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A Study on Mitigating the Communication and Coordination Challenges During Requirements Change Management in Global Software Development

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ABSTRACT Global Software Development (GSD) is widely used by software development organizations to ensure the development of a cost-effective software product. GSD has now become a common engineering practice adopted by a significant number of multinational software development organizations, and even individuals (freelancers) are seeking numerous benefits including low development cost, highly skilled workers, and access to better development ideas. However, communication and coordination challenges remain a prominent research issue in the GSD context, while performing different project-related activities especially for Requirements Change Management (RCM). As a result, improper communication and coordination during RCM require additional time, cost, and development resources. Thus, it is of vital importance to ensure proper communication and coordination before initiating a software project. Inspired by this, current work aims at exploring and mitigating the communication and coordination challenges during RCM in the GSD context. To accomplish the targeted research objective, we performed a tertiary study to provide a landscape of the challenges that occurred during RCM in the context of GSD. Based on the performed study, we found 62 communication and 14 coordination challenges. In total, 107 mitigation strategies are explored and reported that effectively address the categorized sub-challenges of communication and coordination. Moreover, we proposed a conceptual model useful to address the communication and coordination challenges for the RCM process in GSD. Furthermore, we consulted the domain experts for the validation of the proposed conceptual model. Based on the promising results, we believe that this work supports the project managers in managing the cost and time-related issues in the GSD context. Consequently, the proposed conceptual model would help in optimally utilizing the scarce software development resources.

INDEX TERMS Global software development, requirements change management, communication and coordination challenges, mitigation strategy, tertiary study.

I. INTRODUCTION

Global Software Development (GSD) is regarded as a common engineering practice to develop a cost-effective software product. This is due to the fact that GSD offers several benefits to the software development organizations including access to the new markets and technologies, skilled software developers, better relationships with the development organizations (and individuals), low software development cost, and access to the large and diverse human resources [1]–[3].

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Moreover, GSD provides a significant reduction in the development time; thereby, attracting the software development organizations to outsource a software product [4]. Similarly, some other key benefits of GSD are presented in Figure 1 [5].

Note that many Eastern European and Asian countries (i.e. India, China, and Pakistan) are actively contributing to the GSD domain [6], [7]. However, software development organizations have to face several challenges, including temporal distance, geographical distance, and socio-cultural differences, while working in the GSD environment [8]–[12]. To effectively handle the above-mentioned challenges, it is required to maintain a proper coordination mechanism for

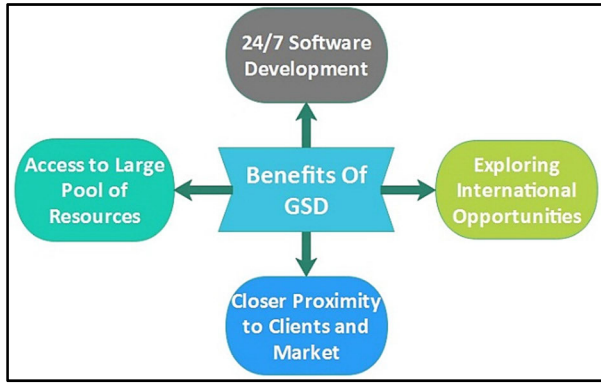


FIGURE 1. Key benefits of GSD.

sharing the knowledge at multiple geographically distributed software development locations [13]–[15].

In contrast, software requirement changes are inevitable. The main reasons for requirement’s evolutions are (i) modification in the current software products, (ii) emergence of new technologies, (iii) eliminating the duplicate requirements, (iv) gaining the competitive edge in the markets, and (v) handling the user’s expectations [16]–[18]. Consequently, Requirements Change Management (RCM) becomes a challenging and resource-consuming activity, especially when requested multiple times in the context of GSD [19]. Additionally, due to the massive number of requirements’ changes, the development organizations conduct the RCM process in an imprecise manner; thereby, significantly increasing the required amount of development cost, time, and human effort [20]–[22]. On the other hand, poor communication and coordination among the stakeholders can

negatively impact the RCM process in GSD [23], [24]. Note that poor communication mainly occurs because of inefficient knowledge sharing, geographical distance, socio-cultural differences, and temporal distances [22], [25]–[28]. As a result, development organizations need to properly manage the communication, coordination, and controlling mechanisms during the RCM process.

In other words, it is required that different stakeholders at multiple sites must be updated with timely feedback [26]. To perform an effective RCM process, the development organization needs to adopt a robust RCM model supporting the communication and coordination challenges [19], [27], [29]. Note that the need for effectively managing the communication and coordination issues significantly increases especially in the context of GSD [30]–[35]. Figure 2 provides an overview of the RCM process performed in the GSD context.

Suppose, the client initiates a requirement change request to a project manager at location 1 (Figure 2). Next, the requirement change request is transferred to the Change Control Board (CCB) for its approval or rejection. In the case of rejection, no change is further transferred. In contrast, if the requirements change request is approved, the new requirements are then transferred to the corresponding multiple software development locations (i.e. locations 2, 3, 4, and 5 in this scenario) for implementation purposes (Figure 2).

This research aims at achieving the following research objectives:

- RO1:** To identify the communication and coordination challenges during RCM in GSD.
- RO2:** To explore the mitigation practices to reduce the identified communication and coordination challenges.

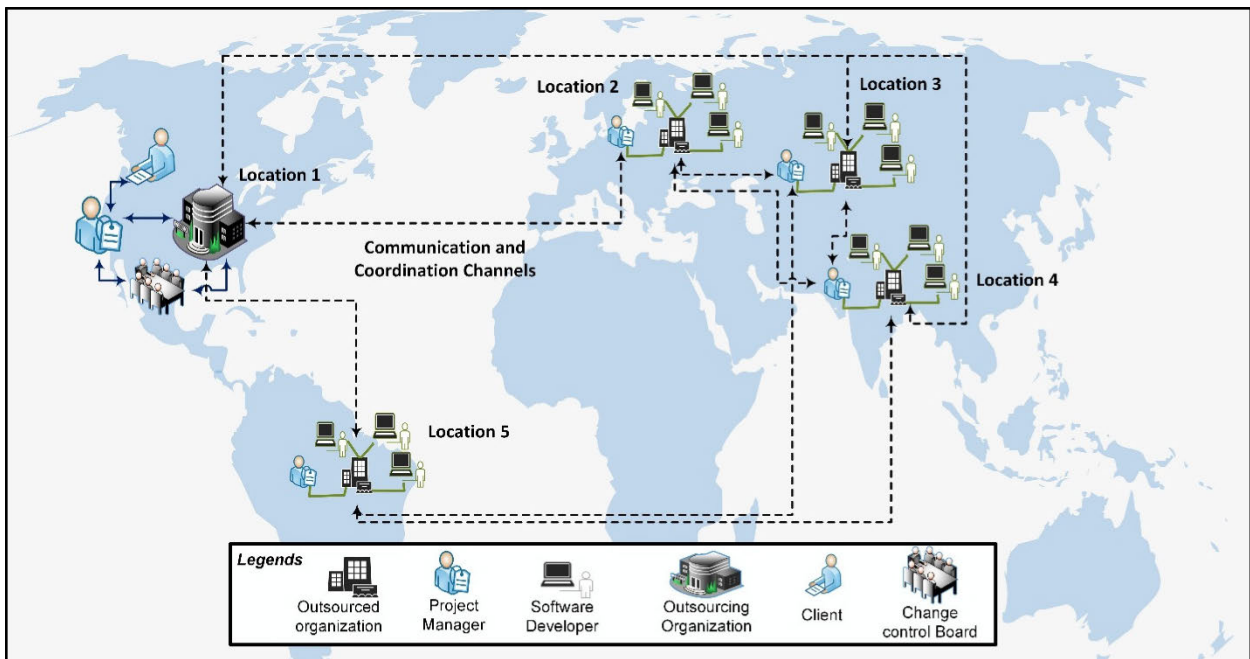


FIGURE 2. High-level view of RCM process in GSD.

RO2.1: To provide a mapping between the mitigation practices and the corresponding communication and coordination challenges.

RO3: To propose a conceptual model to effectively handle the communication and coordination challenges during RCM in the GSD context.

The remaining sections of this paper are organized as follows: Section II provides the research motivation, while Section III discusses the related work. In contrast, Section IV provides details about the adapted research methodology. Moreover, Section V describes the results and findings, while the proposed conceptual model is presented in Section VI. Furthermore, Section VII provides the validity threats, and research implications are outlined in Section VIII. Finally, Section IX presents the conclusion and future work.

II. RESEARCH MOTIVATION

As previously discussed, communication, coordination, and control are essential components in RCM and implementation process, especially when outsourcing a software product [36]–[38]. Thus, it is of vital importance to select the most viable methods, tools, and technology to effectively implement the RCM process in GSD [30]–[32], [39], [40].

In the literature, several challenges related to communication and coordination in GSD context have been reported in the studies [15], [26], [30]–[32], [36], [37], [40]. However, these studies lack in providing a comprehensive set of communication and coordination challenges during the RCM process. Furthermore, few studies [31], [36] focused on discussing the generic communication challenges only and the respective mitigation practices. However, the reported studies lack in addressing the coordination challenges. In contrast, some studies [41], [42] highlighted the coordination challenges; but overlooked the communication challenges during RCM in GSD.

To the best of our knowledge, no reported study has provided a comprehensive set of communication and coordination challenges as well as the corresponding mitigation strategy during RCM in GSD. Motivated by this, the current study focused on collectively addressing the communication and coordination challenges. Moreover, we categorized the existing communication challenges into different classes. Furthermore, we identified the best mitigation practices and mapped to each of the corresponding communication and coordination challenges. Finally, we proposed a conceptual model useful to mitigate the communication and coordination challenges during RCM in the GSD context.

III. RELATED WORK

This section provides the related work to the targeted research context. Demirel *et al.* [18] highlighted multiple challenges that negatively impact the effective requirements collection and management process. There were multiple challenges highlighted that are associated with the software requirements including (i) Ambiguous requirements, (ii) Poor requirements

definition, (iii) Requirements prioritization, (iv) Requirements changes, (v) Requirements traceability, (vi) Technical solutions, (vii) Requirements verification and validation, and (viii) Project management.

Kamal *et al.* [43] reported 21 success factors in agile RCM in GSD. The authors reported that human resource management is an important factor that affects communication and coordination in GSD. In contrast, Nicolás *et al.* [44] identified 25 challenges faced during requirement engineering in GSD. The authors presented the mitigation practices to avoid the explored challenges. However, they lack in focusing on the coordination challenges.

Khan [35] identified three major challenges including geographical, socioeconomic, and temporal distance. Moreover, the author also reported the relevant sub-challenges. However, their proposed framework lacks in fully supporting the coordination challenges.

Umair *et al.* [45] reported the generic barriers that occur during RCM in GSD. The authors highlighted the most commonly observed RCM challenges. However, they lack in devising a framework useful to handle the challenges mentioned in the RCM process.

Akbar *et al.* [46] mentioned ten commonly faced challenges during the RCM process in GSD. Moreover, the authors proposed a model called as Software Requirements Change Management and Implementation Maturity Model (SRCMIMM). However, their study lacks in providing communication and coordination challenges.

Anwer *et al.* [47] identified the in-house development and offshore development challenges during RCM. They further differentiated the challenges based on their impact on the project development and categorized them using the T-test, Chi-square test, and regression analysis. However, the authors identified the generic challenges faced during RCM in GSD. Additionally, they lack in proposing any framework, which is beneficial in handling the mentioned challenges.

Bhatti and Ahsan [48] identified 29 communication challenges, and further categorized them into five major categories: (i) appropriate tools and technology, (ii) availability of the required information, (iii) the commitment of stakeholders, (iv) the correlation among the stakeholders, and (v) cultural impact.

Akbar *et al.* [49] identified the key factors that negatively impact the RCM process in GSD. The authors also proposed a framework capable of assigning the weights to the identified factors grounded on their impact on the targeted project. However, the proposed framework lack in specifically addressing the coordination challenges during RCM in GSD.

Akbar *et al.* [50] identified 30 most commonly faced challenges, where 11 challenges are related to the communication and coordination categories. The authors subdivided the identified challenges into six major sub-categories. However, they lack in providing the mitigation strategies for the identified challenges.

Akbar [51] highlighted 23 most important success factors for the RCM process in GSD. The proposed framework consists of six different categories to support the implementation of the RCM process. The study mainly focused on the RCM process. But, it lacks in addressing all of the communication and coordination challenges during RCM in the GSD context.

