IDENTIFICATION OF THE IMPACT OF MANAGEMENT KNOWLEDGE ON PROJECT DURATION THROUGH MULTIPLE DECISION-MAKING STEPS

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Abstract: *The purpose of this study was to identify the management knowledge areas that significantly contribute to the delay of road construction projects and compare between countries. In this paper one of a probability sampling called simple random sampling technique was used to select sample from client, consultants, and contractors organizations directly involved in roads construction in Addis Ababa City. Four statistical tests: normality, reliability, spearman's rank correlation, and Mann Whitney U test were conducted to identify and rank the roads delay factors accepted by all the stakeholders. Moreover, Road construction delay factors identified from previous studies conducted in Himachal Pradesh State and Ghana. A criterion to assign the identified delay factors into the ten management knowledge areas was defined and a modified equation called the relative aggregate importance index was developed to compute the impact of the management knowledge areas on project duration. As a result, the management knowledge areas namely: Integration, schedule, and stakeholders in the case of Addis Ababa City road projects, schedule and scope in the case of Himachal Pradesh State road projects, and integration, scope and quality management knowledge areas in the case of Ghana road projects have been identified as significant contributor to the extension road construction duration.*

Keywords: *- management knowledge, delay causes, statistical tests, relative aggregate importance index, index interval, average index interval*

1. Introduction

It is a fact that construction delays have been a common occurrence in projects around the world (Kazaz et al., 2012). The studies in various countries show that the situation is getting worse even now a days ((Prasad et al., 2018), (Yap et al., 2021), and (Mahdi & Soliman, 2018)). Even if it is taken as an example, Marzouk & El-Rasas (2014) noted that delay in construction projects in Egypt is common occurrence. Similarly, Gündüz et al. (2013), reported that delays are common in the Turkish construction industry. And also, Khair et al. (2018), described that delays in road construction are common in developing economies, but in Sudan, it is particularly challenging. Moreover, Sambasivan & Soon (2007) also noted that delays in construction projects are global problem and are not unique to Malaysia. Following this, countless research works have been carried out in various parts of the world to identify the root causes of the problem and to suggest solutions. Following this, different researchers such as Durdyev et al. (2017) on construction projects in Cambodia, Rezaei & Jalal (2018) on construction projects in Iraq, Prasad et al. (2018) on construction projects in India, Wong & Vimonsatit (2012) on construction projects in west Australia, Bajjou & Chafi (2018) on construction projects in Morocco, and Braimah & Ndekugri (2008) on construction projects in the United Kingdom, they identified the major causes of construction delays and proposed ways to control them. But even now, a significant number of construction projects are known to take longer than planned. However, there are limitations in identifying the management knowledge areas that play a significant role in construction delays. The purpose of this study is to identify the management knowledge areas that have significant contribution to the delay of road projects and compare between Addis Ababa City, Himachal Pradesh, and Ghana.

2. Project success and management Knowledge areas

It is true that the construction projects performance is based on various dimensions of management knowledge, such as integration, scope, time (schedule), cost, quality, resource, communication, risk, procurement, and stakeholder (Demirkesen and Ozorhon, 2017) and (Huda and Maliki, 2019). These project management knowledge areas are important in terms of guiding the project teams to avoid critical failure in constructions (Alwaly and Alawi, 2020). In addition, their role is high in terms of increasing the competency of managers, and enabling construction companies to survive and achieve excellence (Hwang and Ng, 2013) and (Kivrak et al., 2008), and suitable for formality (Crawford and Pollack, 2007). Although management knowledge areas are very essential for project success, the contribution of each is different (Chou and Yang, 2012). In this study, these management knowledge areas, which are responsible for construction success or failure, are used as factor groups and identified the significant contributors to the delay of road projects and compared between countries.

2.1. Review of previous research works

In this part of the study, four areas of the studies conducted in relation to construction delays reviewed in depth. The first was the factor group designations given to the causes of construction delays, and the second was the statistical tests that were applied to identify the causes that played a significant role in construction delays. The third was the main causes of construction delays, and the fourth was the recommendations that would help to control these causes.

(Al-kharashi, and Skitmore, 2009), in their study of construction delay, identified more than 112 construction delay factors and categorized into client-related, contractor-related, consultant-related, labor-related, contract-related, and contractual-related factor groups. In order to understand the level of agreement between construction actors and the impact level of the delay causes correlation and Average has been used respectively. Following this, failure of a strategic plan, difference in stakeholders' involvement, and lack of agreement between actors were identified as the major factors. In order to control these major causes, it was recommended to prepare future strategic plan in an organized manner, create connections with external organizations so that contractors and consultants can share experience, and establish a uniform system to control quality and progress.

In their research on construction projects in Kazakhstan, (Hossain et al., 2019) identified 55 delay causes and categorized into client-related, contracted-related, consultant-related, material-related, labor and equipment-related, contract-related, contractual relationship-related, and external related factor groups. The statistical tests Spearman's rank correlation and relative importance index were used to understand the level of agreement between stakeholders and the impact of the causal factors respectively. Following this, incomplete or improper design, delay in materials' delivery, financial difficulties of the client, slow decision making, lack of quality control, poor labor productivity, quality of materials, shortage of skilled manpower, poor planning and scheduling, and shortage of materials were identified as the major delay factors. Preparing appropriate and complete design, ensuring timely supply of materials, evaluating and monitoring the clients' cash flow, providing quick responses, establishing and monitoring quality control system, encouraging employees, controlling the quality of materials, applying good estimation on manpower and materials, proper planning and scheduling, and ensuring and providing adequate equipments respectively were suggested to control the major delay factors.

(Samarah & Bekr, 2016) studied the causes of construction delays and their effects on Jordanian construction projects, classified 55 factors into four groups called clients related, contractors related, consultants related, and external related, and used statistical tests called correlation and, importance index, frequency index, and severity index to understand the level of agreements between stakeholders and their impact level. Following this, inadequate management and supervision by the contractor, client's changes of the design, inadequate planning and control by the contractor, using lowest bid that lead to low performance, changes in the extent of the project, errors in design and contract documents, progress payments are not made in time by the client, Rework due to mistakes during construction, Changes in the original design, and Low level productivity were reported as the major delay factors and leads to time overrun, cost overrun, disputes, arbitration, litigation and total abandonment effects.

