sustainability

MDPI

Article

Readiness Factors for Sustainable Lean Transformation of Construction Organizations

Kudrekodlu V. Prasad [1,2] and Venkatesan Vasugi [1,*]

[1] School of Civil Engineering, Vellore Institute of Technology, Chennai 600127, India; prasad.kv2019@vitstudent.ac.in
[2] National Institute of Construction Management and Research (NICMAR), Hyderabad 500101, India
* Correspondence: vasugi.v@vit.ac.in; Tel.: +91-44-3993-1025

Abstract: Despite significant research and development on lean construction over the last two decades, cases of sustained lean transformation are few. Readiness for lean transformation is considered an essential requirement. Several studies have been conducted to identify lean readiness factors and develop assessment frameworks in other sectors such as manufacturing, healthcare, pharmaceutical, emergency, higher education, etc., but none in construction. The main objective of this study is to identify the lean readiness factors for the successful lean transformation of construction organizations. Mixed methods of research have been adopted. Factors initially identified from the literature in other sectors and lean construction were further validated by a large team of lean experts. Seventy-three factors were identified, and a questionnaire survey was conducted to identify the critical lean readiness factors for construction organizations. One hundred and two responses were collected from expert lean practitioners and academicians from all over the world. The factors were ranked based on the Importance Index (II). Reliability analysis and ANOVA tests have been conducted. Support from top management, the process of understanding customer requirements, emphasis on team-working, critical data analysis, and constraint removal were found to be the top-ranked lean readiness factors. The study opens up new research directions in lean readiness evaluation and ensures sustained lean transformation of construction organizations.

Keywords: lean; readiness; factors; change; culture; construction; sustainability; lean transformation; reliability analysis; ANOVA tests

Citation: Prasad, K.V.; Vasugi, V. Readiness Factors for Sustainable Lean Transformation of Construction Organizations. *Sustainability* **2023**, *15*, 6433. https://doi.org/10.3390/su15086433

Academic Editors: Stavros T. Ponis and Péter Tamás

Received: 12 March 2023
Revised: 1 April 2023
Accepted: 6 April 2023
Published: 10 April 2023

1. Introduction

Construction projects underpin economic development [1] and the progress of all nations. The construction industry adds significantly to the Gross Domestic Product (GDP) in a vast majority of countries with nearly 13% of the global GDP [2,3]. However, construction projects are seldom completed within the planned time and cost [4]. Projects linger with management change problems, time overruns, cost escalations, claims, and disputes [5] resulting in huge wastages of time, effort, and all resources. It has also been a concern that over the years construction productivity has remained flat as compared to the manufacturing industry, and this lag translates to about USD 1.6 trillion of loss every year [6]. Research studies have indicated that construction sector productivity can be boosted by 5 to 10 times in some areas by adopting a manufacturing-style production approach [6].

The lean production system originated from Toyota's production system which, when implemented properly, has provided significant dividends to organizations. Despite the huge benefits of the lean production system, many organizations have been unsuccessful in their journey towards lean transformation and most organizations failed to reach the summit stage [7]. Successful lean transformation requires a transformation in the organizational culture [8]. If not addressed appropriately, the project of introducing lean culture

into an organization may not only end up as a failure but may also significantly impair the prevalent practices and routine business processes of the organization as well [9].

Organizational lean readiness reflects upon the organization's ability to undergo a smooth and sustainable lean transition and is developed by setting up practices, conditions, and resources facilitating lean change [10]. Studies have indicated lean implementation failure is also attributed to the fact that little attention is paid to organizational lean readiness [11,12]. To eliminate/reduce the failures in lean implementation, there needs to be an assessment of the organizational readiness levels before committing [13,14]. To ensure successful lean transformation, there needs to be an assessment of the organizational readiness levels [14]. This prior assessment of organizational readiness is intended to cut down the wasted effort and any waste during the process of lean transformation and will help ensure minimum disruption to the organizational process and business [8]. A planned organizational change would be more effective and efficient and would help organizations to measure the ability within the organization and aid in improving organizational capabilities [15].

Many studies have investigated the aspect of lean readiness in manufacturing and SMEs. However, lean implementation in service organizations is even more challenging as the processes are invisible or intangible [16], processes are complex and large, processes require efforts involving a lot of people, are dependent on technology, and are spread across many vendors [17]. There have been few studies in service industries such as healthcare [12,15,18–21], humanitarian organizations [8], and higher education sectors [22–24].

Construction projects are unique and differ from each other in scope, objectives physical setting, and characteristics [25], and it is not possible to generalize a common methodology for all projects. In addition, the peculiar nature of the construction industry and its difference from organizations in other sectors poses issues, and the differences can result in significant impacts on the choices of tools, techniques, and methods to be adopted [26]. Therefore, readiness assessment is extremely important and to date, there are no studies that have holistically investigated and established the lean readiness factors and framework to assess the readiness of construction organizations for lean transformation [27].

The present study, therefore, intends to address the following research questions:

RQ1: What are the lean readiness themes/criteria and the factors for construction organizations?

RQ2: What are the most critical lean readiness themes/factors for construction organizations and how do these vary from other industries/sectors?

RQ3: How can a lean readiness assessment framework be developed for construction organizations based on identified factors?

The present paper is structured as follows: the next section summarizes the literature review; the subsequent section presents the research methodology; the next section presents the analysis of the results; and finally, the paper concludes with some future research directions and limitations.

2. Literature Review

The literature review process was conducted in two stages. Firstly, to comprehend the studies carried out in other sectors, a systematic literature review (SLR) was carried out. Secondly, a traditional review of lean construction studies was conducted to understand the specifics of construction projects and derive the lean readiness factors. The following section of the paper summarizes the literature review.

2.1. Readiness Themes and Factors for Lean Transformation

To assess the works that were carried out on lean readiness, a systematic literature review (SLR) was carried out. The search query string—"Lean readiness" OR "readiness for lean" OR "readiness for lean implementation" OR "lean readiness assessment"—was set to include all journal research articles on lean readiness published in the English language in the Scopus and Web of Science (WOS) databases over the last decade. The search string

resulted in 260 documents from Scopus and 119 documents from the WOS database. The duplicates in the databases were removed with the help of Zotero software. A team of three experts from academia and industry helped to identify and narrow down the literature relevant to the objectives and eliminate any bias for further review. Finally, 53 research articles were selected for analysis.