Later, Akbar *et al.* [52] reported 25 major organizational challenges. The authors presented a framework with the underlying objective of effectively handling the organizational challenges. However, the proposed framework lacks in handling the communication and coordination challenges.

Khan and Khan [53] identified and categorized various communication and coordination challenges in offshore software development. The authors proposed a framework to understand the initial requirements related to a project using a semiformal UML diagram. However, their study only focused on addressing the generic challenges in GSD rather than addressing the communication and coordination challenges in the targeted research context.

Nurdiani *et al.* [54] identified 48 major challenges and categorized them into three major groups: (i) communication, (ii) coordination, and (iii) control. The authors also reported 42 best mitigation practices to mitigate the communication, coordination, and control challenges. However, their work lacks in covering remaining communication and coordination challenges especially during RCM in the GSD context.

Babar and Lescher [55] reported major categories of GSD challenges including geographical sites, target or context systems for requirements, IT organization infrastructure, and employees with different skill sets, languages, and domain experience. Furthermore, the authors mentioned the 10 best practices to handle the communication challenges in GSD projects.

Shameem *et al.* [56] reported 11 major human-based challenges that negatively impact the RCM process in the GSD environment. Although, the authors proposed a hypothetical model to show the negative impact of human-dependent issues or challenges while managing the requirements change process. However, their proposed model lacks in handling the communication and coordination challenges in the context of GSD.

From the discussed related work, it can be concluded that the current state-of-the-art lacks in reporting an extensive set of communication and coordination challenges during RCM in GSD. Moreover, the reported work lacks in proposing a conceptual model that suggested the most suitable mitigation practices against the communication and coordination challenges.

IV. RESEARCH METHODOLOGY

To extensively investigate the communication and coordination challenges, we performed a tertiary study. As a result, it helps in providing a landscape of the mentioned

communication and coordination challenges along with the best mitigation strategies during RCM in the GSD context.

Figure 3 describes the adopted research methodology.

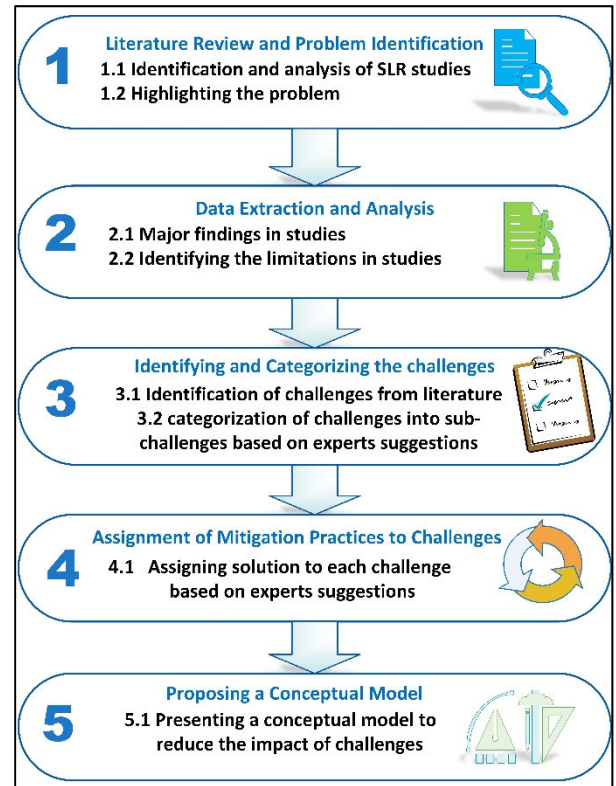


FIGURE 3. The adopted research methodology.

The methodology contains five main steps (Figure 3). In step 1, the relevant SLR and mapping studies were identified, analyzed, and the problem statement was formulated. Next, in step 2, the data was extracted from the selected studies focusing on the targeted research objectives along with their limitations. Note that the search flow of the selected studies is described in Figure 5, while Figure 6 represents the PRISMA flow diagram about the selection of final studies.

In step 3, the communication and coordination challenges were identified and categorized into major classes as sub-challenges. Then, in step 4, the mitigation practices were assigned to the found challenges based on the expert's feedback and suggestions. To achieve this, we conducted three meetings with the participating experts (Table 1). In total, 18 person-hours were taken to collect and analyze the expert's feedback. Finally, in step 5, a conceptual model was proposed to mitigate communication and coordination challenges during RCM in GSD (Figure 9). In addition, we followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [57], [58] to conduct the literature review process.

Table 1 represents the summarized information regarding the domain experts. Note that two experts have participated from Pakistan, while one Malaysian domain expert was consulted.

TABLE 1. The details about the consulted domain experts.

No.	Country	Software Development Experience	Working Experience in the GSD Context
1	Pakistan	14 Years	10 Years
2	Pakistan	5 Years	2 Years
3	Malaysia	4 Years	3 Years

Figure 4 depicts the main phases of the performed tertiary study. It includes three main phases: (i) planning the review, (ii) conducting the review, and (iii) reporting the review results.

**FIGURE 4.** The main phases of the conducted tertiary study.

A. PLANNING THE TERTIARY STUDY

The planning phase is the first and critical phase of a tertiary study, which helps in deciding about different review-related steps. The main phases are: (i) research questions, (ii) search strategy, (iii) data repositories, (iv) search string, (v) quality assessment criteria, (vi) inclusion criteria, (vii) exclusion criteria, and (viii) data extraction from the selected studies. The following sections provide the details regarding the main steps of the planning phase of the conducted study.

1) RESEARCH QUESTIONS (RQs)

This section formulates the research questions. Based on the targeted research objective(s), we have devised the following Research Questions (RQs):

RQ1: What are the communication challenges reported in the previously conducted SLR studies?

RQ1.1: What are the major categories of communication challenges faced during the RCM process in the GSD context?

RQ1.2: What are the best possible mitigation practices for the identified communication challenges?

RQ2: What are the coordination challenges mentioned in the existing SLR studies?

RQ2.1: What are the best possible mitigation practices for coordination challenges?

B. SEARCH STRATEGY

To find the most relevant studies, we followed a search methodology containing four main steps described as follows:

- (i) First of all, the main search terms (keywords) were identified from the targeted problem domain including research objectives and questions.
- (ii) Next, we identified the alternative words (i.e. synonymous) to the search terms to further enhance the relevant studies selection process.
- (iii) After that, we integrated the search words using the Boolean operators (i.e. OR, AND) to complete the search string.
- (iv) Finally, we customized the search string according to the searching criteria of the selected data repositories to find the potential studies.

1) SELECTED DATA REPOSITORIES

In this work, we used the following four online data repositories to find the potential SLR studies:

- (i) IEEE Xplore
- (ii) ACM
- (iii) Wiley Online
- (iv) Science Direct

2) SEARCH STRING

Based on the above-mentioned search strategy, we formulated the following search string:

((“Communication” OR “Coordination”) AND (“Issues” OR “Challenges” OR “Barriers” OR “Problems” OR “Risks”) AND (“Solutions” OR “Mitigation Practices” OR “Improvements” OR “Mitigation Strategies” OR “Enhancement”) IN (“Requirement Change Management” OR “RCM” OR “Requirements Changes” OR “Requirements Modification”) AND (“Global Software Development” OR “GSD” OR “Distributed Software Development” OR “DSD”))

Note that the devised search string was manually tailored and applied to the selected online data repositories to find the potential SLR studies. After executing the search query, we found 1,173 potential studies. Furthermore, Figure 5 presents the flow diagram about the identification and selection of relevant studies based on the executed search query.

3) QUALITY ASSESSMENT CRITERIA

This section discusses the devised Quality Assessment Criteria (QAC) that helped in finally selecting from the potential SLR studies. Table 2 represents the devised QAC questions.

TABLE 2. The formulated quality assessment criteria.

QAC#	Questions	Score
QAC1	Does the selected study focus on the communication and coordination challenges or issues faced during the RCM stage?	“Yes=1, Partially=0.5, No=0”
QAC2	Does the selected study present any framework or model to overcome the communication and coordination challenges during RCM in GSD?	“Yes=1, Partially=0.5, No=0”
QAC3	Does the selected study focus on the GSD or distributed development context?	“Yes=1, Partially=0.5, No=0”

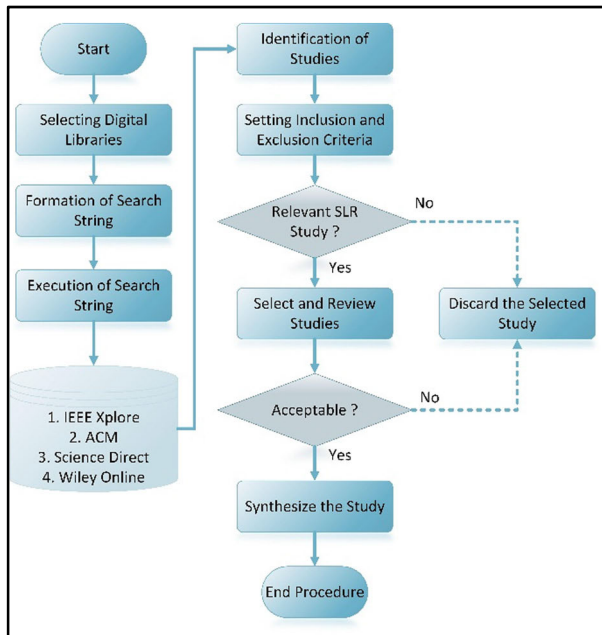


FIGURE 5. Search flow for the selection of SLR studies.

Note that the selected SLR studies were assessed grounded on the following weightage according to their relevancy as: “Yes=1”, “Partially=0.5”, or “No=0”.

4) INCLUSION CRITERIA

The inclusion criteria for the selection of potential SLR studies are mentioned as follows:

- IC1: The study must be written in the English language.
- IC2: The study must be published in a conference or journal paper or a technical report.
- IC3: The study must be relevant to the GSD domain.
- IC4: The study must be a mapping study or SLR study related to RCM challenges in the GSD context.
- IC5: The study must be published between the years 2009 to 2021.
- IC6: The study must be focusing mainly on the challenges, findings, and outcomes during RCM in GSD.

5) EXCLUSION CRITERIA

Similarly, we defined the following exclusion criteria to exclude the irrelevant studies:

- EC1: The studies that lack in focusing on the challenges during the RCM in GSD were excluded.
- EC2: The general literature surveys since they lack in describing any systematic research methodology.
- EC3: The studies published before the year 2009.
- EC4: The grey literature, including personal experiences of the researchers, blogs, websites, and videos, were excluded.
- EC5: The short papers were excluded since they lack in providing the details about the obtained results.
- EC6: The studies that only discussed the process of conducting a systematic review, tertiary study, or mapping study were excluded.

6) DATA EXTRACTION

In this step of the planning phase, the required data is extracted from the selected SLR studies for the devised RQs. The following data was extracted from every selected SLR studies:

- Title of paper.
- Type of study, which includes SLR study, mapping study, generic information, and metadata analysis.
- The main topic of the conducted research.
- The number of primary studies included in the selected study.
- Findings on the communication and coordination challenges or solutions.

C. CONDUCTING THE REVIEW

This section discusses the second phase of the conducted tertiary study (i.e. conducting the review) that focused on performing the review based on the steps as described in the planning phase (Figure 4). This phase includes three main steps: (i) execution, (ii) study selection, and (iii) data synthesis. The subsequent sections provide the details regarding the core steps of conducting the review phase.

1) EXECUTION PHASE

This section provides the execution process of the devised search string. As previously discussed in the *planning* phase, the main search string is tailored according to the selected data repositories to find the most relevant studies. In this work, we considered several well-known data repositories including ACM, IEEE Xplore, Wiley Online, and Science Direct. Next, the search string was executed on the selected data repositories.

Table 3 represents the number of initially selected SLR studies. For example, 129 SLR studies were initially selected from IEEE Xplore (Table 3).

Figure 6 presents the PRISMA flow diagram where 1,173 multiple studies were identified from the literature.

TABLE 3. Data repositories with corresponding number of selected studies.

Data Repository	Initial Studies	Final Stage
IEEE Xplore	129	24
ACM	941	5
Science Direct	15	6
Wiley Online	21	4
Total	1106	39
Final selected studies	---	27

The identified studies were filtered in multiple phases to identify the most relevant SLR studies from the literature. The guidelines that were followed for the PRISMA methodology are mentioned in the study [57], [59]. Furthermore, Figure 6 represents the number of identified studies and statistics of the number of included and excluded research articles. Based on the adapted PRISMA guidelines and steps, the final SLR studies were selected. The following steps were performed based on the followed PRISMA guidelines:

- (i) After the execution of the search query, 129 studies were discovered in IEEE Xplore, 941 studies in ACM, 15 studies in Science direct, and 21 studies in Wiley online.
- (ii) After the removal of duplicate studies, 1106 studies were selected.
- (iii) Based on the screening of publication year (2009-2021), 836 studies were selected.
- (iv) Based on the full-text analysis, 257 studies were discovered.
- (v) Based on relevancy to RCM and GSD context, 39 studies were discovered.
- (vi) In the final step, 27 studies were selected and synthesized from the conducted literature review in this work.

