them as being "Strong Agree", " Agree", "Not Applicable", “Disagree” and “Strong Disagree” .The evaluation process performed by survey would not only help to develop guideline but would also allow the user to identify the sustainable RE practices Model for academic and industries purposed.

Furthermore, another contribution made in this research is the formulation of sustainable RE practices Model. This model is a guideline that would help to the accurate and adequate sustainable software development.

5.5 Limitation of existing works

The limitations of the study are as follows:

- Only the studies related to requirement engineering phase is included in the literature review, so there is a possibility that we may have missed few of the important studies.
- Various guidelines and models exist for RE, but this research has only focused to review those studies which have address the aspects of sustainability or related term.
- Although, existing studies have address little on RE, but specific aspects of RE is focused. This research overcomes this limitation by covering all phase of RE.
- Survey is conducted among software practitioners of Pakistan. Although, a careful consideration is made for the selection of industry practitioners however there is a possibility of increasing the range and diversified respondents in this regard.
- Experts from academia is selected based on the qualification and experience, but there is possibility of limited number of experts which can be increased in future studies.

5.6 Challenges and Future Work

Due to the emerging concern of sustainability into software field, various challenges and future work exist in this context. Some of the future research areas are as follows:

- In future, researchers can validate the sustainable practices model proposed in this research. Further studies can take the comprehensive studies for evaluation purpose.
- Another avenue of future research is related to the Identification of sustainable practices within whole software development life cycle, where current research has only focused on RE phase.
- Future research can include the sustainably aspect in terms of complex software requirements, specifically mega projects of international level to address the sustainability aspects. It would be more interesting to conduct a case study on some live projects that can investigate the new research avenues.

5.7 Conclusion

This research concludes that identifying the sustainability practices in the software requirement engineering phase are crucial. This study has explored these practices from literature and later evaluated these practices from industry how much they are practicing to the identified sustainable requirement engineering practices for software development.

A thorough literature is reviewed on and around sustainability, as a result it limited sustainable practices are found that support sustainability software developments. Little research has focused on capturing requirements which are critical to sustainability improvements in RE. Moreover, limited research exists in particular to RE phase for exploring the requirements addressing sustainability. Therefore, our proposed approach provides sustainable RE practices model for software development. Further to this, industry practitioners have also contributed in this research by providing practicality of the sustainable practices in software development.

In current scenario, industry is overlooking the sustainability aspects in RE phases, thus leading to unsustainable software. Thus, this research directs the ability of industry practitioners by providing the list of sustainable practices in a model form that

can help in capturing requirements for future projects. It can aid in formulating the requirements for requirements engineers to work for small and mega projects requirement engineering.

Future work is also highlighted that could further this study by evaluating the proposed sustainable practices model for RE. Further to this, exploratory study is required to identify sustainable practices model for all SDLC life Cycle phases. Moreover, Future research requires evaluate these identified practices in software development.

Reference**:**

[1] F. Dictionary, “The free dictionary,” 2020. .

[2] C. C. Venters *et al.*, “Software sustainability: The modern tower of babel,” *CEUR Workshop Proc.*, vol. 1216, pp. 7–12, 2014.

[3] P. Glavič and R. Lukman, “Review of sustainability terms and their definitions,” *J. Clean. Prod.*, vol. 15, no. 18, pp. 1875–1885, 2017, doi: 10.1016/j.jclepro.2006.12.006.

[4] Z. Durdik, B. Klatt, H. Koziolek, K. Krogmann, J. Stammel, and R. Weiss, “Sustainability guidelines for long-living software systems,” *IEEE Int. Conf. Softw. Maintenance, ICSM*, pp. 517–526, 2012, doi: 10.1109/ICSM.2012.6405316.

[5] SSI, “The Software Sustainability Institute.” .

[6] C. Calero and M. Piattini, “Green in software engineering,” *Green Softw. Eng.*, pp. 1–327, 2015, doi: 10.1007/978-3-319-08581-4.

[7] M. Dick and S. Naumann, “Enhancing Software Engineering Processes towards Sustainable Software Product Design,” *EnviroInfo 2010, Integr. Environ. Inf. Eur. Proc. 24th Int. Conf. Informatics Environ. Prot.*, vol. 2010, pp. 706–715, 2010.