As may be seen from Figures 1 and 2, out of the 53 articles, 27 of the studies (~51% of the studies) have focused on the manufacturing sector only. A total of 23 studies (43%) have been conducted in the service sectors. Again, as can be seen from Figure 2, these studies have been conducted in healthcare facilities [12,13,15,19,28–31], in emergency departments [16,18,32], higher education [23,33–36], and the construction industry [37–40]. The three service sectors—healthcare, higher education, and emergency—make up 70% of the studies within service sectors.

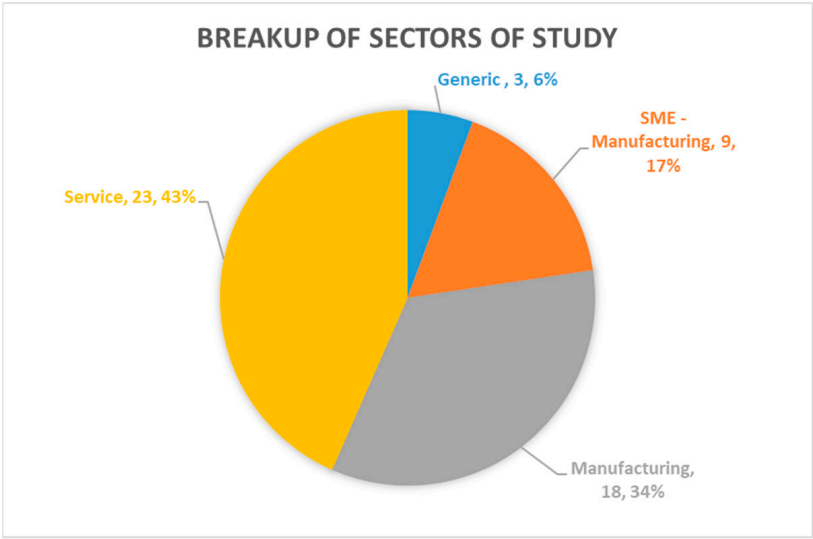

Figure 1. Distribution of articles by sectors.

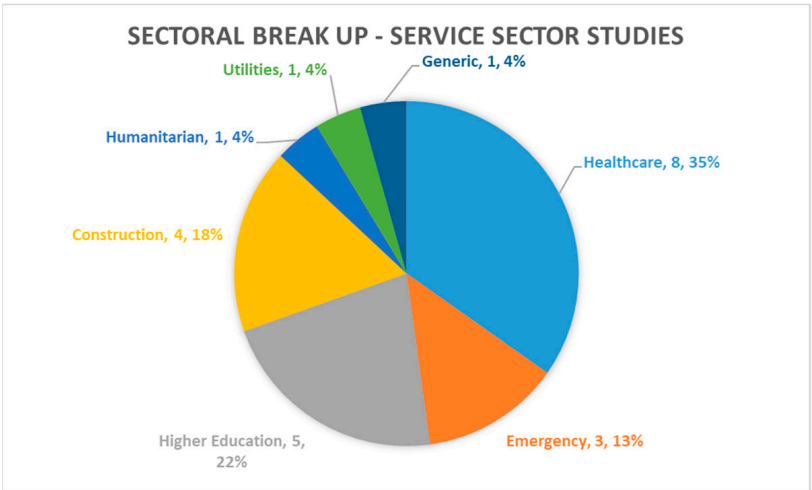

Figure 2. Distribution of service sector articles.

The four studies conducted in the construction sector, the study objectives, and the limitations are outlined in Table 1.

Table 1. Studies on lean readiness in the construction sector.

Study	Focus Area of the Study	Limitations of the Study
[37]	Lean Culture	Focuses only on cultural readiness; no holistic study on all the aspects of lean readiness
[38]	Lean readiness of Azerbaijan construction industry	Themes and factors such as those of the manufacturing sector studies adopted as they are; not customized to the construction industry; the study does not address the construction project lifecycle or processes
[39]	Construction Operations	Focuses only on the implementation of lean construction principles, but not readiness; lacks focus on softer attributes of lean readiness; outdated
[40]	Lean procurement	Focuses on the procurement process alone

As can be seen from Figures 1 and 2, and also Table 1, no comprehensive study has been carried out investigating the lean readiness factors for construction organizations.

This phase of review summarized "Organizational Readiness" themes and associated factors, which are largely applicable irrespective of the type/sector of the organization. These themes and factors represent the soft lean practices which apply to an organization in any sector/stream. These themes are discussed in the following section and factors are presented in Table 2. Twenty-eight lean readiness factors within the themes of leadership and top management commitment, organization Culture, employee/human Resources engagement, customer focus, communications and processes, and technology management were identified from the review of the fifty-three articles.

2.1.1. Top Management Commitment and Leadership

Any change management programme, including lean, needs the management's unwavering support throughout the implementation phases as well as the leadership's willingness to mentor and mitigate the risks of failure. Leadership should be able to create a vision that enables the employees to internalize the anticipated change and shift from current practices to best-in-class practices [23]. Top management must be prepared and show a willingness to be involved in resolving challenges that develop throughout the implementation, and leadership must completely enable the lean implementation teams by providing the necessary resources and infrastructure [19,41].

2.1.2. Organization Culture

Organizational culture can be defined as the shared assumptions regarding deep-rooted organization-wide values, norms, and beliefs [36], and the very definition of lean itself calls for a shift that relates to elements of cultural change. The culture of an organization greatly influences how well Lean transformations happen [42]. Organizational culture subtly directs the actions and behaviours of an organization's members [43]. Organizations can accomplish strengthening the "soft aspects" required for firms to be more successful in their lean transformation by enhancing these positive behaviours and attributes.

2.1.3. Employee/Human Resources Engagement

The success of lean implementation depends on the level of awareness of employees [44] on the concepts of lean, lean tools and techniques, and the benefits which can be realized from the implementation. Hence, educating and involving every employee in and around lean principles, methodologies, and practices is crucial [19]. One of the crucial key criteria for effective adoption is lean training [45]. Management should align organizational objectives with employee performance KPIs, motivate with reward systems, [46] and should encourage to take full ownership and corrective actions to improve the processes [41].

2.1.4. Customer Focus/Customer Relationships

The capacity to define the customer is one of the crucial elements for successfully implementing lean practices in any firm [47]. A well-defined value for a given customer group prevents conflicting needs and objectives and reduces resistance to change [19]. Organizational processes must be structured with the needs of the customer at the centre, and all initiatives for improvement must systematically take customer feedback into account at every stage [23].