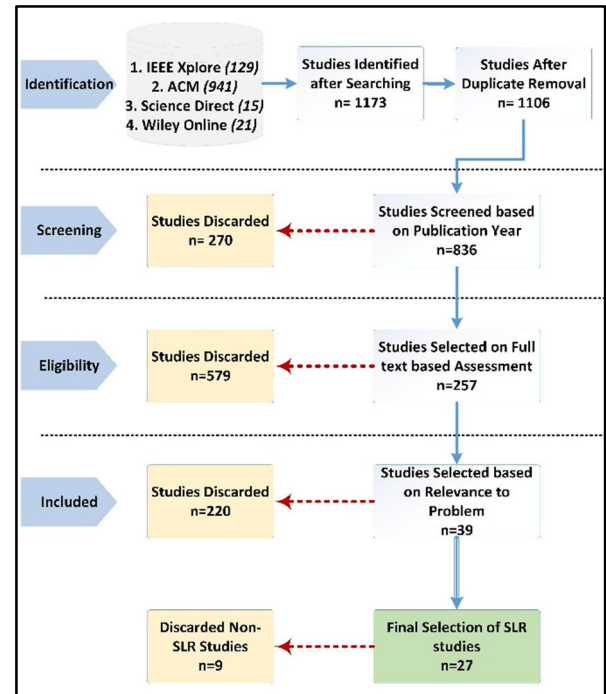
2) STUDIES SELECTION

In this phase, first of all, we manually removed the duplicate studies found from the considered data repositories. Note that a study is regarded as a duplicate study if it is published in at least two data repositories. As a result, we found 1,106 studies for further data analysis (Table 3). Next, the inclusion and exclusion criteria were performed on the identified studies. Note that some of the initially selected studies were neither a systematic review or nor a mapping study. After that, we performed a detailed review process for selecting the final studies. For this purpose, we analyzed the study's titles, abstracts, introduction, conclusion, and results. Finally, we selected 27 studies (Table 3).

Note that the selected studies are mainly the SLRs performed in the targeted research context. As a result, it would help in providing the landscape of the RCM process in the GSD context.

3) DATA SYNTHESIS

To extract the data from the selected studies, we designed a CSV file. Moreover, a pre-designed Word form was used to

**FIGURE 6.** PRISMA flow diagram for the selection of final studies.

record the data about the targeted communication and coordination challenges, mitigation practices, and support level. Moreover, it shows the number of studies, which highlight a specific challenge and mitigation practice(s) in the targeted research context. After a detailed analysis of the 27 SLR studies, the following information was extracted and synthesized:

- The publication year of a study.
- The research methodology used by the author(s).
- The RCM challenges and issues faced during the off-shore software development.
- The reported mitigation practice(s) to handle the communication and coordination challenges during RCM in the GSD context.
- The limitations in the reported conceptual framework or conceptual model.

D. REPORTING THE REVIEW

This section presents the selected SLR studies, which were evaluated against the formulated quality assessment criteria. Appendix A (Table 13) represents the information regarding the selected SLR studies. It includes the information attributes for each of the selected study including publication year, the number of primary studies, quality assessment score, thematic analysis, brief information, and the main limitations in the existing literature.

1) QUALITY ATTRIBUTES

We assessed the quality of each of the selected SLR studies based on the quality assurance criteria defined in Table 3. Note that we used weightage criteria (containing three values)

to select the potential studies. Appendix A (Table 13) shows the attained quality assessment criteria-based score of the selected SLR studies.

2) TEMPORAL DISTRIBUTION OF THE SELECTED STUDIES

Figure 7 shows the temporal distribution of the selected studies. It can be observed (from Figure 7) that relevant studies have been published during two time periods: (i) from the years 2009 to 2015, and (ii) from the years 2017 to 2021. Noticeably, the majority of selected studies were published in the year 2019 (i.e. eight SLR studies). However, no SLR study was published in the year 2016. In study S2 (Table 13), the authors defined six major categories and classified the reported challenges into sub-categories. Also, they mapped the most suitable solution(s) to the corresponding communication and/or coordination challenge. Moreover, the other selected SLR studies have discussed geographical, temporal, and cultural challenges. Additionally, the selected studies also mentioned the respective best possible mitigation practices for each of the above-mentioned challenges.

Tables 4 to 12 represent various communication challenges (i.e. geographical distance, temporal distance, socio-cultural distance, tools and technology differences, improper team formation, client-related challenges, software development organization and architecture, and miscellaneous challenges) and coordination challenge, and their corresponding most suitable mitigation practices. From the targeted research viewpoint, we have reported the mitigation practices useful to resolve the communication and coordination challenges during RCM in the GSD context. For this purpose, we consulted and discussed with the three-domain experts. The main underlying objective was to assign the best mitigation practice to each of the identified communication and coordination sub-challenges. Furthermore, we discussed the assigned practices to a specific sub-challenge in SREG (Software Reliability Engineering Group) at CUI to enhance the validity of each mitigation practice assigned to the relevant challenge (mentioned in Tables 4 to 12).

V. RESULTS AND FINDINGS

This section presents the key results and findings regarding the devised research questions. Appendix A (Table 13) provides the information about the selected SLR studies. Among the 27 selected SLR studies, 19 studies were published in peer-reviewed journals, while 8 studies were published in different conferences. From the comprehensive analysis of the selected studies, it is revealed that no study had explicitly mentioned the existing communication and coordination challenges, which occurred during RCM in the GSD context. Although, only one study, S23 (Table 13) focused on generic communication and coordination challenges. However, it lacks in mentioning the coordination issues. Based on the detailed analysis of the selected studies, there is a demand for an effective and robust conceptual model effective to handle the communication and coordination challenges.

RQ1 (What Are the Communication Challenges Reported in the Previously Conducted SLR Studies?): From the conducted tertiary study, we identified possible communication-related challenges faced by a project manager during RCM in the GSD context. The communication challenges are further categorized into sub-challenges based on the relevant type of challenge. The frequency analysis of each challenge and the relevant mitigation strategy represents the number of analyzed SLR studies that focused on a single communication and coordination challenge. Finally, the importance of each challenge is calculated in terms of the percentage from 27 selected SLR studies.

RQ1.1 (What Are the Major Categories of Communication Challenges Faced During the RCM Process in the GSD Context?): In study S13 (Appendix A), seven major categories of communication challenges were mentioned. However, the mentioned challenges lack in mapping the corresponding mitigation practices and a conceptual model. Furthermore, based on the expert’s feedback and reviews, we categorized the major communication challenges into different sub-challenges. Moreover, we have conducted an SREG meeting to gather more reviews/feedback about the categorization of sub-challenges from the senior members.

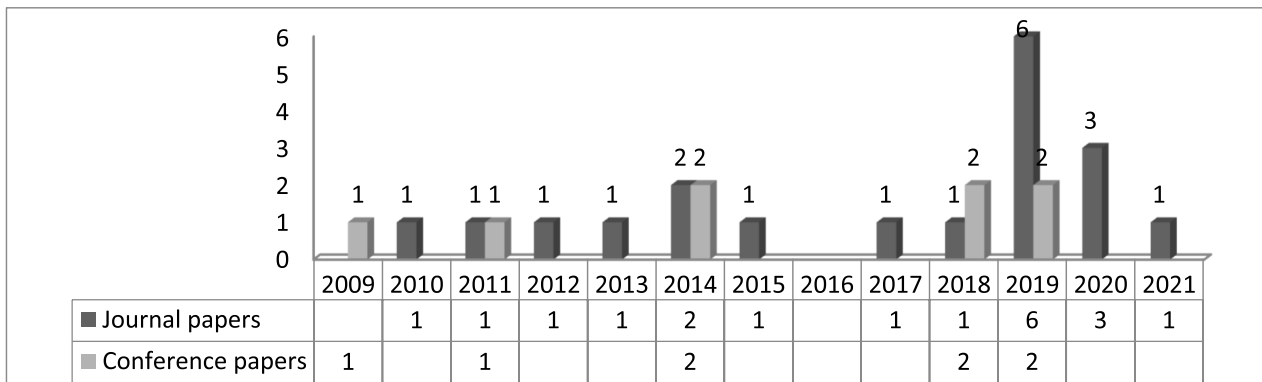


FIGURE 7. Temporal distribution of the selected studies.

Finally, we identified eight major categories of communication challenges. Table 11 represents some miscellaneous challenges that are frequently faced during the RCM process in the context of GSD.

RQ1.2 (What Are the Best Possible Mitigation Practices for the Identified Communication Challenges?): Tables 4 to 11 presents various communication challenges, sub-challenges, and the corresponding most suitable mitigation practices identified from the conducted study. Moreover, the

importance of the sub-challenges and the corresponding mitigation practices is highlighted by performing the frequency analysis of the selected SLR studies. Note that the support level represents the level of occurrences of possible challenges and the relevant solution for the selected studies. Based on the expert’s feedback and suggestions, the best mitigation practices effective in handling the communication challenges were assigned to each sub-challenge (Tables 4 to 11). In this work, we identified multiple mitigation practices for each

TABLE 4. Geographical distance-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	Inadequate face-to-face meetings	S2, S4, S5, S8, S9, S11, S13, S16, S20 S21, S24	40.74%	-Establish a timely face-to-face meeting culture	S2, S9, S18, S20, S24	18.51%
				-Define new communication channels for the meetings	S2, S7, S9, S14, S24	18.51%
2	Trust Issues among the team members	S2, S5, S9 S11, S13, S15, S16, S17, S18, S20, S21, S22, S24	62.96%	-Enhance the knowledge sharing	S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26	44.44%
				-Enhance the team communication	S2, S9, S12, S14, S15 S18, S24, S26	29.62%
				-Visit the remote sites	S1, S9, S18, S24, S25	18.51%
				-Make work progress visible to all stakeholders	S2, S3, S9, S13, S14, S15, S16, S25	25.92%
3	Inadequate use of informal communication	S2, S5, S8. S9, S12, S13, S18, S23, S22, S24	37.03%	-Tight coupling of stakeholders	S2, S9, S14, S18, S24	3.70%
				-Establish initial rules for communication	S2, S9, S14, S18, S24	18.51%
4	Inadequate transfer of information	S2, S4, S5, S8 S9, S10, S12, S13, S21, S18, S20, S23, S22, S24	51.85%	-Build trust by proper team introduction	S2, S9, S18, S24	14.81%
				-Encourage informal communication with good trust	S1, S9, S14, S18, S24	18.51%
				-Establish communication rules	S1, S2, S9, S18, S24	18.51%
5	The extra cost of resources needed for meetings	S8, S17, S13, S24	14.81%	-Define communication protocols for every workgroup	S1, S2, S14, S24	14.81%
				-Transfer the proper and best information	S1, S9, S12, S14, S18, S20, S24	25.92%
				-Use formal means of communication for data sharing	S11, S12, S14, S18, S24	18.51%
6	Lack of relationship among group personnel	S2, S4, S5, S9, S13, S18, S19, S20, S22, S24	37.03%	-Use available common communication tools	S1, S2, S9, S11, S14, S18, S24, S25	29.62%
				-Conduct more informal meetings	S1, S2, S9, S18, S24, S1, S2, S9, S12, S20, S24, S26	18.51%
7	The need additional cost of communication resources	S2, S7, S8, S13, S23	18.51%	-More knowledge sharing during formal meetings	S14, S18, S19	11.11%
				-Use collaboration models	S1, S2, S9, S24	14.81%
				-Ensure best Informal communication among team members	S1, S14, S24	11.11%
				-Ensure in-time response between team members	S25	3.70%
8	Project management issues	S2, S5, S7, S8, S9, S11, S12, S18, S21, S22, S24, S27	44.44%	-Tight coupling of stakeholders	S2, S9, S14, S18, S25	18.51%
				-Use commonly available communication tools	S11, S18, S24	11.11%
				-Online project management tools	S11, S18	7.40%
9	Missing organized groups	S9, S18, S20, S22, S23	18.51%	-Use groupware, email, wiki, blogs	S1, S9, S14, S7, S11, S18, S25	11.11%
				-Employ online project management tools	S24	3.70%
10	Ambiguity in task/ process	S9, S17, S18, S20, S22, S23, S24	25.92%	-Temporarily organize teams at one place during a critical phase	S2, S9, S11, S12, S14, S20, S24	25.92%
				-Informal communication	S2, S9, S11, S24	14.81%
				-Informal/ formal meetings	S1, S12, S18	11.11%
				-Use process improvement leadership		

sub-challenge. Consequently, it helped in reducing the impact of each of the identified sub-challenge of the *communication challenges* category.