[8] M. Mahaux and C. Canon, “Integrating the Complexity of Sustainability in Requirements Engineering,” *1st Int. Work. Requir. Sustain. Syst.*, pp. 1–5, 2013.

[9] D. Pandey and V. Pandey, “Importance of Requirement Management : Requirement Engineering Concern,” *Int. J. Res. Dev.*, vol. 3, no. 2, pp. 301–304, 2014.

[10] R. Chitchyan *et al.*, “Sustainability design in requirements engineering,” *Proc. 38th Int. Conf. Softw. Eng. Companion - ICSE ’16*, pp. 533–542, 2016, doi: 10.1145/2889160.2889217.

[11] S. Oyedeji and B. Penzenstadler, “Experiences from applying the Karlskrona manifesto principles for sustainability in software system design,” *CEUR Workshop Proc.*, vol. 2541, 2019.

[12] P. Lago, “Challenges and Opportunities for Sustainable Software,” *Proc. - 5th Int. Work. Prod. Line Approaches Softw. Eng. PLEASE 2015*, pp. 1–2, 2015, doi: 10.1109/PLEASE.2015.8.

[13] B. Penzenstadler *et al.*, “Raising awareness for potential sustainability effects in Uganda: A survey-based empirical study,” *CEUR Workshop Proc.*, vol. 2541, 2019.

[14] P. Lago, S. A. Koçak, I. Crnkovic, and B. Penzenstadler, “Framing sustainability as a property of software quality,” *Commun. ACM*, vol. 58, no. 10, pp. 70–78, 2015, doi: 10.1145/2714560.

[15] R. Chitchyan, J. Noppen, and I. Groher, “What Can Software Engineering Do for Sustainability: Case of Software Product Lines,” *Proc. - 5th Int. Work. Prod. Line Approaches Softw. Eng. PLEASE 2015*, pp. 11–14, 2015, doi: 10.1109/PLEASE.2015.11.

[16] G. Huzooree, “International Journal of Advanced Research in Computer Science and Software Engineering A Systematic Study on Requirement Engineering Processes and Practices in Mauritius,” vol. 5, no. 2, pp. 40–46, 2015.

[17] A. Raturi, B. Penzenstadler, B. Tomlinson, and D. Richardson, “Developing a sustainability non-functional requirements framework,” *3rd Int. Work. Green Sustain. Software, GREENS 2014 - Proc.*, pp. 1–8, 2014, doi: 10.1145/2593743.2593744.

[18] A. S. Santos, E. P. Amorim, C. F. Ferreira, and C. P. Pirovani, “Water stress in Musa spp.: A systematic review,” *PLoS One*, vol. 13, no. 12, pp. 1–17, 2018, doi: 10.1371/journal.pone.0208052.

[19] D. Renzel, I. Koren, R. Klamma, and M. Jarke, “Preparing research projects for sustainable software engineering in society,” *Proc. - 2017 IEEE/ACM 39th Int. Conf. Softw. Eng. Softw. Eng. Soc. Track, ICSE-SEIS 2017*, pp. 23–32, 2017, doi: 10.1109/ICSE-SEIS.2017.4.

[20] T. R. D. Saputri and S. W. Lee, “Addressing sustainability in the requirements engineering process: From elicitation to functional decomposition,” *J. Softw. Evol. Process*, no. June 2019, pp. 1–25, 2020, doi: 10.1002/smr.2254.

[21] N. Nguyena and R. Chitchyan, “Systems re-design for sustainability: PetShop Case study,” *CEUR Workshop Proc.*, vol. 2541, pp. 1–15, 2019.

[22] G. Lami, F. Fabbrini, and M. Fusani, “A methodology to derive sustainability indicators for software development projects,” *ACM Int. Conf. Proceeding Ser.*, pp. 70–77, 2013, doi: 10.1145/2486046.2486060.

[23] B. Penzenstadler and A. Fleischmann, “Teach sustainability in software engineering?,” *2011 24th IEEE-CS Conf. Softw. Eng. Educ. Training, CSEE T 2011 - Proc.*, pp. 454–458, 2011, doi: 10.1109/CSEET.2011.5876124.