(Koshe & Jha, 2016) identified 88 delay factors responsible for the delay of projects in Ethiopia, and categorized into contractor related, designer's related, consultant related, material related, client related, labor related, and external related factor groups. In order to understand the level of agreement between construction stakeholders, to identify the impact ranks of the causal factors, and to summarize the content in large data table, the statistical tests Spearman's rank correlation, (importance index, frequency index, and severity index), and principal component analysis respectively were implemented. Following this, contractor's' financial difficulties, escalation of materials, ineffective planning and scheduling by contractors, delay in progress payment for completed works, and lack of skilled professional in construction project management in contractor organization were identified as having a significant role, and preparing a complete drawing before construction begins, hiring experienced professionals at a good wages, timely payment of fees, taking inflation into account during cost estimation, allocating reasonable time and schedule, using appropriate project management techniques, and providing incentives and giving training to labors were the recommendations suggested to control these major delay factors.
(Alaghbari et al., 2007) in their research on the causes of delay in Malaysian construction projects, 31 factors were considered, and they were classified into groups of causes named contractor responsibility, consultant responsibility, owner responsibility, and external factors. Frequency, statistical analysis and variance, and multiple comparison statistical tests were applied to identify the main causes. Based on the result, financial and coordination problem were reported as the main contributors. Following this, financial and technical supports were recommended to control these major delay factors.
(Famiyeh et al., 2015) conducted a study to identify the major causes of construction delays in the construction of houses in Ghana. Through a deep review and pilot survey, they classified 37 delay factors into financial, resource, technical, economic, environmental, operational, governmental and political, relationship, security, and legal factor groups. Spearman's rank correlation and frequency of occurrence and relative importance index statistical tests were used to describe the perception of construction actors and the degree of impact respectively. among the identified delay factors, delay in payment to contractor, inflation, price increase in materials, inadequate fund from sponsors, variation of orders, and poor financial market were distinguished in the forefront and any corrective action taken should be focused on these six major factors.
(Prasad et al., 2018) in their study on identifying the major delay causes in Indian construction projects, they classified 60 factors identified in deep review into factor groups that they named planning and design engineering, procurement, financial, human resource, project execution, control management, and external. To understand the perception between project parties and the impact level of the delay factors, the statistical tests ANOVA and importance index were implemented respectively. And the result show that delay in settlement of claim by the owner, contractors financial difficulty, and the payment for extra work were identified as the significant ones. To help manage these high-risk factors, they recommended a sound contract agreement, variation of order clauses, prompt response to design changes, and timely payment for completed works.

2.2. List of major construction delay factors

In this section of the study, previous research works related to construction delays and conducted in Ethiopia have been reviewed in-depth and identified the major construction delay factors. Moreover, scholars associated with the countries in which similar major construction delay factors reported have been identified and listed in the table shown below.

Table1. List of delay factors identified through intensive literature review

		Ethiopia	Se	Ku m	Sa m	Gu	Gü	Oy eg

	Major delay factors	Zewdu (2016)	Koshe and Jha (2016)	Tesfa (2015)	Duso (2020)	Emer and Busier (2017)	Gebrehiwet and Luo (2017)						
1	Ineffective planning and scheduling	*	*		*	*	*	*		*		*	*
2	Late delivery of material and equipment	*		*			*						
3	Slow decision making	*			*			*			*		*
4	Poor site management and supervision by the contractor	*				*	*		*	*	*	*	
5	Cash flow problem during construction	*	*		*	*							
6	Escalation of the materials price		*	*	*		*						
7	Scheduling or resource management		*										
8	Delay in progress payments for completed works		*	*	*							*	
9	Lack of skilled professionals in the field of construction management in the organization		*										
10	Fluctuating labor availability season to season		*										
11	Inaccurate cost estimation			*									
12	Slow site clearance			*									
13	Exchange rate fluctuation			*									
14	Interference of owners			*									
15	Unforeseen site conditions			*									
16	Quality of material			*									
17	Economic condition				*								
18	Time overrun of the project				*								
19	Preparing incomplete bill of quantity				*								
20	Shortage of material				*								
21	Change in drawing and design respectively				*								
22	Type of project bidding and award (lowest bidder)					*							*
23	Lack of high-technology mechanical equipment ranked					*							
24	Inaccurate initial project scope estimate					*							
25	Weak control of the project progress					*							
26	Contractor's staffs not adequately trained in professional construction management techniques					*							
27	Corruption						*						
28	Unavailability of utilities at site						*						
29	Lack of quality materials						*						
30	late design and design document						*					*	
31	Late in approving and receiving of complete project work						*						