2.1.5. Technology/Process Management

Organizations need to set up processes that can analyze the waste across the value stream, cut down on the non-value-adding activities, and improve the quality and value [14]. Organizations must make sure that performance is tracked to decrease variability and find ways to improve. There must be procedures in place to evaluate the costs and benefits of major undertakings and manage risks [12,41].

2.1.6. Communication

Communication is one of the cornerstones of lean practices [48]. Lack of effective communication with the stakeholders of the lean initiative can lead to failure [49] and organizations need to establish clear and effective communication channels to ensure communication with all team members [50]. The organization should set up a communication process that encourages the horizontal and vertical exchange of information and also share lessons on failures and short-term wins [41].

2.2. Readiness Themes and Factors from Lean Construction Studies

Having identified the lean readiness studies in other sectors, it was important to review the lean construction literature to identify lean readiness factors spanning the construction project lifecycle. The Lean Project Delivery System (LPDS) proposed by Prof. Ballard [51], shown in Figure 3, was taken up as a starting point.

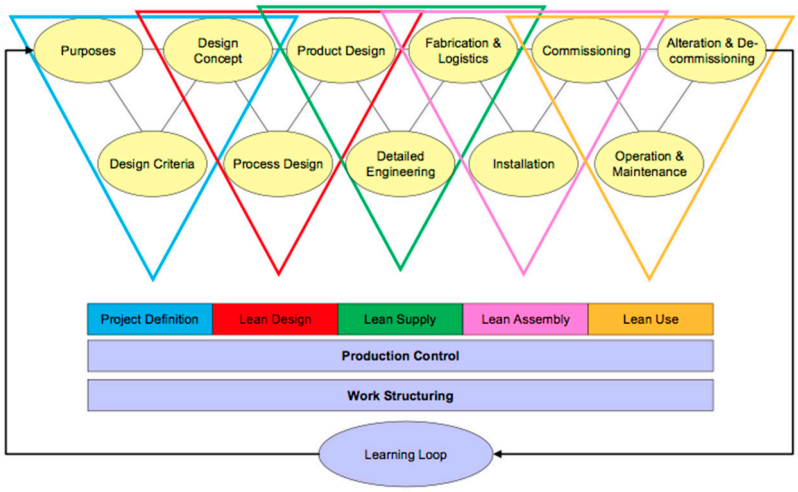

Figure 3. Lean Project Delivery System [51].

2.2.1. Engineering and Design

As can be seen from Figure 3, Project definition starts with the conceptual stage of engineering and design development and this process translated the project objectives to definitive outcomes. The study by [52] investigated the parameters that build lean ideology in the engineering and design management processes in construction projects. The factors identified by this study are selected for our study and listed in Table 3.

2.2.2. Project Planning, Monitoring, and Control

The Last Planner System® (LPS) has been one of the most commonly adopted production control methodologies based on lean philosophy. LPS was proposed as a novel solution by [53] to increase workflow predictability and increase work plan predictability by controlling the quality of assignments in weekly work plans. Studies by [54,55] identified parameters for planning and production control processes based on the LPS philosophy. The recently updated guideline [56], which was also considered, has touched upon the factors of work structuring and the visual management of plans in great detail.

2.2.3. Procurement and Inventory Management

Integrating lean practices with the supply chain, procurement, and material management, has been the interest of many studies [40,57–59]. These studies have advocated pull-based procurement, the use of automation and IT to minimise material requirements, standardized procurements, waste control, material reconciliation, housekeeping, and 5S methodologies in construction projects.

2.2.4. Contract Management

The other aspect of integrated lean project delivery is the aspect of work structuring, a process that designs and connects the project deliverables with suppliers, subcontractors, and other vendors. Towards this, studies [60–62] have advocated the practice of a relational contracting system that promotes balanced risk and opportunity sharing between the parties, transparency, and trust, and develops partnerships to build these in the supply chain contracts with all the vendors and contractors.

Twenty-five lean readiness factors were identified through a review of lean construction literature and are summarized in Table 3.

Table 2. Lean readiness themes and factors from the literature (organizational readiness themes).

Theme	Lean Readiness Factors
Top Management Commitment and Leadership	1. Support and commitment to new initiatives by providing the needed infrastructure [41,63]; 2. Commitment from the organization to economic and financial objectives along with growth and long-term survival [15,41]; 3. Dedication of time by senior management to ensure the adoption of improvement initiatives [21]; 4. Humble leadership with mutual respect for subordinates and peers [12].
Organization Culture	1. Strategic efforts and business goals, connected by systemic thinking [64]; 2. Cooperation between the organization and all of its stakeholders viz. customers, suppliers, etc. [12]; 3. Flexibility to respond to changing market conditions, client demands, and needs [41]; 4. Existence of a blame-free culture within the company [41]; 5. Focus on team collaboration in a project- or management-related environment [8].

Table 2. *Cont.*

Theme	Lean Readiness Factors
Employee Engagement/HR	1. Full participation of the workforce in all activities [16,19,41]; 2. Periodic multifunctional training employees to ensure employees develop the skill set to deploy problem-solving tools and techniques [15,20]; 3. Empowerment of the employees with full ownership to improve their work processes and implement corrective actions [14,41]; 4. Efforts of the employees are recognized and rewarded [8,65]; 5. Employee initiative to support projects and activities for continual improvement [41]; 6. Participation of lower-level or junior staff in project review meetings [21]; 7. Periodic feedback on employee performance [28].
Customer Focus	1. Project selection based on organizational competencies [23,66]; 2. Existence of a mechanism for determining the needs of and adding value to customers [19,23]; 3. Participation of the client in the project's planning and development [11,14,21]; 4. Customer feedback processes and mechanisms for ongoing improvement [11,14,21,23].
Communication	1. Regular communication on strategy and vision of key initiatives [29]; 2. Communicating with all employees the purpose, vision, strategy, goals, and objectives of the business [41,66,67]; 3. Information exchanges across the hierarchy—horizontal and vertical [15,41]; 4. Effective communication of short-term successes and failures [16,41,68].
Technology and Process Management	1. Benchmarking against the competition * [14,16,21]; 2. Using a performance measurement system (PMS) to comprehend the process's current state and potential improvement routes [41,66]; 3. Share the implementation's lessons learned with the entire firm, standardize the adjustments, and keep a record of them [66,67]; 4. Control mechanisms to minimize variation and sustain improvement [41].

* This attribute was revised further based on expert opinion.

Table 3. Lean readiness themes and factors from lean construction studies (lean project delivery themes).