[24] J. Horkoff *et al.*, “Goal-oriented requirements engineering: an extended systematic mapping study,” *Requir. Eng.*, vol. 24, no. 2, pp. 133–160, 2019, doi: 10.1007/s00766-017-0280-z.

[25] R. F. Schmidt, “Software Requirements Analysis Practice,” *Softw. Eng.*, pp. 139–158, 2013, doi: 10.1016/b978-0-12-407768-3.00008-2.

[26] SSI, “Summary of the First Workshop on Sustainable Software for Science: Practice and Experiences (WSSSPE1),” *J. Open Res. Softw.*, vol. 2, no. 1, p. e6, 2014, doi: 10.5334/jors.an.

[27] C. C. Venters, L. Lau, M. K. Griffiths, V. Holmes, R. R. Ward, and J. Xu, “The Blind Men and the Elephant : Towards a Software Sustainability Architectural Evaluation Framework,” *J. Open Res. Softw.*, vol. 2, no. 1, pp. 1–6, 2014, doi: doi:10.6084/m9.figshare.790758.

[28] O. Kaiwartya *et al.*, “Guidelines for performing Systematic Literature Reviews in Software Engineering,” *IEEE Access*, vol. 4, pp. 5356–5373, 2016, doi: 10.1109/ACCESS.2016.2603219.

[29] M. Kasunic, “Designing an effective survey. Handbook. Carnegie Mellon University,” *Softw. Eng. Inst.*, no. September, p. 140, 2005.

Appendix – Questionnaire Design

	Invitation to Practices of Requirement Engineering					
	Introduction: sustainability has emerged into varied fields industries well needed software fields. Sustainability in the information technology (IT) and software engineering (SE) has recently emerged as critical concern that describes a software able to continue with minimal long-term environmental effect is called sustainable software, there are two main factors for the sustainability are time or longevity					
	NAME & DESIGNATION:					
	QUALIFICATION:	**5**	**4**	**3**	**2**	**1**
	Categorized - Practices & Sub-Practices	Strongly Agree No.	Agree No.	Not Applicable No.	Disagree No.	Strongly Disagree No.
	Requirement Elicitation					
P1	***Explicit the Sustainability purpose of a system.***	…….	…….	…….	…….	…….
S1P1	Elicit requirements that have overlay of lean understanding for resources.	…….	…….	…….	…….	…….
S2P1	Elicit requirements that is evolving in nature to foresee how software can cope these changes.	…….	…….	…….	…….	…….
S3P1	Elicit requirements that have impact on environment.	…….	…….	…….	…….	…….
S4P1	Elicit sustainability goals and constraints of the system requirements.	…….	…….	…….	…….	…….
S5P1	Help stakeholder to understand the impact of system on sustainability and vice versa.	…….	…….	…….	…….	…….
S6P1	Examine the requirements as usable requirements for social sustainability	…….	…….	…….	…….	…….
S7P1	Other Any:	…….	…….	…….	…….	…….
S8P1		…….	…….	…….	…….	…….
	Requirement Analysis					
P2	· ***Analyze requirements with sustainability aspects (social, economic, and environment)***					

S1P2	Analyze the economic aspect of requirements to be sustainable (for software and by software).	…….	…….	…….	…….	…….
S2P2	Evaluate the system technical components and requirements and foresee the quality attribute of sustainable design.	…….	…….	…….	…….	…….
S3P2	Analyze the consistency in requirements to rationalize the functional completeness.	…….	…….	…….	…….	…….
S4P2	Analyze quality of requirements as usable enough that can sustain over the longer period.	…….	…….	…….	…….	…….
S5P2	Ensure/Analyze the requirement for being feasible to be implemented in sustainability dimension.	…….	…….	…….	…….	…….
S6P2	Examine the requirements whether they adhere legislation related to social and environmental sustainability.	…….	…….	…….	…….	…….
S7P2	Other Any:	…….	…….	…….	…….	…….
		…….	…….	…….	…….	…….
	Requirement Specification					
P3	· ***Specified defines a set of requirements***	…….	…….	…….	…….	…….
S1P3	The requirement should be categorized on basis on economic, social.	…….	…….	…….	…….	…….
S2P3	The checklist-based template should include following consists (economic, social, technical).	…….	…….	…….	…….	…….
S3P3	Templates are tailor to acquire information about sustainability as a design concern.	…….	…….	…….	…….	…….
S4P3	The template will be sustainability goals.	…….	…….	…….	…….	…….
S5P3	other Any:	…….	…….	…….	…….	…….
		…….	…….	…….	…….	…….
	Requirement Validation					
P4	· ***checking the requirements for realism, consistency and completeness***	…….	…….			
S1P4	Ensure the requirement is understandable by the broad community stakeholders with	…….	…….	…….	…….	…….