32	Late release budget/funds						*						

3. The Research Methodology

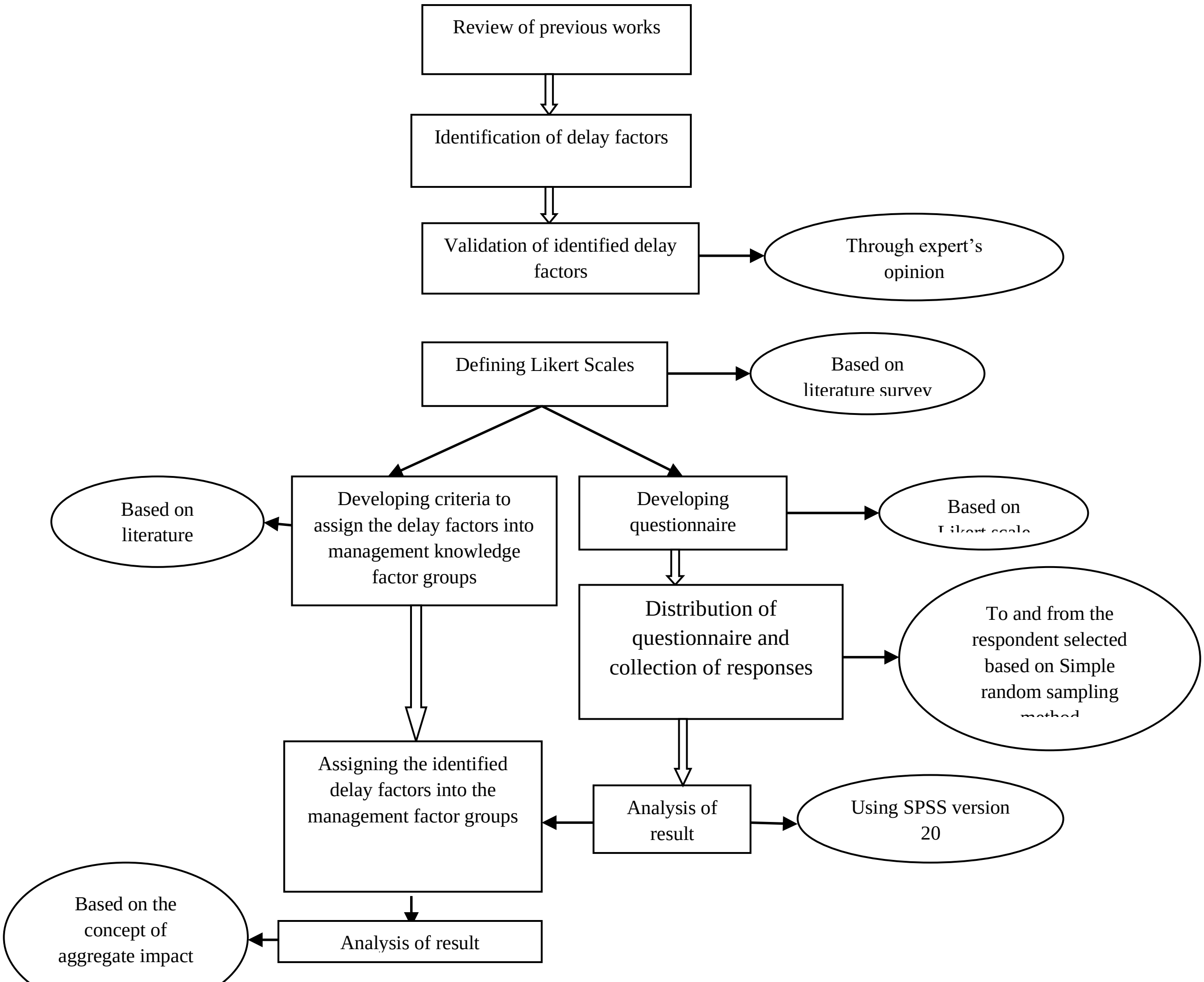

Figure1. Organization of the study

3.1. Organization of the research

Research design is the process by which research is conducted in a scientific manner, from the development of the research plan to collection and analysis of data. Choosing the right research design is certainly important for the success of a study (Bordens and Abbott, 2018). Five basic steps were used to conduct this study.

✓ First, an in-depth review of previous studies was conducted and consulted with experts to identify the delay factors that represent the study area.

✓ Second, questionnaire was developed and disseminated to respondents sampled from the study area to get their perception on the delay factors.

✓ Third, various statistical were applied to identify the delay factors that all the stakeholders agree upon.

✓ Fourth, the identified delay factors were classified into the ten management knowledge areas based on the criteria defined for this study and their relative aggregate importance indexes (RAII) were computed using the modified equation developed for this study.

✓ Fifth, results were analyzed and compared between countries.

3.2. The population of the study

The population considered in this study includes professionals who work in the Addis Ababa City Roads Authority and are directly involved in the road construction projects, professionals who were employed by contractors and participated in road construction projects under the auspices of the Addis Ababa City Roads Authority, and professionals who were employed by consulting firms and involved in the road construction projects under control of the Addis Ababa City Road Authority. The table below shows the number of professionals from Addis Ababa City Road Authority, the contractors' organization, and the consultants' organization.

Table2. The population identified from the stakeholders organizations

Study Area	Professionals in Client organization	Professionals in Contractors organizations	Professionals in Consultants organizations	Total
Addis Ababa	174	96	60	330

3.3. The sample size

The formula developed by Yemane (1997), used by Zewdu (2016) and Acharya et al. (2021), and given in (1) below has been used to determine the sample size for the defined population.

$$n_0 = \frac{N}{1+Ne^2} --- (1)$$

Where n_0 is sample size, e is level of precision, and N is the population defined

Putting the values (N=330) and (e=10%), the sample size $n_0 = 77$. However, the sample is increased by 30% to compensate the non-response (Israel, 1992).

3.4. Sampling technique

Sampling is used when it is not possible to include the entire population of the study in terms of cost and time (Olken and Rotem, 1986). Types of sampling methods are known as probability and non-probability and the probability sampling method give equal opportunity to the entire population (Kothari, 2004). In this study, a simple random sampling technique was used to ensure that all participants had equal chances. To do this, a random number table and its guidelines published by Rand corporation has been used and identified 50 professionals from client organizations while 13 are reserve respondents, 22 professionals from consultants organizations while 5 are reserve, and 28 professionals from contractors organizations while 5 are reserve.

3.5. Questionnaire design

Three types of questionnaires were prepared to conduct this study. All of the questionnaires consisted of three parts, the first part containing information about the researcher's identity, the purpose of the study, and the collaboration. The second section covered respondent's organization, profession, position, educational level, and work experience and the third section contain questions related to construction delay factors.

The first questionnaire was prepared for the experts, and it was designed to determine whether the factors for the delay identified from different sources were not representative of the location of this study. To help accomplish this, a five point likert scales was used to let experts express their level of agreement. After analyzing the responses of the experts, some of the delay factors whose agreement indexes less than or equal to 0.599 have been excluded based on the method used by Agbenohevi et al. (2017) and the delay factor 'right-of-way issues' that was not the part of the listed factors in table 1 has been included based on experts suggestions. Following this, 21 delay causes that represented the study area have been identified. The second questionnaire was prepared and distributed to 100 selected sample professionals to get their opinion on the delay causes and the third questionnaire was designed and distributed for experts to suggest on the source and mitigation measure of the significant delay factors identified in this study.

Table3. The likert scales used to prepare questionnaire 1 and 2

Likert scales	1	2	3	4	5	Remark
Level of agreement	Not agree	Slightly agree	Agree	Strongly agree	Very strongly agree	Questionnaire 1
Level of importance	Not important	Slightly important	Important	Very important	Extremely important	Questionnaire 2

3.6. Data collection

After the respondents were identified using the simple random sampling method, each individual was contacted in person and the purpose of the research was explained to them. Following this, the questionnaires was distributed and told them to fill it and back within fifteen days. Based on the time frame the questionnaires were collected from the respondents and almost all of the respondents were absolutely completed the requested information.