From Table 4, it is can be observed that *trust issues* are highly caused by geographical distance. This is due to the observation that the majority of selected studies (62.96%) highlight this sub-challenge of graphical distance. To handle this sub-challenge, the majority of the studies (44.44%) suggested *knowledge sharing* as a key mitigation practice. In contrast, *inadequate transfer of information* is found to be the second major sub-challenge (51.85%) of geographical

distance (Table 4). Hence, reducing the geographical distance-related sub-challenges can play a major role in trust-building and transferring up-to-date information to all of the stakeholders located at multiple geographical locations.

From Table 5, it is found that the *diversity in time zones* of globally dispersed countries caused challenges related to communication among different development team members at different locations. Interestingly, 44.44% of studies highlighted that the *diversity in time zones* and *time-delayed responses* are the main sub-challenges of temporal distance challenge. Furthermore, it is observed that *lack of proper*

TABLE 5. Temporal distance based-sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	Diversity in time zones of countries	S2, S5, S9, S11, S13, S15, S16, S17, S18, S21, S22, S24	44.44%	-Use reliable communication channels -Involve the communication manager	S1, S2, S12, S24 S2, S9, S11, S14, S18, S24	14.81% 22.22%
2	Poor synchronous communication	S2, S7, S9, S11, S13, S16, S18, S20, S21, S22, S24	40.74%	-Use the communication tools supporting a collaborative work environment -More face-to-face meetings -Increased use of synchronous and asynchronous communication tools -Allocate time slots to the teams	S2, S9, S14, S2, S2, S7, S9, S11, S12, S18, S24, S25 S25	14.81% 29.62% 3.70%
3	Time delay in the responses	S2, S5, S7, S9, S11, S13, S16, S18, S20, S22, S23, S24	44.44%	-Use communication models -Predefined communication protocols -Use best communication tools and methods/ techniques -Use overnight task allocation	S1, S2, S9, S24 S1, S2, S12, S18, S24 S7, S9, S12, S18, S20, S24, S25 S25	14.81% 18.51% 25.92% 3.70%
4	Improper communication tool's selection	S2, S5, S9, S13, S18, S22, S24, S27	25.92%	-Use commonly used communication tools that support communication and coordination in a distributed environment -Use tools that support iterative planning of work	S2, S9, S18, S24, S25 S2	18.51% 3.70%
5	Time overlapping	S2, S4, S9, S13, S15, S22, S24	25.92%	-Use the communication managers -Appoint liaison or some steering group between distributed teams -Increased number of overlapping hours	S2, S9, S11, S14, S18, S24, S25, S26 S9, S11, S14, S24, S25 S2, S9, S24, S25	29.62% 18.51% 14.81%
6	Low communication usage	S2, S8, S9, S11, S12, S13, S20, S22, S24	33.33%	-More face to face meetings -Predefined communication protocols -Selection of communication tools with distributed work environment support -Use databases for previous data storage	S2, S9, S11, S18, S20, S24 S2, S9, S18, S24 S1, S2, S24, S25 S14, S24	22.22% 14.81% 14.81% 7.40%
7	Lack of proper synchronous communication	S4, S5, S7, S8 S9, S11, S12, S13, S18, S22, S24	40.74%	-Proper tools selection and implementation -Focus on the face to face meetings -Focus on informal communication -Focus on more knowledge sharing -Use Agile and Scrum practices	S1, S2, S9, S24, S25 S2, S9, S11, S18, S24 S2, S9, S18, S24 S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S1, S9, S25, S26	18.51% 18.51% 14.81% 44.44% 14.81%
8	Time estimation to complete a task	S4, S9, S17, S22, S24	18.51%	-Use proper estimation of efforts -Sifting work hours	S8 S9, S11, S24	3.70% 11.11%
9	Limited availability of group members	S9, S18, S22, S24	14.81%	-Time synchronization -Communication managers	S11, S24, S2, S9, S11, S24	7.40% 14.81%
10	Task synchronization	S12, S15, S16, S18, S21, S22, S24	29.62%	-Ensure in-time response between teams -RCM work synchronization	S1, S18, S24 S1, S12, S24	11.11% 11.11%

synchronous communication highly impacts (40.74%) the work progress during the RCM process.

From Table 6, it can be concluded that the cultures of different countries also play an important role in understanding the need for requirements change. Thus, socio-cultural distance challenge can be reduced effectively via

good communication and coordination practices as reported by 55.55% of the studies. Besides, the proper use and understanding of foreign languages are also important as reported by 44.44% of studies. Consequently, it would help in enhancing the mutual understanding among the globally dispersed stakeholders

TABLE 6. Socio-cultural distance-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	Diverse cultures	S1, S2, S5, S7, S9, S10, S11, S13, S15, S17, S20 S21, S22, S23, S24	55.55%	-Bridge gap between cultures -Gender analysis -Understand the other culture	S1, S2, S9, S11, S18, S20, S24 S2 S1, S20, S18,	25.92% 3.70% 11.11%
2	Communication language barriers	S2, S5, S9, S11, S13, S20, S21, S18, S22, S23, S24, S25	44.44%	-Use more Common languages -Increased training of team members -Use multilingual tools -Appoint language translator -Use the buddy system	S1, S2, S9, S11, S18, S20, S24 S1, S9, S12, S14, S19, S24, S26 S9 S14, S18, S24 S24	25.92% 18.51% 3.70% 11.11% 3.70%
3	Lack of mutual understanding among teams	S2, S8, S9, S11, S13, S15, S20, S21, S18, S22, S23 S24	44.44%	-Team support for the members -Build good relationships among team members -Create roles and relationships	S1, S2, S9, S12, S14, S24 S1, S9, S14, S18, S1, S18, S20, S24, S25, S26	22.22% 14.81% 22.22%
4	Differences in team members project knowledge and backgrounds	S2, S7, S9, S11, S13, S20, S22, S24, S27	33.33%	-Establish common rules for resolving knowledge conflicts -Common process will be suitable for GSD models -Effective and efficient knowledge sharing among team members -Choose the most appropriate team members for a specific project -Create a team having technical skills and cultural idea -Use new methodologies to support GSD -Avoid uncertainty by sharing project artifacts	S1, S2, S14, S24 S2, S9 S1, S2, S9, S11 S12, S14, S18, S20, S24, S26 S1, S2, S7, S9, S19 S1, S2, S9, S20, S24 S1, S9, S15 S24	14.81% 7.40% 37.03% 18.51% 18.51% 11.11% 3.70%
5	Different business logics of members	S5, S9, S11, S13, S18, S22, S24	25.92%	-More knowledge sharing -Use more informal communication to increase the understanding -Use standard work template -Build teams with mixed domain knowledge	S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S2, S9, S11, S12, S14, S20, S24 S1, S9 S24	44.44% 25.92% 7.40% 3.70%
6	Different work style approaches	S2, S5, S9, S11, S13, S18, S24	25.92%	-Predefined work styles/protocols for common job -Visit the distant development sites -Define work procedure or standard	S1, S2, S9, S14, S24 S1, S9, S11, S18, S24 S9, S14, S24, S25	18.51% 18.51% 14.81%
7	Information hiding	S8, S9 S18, S24	14.81%	-Build trust among team members -More informal and asynchronous communication -Motivate team members to share more information -Arrange knowledge sharing sessions and activities between team members	S1, S7, S9, S11, S14, S18, S24 S9, S11, S14, S24 S9, S24, S26 S9, S11, S14, S18, S20, S24, S25, S26	25.92% 14.81% 11.11% 29.62%
8	Low problem understandability	S2, S7, S9, S18, S20, S21, S22, S23	29.62%	-More informal communication to increase project knowledge -More training of team members -Conduct workshops -Conduct technical meetings	S2, S9, S11, S14, S18, S24 S1, S9, S12, S14, S19, S24, S26 S9, S24, S9, S11, S24	22.22% 25.92% 7.40% 11.11%
9	Political or legal issues	S10, S20, S22, S23	14.81%	-Team management and socializing	S7, S14	7.40%

From Table 7, it is found that the initial decision regarding communication technology plays a crucial role during the RCM in GSD. Generally speaking, proper communication is the backbone of outsourcing any software product. The tools and techniques used during the RCM must be clearly defined before the implementation of new requirements change. Certainly, *improper tools and technology usage* could lead to software failure. This issue is supported by 33.33% of studies. On the other hand, these improper decisions also cause a *lack of technical bounding among team members* (33.33%).

From Table 8, it is concluded that the selection of a proper and well-experienced software development team plays an important role in managing the requirements change, especially when managing the complex requirements changes. The major sub-challenge caused by the inexperienced team members is *lack of knowledge transfer* (62.96%) about the RCM. As a result, it would lead to the development of an undesired software product. Also, it is necessary to maintain

the proper coordination among the team members during requirements change as highlighted by 51.85% of the selected studies.

From Table 9, it can be observed that proper and timely involvement of all stakeholders is very important while negotiating on the new requirements, especially to avoid the future rework effort. Due to improper communication, some client's requirements are misunderstood or lacks in properly managing during the RCM process. The *lack of clear understanding of the client's requirements* and *missing feedback to clients* about change implementation are found as major sub-challenges (37.03%) faced in GSD.

From Table 10, it can be concluded that the infrastructure, architecture, and overall work environment of the software development organization are very important during the RCM process in the GSD context. *Managerial support* is highly important (59.25%) to perform the RCM process at different software development sites. To handle this sub-challenge,

TABLE 7. Tools and technology differences-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	Improper communication about tools decision	S1, S2, S5, S9, S12, S13, S22, S23, S24, S27	33.33%	-Predefined communication tools for all teams -More focus on informal communication methodologies -Encourage the use of the Internet-Based Inspection System (IBIS) "asynchronous discussions could be good. -Encourage video/Audio conferencing during project development and meeting -Use video conference tools, Web-based tools, Voice over IP, Electronic meeting systems, Latest online communication tools, and web-based tech for collaboration.	S1, S2, S9, S14, S24 S2, S9, S11, S18 S2 S9, S18 S2, S9, S11, S18, S25	18.51% 14.81% 3.70% 7.40% 18.51%
2	Connectivity issues	S9, S11, S13, S18, S22	18.51%	-Use communication manager/Liaison -Use more commonly used communication methods	S2, S9, S11, S14, S18, S24, S25 S2, S18, S24	25.92% 11.11%
3	Improper communication about tools/technology/methodologies	S2, S9, S11, S13, S18, S24	22.22%	-Use the tools that support communication and coordination in a distributed environment -Use the communication models in GSD -Use a framework called communication fabric for GSD -Promote groupware application tools -Use intranet and extranet	S2, S24, S25 S1, S2, S9, S26 S9 S9 S9	11.11% 14.81% 3.70% 3.70% 3.70%
4	Inadequate communication speed	S2, S9, S11, S13, S18	18.51%	-Use effective communication tools/ techniques	S1, S9, S14, S18, S25	18.51%
5	Low technical team support for the team	S9, S13, S15, S22, S24, S27	18.51%	-Use the communication managers, liaisons, or steering groups to resolve the conflicts -visit the remote sites frequently -Arrange stakeholders training sessions	S2, S9, S11, S14, S25 S1, S9, S11, S25 S14, S18, S24, S26	18.51% 14.81% 18.51%
6	Lack of technical bounding among team members	S2, S5, S9, S12, S13, S18, S22, S23, S24, S27	33.33%	-Build relationships with an increased level of trust -Use more informal communication -Use of rich communication -Use intranet between distributed sites	S2, S7, S9, S18, S20 S2, S9, S12, S14, S18 S9, S14, S18, S20 S9	18.51% 18.51% 18.51% 3.70%

the majority of the studies (22.22%) recommended *choosing the best available person and teams* as the key mitigation practice.