	perspective of sustainability effects.					
S2P4	Ensure the system requirements are complying the sustainability goals.	…….	…….	…….	…….	…….
S3P4	Ensure the system requirements are considering risks related to sustainability aspects.	…….	…….	…….	…….	…….
S4P4	other Any:	…….	…….	…….	…….	…….
		…….	…….	…….	…….	…….
	Requirement management					
P5	· ***Managing / changes to requirements with sustainability aspect***	…….	…….	…….	…….	…….
S1P5	Change in existing requirement should be ensured with sustainability dimension.	…….	…….	…….	…….	…….
S2P5	New requirement must be complied with sustainability development goals.	…….	…….	…….	…….	…….
S3P5	It is ensured that the changes should not impact on the existing requirement for the sustainability impact.	…….	…….	…….	…….	…….
S4P5	Ensure that process, quality and deployment requirements are aligned with social, economic and environmental sustainability.	…….	…….	…….	…….	…….
S5P5	other Any:	…….	…….	…….	…….	…….

Appendix–B

Form of Data Extraction		
Paper Title:	Software Sustainability: The Modern Tower of Babel	
Paper ID:	P1	
Type:	Journal	
Methodology:	Case study	
Country:	UK	
Year:	2014	
Author	Venters, C. C.	**Sustainable / RE Context**
		YES
Paper Title:	A Systematic Literature Review for Software Sustainability Measures	
Paper ID:	P2	
Type:	Journal	
Methodology:	SLR	
Country:	Spain	
Year:	2013	
Author:	Calero, Coral	**Sustainable / RE Context**
		YES
Paper Title:	Sustainability Guidelines for Long-Living Software Systems	
Paper ID:	P3	
Type:	Journal	
Methodology:	Conceptual Method	
Country:	Germany	
Year:	2012	
Aims Clearly Stated:	Yes	**Sustainable / RE Context**
		Yes
Paper Title:	Challenges and Opportunities for Sustainable Software	
Paper ID:	P4	
Type:	Journal	
Methodology:	Conceptual Method	
Country:	Netherlands	
Year:	2015	
Aims Clearly Stated:	Yes	**Sustainable / RE Context**
		Yes
Paper Title:	Integrating the Complexity of Sustainability in Requirements Engineering	

Paper ID:	P5	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Belgium	
Year:	2013	
Aims Clearly Stated:	Yes	**Sustainable / RE Context**
		Yes
Paper Title:	Developing a Sustainability Non-functional Requirements Framework	
Paper ID:	P6	
Type:	Journal	
Methodology:	Conceptual FRAMEWORK	
Country:	USA	
Year:	2014	
Author	Raturi, Ankita Penzenstadler	**Sustainable / RE Context**
		Yes
Paper Title:	A Proposed Recommender System for Eliciting Software Sustainability Requirements Kristin	
Paper ID:	P7	
Type:	Journal	
Methodology:	Case Studies This	
Country:	USA	
Year:	2013	
Author	Roher, Kristin	**Sustainable / RE Context**
		Yes
Paper Title:	Requirements: The Key to Sustainability	
Paper ID:	P8	
Type:	Journal	
Methodology:	Case Studies This	
Country:		
Year:	2016	
Author	Becker, Christoph	**Sustainable / RE Context**
		Yes
Paper Title:	Preparing Research Projects for Sustainable Software Engineering in Society Dominik	
Paper ID:	P9	
Type:	Journal	
Methodology:	Conceptual Model.	
Country:	Germany	
Year:	2017	
Author	Renzel, Dominik	**Sustainable / RE Context**
		Yes
Paper Title:	The GREENSOFT Model: A reference model for green and sustainable software and its engineering	
Paper ID:	P10	
Type:	Journal	
Methodology:	Conceptual Model.	