3.7. Criteria to assign the delay causes into the ten management knowledge areas defined as factor groups

i. Delay factors related to integration management knowledge area

Project integration management knowledge includes identifying, defining, unifying, and coordinating all activity processes (PMBOK, 2017). It is clear that integration of the various activities for the completion of construction projects plays an important role in its success (Demirkesen & Ozorhon, 2017). In this study, the causes for delay in the construction of the road projects those involve two or more activities assigned into integration management knowledge area.

ii. Delay factors related to scope management knowledge area

Project scope management knowledge includes all types of works and their quantities, required input types and amount, and required workforce types and amount to complete a project (PMBOK, 2017). However, uncertainty about the size and type of work, the size and type of materials and equipments, and the amount and type of workforce are widely observed in projects and have a fundamental impact on project management (Atkinson et al., 2007). Following this, the causes for the delay in the construction of the road projects that are related to the size and types of work, the size and types of materials and equipments, and the amount and types of workforce have been assigned to scope management knowledge area.

iii. Delay factors related to schedule management knowledge area

Project schedule management includes identifying and defining tasks for completion of projects, identifying work sequences, estimating the time for activities, planning to deliver resources, and controlling schedule (PMBOK, 2017). However, it is well known that project delays related to project time management and control are the causes of disputes between stakeholders (Solís-carcaño et al., 2015). In this study, the causes of road construction delays related to activities planning, materials and equipments delays, and workforce delays have been categorized into schedule management knowledge area.

iv. Delay factors related to cost management knowledge area

Project cost management knowledge requires planning, estimating, financing, funding, managing, and overseeing projects costs (PMBOK, 2017). Managing and controlling project cost plays an important role in ensuring that projects are completed within the planned budget (Aziz, 2013). However, projects that manage cost consistently perform better than projects that have lack of consistent financial flow information (Salem et al., 2018). In this study, the factors that cause construction delays and related to inflation, financial flow, funding, and reserve budget are categorized into cost management area.

v. Delay factors related to quality management knowledge area

Project quality management involves implementing, monitoring and controlling the requirements defined for successful completion of the projects (PMBOK, 2017). Most of the problems associated with poor quality are caused by human factor (Abdul-rahman et al., 2010). These factors related to construction errors, design quality defects, and material quality defects have been classified into quality management knowledge area.

vi. Delay factors related to resource management knowledge area

Project resource management involves identifying, mobilizing, and managing resources to successfully complete projects (PMBOK, 2017) In order to be competitive and profitable in the construction industry, coordination materials takeoff, purchasing, preparation of storage and distribution site play an important role (Bell and Stukhart, 1986). However, in developing economy countries inefficient resource management is associated with the contractors and sub contractors organizations. The cause for the delays in road construction and related to material management, equipment management, and labor management have been assigned to resource management knowledge area.

vii. Delay factors related to communication management knowledge area

Effective communication plays an important role in the success of construction projects (Senaratne & Ruwanpura, 2016). Thus, it requires planning, managing, monitoring, and controlling of communication processes (PMBOK, 2017). In this study, the causes for road delays related to information complexity, information flow problems, lack of communication and coordination between construction actors have been categorized into communication management knowledge area.

viii. Delay factors related to risk management knowledge area

Risks are common, especially in the construction industry, and to help prevent them, it is important to identify, classify, plan, analyze, implement, and monitor the risks before they occur ((PMBOK, 2017) and (Szymański, 2017)). In this study, the road delay factors related to incidents have been categorized into risk management knowledge area.

ix. Delay factors related to procurement management knowledge area

Project procurement management involves managing contract matters, procurement orders, memoranda of agreements, and internal level service agreements, including procurement of products and services, and requires planning, conducting, and controlling of procurements (PMBOK, 2017). In this study, the cause for road delays related to product and service procurement agreement, bid management, and input suppliers have been assigned to the procurement management knowledge area.

x. Delay factors related to stakeholders management knowledge area

Project stakeholder management involves identifying, planning, engagement managing, and monitoring groups or organizations that could affect or be affected by a project (PMBOK, 2017). In this study, the cause for road delays related to the way to handle stakeholders, stakeholders' identification and classification, and stakeholders' engagement, monitoring, and controlling have been assigned to the stakeholder management knowledge area.

3.8. Result Analysis

3.8.1. Respondents' Background

The results detailed in table 4 and figure 1 below indicates the work experience of the sampled respondents. As shown in figure 1, about 21% of the respondents have 0 – 5 years of work experience, 40% of the respondents have 5 - 10 years of work experience, 22% of the respondents have 11 - 15 years work of experience, and 17% of the respondents have ≥15 years of work experience.

Table4. Work experience of sampled respondents

Respondents Work experience in Years	[0-5)	[5-10)	[10-15)	≥15	Total
Client	10	14	7	6	37
Consultants	0	5	6	6	17
Contractors	6	12	4	1	23
Total	16	31	17	13	77

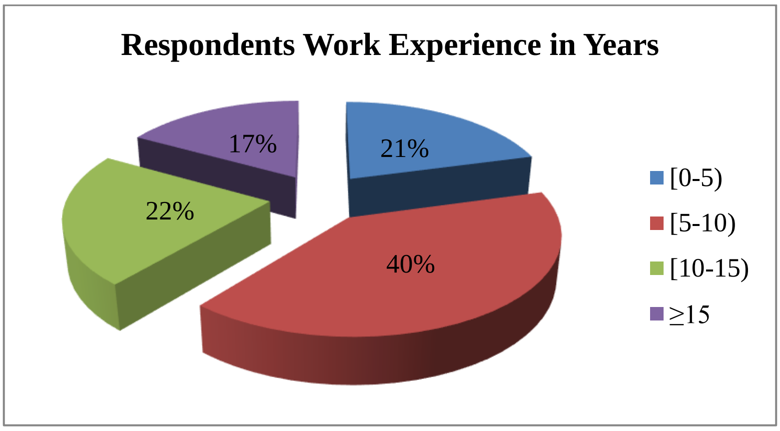

Fig2. The percentage of respondents work experience in years

3.8.2. Statistical Tests

Although it is difficult for researchers to choose the right statistical tests (Beath & Jones, 2018), it is possible taking into account the design of the study, the level of measurements, and the hypothesis to be tested (Parab & Bhalerao, 2010). Non-parametric test is preferred if there are no more assumptions on the population of the study and the objective of the study is to test the rank and order of factors (Siegel, 2012). In connection with the likert scales used in questionnaire preparation and ranking of the delay factors, most of the statistical tests employed in this study are non-parametric. The following four tests were performed to help identify the major delay factors in road constructions.

i. Normality test

Since normality test is prerequisite for many statistical tests (Mishra et al., 2019), it was first applied in this study to understand the distribution of data. Although there are many types of statistical tests to understand the distribution of data, the Shapiro-Wilk and Kolmogorov-Smirnov tests were used. The Shapiro-Wilk test is suitable for sample size less than 50 and Kolmogorov-Smirnov test is suitable for sample size greater than or equal to 50 (Mishra et al., 2019). Both the tests are dependent on the p value, if $p > 0.05$ the null hypothesis is accepted that is the data is normally distributed and otherwise rejected (the distribution is not normal) (Mishra et al., 2019).