Stage of Project Development	Lean Readiness Factors
Engineering and Design	1. Involvement of specialist designers [52]; 2. Exhaustive stakeholder requirement identification [52]; 3. Systematic participation of clients in the design phase [52]; 4. Collaboration with stakeholders during design meetings [52]; 5. Systematic identification, and release of the constraints [52]; 6. Consideration of all lifecycle stages in the design process [52].
Project Planning	1. Formalized planning process [54]; 2. The correct definition of work packages [55]; 3. Standardization of planning meetings [54,55]; 4. Use of a transparent, understandable master plan; 5. Inclusion of constraint-free work packages [56]; 6. Shared decision-making [56].
Project monitoring	1. Use of visual devices [55,56]; 2. Performance metrics [55]; 3. Constraint analysis [54]; 4. Workable backlogs [56]; 5. Analysis of physical flows [56]; 6. Schedule performance indicators [56]; 7. Corrective actions [54–56].
Procurement and Inventory Management	1. Pull-based procurement [40]; 2. Existence of housekeeping procedures and material classification by class or category [40,57–59].
Contract Management	1. Risk sharing [62]; 2. Transparency [61]; 3. Regular communication [60]; 4. Incentives for performance linked with KPIs [62].

3. Research Methodology

The entire research work was carried out in four stages as summarized in Figure 4.

A four-stage methodology has been adopted for the present study. Initially, a systematic literature review was conducted to identify the lean readiness attributes from the literature in other sectors. During this phase, fifty-three studies were reviewed, and twenty-eight attributes were identified. These are presented in Table 2. These identified factors represent organizational themes that shall be applicable in any sector/type of organization. However, these factors by themselves will not represent the construction industry and its operations. Therefore, a review of lean construction studies was carried out. The factors were identified so as to represent the full life cycle of the construction project delivery. In this phase, twenty-five attributes were identified. These are presented in Table 3. After this stage, it was necessary to examine and validate the factors identified. Expert opinion was sought from seventeen international lean construction experts who reviewed and recommended the addition of a further twenty factors, which are presented in Table 4. The finalized list of fifty-three attributes was taken up for the questionnaire survey and a Likert scale survey was carried out to examine the critical lean readiness factors for construction organizations. One hundred and two experts from twenty-two nations participated in the survey. The survey tests were analyzed with SPSS software, and Reliability, ANOVA, and

post hoc tests were conducted. The respondent profile is summarized in Table 5. Reliability test results are summarized in Table 6.

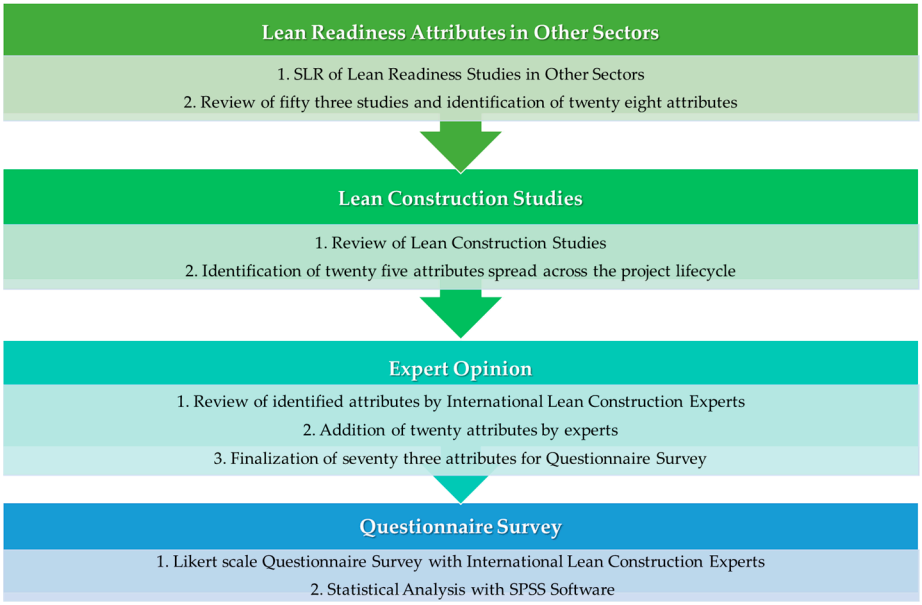

Figure 4. Research methodology adopted for the study.

Table 4. Expert comments on the initially identified lean readiness factors.

Expert No	Lean Construction Experience (Academic + Research)	Nationality	Expert Comments on Initial List of Factors
1	40	India	Refine some factors for clarity and readability. Add further factors: 1. Analyzing the cost–benefit of important initiatives and classifying the crucial processes; 2. Use of portable devices for monitoring.
2	21	Canada	Interesting topic and further research is called for. Add the factors of lean culture listed below within the organizational culture theme: 1. Scientific thinking; 2. Perfection.
3	15	India	1. Short-term collaborative planning to be emphasized.
4	12	UK	The factors summarized are found relevant.
5	15	India	1. Planning the budget for continuous improvement/lean as a factor needs to be included in project planning.
6	9	India	No comments. Agreed in principle.
7	17	Singapore	Agreement in principle on the factors proposed.
7	16	India	Agreement in principle on the factors proposed.
9	16	India	1. Technology for seamless process integration to be included.
10	16	India	No comments. Agreed in principle.
11	32	India	To include the below factor in project planning: 1. Involvement of employees at the lowest level—last planners in the project planning activities.

Table 4. *Cont.*

Expert No	Lean Construction Experience (Academic + Research)	Nationality	Expert Comments on Initial List of Factors
12	32	Chile	Factors considered comprehensive. Include further factors for 1. Non-hierarchical culture; 2. Active management of the network of commitments; 3. Continuous measurement of value throughout the project lifecycle; 4. Focus on planned execution than monitoring of variances; 5. Alignment of project interests with all stakeholders.
13	17	Finland	1. To include transparency of project performance.
14	32	USA	1. Benchmarking against competition as a practice is not appropriate. Revise this factor to "learning from whomever including competitors and own past performance."
15	32	UK	Factors are comprehensive.
16	17	India	No comments. Agreed in principle.
17	15	India	Include additional factors listed below within the inventory and wastage control theme: 1. Rationalized site layouts; 2. Procuring supplies in the required sizes, lengths, and dimensions on the job site; 3. Reconciliation practices; 4. IT tools for optimised resource consumption; 5. Analysis, review, and control of the cost of quality.

Table 5. Profile of the Participants.