Similarly, *change control management* is also crucial (40.74%) while managing the new changes in the requirements. To overcome the impact of the change control

TABLE 8. Improper team formation-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	Religious backgrounds	S5, S20	7.40%	-Use nearshoring -Choose teams carefully	S24 S2, S7, S24, S25	3.70% 14.81%
2	The large and complex team	S2, S5, S9, S11, S13, S18	22.22%	-Use risk management model in GSD -Use Agile or Scrum practices -Encourage staff exchange	S2, S7 S1, S9, S25, S26 S1, S9, S24, S25	7.40% 14.81% 14.81%
3	Missing collaboration among team members	S2, S3, S4, S5, S8, S9, S11, S12, S13, S18, S22, S23, S24, S27	51.85%	-Use informal communication -Build more trust by sharing more knowledge -Use of common language and team support -Visiting distant development sites	S2, S9, S12, S14, S18, S20, S24 S2, S7, S9, S12, S14, S19, S18, S24 S2, S9, S11, S18, S20, S24 S1, S9, S11, S18, S24, S25	25.92% 29.62% 22.22% 22.22%
4	Inadequate distribution of work/ responsibilities	S2, S7, S11, S13, S16, S19, S24, S26	29.62%	-Ensure there is a good team -Use suitable GSD process models -Encourage more task separation -Staff involvement	S1, S2, S7, S9, S15 S1, S2 S9, S24 S1, S14	18.51% 7.40% 7.40% 7.40%
5	Lack of knowledge transfer	S2, S4, S5, S7, S8, S9, S10, S11, S12, S13, S16, S18, S20, S19, S22, S23, S24	62.96%	-Predefined rules for team coordination -Common communication language -Team support -More knowledge sharing via formal and informal meetings -Arrange knowledge sharing sessions and activities between team members -RCM process awareness	S1, S2, S9, S14, S24 S2, S9, S18, S20, S24 S1, S2, S9, S12, S14, S24 S2, S7, S12, S18, S20 S1, S9, S11, S14, S20, S24, S26 S1, S12, S24	18.51% 18.51% 22.22% 18.51% 25.92% 11.11%
6	Loss of good team spirit among the team members	S5, S9, S13	11.11%	-Use more synchronous communication to remove ambiguity and frustration -Always be available to your team -Establish the common goals	S9, S12, S14, S18, S24 S1, S9, S18, S24 S25	18.51% 14.81% 3.70%
7	Identity hiding of team members	S9, S18, S22, S24	14.81%	-Encourage team building activities -Use the proper introduction of members at the beginning of the project to build mutual trust and loyalty	S9, S24 S9, S18	7.40% 7.40%
8	Lack of belief in others	S9, S18, S20, S22, S27	18.51%	-Promote team socializing -Promote awareness of remote team culture	S9, S11, S18 S1, S7, S9, S18, S20, S24, S25	11.11% 25.92%
9	Fear to express feelings	S9, S18, S20, S24, S27	14.81%	-Encourage direct communication (Pair to Pair links among team members) -Encourage more verbal communication during decision making	S9, S11 S9	7.40% 3.70%
10	Team members attitude	S9, S13, S18, S17, S20, S22, S27	22.22%	-Negotiation support systems will help reliable outcomes from individuals -Encourage polite and complimentary behavior and be enthusiastic. -Don't rush to judge others statements -Take inequality and justice approach	S9 S9, S18 S9 S9, S24	3.70% 7.40% 3.70% 7.40%
11	Distributed pair programming	S11	3.70%	-Frequent code reviewing meetings	S11	3.70%
12	Inadequate whiteboard discussions	S11	3.70%	-Use online data conferencing tools	S2, S9, S11, S18, S24, S25	22.22%
13	Availability of members	S9, S18, S22	11.11%	-Use online tools -Time synchronization	S2, S9, S11, S18, S24, S25 S9, S14, S18, S24	22.22% 14.81%
14	The mindset of team members	S11, S18, S20, S24, S27	14.81%	-Evaluate capabilities of a remote team	S24, S25	7.40%
12	Lack of domain knowledge	S2, S5, S9, S11, S13, S17, S18, S19, S20, S24, S25, S27	40.74%	-Team support for team members - Arrange knowledge sharing sessions and activities between team members - Domain knowledge transfer	S1, S2, S9, S12, S14, S24 S9, S11, S14, S18, S20, S24, S25, S26 S7, S11, S24, S25	22.22% 29.62% 14.81%
13	Lack of motivation	S26	3.70%	-Encourage team building activities -Motivate teams via rewards	S9, S24 S25	7.40% 3.70%

management sub-challenge, the only mitigation strategy suggested by 14.81% of studies is to use version control repositories or databases.

From Table 11, it can be concluded that unclear requirement’s understanding remains a major miscellaneous challenge caused by improper communication. Consequently, it causes new changes to the already implemented requirements. Moreover, it also affects the requirements change process as reported by 37.03% of studies. Moreover, inadequate change impact analysis after implementing the new requirements is also caused by the mismanaged communication (22.22%) at distributed development locations.

RQ2 (What Are the Coordination Challenges Mentioned in the Existing SLR Studies?): From a detailed analysis of the selected SLR studies, we found that 14 major coordination challenges could be faced by the project manager during RCM in GSD sites. Among the 14 coordination challenges, cultural difference is the majorly occurred challenge (51.85%). Ultimately, this remains a major obstacle for the offshore stakeholders, who faced different language barriers in understanding the need for requirements change in an ongoing or completed software project. In contrast, lack of trust among team members and lack of face-to-face meetings are found to be the second major coordination challenge (48.14%). Interestingly, the personality clash challenge causes the lowest impact (3.70%) on the coordination challenges during RCM in GSD. Moreover, there was no mitigation strategy proposed in the literature that can handle the personality clash challenge.

RQ2.1 (What Are the Best Possible Mitigation Practices for Coordination Challenges?): Table 12 represents different coordination challenges identified and analyzed in the selected studies. Moreover, the best mitigation practices identified from the literature review and expert feedback are also mentioned and assigned to every coordination challenge.

From Table 12, it was found that cultural differences can significantly hinder the understandability of the client’s and other stakeholder’s information, knowledge, and needs as compared to the other coordination challenges during the RCM. This observation is supported by 51.85% of the selected SLR studies. Furthermore, lack of trust among team members (48.14%) caused the delayed and inadequate responses, while managing the requirements change at different sites. In comparison to lack of trust, lack of face-to-face meetings negatively impacted the understandability of team members (48.14%). Furthermore, the lack of face-to-face meetings and inadequate knowledge sharing increases the distrust among the GSD teams.

Figure 8 represents the most commonly faced challenges as identified from the selected SLR studies. From Figure 8, it can be observed that missing or lack of knowledge transfer at different offshore sites causes the failure in software projects as reported by 62.96%. In contrast, trust issues among the software development team members and other stakeholders were reported by 59.25% of the studies. Furthermore, cultural differences act as a communication barrier at offshore sites mentioned in 55.55% of studies.

TABLE 9. The client-related sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	The improper behavior of the client	S4, S5, S13	11.11%	-Predefined set of rules for conflicts resolution -Use risk management models in GSD -Build long term relationships to gain clients trust	S1, S2, S9, S12, S14, S2, S24 S9, S14	18.51% 7.40% 7.40%
2	Lack of clients involvement	S2, S4, S5, S8, S11, S13, S22	25.92%	-More informal communication -Knowledge sharing -Build strong and long term mutual relationships	S2, S7, S9, S12, S14, S18, S24 S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S9	25.92% 44.44% 3.70%
3	Lack of clear understanding of the client's requirements	S1, S2, S7, S11, S12, S13, S18, S20 S22, S25	37.03%	-Completely involve and inform your client -Use voice or video conference at the kick of meeting for requirements negotiation - Proper requirements transfer	S2, S9, S14 S9, S11, S18, S24 S1, S11, S14, S25	11.11% 14.81% 14.81%
4	Missing feedback to the clients	S2, S4, S5, S8, S9, S13, S17, S20, S22, S26	37.03%	-Use asynchronous and informal communication -Build trust -Be honest with your client	S9, S14, S18, S24 S1, S2, S9, S11, S24 S1, S9	18.51% 7.40% 7.40%
5	Knowledge of client	S10, S11, S22, S25	14.81%	-Involve stakeholders in workshops -More technical meetings -Domain knowledge transfer	S9, S11, S14 S9, S11 S1, S11, S22, S24, S25	11.11% 7.40% 18.51%
7	Customer work standardization	S12, S22	7.40%	-Use standard work methods	S1, S22, S24	11.11%

The *inadequate transfer of information* was highlighted in 51.85% of studies, *missing collaboration in teams* was reported in 48.14% of studies. In contrast, *diversity in time zones, time delay in responses, language barriers, and missing mutual understanding* among the team members were reported by 44.44% of the studies.

Figure 9 shows the widely adapted recommended mitigation practices to handle the communication and coordination challenges at offshore sites.

From Figure 9, we found that focus on *knowledge and information sharing* with the stakeholders is the widely adapted mitigation practice (44.44%) to handle

the trust deficit issue in the distributed software development teams. Similarly, *effective and efficient knowledge sharing* is the second highly suggested practice as reported in 37.03% of the analyzed studies. The usage of *commonly available tools, face-to-face meetings, using communication managers or liaisons, and more communication establishments* were recommended in 29.62% of the selected studies. In addition to the above-mentioned mitigation practices, *bridging the gap between cultures, informal communication, knowledge sharing sessions, and work progress visibility* was supported by 25.92% of the selected studies.

TABLE 10. Software development organization-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenges	Study	Support Level	Mitigation Practice	Study	Support Level
1	The improper software development process	S2, S3, S5, S7, S11, S13, S17, S21, S23	33.33%	-Use proper SDLC process and risk mitigation Practices -Client must provide complete and direct access to System analysts to their organization -Ensure key contact people -Frequently contact stakeholders	S1, S2, S7, S9, S22 S2 S11, S25 S11, S18, S22, S24	18.51% 3.70% 7.40% 14.81%
2	Managerial/ leadership support	S2, S3, S7, S9, S10, S13, S15, S16, S18, S19, S20, S21, S22, S23, S24, S26	59.25%	-Choose the best available person and teams -Team backup support -Encourage the use of project management tools -Encourage management availability throughout the project -Document every work event -Avoid the rework	S1, S2, S7, S9, S12, S25 S1, S2, S9, S24 S9 S1, S9, S19 S9, S11, S12, S14, S24 S24	22.22% 14.81% 3.70% 11.11% 18.51% 3.70%
3	Inappropriate architecture	S2, S9, S10, S11, S13, S18, S20, S21, S22, S23	37.03%	-Use central architectural approach for client and analyst -Start locally and then grow globally - Provide or select a suitable and best IT infrastructure	S9 S25 S25	3.70% 3.70% 3.70%
4	Change control management	S1, S3, S7, S8, S12, S16, S20, S19, S21, S22, S23	40.74%	-Use version control repositories or databases	S9, S12, S14, S24	14.81%
5	Limited or no experience with GSD practices and environment	S9, S10, S11, S15, S16, S17, S24, S27	25.92%	-More technical meetings for Groups and staff exchange with a good experience -hire people with good GSD experience	S9, S11, S18, S24 S1, S15, S26	14.81% 11.11%
6	Poor software development infrastructure	S11, S16, S17, S18, S21, S22, S23 S24	29.62%	- Provide or select a suitable and best IT infrastructure	S25	3.70%
7	Improper software documentation	S11 S12, S18, S22	14.81%	-Include the offshore team in client meetings -Use audio/video recordings -Use proper software documentation	S11, S14, S26 S11, S18 S12	11.11% 7.40% 3.70%
8	Organizational politics	S7, S15, S17 S18, S20, S22, S24	25.92%	N/A	-	-
9	Organizational rules and policies	S7, S15, S17, S22	14.81%	N/A	-	-
10	Maximum workloads	S17, S21	7.40%	-Additional team support	S1, S2, S9, S14, S24	18.51%
11	Process certification	S1	3.70%	-Use Agile requirements change management process -Use CMMI models	S1, S25 S18, S26	7.40% 7.40%

* N/A in mitigation practices indicates the no best practice has been mentioned by any of the selected studies

TABLE 11. Miscellaneous-based sub-challenges and corresponding mitigation practices.