- The null hypothesis (H_0): the responses on each delay factor is normally distributed
- The alternative hypothesis (H_1): the responses on each delay factor is not normally distributed

The output in table 5 indicates the Shapiro-Wilk and Kolmogorov-Smirnov normality test analyzed using SPSS Version 20. In both of the tests the value of $p < 0.05$ on each construction delay factors and indicates that the data is not normally distributed.

Table5. Test of normality for each delay factors

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Delay causes	Statistic	df	Sig.	Statistic	df	Sig.
A poor site management and supervision of contractors	.246	77	.000	.864	77	.000
Change in drawing and design	.201	77	.000	.905	77	.000
Delay in progress payment for completed works	.186	77	.000	.916	77	.000
Economic condition	.282	77	.000	.844	77	.000
Fluctuation in material price	.248	77	.000	.895	77	.000
Inaccurate initial project scope estimate	.228	77	.000	.893	77	.000
Ineffective project planning and scheduling	.294	77	.000	.816	77	.000
Lack of high-technology mechanical equipment ranked	.340	77	.000	.783	77	.000
Lack of quality materials	.229	77	.000	.895	77	.000
Lack of skilled professionals in the field of construction management in the organization	.204	77	.000	.913	77	.000
Late delivery of materials and equipments	.252	77	.000	.831	77	.000
Late design and design documents	.215	77	.000	.889	77	.000
Late in approving and receiving of completed project work	.244	77	.000	.883	77	.000
Poor financial control of the project	.328	77	.000	.785	77	.000
Right-of-way issue	.391	77	.000	.655	77	.000
Shortage of materials	.173	77	.000	.917	77	.000
Slow decision making	.205	77	.000	.892	77	.000
Type of project bidding and award (lowest bidder)	.275	77	.000	.836	77	.000
Unavailability of utilities at site	.241	77	.000	.893	77	.000
Unforeseen site condition	.216	77	.000	.877	77	.000
Weak control of the project progress	.312	77	.000	.756	77	.000

a. Lilliefors Significance Correction

ii.Reliability test

Second, the reliability test was applied in this study using SPSS Version 20 to understand the internal consistency of the items. The internal consistency of the items dependent on reliability coefficient called Cronabach's alpha value. A study by Taber (2016) noted that if the value of Cronabach's alpha is (0.71 – 0.91), the internal consistency between the items is good. As shown in Table 6 below, the value of Cronabach's alpha for the items used in this study is 0.827, and indicating that it is reliable.

Table6. The reliability of the items prepared in this study

Variable	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Items	.827	.820	21

iii.Spearman's rank correlation test

Third, the Spearman's rank correlation test was performed to understand the level of agreement between stakeholders (clients, consultants, and contractors). Schober et al. (2018) in their study of the proper use of correlation coefficients suggested that the use of Spearman's correlation coefficient could help to understand the connection of two or more monotonic but non linear data. They also noted that if the correlation coefficient value is between 0.7 and 0.89, there is strong correlation and if it is between 0.4 and 0.69 there is a moderate correlation.

Table7. Spearman rank correlation between client, consultant, and contractor responses.

			Client	Consultant	Contractor
Spearman's rho	Client	Correlation Coefficient	1.000	.916**	.777**
		Sig. (2-tailed)		.000	.000
		N	21	21	21
	Consultant	Correlation Coefficient	.916**	1.000	.767**
		Sig. (2-tailed)	.000		.000
		N	21	21	21
	Contractor	Correlation Coefficient	.777**	.767**	1.000
		Sig. (2-tailed)	.000	.000	
		N	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in table 7 above, the correlation between client and consultant is 0.916, the correlation between client and contractor is 0.777, and the correlation between consultant and contractor is 0.767. This indicates that there is a strong correlation (agreement) between the stakeholders.

iv.Mann-Whitney U test

Fourth, in addition to Spearman's rank correlation, Mann-Whitney U test was applied to understand the status of stakeholders' perception on each cause of construction delays. The significant level (p-value) considered is 0.05 and the hypothesis to be tasted are stated in the bullets given below:

✓ Null hypotheses H_0: the stakeholders (client, consultant, and contractors) have the same perception ($p \geq 0.05$)

✓ Alternative hypotheses H_1: the stakeholders (client, consultants, and contractors) have different perception ($p < 0.05$)

The table below shows the status of perception of client and consultants, client and contractors, and consultants and contractors.

Table8. Mann-Whitney U test to check the perception status between client and consultant, client and contractors, and consultants and contractors

***Mann-Whitney U test to check the level of perception among project stakeholders (Client, Consultants,**

and Contactors)						
	Client / Contractor		Client/ Consultant		Consultants / Contractors	
Delay factors	p-value	significance at 0.05 level	p-value	significance at 0.05 level	p-value	significance at 0.05 level
A poor site management and supervision by contractor	0.741	Not Significant	0.080	Not Significant	0.120	Not Significant
Change in drawing and design	0.915	Not Significant	0.002*	Significant	0.113	Not Significant
Delay in progress payment for completed works	0.734	Not Significant	0.001*	Significant	0.032*	Significant
Economic condition	0.992	Not Significant	0.422	Not Significant	0.665	Not Significant
Fluctuation in material price	0.951	Not Significant	0.384	Not Significant	0.464	Not Significant
Inaccurate initial project scope estimate	0.162	Not Significant	0.002*	Significant	0.002*	Significant
Ineffective project planning and scheduling	0.562	Not Significant	0.160	Not Significant	0.607	Not Significant
Lack of high technology equipment	0.083	Not Significant	0.765	Not Significant	0.290	Not Significant
Lack of quality materials	0.640	Not Significant	0.506	Not Significant	0.914	Not Significant
Lack of skilled professionals in the field of construction management in the organization	0.522	Not Significant	0.738	Not Significant	0.725	Not Significant
Late delivery of materials and equipments	0.135	Not Significant	0.137	Not Significant	0.914	Not Significant
Late design and design document	0.200	Not Significant	0.001*	Significant	0.000*	Significant
Late in approving and receiving of completed project	0.547	Not Significant	0.000*	Significant	0.001*	Significant
Poor financial control of the project	0.425	Not Significant	0.093	Not Significant	0.551	Not Significant
Right-of-way issues	0.681	Not Significant	0.162	Not Significant	0.201	Not Significant
Shortage of materials	0.764	Not Significant	0.517	Not Significant	0.498	Not Significant
Slow decision making	0.401	Not Significant	0.005	Not Significant	0.009	Not Significant
Type of project bidding and award (Lowest bidder)	0.920	Not Significant	0.897	Not Significant	0.871	Not Significant
Un availability of utilities at site	0.609	Not Significant	0.082	Not Significant	0.432	Not Significant
Unforeseen site conditions	0.743	Not Significant	0.974	Not Significant	1.000	Not Significant
Weak control of project progress	0.797	Not Significant	0.414	Not Significant	0.416	Not Significant

Although there was a strong agreement among construction stakeholders on Spearman's rank correlation, the Man Whitney U test results generated from SPSS version 20 and described in table 8 above shows that there is no significant difference in perception between client and consultant. However, there are significant differences in perception on five delay causes between client and contractors and four delay causes between consultants and contractors.