Parameters	Number of Responses	%	Parameters	Number of Responses	%
Role			**Countries**		
Clients	11	11%	India	57	56%
Contractors	32	31%	Brazil	8	8%
Architects and Consultants	15	15%	UAE	4	4%
Academicians	44	43%	Australia	4	4%
Total	**102**		Chile	4	4%
			Malaysia	3	3%
Professional Experience			USA	3	3%
<5 Years	12	12%	England	2	2%
5 to 10 Years	21	20%	Saudi Arabia	2	2%
10 to 15 Years	32	31%	Qatar	2	2%
15 to 20 Years	11	11%	Canada	2	2%
>20 Years	26	26%	Other 11 countries (1 each)	11	10%
Total	**102**		**Total**	**102**	

Table 6. Reliability test results.

Description	Number of Items	Cronbach's Alpha
Questionnaire Responses	73	0.962

3.1. Design of the Questionnaire

The questionnaire was designed to seek and capture responses from lean construction experts from all over the world. The literature review and expert opinion phase elaborated in earlier sections of the paper helped finalize the lean readiness factors for construction organizations. This list was categorized broadly into two groups. The first one comprised organizational lean readiness themes commonly applicable for any organization viz. leadership and top management commitment, organizational culture, employee engagement, customer focus, communications, and technology and process management; and the other group comprised themes and factors specifically applicable to lean project delivery viz. engineering and design management, project planning, project monitoring, procurement and inventory management, and contract management. These are shown in Tables 7 and 8.

Table 7. Lean readiness themes and factors with ANOVA results (organizational themes).

Lean Readiness Theme	Lean Readiness Factors	RII	ANOVA Test Significance
Top Management Commitment and Leadership (RII: 0.884)	• Support and commitment to new initiatives by providing needed infrastructure;	0.945	0.203
	• Commitment from the organization to economic and financial objectives along with growth and long-term survival;	0.886	0.337
	• Humble leadership with mutual respect for subordinates and peers	0.875	0.490
	• Dedication of time by top management to ensure the adoption of initiatives for continuous improvement.	0.882	0.694
Customer Focus (RII: 0.845)	• Project selection based on organizational competencies;	0.814	0.201
	• Existence of a mechanism for determining the needs of and adding value to customers;	0.904	0.332
	• Participation of the client in the project's planning and development;	0.790	0.892
	• Customer feedback processes and mechanisms for ongoing improvement;	0.845	0.291
	• Value is monitored and measured continuously during the project lifecycle.	0.873	0.929
Organization Culture (RII: 0.847)	• Strategic efforts and business goals, connected by systemic thinking;	0.847	0.356
	• Cooperation between the organization and all of its stakeholders viz., customers, suppliers, etc.;	0.851	0.757
	• Flexibility to respond to changing market conditions, client demands, and needs;	0.849	0.122
	• Existence of a blame-free culture within the company;	0.865	0.994
	• Focus on team collaboration in a project- or management-related environment;	0.894	0.780

Table 7. *Cont.*

Lean Readiness Theme	Lean Readiness Factors	RII	ANOVA Test Significance
Organization Culture (RII: 0.847)	• Non-hierarchical culture, reduced barriers to creativity and innovation from all organizational levels;	0.775	0.334
	• Culture of seeking perfection;	0.745	0.118
	• Culture of embracing scientific thinking;	0.776	0.396
	• The network of commitments is actively managed across the organization.	0.808	0.889
Employee Involvement and Engagement (RII: 0.852)	• Full participation of the workforce in all activities;	0.757	0.061
	• Periodic multifunctional training employees to ensure employees develop the skill set to deploy problem-solving tools and techniques;	0.812	0.314
	• Empowerment of the employees with full ownership to improve their work processes and implement corrective actions;	0.865	0.507
	• Efforts of the employees are recognized and are rewarded;	0.880	0.723
	• Employee initiative to support projects and activities for continual improvement;	0.839	0.859
	• Participation of lower-level or junior staff in project review meetings;	0.761	0.364
	• Employees are assigned clear roles and responsibilities;	0.871	0.421
	• Periodic feedback on employee performance.	0.867	0.317
Communication (RII: 0.854)	• Regular communication on strategy and vision of key initiatives;	0.867	0.337
	• Communicating with all employees the purpose, vision, strategy, goals, and objectives of the business;	0.841	0.479
	• Information exchanges across the hierarchy—horizontal and vertical;	0.880	0.225
	• Effective communication of the short-term successes and failures.	0.831	0.691
Technology/Process Management (RII: 0.847)	• Learn from whomever you can, including competitors, but benchmark against your own previously best performance;	0.839	0.391
	• Measuring and analyzing the cost of key initiatives, categorizing the critical processes;	0.851	0.026 *
	• Using a performance measurement system (PMS) to comprehend the process's current state and potential improvement routes;	0.843	0.459
	• Share the implementation's lessons learned with the entire firm, standardize the adjustments, and keep a record of them;	0.865	0.409
	• Availability of appropriate technology for seamless implementation of the organizational processes;	0.818	0.524
	• Control mechanisms to minimize variation and sustain improvement.	0.851	0.508

* Indicates difference in perception between the group of respondents is significant at the 95% confidence level.

Table 8. Lean readiness themes and factors with ANOVA results (lean project delivery themes).

Lean Readiness Theme	Lean Readiness Factors	RII	ANOVA Test Significance
Engineering and Design (RII: 0.866)	• Involvement of specialized designers in the project's early stages;	0.867	0.192
	• Exhaustive identification of the stakeholders' requirements and definition of special requirements, technical specifications, and project constraints;	0.865	0.504
	• Seek out and incorporate regular client input during the design phase;	0.867	0.405
	• Collaboration with stakeholders during design meetings concerning decision-making and problem resolution;	0.865	0.201
	• Process of systematic and collaborative identification, and the release of the constraints in the design process by a responsible person;	0.857	0.532
	• Consideration of all lifecycle stages in the design process.	0.871	0.572
Project Planning (RII: 0.851)	• Formalization of the planning and control process;	0.888	0.323
	• A correct definition of work packages;	0.871	0.178
	• Standardization of meetings for short- and long-term planning;	0.851	0.108
	• Use of a transparent, understandable master plan;	0.853	0.939
	• Emphasis on short-term planning;	0.804	0.458
	• Inclusion of only work packages without constraints in short-term plans;	0.757	0.825
	• Participation of crew members and last planners in collaborative planning;	0.880	0.471
	• Participation of project stakeholders in short-term planning sessions;	0.810	0.510
	• Provision and commitment of adequate financial resources in the base budget/plan/tender for "lean/improvement initiatives/processes".	0.851	0.010 *
Project Monitoring and Control (RII: 0.834)	• Use of visual devices to disseminate information at the construction site;	0.806	0.006 *
	• Utilizing metrics to assess performance and taking remedial actions based on the causes of non-completions of plans;	0.849	0.108
	• Analyzing data critically and systematically removing restrictions;	0.892	0.093
	• Systematic revision of the master plan as needed;	0.841	0.960
	• Planning and controlling physical flows;	0.855	0.756
	• Use of indicators to assess schedule accomplishment;	0.851	0.576
	• The practice of scheduling a workable back-log of tasks;	0.820	0.582
	• Continuous, transparent automated process measurement;	0.820	0.500
	• Utilizing portable devices to keep track of and update projects;	0.776	0.452
	• Focus on ensuring that the project is executed as planned instead of variance detection.	0.827	0.275