No.	Sub-Challenge	Studies	Support level	Mitigation Practice	Study	Support Level
1	Fear of losing the job	S9	3.70%	N/A	–	–
2	Unclear requirements	S1, S2, S7, S9, S11, S12, S18, S20, S22, S25	37.03%	-Ensure proper knowledge management practices -Risk mitigation practices -Involve your client in work -Use a predefined set of work rules -Be always available to your clients -Document every information	S1, S7, S9, S11 S12, S14, S18, S20 S2, S9, S14, S18 S2, S9, S14, S26 S1, S2, S9, S14, S18 S1, S2, S9, S14, S24 S9, S11, S12, S14, S20	29.62% 14.81% 14.81% 18.51% 18.51% 18.51%
3	Improper Implementation of RCM techniques	S7, S15, S22	11.11%	-Use globally distributed change control board suggestions	S1	3.70%
4	Inadequate change impact analysis	S1, S15, S16, S19, S22, S23	22.22%	-Monitor the main impact factors like cost, time, staff scope, and efforts.	S1, S12, S15	11.11%
5	Lack of risk assessment at distant sites	S7, S15, S22, S24	14.81%	-Frequently visiting the distant work sites	S1, S9, S18, S24, S25	18.51%
6	The economic stability of countries	S15	3.70%	-Assess the inflation rate of different countries	S24	3.70%
7	Artifacts in an incompatible format	S21, S24	7.40%	-Manage work artifacts properly	S24	3.70%
8	Budget constraints	S7, S22, S24, S24	14.81%	-Use effective cost estimation methods	S12, S14	7.40%
9	Work integration issues	S24	3.70%	-Manage and share a common work items repository	S9, S12, S14, S24	14.81%
10	Improper cost estimation	S22, S24	7.40%	- Manage a proper cost inflation	S24	3.70%

* N/A in mitigation practices indicates the no best practice has been mentioned by any of the selected studies.

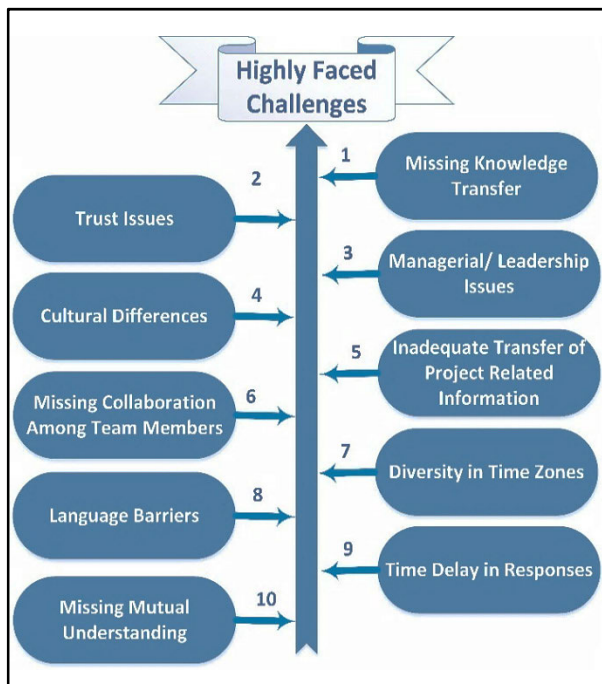


FIGURE 8. Commonly faced challenges.

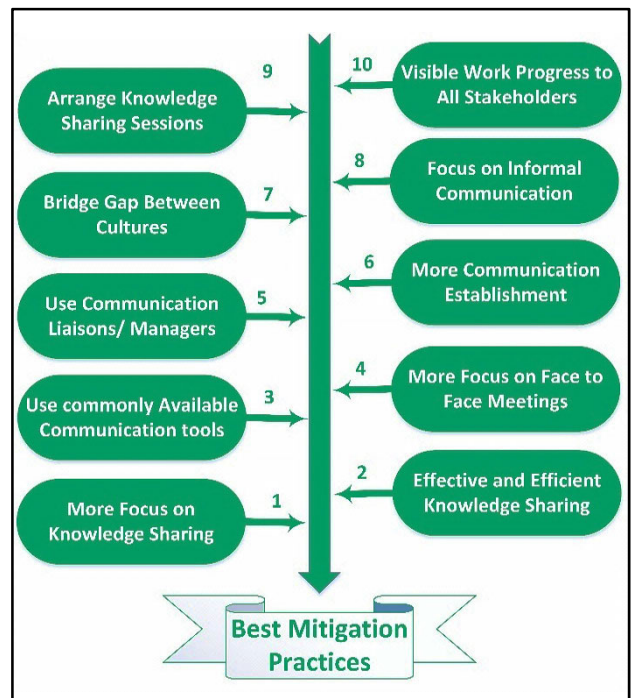


FIGURE 9. Commonly adapted mitigation strategies.

VI. PROPOSED CONCEPTUAL MODEL

This section presents the proposed conceptual model, which is useful to effectively handle the communication

and coordination challenges by suggesting the most suitable mitigation practice during RCM in the GSD context.

TABLE 12. Coordination-based challenges and corresponding mitigation practices.

No.	Challenge	Study	Support Level	Mitigation Practice	Study	Support Level
1	Missing work/task synchronization at offshore sites	S2, S7, S9, S15, S12, S16, S18, S20, S22, S23, S24	40.74%	-Use the communication tools that support a collaborative work environment -More face-to-face meetings -Increased use of synchronous and asynchronous communication tools -Use joint management infrastructure -RCM work synchronization	S2, S9, S24 S2, S7, S9, S20, S18, S24 S9, S11, S12, S14, S18, S22, S24, S25 S1 S1, S24	11.11% 22.22% 29.62% 3.70% 7.40%
2	Missing client and vendor relationships at offshore sites	S2, S4, S5, S8, S13, S15, S18, S20, S22, S24, S26	40.74%	-More informal communication -Knowledge sharing -Build strong and long term mutual relationships -Completely involve your client in the whole project development -Tight coupling of stakeholders	S2, S9, S14, S18, S20, S24, S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S9, S14, S20, S22 S2, S9, S14, S26 S25	22.22% 44.44% 14.81% 14.81% 3.70%
3	Lack of organizational support	S2, S3, S7, S9, S10, S15, S17, S18, S22, S24	37.03%	-Choose the best person and teams available -Encourage management availability throughout the project -Provide team backup support	S1, S2, S7, S9, S25 S1, S9, S19, S24 S1, S2, S9, S24	18.51% 14.81% 14.81%
4	Lack of trust among team members	S2, S5, S9, S11, S13, S15, S16, S17, S18, S20, S21, S22, S24	48.14%	-More knowledge sharing -More communication establishment -Visit the remote sites -Make work progress visible to all stakeholders -Build trust by proper team introduction -Encourage informal communication with good trust	S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S1, S2, S9, S18, S20, S24 S1, S9, S18, S24, S25 S2, S3, S9, S13, S15, S16, S22 S1, S2, S9, S18, S20, S24 S9, S14, S18, S24	44.44% 22.22% 18.51% 25.92% 22.22% 14.81%
5	Lack of 3Cs (communication, Coordination & Control)	S1, S2, S9, S11, S12, S17, S18, S20, S21, S22, S24, S27	40.74%	-More informal communication -Knowledge sharing -Monitor the factors like cost, time, resources, and so on. -Conduct technical meetings -Hire people with good GSD experience -Document work artifacts -Use Version control databases/repositories	S1, S2, S7, S9, S12, S14, S18, S24 S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S1, S15, S24 S9, S11, S24 S1, S7, S15, S24, S25 S9, S11, S12, S14, S24 S9, S12, S14, S24	29.62% 44.44% 11.11% 11.11% 18.51% 18.51% 14.81%
6	Lack of face to face meetings	S2, S4, S5, S8, S9, S11, S13, S16, S18, S20, S21, S23, S24	48.14%	-Establish a timely face to face meeting culture -Define new communication channels for meetings -Completely involve and inform your client -Use voice or video conference at the kick-off meeting.	S2, S9, S18, S24 S2, S9, S24 S2, S9, S14 S9, S11, S18, S24	14.81% 11.11% 11.11% 14.81%
7	Delay in response/feedback	S2, S5, S9, S11, S13, S16, S17, S18, S22, S23, S24, S26	44.44%	-Establish initial rules for communication -Promote team socializing -Define communication protocols for every workgroup -Conduct more informal meetings -Tight coupling of stakeholders	S1, S2, S9, S14, S18, S24 S9, S11, S14 S1, S2, S14, S24 S2, S9, S18, S24 S25	22.22% 11.11% 14.81% 14.81% 3.70%
8	Lack of understanding of requirement management	S2, S7, S9, S16, S12, S18, S20, S21, S22, S23, S25	40.74%	-Ensure proper knowledge management practices -Involve your client in work -Use a predefined set of work rules -Be always available to your clients and teams -Document every information	S1, S9, S11, S12, S14, S20, S24 S2, S9, S12, S14, S26 S1, S2, S9, S14, S20, S24 S1, S9, S11, S14, S24 S9, S11, S12, S14, S20	25.92% 18.51% 22.22% 18.51% 18.51%

TABLE 12. (Continued.) Coordination-based challenges and corresponding mitigation practices.

9	Cultural differences	S2, S13, S5, S9, S10, S11, S15, S17, S18, S20, S21, S22, S23, S24	51.85%	-Bridge gap between cultures -Gender Analysis -Understand the other culture	S1, S2, S9, S11, S18, S20 S2 S1, S20, S24	22.22% 3.70% 11.11%
10	Personality clashes	S17	3.70%	N/A	–	–
11	Communication patterns	S12, S21, S22, S24	14.81%	-Use communication manager/Liaison -Promote groupware application tools -Use intranet and extranet	S2, S9, S11, S14, S18, S24, S25 S9 S9	25.92% 3.70% 3.70%
12	Remote communication difficulty	S18, S20, S21	11.11%	-Use the communication managers, liaisons, or steering groups to resolve the conflicts -visit the remote sites frequently -Arrange stakeholders training sessions	S2, S9, S11, S14, S18, S24, S25 S1, S9, S11, S18, S24, S25 S14, S18, S24, S26	25.92% 22.22% 14.81%
13	Gaps in communication groups	S2, S3, S5, S8, S9, S11, S13, S18, S20, S21, S23	40.74%	-Establish a timely face to face meeting culture -More knowledge sharing - Encourage management availability throughout the project - More informal communication	S2, S9, S18, S20, S24 S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S1, S9, S19, S24 S2, S9, S14, S18, S24	18.51% 44.44% 14.81% 18.51%
14	Alignment of software development methods	S2, S11, S17, S18, S21, S22, S24	25.92%	-Document every work event -Share knowledge -Understand the RCM process -Use version control repositories or databases	S9, S11, S12, S14, S24 S1, S2, S7, S9, S14, S15, S18, S20, S22, S24, S25, S26 S1 S9, S12, S14, S24	18.51% 44.44% 3.70% 14.81%

* N/A in mitigation practices indicates the no best practice has been mentioned by the selected study.

Figure 10 represents the architecture of the proposed conceptual model. It contains three main phases, which further include a set of relevant steps to support the targeted research objective.

Phase 1 shows the project's initiation, which is activated once the need for requirements change management is identified (step 1). Note that the stakeholders, including the clients and project managers, intimate about the need for requirements change communicated. Next, different challenges are identified that pose a potential threat to the communication and coordination mechanism during the RCM process at offshore sites (step 2). As previously discussed, we found 62 and 14 different communication and coordination challenges (respectively) through the conducted tertiary study. Finally, in phase 1, after finding the relevant challenge(s), the request is forwarded to find the best mitigation strategy (step 3).

In phase 2, the best possible mitigation practice(s) is/are allocated to the mentioned challenge (step 4). Note that we found 107 mitigation strategies that effectively handle the raised challenges in the RCM process. In other words, the main aim of phase 2 is to extract the best mitigation strategies effective in handling the given challenges.

Finally, in phase 3, a standard list of mitigation practices is transferred to all stakeholders as a standard set of solutions (step 5). Next, the basic communication protocols are

adapted at all the offshore sites to avoid any communication and coordination challenges during RCM in GSD (step 6). Lastly, the requirements are changed and managed under predefined communication and coordination standards at multiple globally distributed locations (step 7).

VII. VALIDITY THREATS

This section provides the validity threats. The SLR studies included in this research are published between the years 2009 to 2021, as represented in Appendix B (Table 14). We nevertheless acknowledge that trends, techniques, and methodologies are rapidly changing in the GSD domain. Thus, we excluded the SLR studies published before the year 2009. Although, there could be a chance that we might miss some important studies. To tackle this issue, we have adopted a systematic review process to provide an unbiased view of the literature.

The selected studies were carefully filtered grounded on the devised inclusion-exclusion criteria to select the most relevant studies on the RCM process in GSD. In total, 27 most relevant studies were selected through the conducted systematic review. However, except for one study, S23 Appendix A (Table 13), no other study has comprehensively focused on communication and coordination issues during the RCM process in the distributed development environment. Hence, we carefully analyzed the remaining 26 studies and extracted

TABLE 13. Analysis of the selected primary SLR studies.