3.8.3. The relative importance index (RII) of the delay causes

In construction management research, it is a common practice to prepare questionnaires with likert scale, ask concerned professionals to express their opinion, and rank the responses using the relative importance index method (Holt, 2014). As evidence of this, the relative importance index method has been used in numerous research studies related to construction delay to rank respondents opinion. To cite just a few, Hossain et al. (2019) on construction projects in Kazakhstan, Sanchez et al. (2020) on construction projects in Colombia, Aziz & Abdel-hakam (2016) on construction projects in Egypt, Braimah & Ndekugri (2008) on construction projects in UK, and Wong & Vimonsatit (2012) on construction projects in west Australia used the relative importance index to rank the delay factors. Similarly, in this study, the relative importance index formula described in (1) below have used to identify the impact of the cause for the delays in road construction projects in Addis Ababa City.

$$RII = \frac{1*n_1 + 2*n_2 + 3*n_3 + 4*n_4 + 5*n_5}{K_n * m} --- (2)$$

$$K_n \text{ is the maximum weight given to the likert scales}$$

$$m \text{ is the total number of respondents}$$

$$\text{where } n_1, n_2, n_3, n_4, \& n_5 \text{ are frequencies of respondents}$$

Table9. The relative importance index in each stakeholder point of view, the average relative importance index, and ranks of the delay factors

Delay factors	Client point of view(RII)	Consultants point of view (RII)	Contractors point of view (RII)	Average RII	Rank	Remark
A poor site management and supervision by contractor	0.692	0.671	0.774	0.712	7	
Change in drawing and design	0.605	0.624	0.748	0.659*		Not considered
Delay in progress payment for completed works	0.557	0.588	0.748	0.621*		Not considered
Economic condition	0.497	0.529	0.557	0.528	13	
Fluctuation in price of material	0.622	0.635	0.574	0.610	9	
Inaccurate initial project scope estimate	0.622	0.553	0.739	0.638*		Not considered
Ineffective project planning and scheduling	0.768	0.800	0.826	0.798	3	
Lack of high technology equipment	0.530	0.459	0.513	0.501	15	
Lack of quality materials	0.514	0.494	0.496	0.501	15	
Lack of skilled professionals in the field of construction management in the organization	0.632	0.576	0.617	0.608	10	

Late delivery of materials and equipments	0.773	0.835	0.835	0.814	2	
Late design and design document	0.611	0.541	0.765	0.639*		Not considered
Late in approving and receiving of completed project	0.573	0.553	0.739	0.622*		Not considered
Poor financial control of the project	0.686	0.729	0.748	0.721	6	
Right-of-way issues	0.930	0.941	0.887	0.919	1	
Shortage of materials	0.627	0.647	0.591	0.622	8	
Slow decision making	0.692	0.647	0.835	0.723	5	
Type of project bidding and award (Lowest bidder)	0.546	0.541	0.565	0.551	12	
Un availability of utilities at site	0.562	0.529	0.478	0.523	14	
Unforeseen site conditions	0.562	0.565	0.565	0.564	11	
Weak control of project progress	0.746	0.753	0.722	0.740	4	

The results shown in table 9 above indicate the delay factors with associated relative importance indices. However, the delay factors whose relative importance indices described with asterisks are not considered because the stakeholders' perception was significantly different ($p < 0.05$).

3.8.4. The relative aggregate importance index

The relative aggregate importance index is developed through modification of the relative importance index used by Alaghbari et al. (2017) and the index interval defined by Fashina et al. (2021) as shown below.

$$RII(\%) = \frac{5n_1 + 4n_2 + 3n_3 + 2n_2 + 1n_1}{5(n_5 + n_4 + n_3 + n_2 + n_1)} * 100 - - - (3)$$

Table10. The index intervals defined by Fashina et al. (2021), the average of the index intervals, and the designation of the average intervals

Index intervals defined by Fashina et al. (2021)	Average of the index intervals (IIA)	Designation of the averages
(0.0 - 0.2]	0.1	IIA1
(0.2 - 0.4]	0.3	IIA2
(0.4 - 0.6]	0.5	IIA3
(0.6 - 0.8]	0.7	IIA4
(0.8 - 1]	0.9	IIA5 or $APII_{max}$

In table 10 given above, column 1 indicate the intervals defined by Fashina et al. (2021), column 2 indicate the average of the intervals, column 3 indicate the designation of the average values. Based on the average values of the index intervals defined in table 10, the pattern of the formula used to calculate the relative importance index, and the frequencies of the delay factors classified in each management knowledge area, the relative aggregate importance index (RAII) can be defined as:-

$$\text{RAII} = \frac{\sum_{i=1}^{n} fi * IIAi}{IIAmax \sum_{i=1}^{n} fi} --- 4)$$

Where f_i is the frequency of the delay factors

The results described in table 11 – 13 show the causes of road delays and their relative importance indexes, the management knowledge areas that the delay factors assigned, and the importance index intervals (III) that the relative importance indexes of the delay factors classified in the case of Addis Ababa City, Himachal Pradesh State, and Ghana respectively.