Table 8. *Cont.*

Lean Readiness Theme	Lean Readiness Factors	RII	ANOVA Test Significance
Inventory and Wastage Control (RII: 0.837)	• Inventory planning and procurement based on production plan—"Pull" based approach;	0.841	0.135
	• Rationalized planning and location of material stockyard facilities suiting to site and work requirements;	0.837	0.463
	• Existence of housekeeping procedures and material classification by class or category;	0.808	0.191
	• Procuring supplies in the required sizes, lengths, and dimensions on the job site;	0.845	0.176
	• The existence of practices for the reconciliation of materials, determining wastage and control;	0.835	0.007 *
	• Use of IT tools to optimize the usage of resource consumption and cost reduction;	0.829	0.041 *
	• Analysis, review, and control of the cost of quality.	0.878	0.047 *
Contract Management (RII: 0.853)	• The interests of all stakeholders are aligned;	0.859	0.445
	• Structuring of agreements with key risks shared, such as delay risk or rectification work;	0.853	0.076
	• Operational transparency through open-book accounting;	0.798	0.381
	• Substantial and consistent communication to address new challenges;	0.863	0.945
	• Existence of a reward system that is based on project results or KPIs.	0.847	0.139

* Indicates difference in perception between the group of respondents is significant at the 95% confidence level.

The authors invited the opinion of ten experts for the review and evaluation of the questionnaire. The experts included five senior academicians with significant lean construction research experience and five experts from the construction industry engaged in the implementation of lean construction practices. Some sections and parts of the questionnaire were refined, and some factors were reframed for better clarity as recommended by the experts during their initial review.

The questionnaire was structured into five parts. The first part of the questionnaire explained the context, needs, and objectives of the study, the questionnaire structure and what was expected from the respondents, and the process of responding to the questions. The second part sought information on the respondents' profile viz. name of the organization, job designation, the role of the organization (clients/contractors/consultants/academicians, etc.), and the total professional experience. The fourth part required respondents to rate the organizational lean readiness factors (applicable for any organization), and the fifth part required respondents to rate construction organization-specific lean readiness factors on a Likert scale of 1 to 5 with 1 for an attribute with the lowest importance to lean readiness and 5 for an attribute with the highest importance to lean readiness. The Relative Importance Index (RII) for the factors was calculated using the following formula:

$$\text{Relative Importance Index (RII)} = \sum W/(A \times N).$$

W depicts the rating provided by the respondents (from 1 to 5) for each of the lean readiness factors, A is the highest rating that can be assigned to an attribute (which is 5 in the present case), and N represents the total valid number of respondents in the survey.

The values of the Relative Importance Index (RII) range from 0 to 1. A higher value (nearer to 1) indicates that the attribute is more pertinent and important for organizational lean readiness. The lean readiness factors were ranked based on RII. The higher the value of RII, the higher the ranking of the lean readiness attribute and its sig-

nificance for organizational lean readiness. The questionnaire PDF copy is annexed as Supplementary Material S1.

3.2. Questionnaire Dissemination and Data Collection

The research work is intended to cover leading academicians, researchers, and industry professionals in the field of lean construction. Connecting with global practitioners was initially perceived as a challenge. Every year, the International Group of Lean Construction (IGLC) and the Lean Construction Institute (LCI) organize an annual conference which discusses the latest research activities and works in the field of lean construction. The IGLC also releases the conference proceedings, which are available on the website. The authors retrieved the proceedings of the last three annual conferences, which provided the contact details of the authors. The name, emails, and affiliations of the authors were populated in an excel spreadsheet. The initial list generated 702 entries. This list, however, included undergraduate, graduate students, and postgraduate students. Filters were applied and the list was restricted to academicians/faculties, doctoral research scholars, and industry professionals. Authors had set up conditional formatting to detect any duplicates in the entries and these were also simultaneously removed. This reduced the list to 423 entries. However, it was found that the email addresses were invalid or had moved from the organizations when the authors tried to contact these email IDs, as emails bounced. Effectively, about 145 respondents could be contacted. The questionnaire was designed and prepared in Google forms and was sent to the correct list of finalized respondents.

3.3. Data Analysis and Synthesis

The finalized questionnaire was communicated through google forms to 145 respondents. In aggregate, 102 valid responses were obtained (a rate of response of 70%). The responses were received from 22 different nations across the world. The details of the respondents are summarized in Table 5.

As may be seen from Table 5, the respondents comprise a good mix of all of the professional roles, with 68% of the respondents having experience of more than 10 years, and they originate from 22 nations across the world.

One of the essential requirements of data analysis in a questionnaire survey is the reliability of the responses. Reliability reflects the degree of internal consistency of the items in a questionnaire. This is evaluated by Cronbach's alpha in SPSS Version 26. A value of alpha exceeding 0.7 is considered to be acceptable and, in the present case, the SPSS test results returned a value of 0.962, which is well above the threshold and therefore confirms that the questionnaire is very reliable. The results are presented in Table 6.

To examine whether any significant statistical difference exists in the opinion of the four groups of respondents, a one-way analysis of variance (ANOVA) test was conducted. For this analysis, the respondents were divided into four groups by their professional role viz. academicians, clients/owners, contractors, and architects/consultants. The ANOVA test was conducted at a 95% confidence level. The test results with the various lean readiness themes and factors, including significance values, are presented in Tables 7 and 8. From the test results, it can be seen that 68 factors (93%) out of a possible 73 factors were found to be without any significant statistical difference, which meant there was a general agreement in the opinion of all the groups of respondents. To further examine these differences, post hoc tests were also conducted. The authors carried out a Turkey Honestly Significant Difference (Turkey HSD) statistical test. Turkey HSD implements pairwise comparisons among all groups and tests for significant statistical differences. It was found among the five factors, only two factors had significant differences—provision and commitment of adequate financial resources; and use of visual devices to disseminate information at the construction site. The difference was observed between academicians and contractors. This can be attributed to the fact that the academics are aware of, and insist on, sufficient financial resources for lean implementation, and also provide visual updates.