Country:	Germany	
Year:	2011	
Author	Naumann, Stefan Dick	**Sustainable / RE Context** Yes
Paper Title:	A Systematic Study on Requirement Engineering Processes and Practices in Mauritius	
Paper ID:	P11	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2015	
Author	Huzooree, Geshwaree	**Sustainable / RE Context** Yes
Paper Title:	Measuring the Sustainability Performance of Software Projects	
Paper ID:	P12	
Type:	Journal	
Methodology:	Case Study	
Country:	China	
Year:	2010	
Author	Albertao, Felipe Xiao	**Sustainable / RE Context** Yes
Paper Title:	Software Evaluation: Criteria-based Assessment	
Paper ID:	P13	
Type:	Journal	
Methodology:	Case Study	
Country:	UK	
Year:	2011	
Author	Jackson, Mike Crouch	**Sustainable / RE Context** Yes
Paper Title:	Sustainability Design in Requirements Engineering: State of Practice	
Paper ID:	P14	
Type:	Journal	
Methodology:	State of Practice	
Country:	UK	
Year:	2016	
Author	Chitchyan	**Sustainable / RE Context** Yes
Paper Title:	Sustainable Software System Engineering	
Paper ID:	P15	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Germany	
Year:	2014	
Author	Betz, Stefanie Caporale	**Sustainable / RE Context** Yes

Paper Title:	Software Analysis Method for Assessing Software Sustainability	
Paper ID:	P16	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	S. Korea	
Year:	2020	
Author	Saputri	**Sustainable / RE Context**
		Yes

Paper Title:	Addressing sustainability in the requirements engineering process: From elicitation to functional decomposition	
Paper ID:	P17	
Type:	Journal	
Methodology:	Empirical study	
Country:	S. Korea	
Year:	2020	
Author	Saputri	**Sustainable / RE Context**
		Yes

Paper Title:	Requirement Engineering Challenges in Development of Software Applications and Selection of Customer-off-the-Shelf (COTS) Components	
Paper ID:	P18	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Pakistan	
Year:	2010	
Author	Asghar, Sohail Umar, Mahrukh	**Sustainable / RE Context**
		Yes

Paper Title:	Raising Awareness for Potential Sustainability Effects in Uganda: A Survey-based Empirical Study	
Paper ID:	P19	
Type:	Journal	
Methodology:	Survey-based Empirical Study	
Country:	Sweden	
Year:	2019	
Author	Penzenstadler	**Sustainable / RE Context**
		Yes

Paper Title:	Blueprint and Evaluation Instruments for a Course on Software Engineering for Sustainability	
Paper ID:	P20	
Type:	Journal	
Methodology:	Survey	
Country:	USA	
Year:	2018	
Author	Penzenstadler	**Sustainable / RE Context**
		Yes

Paper Title:	The Blind Men and the Elephant: Towards an Empirical Evaluation Framework for Software Sustainability	
Paper ID:	P21	
Type:	Journal	
Methodology:	Conceptual Model	
Country:		
Year:	2014	
Author	Venters	**Sustainable / RE Context**
		Yes

Paper Title:	SUMMARY OF THE FIRST WORKSHOP ON SUSTAINABLE SOFTWARE FOR SCIENCE: PRACTICE AND EXPERIENCES (WSSSPE1)	
Paper ID:	P22	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	UK	
Year:	2014	
Author	SSI	**Sustainable / RE Context**
		Yes

Paper Title:	Enhancing Software Engineering Processes towards Sustainable Software Product Design	
Paper ID:	P23	
Type:	Journal	
Methodology:	Conceptual Model	
Country:		
Year:	2010	
Author	Dick, Markus Naumann	**Sustainable / RE Context**
		Yes