Table11. The delay factors, their relative importance index, their classification into the ten management knowledge areas, and their classification into the index intervals in the case of Addis Ababa City Administration Road projects

		The ten management knowledge areas										**Intervals**				
The delay causes	RII	Integration	Scope	Schedule	Cost	Resource	Quality	Communication	Procurement	Risk	Stakeholders	(0.0 - 0.2]	(0.2 - 0.4]	(0.4 - 0.6]	(0.6 - 0.8]	(0.8 - 1]
A poor site management and supervision by contractor	0.712	*													*	
Economic condition	0.528				*			*						*		
Fluctuation in price of material	0.610				*										*	
Ineffective project planning and scheduling	0.798			*											*	
Lack of high technology equipment	0.501					*								*		
Lack of quality materials	0.501					*								*		
Lack of skilled professionals in the field of construction management in the organization	0.608										*				*	
Late delivery of materials and equipments	0.814			*												*

Poor financial control of the project	0.721				*										*	
Right-of-way issues	0.919	*														*
Shortage of materials	0.622					*									*	
Slow decision making	0.723			*											*	
Type of project bidding and award (Lowest bidder)	0.551								*					*		
Un availability of utilities at site	0.523					*								*		
Unforeseen site conditions	0.564									*				*		
Weak control of project progress	0.740	*													*	

Table12. The delay factors, their relative importance index, their classification into the ten management knowledge areas, and their classification into III in the case of HP State

		The ten management knowledge areas (H.P State)										Intervals				
Delay Causes	RII (S.I)	Integration	Scope	Schedule	Cost	Resource	Quality	Communicatio	Procurement	Risk	Stakeholders	(0.0 - 0.2]	(0.2 - 0.4]	(0.4 - 0.6]	(0.6 - 0.8]	(0.8 - 1]
Design errors	0.7373						*								*	
Inaccurate details in drawings	0.8824						*									*
Change in design	0.8569		*													*
Not following contract conditions	0.652								*						*	
Impractical contract duration	0.6971			*											*	
Inaccurate contract documents	0.6892								*						*	
Financial difficulties	0.7941				*										*	
Delayed payment	0.8284			*												*
Increase in material cost	0.6471				*										*	
Delayed design documents	0.6843			*											*	
Inadequate consultant experience	0.6314										*				*	
Less contractor experience	0.8461										*					*
Management difficulties by contractor	0.8265	*														*
Rework due to wrong work	0.8333						*									*
Insufficient machinery/equipment	0.7961					*									*	
Failure of equipment	0.8069					*										*
Unskilled operator for Machinery	0.6627										*				*	
Delay in transportation construction materials	0.8275			*												*
Reworks because of poor	0.7137						*								*	

materials																
Poor construction materials	0.6804						*								*	
Inaccuracy in soil investigation	0.6647						*								*	
Unpredicted underground condition	0.649									*					*	
Sudden rise in underground water	0.6637									*					*	
Wrong project cost estimate	0.6304				*										*	
Poor project management	0.8167	*														*
Poor contractor staff management	0.7167										*				*	
Problem of occupant land expropriation	0.7461										*				*	
Delayed design documents	0.6137			*											*	
Delay in payment of finished works	0.8603			*												*
Skilled labor	0.5873										*			*		
Deficient laborers	0.7186										*				*	
Less laborers productivity	0.7010										*				*	
Labor disputes	0.7000							*							*	
Physical obstructions during construction	0.5147									*				*		
Rain effect on road activities	0.8255									*						*
Road blockage and traffic at site	0.5029									*				*		
Sudden Changes in government laws	0.5304									*				*		
Getting permissions from government	0.7039							*							*	
Difference between design specification and codes	0.5608						*							*		
Material misuse	0.6382					*									*	

Table13. The delay factors, their relative importance index, their classification into the ten management knowledge areas, and their classification into III in the case of Ghana

		The ten management knowledge areas (Ghana)										Intervals				
Delay Causes	RII (S.I)	Integration	Scope	Schedule	Cost	Resource	Quality	Communicatio	Procurement	Risk	Stakeholders	(0.0 - 0.2]	(0.2 - 0.4]	(0.4 - 0.6]	(0.6 - 0.8]	(0.8 - 1]
Delay in payment by owners (government	0.7789			*											*	
Delay to furnish and deliver the site to the contractor	0.6959			*											*	
Changes of scope by the owner during construction	0.7008		*												*	

Owner interference	0.6390										*				*	
Slow decision making	0.6569			*											*	
Unrealistic contract duration	0.5723			*										*		
Suspension of work	0.5886			*										*		
Mistakes and discrepancies in design documents	0.6358						*								*	
Unclear and inadequate details in drawings	0.6325						*								*	
Delay in approving shop drawings and sample	0.5870			*										*		
Inadequate experience of consultant	0.5528										*			*		
Difficulties in financing project by contractor	0.6780				*										*	
Ineffective planning and scheduling of projects	0.5837			*										*		
Poor site management and supervision	0.6341	*													*	
Delays in sub-contractors work	0.6455			*											*	
Inadequate contractor experience	0.7496										*				*	
Rework due to errors during construction	0.6536						*								*	
Delay in site mobilization	0.6732			*											*	
Delay in the preparation of shop drawings	0.6602			*											*	
Inflexible funding allocation for project items	0.6862				*										*	
Delay in the release of donor funds	0.6406			*											*	
Withdrawal of funding due to noncompliance with requirements	0.5902				*									*		
No objection requirements	0.5707						*							*		

The results given in Table 14 and Figure 3 show the relative aggregate importance indexes of and its percentages of the management knowledge areas in the case of Addis Ababa City, Himachal Pradesh State, and Ghana.

Table14. The computed RAII of the ten management knowledge areas in the case of Ghana Addis Ababa and Himachal Pradesh

	Ghana Road RAII	Addis Ababa Road RAII	Himachal Pradesh Road RAII
Integration	0.778	0.852	1
Scope	0.778	0	1
Schedule	0.700	0.852	0.720
Cost	0.704	0.704	0.778

Resource	0	0.611	0.778
Quality	0.722	0	0.778
Communication	0	0.556	0.778
Procurement	0	0.556	0.778
Risk	0	0.556	0.704
Stakeholders	0.704	0.778	0.646

Fig3. The percentage of the relative aggregate importance indexes of the ten management knowledge areas in the case of Addis Ababa City, Himachal Pradesh, and Ghana road projects

4. Discussion

Management knowledge areas are responsible for the success or failure of construction projects (Chou and Yang, 2012). The main objective of this study was to define the management knowledge areas as factor groups, to set criteria that help to classify the delay factors into related management knowledge areas, to develop a modified model equation that helps to compute the aggregate importance index of each management knowledge area, and to compare the results between Addis Ababa City, Himachal Pradesh State, and Ghana.

First, it was possible to identify the delay causes associated with its relative importance indexes that all the construction stakeholders agreed upon in the case of Addis Ababa City based on the data obtained from sampled respondents and through applying different statistical tests. Subsequently, by thoroughly reviewing previous studies conducted in Himachal Pradesh State and Ghana, the causes of road construction delays were identified with their relative importance indexes. Finally, based on the defined criteria the identified delay factors were classified into the ten management knowledge areas and the aggregate impact of each management knowledge area was computed using the modified equation developed for this study.