However, for a contractor, this involves cost/expense, and they may be constrained to provide this upfront.

4. Results and Discussion

The finalized list of lean readiness factors, along with the results of the statistical analysis, are presented in Tables 7 and 8. The "organizational readiness" themes are presented in Table 7. Through the literature review, initially, 28 lean readiness factors were identified, and, with further expert opinion, the experts recommended a further eight factors. Thus, a total of 36 factors were developed for the organizational readiness group. In the second phase, the lean construction literature was reviewed, and 25 factors were initially identified. Further, 11 additional factors were recommended by the experts. Thus, a total of 37 factors were developed within the "Lean Project Delivery Group". These are presented in Table 8.

The results of the survey with the top fifteen lean readiness factors for construction organizations are presented in Table 9.

Table 9. Top lean readiness factors.

Lean Readiness Factors	Relative Importance Index (RII)
Support and commitment to new initiatives by providing needed infrastructure	0.945
Existence of a mechanism for determining the needs of and adding value to customers	0.904
Focus on team collaboration in a project- or management-related environment	0.894
Critical analysis of data and systematic removal of constraints	0.892
Formalization of the planning and control process	0.888
Commitment from the organization to economic and financial objectives along with growth and long-term survival	0.886
Humble leadership with mutual respect for subordinates and peers	0.882
Efforts of the employees are recognized and are rewarded	0.880
Information exchanges across the hierarchy—horizontal and vertical	0.880
Participation of crew members and last planners in collaborative planning	0.880
Analysis, review, and control of the cost of quality	0.878
Dedication of time by top management to ensure the adoption of initiatives for continuous improvement	0.875
Value is monitored and measured continuously during the project lifecycle	0.873
Employees are assigned clear roles and responsibilities	0.871
Consideration of all lifecycle stages in the design process	0.871

As can be seen from the results, support from top management ranks the highest (RII: 0.945) among all factors. It can also be seen that out of the fifteen factors, all four factors associated with the theme of top management commitment and support viz. the commitment from the organization to economic and financial objectives along with growth and long-term survival (RII: 0.886), humble leadership with mutual respect for subordinates and peers (RII: 0.882), the dedication of time by top management to ensure the adoption of initiatives of continuous improvement (RII: 0.875) have been ranked high. Lean transformation is a management change initiative, and handholding and support from top management are vital [46]. Guidance during the journey of change management is one of the major requirements during the implementation of lean transformation. The top management and leadership within an organization are responsible for providing this guidance [69]. A lack of readiness will expose the organization to unexpected challenges

and constraints, derailing the initiative [12]. The leadership team needs to lay down the roadmap for implementation and they need to visualize the future state. The top management team needs to be prepared and committed. The organization can demonstrate this by developing a clear vision and strategic leadership that ensures sufficient financial resources [46]. Humble leadership, showing respect for peers and subordinates, helps the employees grow and promotes creative thinking, individual and team performance, job satisfaction, a sense of empowerment, and work engagement [70], which is very important for lean transformation.

One of the core principles of the lean production philosophy is to produce a product or provide a service which is of more value to the end customer whilst simultaneously optimizing resources. Two of the factors of customer value—the existence of a mechanism for determining the needs of and adding value to customers (RII: 0.904) and the monitoring of customer value at all the project lifecycle stages (RII: 0.873)—have been ranked highly. Capturing the customer requirements helps in defining the customer and eliminating wastes from the project activities that do not add any value [71].

Focus on team collaboration in a project is the third most highly ranked attribute (RII: 0.894). Lean transformation and sustainable results require solid teamwork. Effective teamwork is essential for successful lean organizations as improving the processes and solving problems are managed effectively by work teams; successful lean organizations must ensure effective teamwork [72].

In a construction project, the planning of the project forms a very important aspect, and it paves the way for the successful delivery of the project. Nearly 74% of the processes relating to construction project management belong to planning and monitoring [52]. Two factors of project planning—formalization of the planning and control process (RII: 0.888) and collaborative planning with last planners (RII: 0.880)—are the essential factors which help in developing a foolproof plan. The organizations need to have an established planning process and when the plans are developed involving the last planners, there is greater understanding and also shared accountability, which ensures the plan is properly implemented on the site. In addition, the attribute of critical analysis of data and systematic removal of constraints (RII: 0.892), ranked fourth, is also very important to ensuring that the project does not become affected by constraints, and a periodic check, review, and removal of these constraints ensures the project activities are executed as per the plan with the least wastage of time and resource efforts. Proactive removal of constraints helps in channeling only constraint-free work to execution, improves the workflow continuity while increasing the reliability of the planning process [73], and therefore ensures optimum usage of resources.

In the lean philosophy, people form an integral part of the process of value creation, and these are highly dependent on commitment from employees and employee engagement in the process of learning and problem-solving [74]. One of the key challenges during the lean transformation is attaining employee engagement. Rewarding and recognizing employees for their efforts (RII: 0.880) is ranked eighth. An organization should have a mechanism to periodically monitor employees' contributions and reward them, which can motivate them [75] to engage in organizational activities properly. The attribute of employees being assigned clear roles and responsibilities (RII: 0.871) is ranked fourteenth. Ambiguity in roles and responsibilities would lead to a negative impact and commitment toward lean transformation [76]; therefore, the organization needs to provide this clarity to all employees.

Information exchanges across the hierarchy—horizontal and vertical—is ranked ninth (RII: 0.880). Communication is the primary thread that runs through the lean transformation, and, in many ways, it drives the change management efforts [77]. When the process of lean transformation begins to take shape in an organization, communication and cross-boundary collaboration must be ensured and the lean environment must promote vertical, horizontal, and two-way communication. To ensure the dissemination of valuable and timely information about the various ongoing changes within the organization, and alarm

or warn relevant parties about any potential barriers that may arise during the progressive implementation of the changes, bottom-up communication is also essential [78].