Paper Title:	Introduction to Green in Software Engineering	
Paper ID:	P24	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2015	
Author	Coral Calero	**Sustainable / RE Context**
		Yes

Paper Title:	What can Software Engineering Do for Sustainability: Case of Software Product Lines	
Paper ID:	P25	
Type:	Journal	
Methodology:	Case Study	
Country:	UK	
Year:	2015	
Author	Chitchyan	**Sustainable / RE Context**
		Yes

Paper Title:	The SusA Workshop - improving sustainability awareness to inform future business process and systems design	
Paper ID:	P26	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	UK	
Year:	2015	
Author	Penzenstadler	**Sustainable / RE Context**
		Yes
Paper Title:	Software Requirements Analysis Practice	
Paper ID:	P27	
Type:	Book	
Methodology:	Theorical	
Country:		
Year:	2013	
Author	Schmidt, Richard F.	**Sustainable / RE Context**
		Yes
Paper Title:	Goal-oriented requirements engineering: an extended systematic mapping study	
Paper ID:	P28	
Type:	Journal	
Methodology:	Survey	
Country:		
Year:	2019	
Author	Horkoff, Jennifer	**Sustainable / RE Context**
		Yes
Paper Title:	Review of sustainability terms and their definitions Peter	
Paper ID:	P29	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2017	
Author	Glavič, Peter	**Sustainable / RE Context**
		Yes
Paper Title:	An Effective Requirement Engineering Process Model for Software Development and Requirements Management	
Paper ID:	P30	
Type:	Journal	
Methodology:	Theorical	
Country:	India	
Year:	2010	
Author	Pandey, Dhirendra	**Sustainable / RE Context**
		Yes
Paper Title:	Framing sustainability as a property of software quality	

Paper ID:	P31	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2015	
Author	Lago, Patricia	**Sustainable / RE Context**
		Yes
Paper Title:	Importance of Requirement Management: A Requirement Engineering Concern	
Paper ID:	P32	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2014	
Author	Pandey, Dhirendra	**Sustainable / RE Context**
		Yes
Paper Title:	Requirements Elicitation: A Survey of Techniques, Approaches, and Tools	
Paper ID:	P33	
Type:	Journal	
Methodology:	Theorical	
Country:		
Year:	2015	
Author	Didar Zowghi and Chad Coulin	**Sustainable / RE Context**
		Yes
Paper Title:	Teach Sustainability in Software Engineering? Birgit	
Paper ID:	P34	
Type:	Journal	
Methodology:	Theorical	
Country:	USA	
Year:	2011	
Author	Penzenstadler	**Sustainable / RE Context**
		Yes
Paper Title:	Tailoring Requirements Negotiation to Sustainability	
Paper ID:	P35	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Canada	
Year:	20118	
Author	Seyff, Norbert	**Sustainable / RE Context**
		Yes
Paper Title:	SuSoftPro: Sustainability Profiling for Software	
Paper ID:	P36	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Brazil	
Year:	2018	

Author	Ahmed D	**Sustainable / RE Context**
		Yes
Paper Title:	A Methodology to Derive Sustainability Indicators for Software Development Projects	
Paper ID:	P37	
Type:	Journal	
Methodology:	Conceptual Model	
Country:	Italy	
Year:	2013	
Author	Lami, Giuseppe	**Sustainable / RE Context**
		Yes
Paper Title:	Experiences from Applying the Karlskrona Manifesto Principles for Sustainability in Software System Design	
Paper ID:	P38	
Type:	Journal	
Methodology:	Case Study	
Country:	Finland	
Year:	2019	
Author	Penzenstadler	**Sustainable / RE Context**
		Yes
Paper Title:	Systems re-design for sustainability: PetShop Case study	
Paper ID:	P39	
Type:	Journal	
Methodology:	Case Study	
Country:	Finland	
Year:	2019	
Author	Nguyena	**Sustainable / RE Context**
		Yes
Paper Title:	Survey Guidelines in Software Engineering: An Annotated Review	
Paper ID:	P40	
Type:	Journal	
Methodology:	Survey	
Country:	Sweden	
Year:	2016	
Author	Molléri, Jefferson	**Sustainable / RE Context**
		Yes