The impact of management knowledge areas on road construction delays

i. **In the case of Addis Ababa City road projects**

According to the result shown in Table 11 and Figure 3, the main causes for the delay in Addis Ababa City road construction projects are integration, schedule, and stakeholder management knowledge areas. As can be understood from the results shown in Table 11, the delay causes classified under the integration management knowledge areas are: poor site management by contractor, right-of-way issues, and weak control of project progress. Out of these factors, right-of-way issues and weak control of progress are unique to the location of this study. But, Poor site management and supervision by contractor is reported in the study conducted by Kumaraswamy & Chan (2010) in Hong Kong and Niazai & Gidado (2012) in Qatar. The delay causes classified under schedule management areas are: Ineffective project planning and scheduling, late delivery of materials and equipments, and slow decision making. Out of these factors, in effective project planning and scheduling is also reported in the study conducted by Gündüz et al. (2013) in Turkey and Hossain et al. (2019) in Kazakhstan, late delivery of materials and equipments is also reported in the study conducted by Durdyev et al. (2017) in Cambodia and (Gündüz et al., 2013) in Turkey, and slow decision making is also reported in the study conducted by Seboru (2015) in Kenya, Gündüz et al. (2013) in Turkey, Prasad et al. (2018) in India, and Hossain et al. (2019) in Kazakhstan. The delay causes classified under stakeholder management knowledge is: Lack of skilled professionals in the field of construction management in the contractor organization and this is also reported in the study conducted by Niazai & Gidado (2012) in Afghanistan.

ii. **In the case of Himachal Pradesh State road projects**

According to the result shown in Table 12 and Figure 3, the main causes for the delay in Himachal Pradesh State road construction projects are integration and scope management knowledge areas. As can be understood from the results shown in Table 12, the delay causes classified under the integration management knowledge areas are: Management difficulties by contractor and Poor project management. Out of these factors, Management difficulties by contractor are reported in the study conducted by Kumaraswamy & Chan (2010) in Hong Kong and Niazai & Gidado (2012) in Qatar. The delay cause classified under scope management knowledge area is: Change in design and this factor is also reported in the studies conducted by (Oyegoke and Sabitu (2016) in Oman and Gündüz et al. (2013) in Turkey.

iii. **In the case of Ghanaian road projects**

According to the result shown in Table 13 and Figure 3, the main causes for the delay in Himachal Pradesh State road construction projects are integration, scope, and quality management knowledge areas. As can be understood from the results shown in Table 13, the delay causes classified under the integration management knowledge areas is: Poor site management and supervision and this factor is also reported in the study conducted by Kumaraswamy & Chan (2010) in Hong Kong and Niazai & Gidado (2012) in Afghanistan, the delay cause classified under scope management knowledge area is: Changes of scope by the owner during construction is also reported in the study conducted by Prasad et al. (2018) in India. The delay causes classified under quality management knowledge area are: Mistakes and discrepancies in design documents, unclear and inadequate details in drawings, rework due to errors during construction, and no objection requirements. Out of these factors, Mistakes and discrepancies in design documents is also reported in the study conducted by Rezaei & Jalal (2018) in Iraq, unclear and inadequate details in drawings is also reported in the study conducted by Gardezia et al. (2014) in Pakistan, rework due to errors during construction is also reported in the study conducted by Bajjou & Chafi (2018) in Morocco, and no objection requirements is unique to the study area.

Finally, the output of this study is compared with previous studies conducted by Javed et al. (2015) in Pakistan and Zwikael (2009) in Australia. According to the study conducted by Javed et al. (2015), the management knowledge areas most important for project success are: quality, time, communication, cost, and scope and according to Zwikael (2009), the management knowledge areas most important for project success are: time, risk, scope, and human resource (stakeholder). In this study, the management knowledge areas most important for the failure project success are: integration, schedule, and stakeholder management in the case of Addis Ababa road projects, integration, scope, and communication in the case of Himachal Pradesh State, and integration, scope, and quality management knowledge areas in the case of Ghanaian road projects.

5. Mitigation measures

With regard to **integration management knowledge factor group**, to address right-of-way issues, since the work is being coordinated by a number of government sectors, so it is important to set up a system in which all parties accountable for their actions, appropriate cost estimation should be done to execute compensation payment, and awareness should be created on evacuees . To address poor site management and supervision, an independent professional should be assigned in the field and contractors need to be free from traditional practices. To address weak control of project progress, contractors should use appropriate technology to control the physical, financial, and quality progress. And if appropriate technology is not available, the problem should be addressed through the use of traditional practices in an organized manner.

With regard to **schedule management factor group**, to address late delivery of materials and equipments and slow decision making, contractors should impose realistic time to deliver materials and equipments on time and to make timely decision makings. To address inappropriate scheduling and planning, a series of training in relation to schedule management should be provided for the professionals who participate in the scheduling process.

With regard to **scope management factor group**, to address changes in design and change of scope by the owner during construction stage, it is necessary to complete the design and documentation work that is accurate and certain before construction work begins.

With regard to **quality management knowledge factor group**, to address unclear and inadequate detail drawings, rework due to error during construction, and no objection requirements, it is necessary to establish quality assurance check list system, to follow proper construction steps and methods, and to set objection requirements.

6. Conclusion

This study was conducted to identify the management knowledge areas significantly contributed to the delay of road projects in Addis Ababa City and compared with Himachal Pradesh State and Ghana. The survey was based on the delay factors identified from the results of studies of other countries and the study area (country) and the analysis performed through multiple decision making steps. The Spearman's rank correlation indicated a strong agreement between stakeholders and the Man Whitney U test helped to identify the perception of stakeholders in each delay causes. The management knowledge areas contributed significantly to the duration of the road projects ranked using the relative aggregate importance index methods developed for this study. The results showed that in the case of Addis Ababa City road projects the aggregate importance index of integration management knowledge area is (RAII = 0.852), schedule management knowledge area is (RAII = 0.852), and stakeholder management knowledge area is (RAII = 0.778). In the case of Himachal Pradesh State, the relative aggregate importance index of integration management knowledge area is (RAII = 1) and scope management knowledge area is (RAII = 1). In the case of Ghana, the relative aggregate importance index of integration management knowledge area is (RAII = 0.778), scope management knowledge area is (RAII = 0.778), and quality management knowledge area is (RAII = 0.722).

This study is limited to the identification of the management knowledge areas that contributed significantly to the delay in road construction in Addis Ababa City, Himachal Pradesh State, and Ghana. It is important to conduct study on civil structures different from road using the concept employed in this study.

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