Study ID	Publication Year	Total Primary Studies	Quality Assessment Score	Thematic Analysis	Brief Information	Limitations
S1	2020	83	2	Identification of agile requirements change management success factors in GSD	The study discussed the 21 success factors that impact the RCM in agile global software development via literature review and survey-based results.	<ul style="list-style-type: none"> The study generically discussed the factors which impact the success of agile software development only Communication and coordination are generically discussed.
S2	2018	85	2	Risk Identification and prevention factors from an existing literature review.	Identification of 25 major GSD challenges and 29 Methodologies to avoid the possible challenges. The impact of projects based coordination is also briefly discussed in the study.	<ul style="list-style-type: none"> Generic risk factors are identified. Mainly focused on RE instead of RCM. No framework to overcome communication and coordination issues regarding requirement engineering or RCM.
S3	2019	43	1.5	Challenges faced during the RCM process in GSD	Identification of 10 generic challenges during RCM in GSD. Specifically highlighted the 3 major challenges faced during the RCM in GSD projects.	<ul style="list-style-type: none"> Only generic factors are identified from existing literature, including the Communication and coordination risks. There is no framework highlighted to support our research topic.
S4	2015	62	3	Identification of communication challenges in GSD projects.	There were three major risks in GSD were identified. The multiple sub-challenges of Temporal distance, sociocultural differences, and geographical distance were highlighted in the study. Furthermore, the reasons for the challenges to occur and mitigation strategies to reduce the communication challenges were discussed in the study. The data were obtained via observation of employees and companies.	<ul style="list-style-type: none"> There were no coordination challenges discussed in the study. The framework doesn't tackle any coordination issues.
S5	2019	N/A	2.5	Discussed the generic requirements change management Process challenges in GSD.	Generic challenges related to the RCM process are identified. The identified challenges were briefly mentioned as generic barriers that are faced during RCM in GSD projects.	<ul style="list-style-type: none"> There are only generic barriers highlighted. No framework is proposed. The coordination challenges are the least discussed challenges.
S6	2011	9	3	Identification of multiple collaboration models in GSD	The different phases of the software development model were analyzed from the literature. The phases were categorized to observe the main activities performed in GSD. Multiple collaboration techniques in GSD were highlighted in the study.	<ul style="list-style-type: none"> The communication challenges were not thoroughly discussed. The study does not mention any framework to overcome the Communication and Coordination (C&C) challenges during RCM in GSD.
S7	2018	100	2.5	Project administration challenges during RCM in GSD are discussed	The study highlighted the major challenges related to project administration in GSD were highlighted among those challenges, 10 challenges highly impact the communication and coordination during RCM in GSD.	<ul style="list-style-type: none"> There are only ten generic RCM challenges discussed. No communication and coordination challenges were mentioned. The proposed model is based on maturity models which are partially mitigating the RCM challenges in GSD.

TABLE 13. (Continued.) Analysis of the selected primary SLR studies.

S8	2019	43	1.5	Analysis and comparison of challenges between Collocated and offshore located software development sites.	The generic challenges between in-house and GSD development were identified. The challenges were categorized in multiple categories and the impact factors of multiple challenges were analyzed using a T-test, regression analysis, and Chi-square test.	<ul style="list-style-type: none"> The challenges identified from the existing literature are very generic. Moreover, there is no defined framework to overcome those challenges. This is a comparison-based study that doesn't fully support C&C challenges in GSD.
S9	2012	88	2	Discussion about the risk factors in GSD along with the reasons to occur.	The major risk factors in GSD were identified from existing literature and via conducting surveys and interviews. The risks in GSD, causes and possible mitigation practices were identified.	<ul style="list-style-type: none"> The GSD risks, causes, and mitigation practices are more generic while these are all related to communication, but no coordination challenges and frameworks were addressed in the study.
S10	2009	8	1	Highlighted the success factors that impact the RCM in GSD	From the previous literature review, all the possible success factors were identified that could help software production and help the RCM process to be implemented successfully.	<ul style="list-style-type: none"> Only generic challenges were highlighted. No framework was proposed to effectively reduce the identified challenges.
S11	2019	10	2	Possible communication challenges during GSD were discussed.	Identification of communication challenges from the literature. Categorization of the challenges into solved, not solved, and impossible to solve categories. Areas, where the GSD is highly affected by poor communication, were highlighted.	<ul style="list-style-type: none"> There is a generic analysis of the risk factors in the GSD communication process while Coordination challenges are still lacking. RCM challenges were not specifically discussed.
S12	2013	330	1.5	Exploration of GSD solutions along with Process Area Map (PAM)	127 solutions to reduce the global software development challenges were highlighted. Furthermore, the Process Area Map (PAM) model was discussed to solve the GSD challenges.	<ul style="list-style-type: none"> Partially focused on communication and coordination. The framework discussed is highly focusing on generic GSD challenges. Least discussed the RCM based challenges. Solutions for the GSD challenges were mainly focused.
S13	2019	64	2	Identification of communication challenges or risks in GSD projects.	The author identified the possible communication challenges along with their impact via conducting an SLR. There is a framework developed to avoid the challenges. There were identified 35 major communication challenges in the study.	<ul style="list-style-type: none"> The study lacks a focus on coordination challenges and mitigation practices. The proposed framework does not mitigate all the communication and coordination challenges to improve the RCM process in GSD.
S14	2017	42	2.5	Highlighted the major communication challenges in the GSD context.	There were 29 communication challenges identified that negatively impact the GSD-based software projects and f the challenges were further categorized into five major categories.	<ul style="list-style-type: none"> Only the communication challenges were partially discussed. No coordination challenges were discussed. The framework doesn't mitigate the coordination challenges.
S15	2019	100	2.5	Presentation of RCM challenges in GSD	The major factors that hinder the RCM process at distributed locations were discussed. Multiple communication and coordination challenges were discussed that negatively affect the RCM.	<ul style="list-style-type: none"> The discussed factors are very limited in our research context as well as the study didn't propose a conceptual model to reduce the possible challenges.
S16	2019	54	3	Identification and categorization of RCM challenges	There were 30 challenges identified in the study. Among the identified challenges, 11 challenges were highly affecting the C&C during RCM in GSD. The identified challenges were further categorized into six different categories.	<ul style="list-style-type: none"> The framework proposed doesn't provide a pathway to specifically tackle the C&C issues during RCM in GSD. The proposed framework only mitigates the generic challenges during the RCM in GSD.

TABLE 13. (Continued.) Analysis of the selected primary SLR studies.

S17	2020	131	2	Discussed the motivational factors for the RCM in GSD	There is a systematic literature review as well as a survey conducted to find the main reasons to initiate a change in the requirements in GSD projects and possible challenges that cause ineffectiveness in this process.	<ul style="list-style-type: none"> The study mainly discussed the RCM process as well as the challenges in the RCM process. The communication and coordination challenges were partially discussed.
S18	2010	26	2	Analysis of collaboration challenges and solutions in GSD	There are seven major challenges identified from the literature as well as some best solutions were also highlighted to reduce the identified challenges. Multiple coordination challenges were also highlighted in this study	<ul style="list-style-type: none"> Generic seven major challenges were discussed with no subcategories. The mitigations strategies are not enough to handle all the possible challenges. No framework was proposed.
S19	2019	107	3	Success factors for the RCM process in GSD were discussed	Twenty-three most important success factors for a successful RCM process implementation in GSD were identified. Among those, 8 factors were highly sophisticated that must be reduced during the RCM in GSD.	<ul style="list-style-type: none"> There is the least focus on C&C factors in this study, and only coordination challenges are briefly discussed.
S20	2014	23	1.5	Exploration and analysis of cultural issues in GSD	The study discussed the major cultural challenges that affect the software development activities in GSD.	<ul style="list-style-type: none"> Only cultural issues were identified. No mitigation framework was proposed.
S21	2014	45	2	Generic RCM Framework development	All the possible RCM challenges were identified and mentioned after analyzing the literature.	<ul style="list-style-type: none"> The study does not specifically address the communication and coordination challenges. The proposed framework is generic for all communication problems.
S22	2020	69	3	Analysis of organization based challenges during RCM in GSD	25 major organization-based challenges for RCM in GSD were identified from literature analysis. Furthermore, a survey was conducted to test the validity of the identified organization's challenges.	<ul style="list-style-type: none"> Communication and coordination issues were not specifically focused on. RCM is specifically based on the organizations' size and type. The proposed framework is addressing generic challenges during the RCM process.
S23	2014	101	3	Understanding the project-based knowledge during RCM in GSD	The study focused on the importance of knowing project-based information. All the possible communication and coordination factors are identified from previous literature by conducting an SLR.	<ul style="list-style-type: none"> The study doesn't specifically target the RCM context while it addresses many of the generic issues that could occur during RCM in the GSD context.
S24	2011	86	2	Risk identification and risk mitigation in GSD	48 major risks along with 42 mitigation methods were identified to overcome the commonly faced risks during communication, coordination, and control in GSD.	<ul style="list-style-type: none"> Generic communication and coordination challenges were identified. No framework was proposed to reduce the challenges.
S25	2014	60	2.5	Identification of solutions in GSD	Four major factors that cause complexity in GSD projects were identified as well as ten best solutions to overcome the communication and coordination challenges were mentioned.	<ul style="list-style-type: none"> Only ten generic solutions were discussed. Partially addressed the RCM process in the context of GSD. No framework to overcome the communication and coordination challenges was mentioned.
S26	2018	18	2	Identification of human-related challenges in GSD	There were 11 major human-based challenges identified that could impact the RCM process implementation in GSD.	<ul style="list-style-type: none"> The proposed framework discussed the generic challenges. Eleven challenges are not enough to effectively address communication and coordination challenges.
S27	2021	44	1.5	Role of software project management during project development in GSD	There are 12 major challenges identified via an SLR that impact the software development in GSD mainly in the context of software project managers at distributed locations.	<ul style="list-style-type: none"> There were generic challenges discussed that can be faced during the RCM. No framework or conceptual model was proposed to eliminate the identified challenges. No mitigation solutions were discussed.

TABLE 14. The selected SLR studies.

Study ID	Reference
S1	T. Kamal, Q. Zhang, M. A. Akbar, M. Shafiq, A. Gumaedi, and A. Alsanad, "Identification and Prioritization of Agile Requirements Change Management Success Factors in the Domain of Global Software Development," <i>IEEE Access</i> , vol. 8, pp. 44714–44726, 2020. doi: 10.1109/ACCESS.2020.2976723.
S2	J. Nicolás, J. M. Carrillo De Gea, B. Nicolás, J. L. Fernández-Alemán and A. Toval, "On the Risks and Safeguards for Requirements Engineering in Global Software Development: Systematic Literature Review and Quantitative Assessment," in <i>IEEE Access</i> , vol. 6, pp. 59628–59656, 2018. doi: 10.1109/ACCESS.2018.2874096.
S3	S. Anwer, L. Wen, and Z. Wang, "A Systematic Approach for Identifying Requirement Change Management Challenge Preliminary Results," in 2019 <i>International Conference on Evaluation and Assessment on Software Engineering (EASE)</i> , Copenhagen, Denmark, April 2019, pp. 230–235. doi:10.1145/3319008.3319031
S4	A. A. Khan, "A Communication Risk Framework For Requirements Change in Global Software Development," Master's Thesis, Universiti Teknologi Petronas, Perak, Malaysia. November 2015. doi: 10.13140/RG.2.1.4755.1447.
S5	M. Umair, M. A. Shah, and M. Hamza Sarwar, "Barriers of Requirement Change Management Process in the Context of Global Software Development," in 2019 <i>25th International Conference on Automation and Computing (ICAC)</i> , Lancaster, United Kingdom, Sep. 2019, pp. 1–6. doi: 10.23919/ICAC.2019.8894922.
S6	R. G. C. Rocha, C. Costa, C. M. de Oliveira Rodrigues, R. R. de Azevedo, I. H. de Farias Junior, S. R. de Lemos Meira, and R. Prikładnicki, "Collaboration Models in Distributed Software Development: A Systematic Review," <i>CLEI Electron. J.</i> , vol. 14, no. 2, 2011
S7	M. A. Akbar, Nasrullah, M. Shameem, J. Ahmad, A. Maqbool, and K. Abbas, "Investigation of Project Administration related Challenging Factors of Requirements Change Management in Global Software Development: A Systematic Literature Review," in 2018 <i>International Conference on Computing, Electronics and Electrical Engineering (ICE Cube)</i> , Quetta, Nov. 2018, pp. 1–7. doi: 10.1109/ICCECUBE.2018.8610966.
S8	S. Anwer, L. Wen, Z. Wang, and S. Mahmood, "Comparative Analysis of Requirement Change Management Challenges between in-House and Global Software Development: Findings of Literature and Industry Survey," <i>IEEE Access</i> , vol. 7, pp. 116585–116611, 2019. doi: 10.1109/ACCESS.2019.2936664.
S9	Iqbal and S. S. Abbas, "Communication Risks and Best Practices in Global Software Development," Masters Thesis Software Engineering. Blekinge Institute of Technology, Karlskrona, Sweden p. 212, 2011.
S10	S. U. Khan, M. Niazi, and R. Ahmad, "Critical Success Factors for Offshore Software Development Outsourcing Vendors: A Systematic Literature Review," in 2009 <i>Fourth IEEE International Conference on Global Software Engineering (ICGSE)</i> , Limerick, Ireland, Jul. 2009, pp. 207–216. doi: 10.1109/ICGSE.2009.28.
S11	I. Ghani, A. Lim, M. Hasnain, I. Ghani, and M. I. Babar, "Challenges in Distributed Agile Software Development Environment: A Systematic Literature Review," <i>KSIIT Transactions on Internet and Information Systems</i> . vol. 13, no. 9, pp. 4555–4571, 2019. doi: 10.3837/tiis.2019.09.013.
S12	S. Schneider, R. Torkar, and T. Gorschek, "Solutions in Global Software Engineering: A Systematic Literature Review," <i>International Journal of Information Management</i> , vol. 33, no. 1, pp. 119–132, Feb. 2013. doi: 10.1016/j.ijinfomgt.2012.06.002.
S13	G. Ammad, U. Iqbal Janjua, T. M. Madni, M. F. Cheema and A. R. Shahid, "An Empirical Study to Investigate the Impact of Communication Issues in GSD in Pakistan's IT Industry," <i>IEEE Access</i> , vol. 7, pp. 171648–171672, 2019. doi: 10.1109/ACCESS.2019.2953008.
S14	M. W. Bhatti, "Effective Communication among Globally Distributed Software Development Teams," <i>Journal of Global Information Management</i> , vol. 25, no. 3, p. 24, 2017.
S15	M. A. Akbar, M. Shafiq, T. Kamal, and M. Hamza, "Towards the Successful Requirements Change Management in the Domain of Offshore Software Development Outsourcing: Preliminary Results," <i>International Journal of Computing and Digital Systems</i> , vol. 8, no. 3, pp. 205–215, 2019. doi: 10.12785/IJCD/080301.
S16	M. A. Akbar, J. Sang, A. A. Khan, and S. Hussain, "Investigation of the Requirements Change Management Challenges in the Domain of Global Software Development," <i>Journal of Software: Evolution and Process</i> , vol. 31, no. 10, Oct. 2019. doi: 10.1002/smr.2207.
S17	A. A. Khan and M. A. Akbar, "Systematic Literature Review and Empirical Investigation of Motivators for Requirements Change Management Process in Global Software Development," <i>Journal of Software: Evolution and Process</i> , vol. 32, no. 4, April 2020. doi: 10.1002/smr.2242.
S18	B. J. Noll, S. Beecham, and I. Richardson, "Global Collaboration : Software Development Solutions," <i>ACM Inroads</i> . 1. vol. 1, no. 3, pp. 66–78, 2010. doi: 10.1145/1835428.1835445.
S19	Azeem Akbar, Muhammad & Sang, Jun & Nasrullah, Dr & Khan, Arif & Mahmood, Sajjad & Furqan Qadri, Syed & Hu, Haibo & Xiang, Hong. (2019). Success factors influencing requirements change management process in global software development. <i>Journal of Computer Languages</i> . 51. 10.1016/j.col.2018.12.005.
S20	A. Mishra and D. Mishra, "Cultural Issues in Distributed Software Development: A Review," in <i>On the Move to Meaningful Internet Systems (OTM) 2014 Workshops</i> , vol. 8842, R. Meersman, H. Panetto, A. Mishra, R. Valencia-García, A. L. Soares, I. Ciuciu, F. Ferri, G. Weichhart, T. Moser, M. Bezzi, and H. Chan, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 448–456, 2014.
S21	N. M. Minhas, Qurat-ul-Ain, Zafar-ul-Islam, and A. Zulfiqar, "An Improved Framework for Requirement Change Management in Global Software Development," <i>Journal of Software Engineering and Applications</i> , vol. 07, no. 09, pp. 779–790, 2014. doi: 10.4236/jsea.2014.79072.
S22	M. A. Akbar, S. Mahmood, A. Alsanad, M. Shafiq, A. Gumaedi, and A. A. Alsanad, "Organization Type and Size Based Identification of Requirements Change Management Challenges in Global Software Development," <i>IEEE Access</i> , vol. 8, pp. 94089–94111, 2020. doi: 10.1109/ACCESS.2020.2995238.
S23	R. A. Khan and S. U. Khan, "Communication and Coordination Challenges in Offshore Software Development Outsourcing Relationship From Vendors' Perspective: Preliminary Results," <i>Malaysian Special Issue Science International (Lahore)</i> , vol. 26, no. 4, pp. 1425–1429, 2014.

TABLE 14. (Continued.) The selected SLR studies.

S24	I. Nurdiani, R. Jabangwe, D. Šmite, and D. Damian, "Risk Identification and Risk Mitigation Instruments for Global Software Development: Systematic Review and Survey Results," in <i>2011 IEEE Sixth International Conference on Global Software Engineering (ICGSE) Workshop</i> , Helsinki, Finland, Aug. 2011, pp. 36–41. doi: 10.1109/ICGSE-W.2011.16.
S25	M. A. Babar and C. Lescher, "Global Software Engineering: Identifying Challenges is Important and Providing Solutions is Even Better," <i>Information and Software Technology</i> , vol. 56, no. 1, pp. 1–5, Jan. 2014., doi: 10.1016/j.infsof.2013.10.002.
S26	M. Shameem, B. Chandra, R. R. Kumar and C. Kumar, "A systematic literature review to identify human related challenges in globally distributed agile software development: towards a hypothetical model for scaling agile methodologies," 2018 4th International Conference on Computing Communication and Automation (ICCCA), 2018, pp. 1–7, doi: 10.1109/CCAA.2018.8777533.
S27	M. Hussain, H. U. Khan, A. W. Khan, and S. U. Khan, "Prioritizing the Issues Extracted for Getting Right People on Right Project in Software Project Management From Vendors' Perspective," <i>IEEE Access</i> , vol. 9, pp. 8718–8732, 2021. doi: 10.1109/ACCESS.2021.3049226.

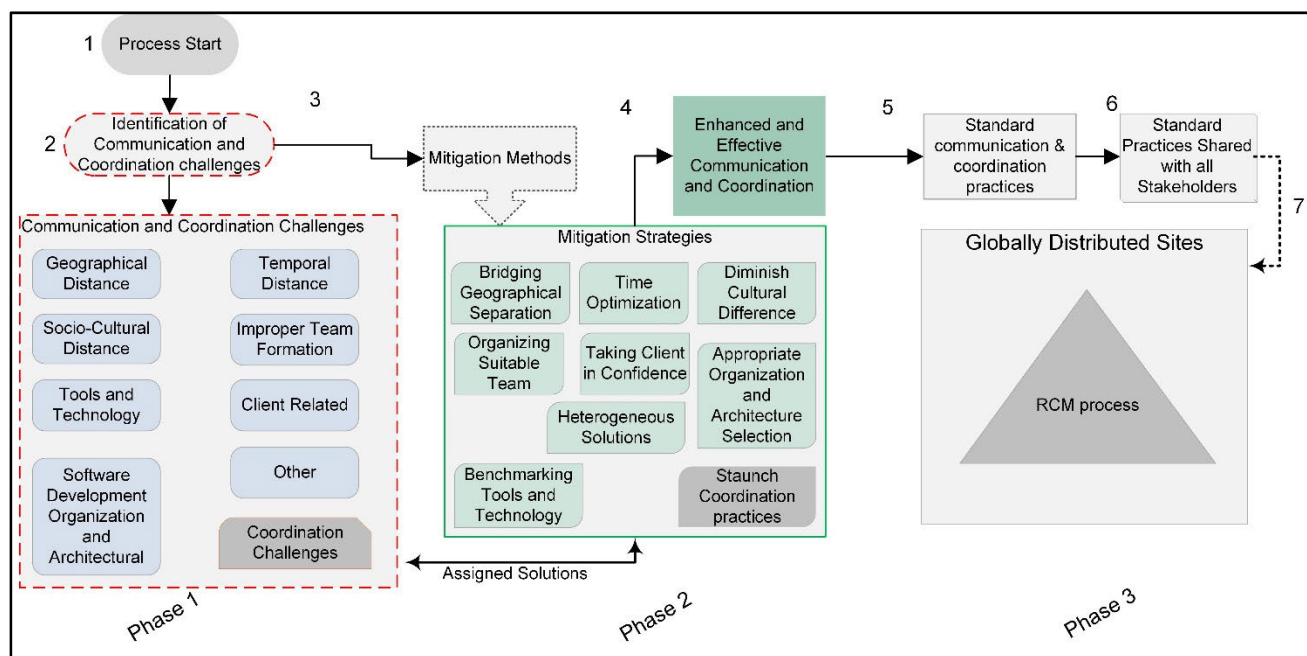


FIGURE 10. The proposed conceptual model.

different factors after conducting a detailed analysis. It might be possible that we missed some important challenges and solutions while analyzing a large number of challenges and mitigation practices. However, this threat has minimal impact on the found challenges and the corresponding mitigation practices. This is because that limited research has been conducted on the targeted research context. Thus, we have included some studies that partially addressed the communication and coordination challenges during the RCM in the GSD context.

After extracting and analyzing the relevant information regarding challenges and mitigation practices, we consulted with the domain experts (having strong industrial backgrounds) to categorize the different challenges and also highlight the best mitigation strategy.

VIII. RESEARCH IMPLICATIONS

The identified challenges and mitigation strategies support the practitioners, researchers, and stakeholders to effectively

manage the communication and collaboration at various off-shore sites. Note that the challenges and solutions are not only specific to the RCM process. Instead, the mitigation practices can be used to minimize the risks faced at any stage in the distributed development environment. As previously mentioned, improper communication and coordination are the main root causes of the failure of any software project. Hence, all the stakeholders must be prepared to effectively and timely communicate with each other at distributed locations.

Another research implication is that necessary tools supporting communication and coordination issues need to be developed. Thereby, it would help in optimally utilizing the development resources during RCM in the GSD context. The predefined standards and protocols for managing the requirement change, and communication and coordination are imperative for the project's success. Hence, the communication tools and practices highlighted in this research can help the offshore stakeholders to promptly

manage the important tools and techniques before outsourcing a software project.

The current work has categorized different communication challenges into different categories. Consequently, it would help in enhancing the understanding of novice researchers in the targeted research context. Additionally, the best mitigation practices are identified and reported that supports in managing the impact of communication and coordination challenges. As a result, it would support the researchers in understanding the complexity of the distributed software development process. From the software development organization's perspective, it would facilitate them to constructively manage the new requirements changes at multiple development sites.

IX. CONCLUSION AND FUTURE WORK

Requirements Change Management (RCM) in Global Software Development (GSD) is a troublesome, laborious, and time-consuming process that requires an enormous cost to manage the requirements changes. Effective communication and coordination protocols play an important role in the project's success, especially when the stakeholders are positioned at multiple geographically dispersed locations. To deal with this situation, RCM must be implemented by defining the basic set of rules, standards, and communication and coordination protocols to mutually respond to the stakeholders.

In this research, we performed a tertiary study by following the PRISMA guidelines and identified the communication and coordination challenges (and sub-challenges) faced by the stakeholders and project managers during the RCM process in GSD. Moreover, we also identified a generic set of challenges that occurred during requirements changes in the distributed development environment. Furthermore, the best mitigation strategies are mentioned that can effectively handle the identified communication and coordination challenges during the offshore development process. Finally, we proposed a conceptual model that provides complete support to the RCM process in the GSD context. To validate the proposed conceptual model, we consulted the domain experts. It has been observed that the standard communication channels can greatly help in handling the RCM process in GSD. As a result, it would help in reducing the development cost, effort, and time in the context of GSD. We believe that this study facilitates in bridging the gap between the researchers, practitioners, and stakeholders by extensively reviewing the current state-of-the-art in GSD research context, and providing a conceptual model effectively handle the found challenges.

In the future, we plan to enhance the proposed conceptual model by including more challenges and mitigation practices in the distributed development environment. In addition, we also plan to implement the proposed conceptual model on small-scaled global software development organizations in Pakistan to observe and present the performance-based results of the currently proposed conceptual model in future research work.

APPENDIX A

See Table 13.

APPENDIX B

See Table 14.

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