All lifecycle stages are considered in the design (RII: 0.871) as the fifteenth-ranked attribute. The successful execution of construction projects stems from a constructible, well-thought-of, implementable design which considers all the constraints on the project site. The project plans, methodology, and execution all rest on the design of the project and its components. If the design stages and iterations are not appropriately planned, this can result in repetition, the redesigning of work, rework, and time and cost overruns [79]. The organization needs to consider all parameters and all stages during the design stage itself, which has the potential to eliminate much waste. The integration of these lean principles in design stages has been found to improve stakeholder satisfaction and collaboration [52]

Analysis, review, and control of the cost of quality (RII: 0.878) factor is ranked sixteenth. The essence of the lean philosophy is the reduction of waste in all forms. It has been estimated that the rework and defects and non-conformance in construction projects account for about 10% to 20% of total project cost [80]. This is a phenomenal amount of waste considering the sustainability aspects and the huge scarcity of natural resources today. Organizations should have systems in place to periodically review the cost of quality (control costs and costs of failure) and ensure minimum wastage [81].

As seen from the results of the top 15 factors, factors are distributed over all of the lean readiness themes, and it is therefore essential for construction organizations to carefully look into these themes and factors in their journey towards lean transformation.

5. Theoretical Implications

The present study, for the very first time, has identified the lean readiness factors for construction organizations. During the review of lean construction literature, it surfaced that no attempt at a detailed study to investigate the lean readiness of construction organizations had been taken up to date.

Regarding the first RQ1—What are the lean readiness themes/criteria and the lean readiness factors for construction organizations?—through a multistage process of literature review and expert opinion, the present study has identified 73 lean readiness factors for construction organizations. Here, again, the study has made a clear distinction between the "organizational readiness" group with six themes and the "lean project delivery" group with five themes. The results of the survey also indicate that 10 out of 15 top-ranked factors were from the "organizational readiness themes", reinforcing one of the earlier study's [80] findings that soft lean practices enhance organizational readiness and pave the way for successful lean implementation, which would stand good for construction organizations as well.

Secondly, regarding the RQ2—What are the most critical lean readiness themes/factors for construction organizations and how do these vary from other industries/sectors?—the present study has identified unique themes "Engineering and Design", "Project Planning", "Project Monitoring", "Inventory and Wastage Control" and "Contract Management", which have never been documented in any lean readiness study earlier. With the RII of the themes (mentioned in Table 6), it could be found that "Engineering and Design" (RII: 0.866) is the highly ranked theme as it sets the path for construction project delivery and therefore lays the foundation for lean readiness upfront. Secondly, "Contract Management" focuses on developing partners and collaborative partnerships, which is essential for a "lean project delivery" in its true sense. Without the meaningful participation of all of the contractual parties, the lean transformation will not be sustained. These are followed by "Project Planning", "Project monitoring", and "Inventory and Waste Control", which develop the course [82] and strategy and build the project objectives into reality.

Further, regarding the RQ3—How can a lean readiness assessment framework be developed for construction organizations based on identified factors?—based on the lean readiness factors, further studies need to be conducted on developing lean readiness assessment frameworks for construction organizations. These frameworks shall assess or-

ganizational readiness and identify potential areas of improvement for sustained lean transformation. Previous assessment frameworks are based on subjective questionnaires [14,21] and complex fuzzy systems [20,66,67], which shall not help with the construction project characteristics mentioned in the earlier section, and the framework should consider objectively evaluating the lean readiness level by verifying the state of the processes and practices supported by documentation review. The framework shall also consider the importance of the various criteria and should weigh those accordingly, unlike the linear scales and the Likert scale surveys adopted by earlier studies, which shall help in a more realistic assessment.

6. Practical Implications

The study contributes significantly to the industry; that is, to organizations embarking on lean transformation which can focus on the lean readiness factors identified in this study and the institutionalizing mechanisms and processes for establishing organizational settings as depicted by the listed factors which shall immensely reduce wasteful transformation efforts and failures and ensure sustainable transformation. One of the significant difficulties faced by service organizations is that the processes are intangible [16] and involve many people; this is even more the case with construction organizations, which makes it difficult to measure the extent of deployment. Through the present study and the identified attributes, construction organizations can incrementally focus on lean readiness conditions in individual processes such as engineering, planning, etc., evaluating the identified themes, and then scale it up across all the processes/the entire lifecycle. The respective departments within the organization may be taken up for training and transformation in an incremental manner and clear progress and visibility is possible with the identified factors.

7. Conclusions

The present study has demonstrated the unique lean readiness factors for construction projects. The present study expanded lean readiness to the full lifecycle of construction projects, covering all processes and key activities, and identifying lean readiness factors within each of these stages. The survey conducted has provided rich insights into the factors pertaining to lean readiness for construction projects. The top management's commitment and support, organization culture, communication, and employee engagement themes were the generic organizational readiness themes which were highly rated. With expert opinion, twenty new lean readiness factors were identified for construction organizations. The present study has developed the "lean project delivery" group with 37 lean readiness factors (literature + expert opinion) which is a unique contribution of the study. Amongst the construction project lifecycle themes, "Engineering and Design", "Contract Management" and "Project Planning" were found to be the top-ranked lean readiness themes. Construction organizations embarking on lean transformation should carefully look into the themes and factors and investigate the readiness based on the factors identified in this study to ensure successful, sustainable, lean transformation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15086433/s1, The questionnaire is enclosed as Supplementary Material S1.

Author Contributions: Conceptualization, K.V.P.; methodology, K.V.P.; software, K.V.P.; validation, K.V.P. and V.V.; formal analysis, K.V.P.; investigation, K.V.P.; writing—original draft preparation, K.V.P.; writing—review and editing, K.V.P.; supervision, V.V.; project administration, V.V. All authors have read and agreed to the published version of the manuscript.

Funding: The Article Processing Charges towards Open Access Publishing of this research are funded by the Vellore Institute of Technology, Chennai, India.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all the participants of this study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the ethical requirements and confidentiality of the participant details.

Acknowledgments: The authors would like to acknowledge and thank all of the experts who provided their valuable inputs, recommendations, and guidance to identify and finalize the lean readiness factors for construction organizations. The authors also acknowledge the participants of the survey for their valuable input. The authors thank the reviewers and editors for valuable recommendations towards the improvement of this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Prasad, K.V.; Vasugi, V.; Venkatesan, R.; Bhat, N.S. Critical causes of time overrun in Indian construction projects and mitigation measures. *Int. J. Constr. Educ. Res.* **2019**, *15*, 216–238. [CrossRef]
2. International Labour Organization. Impact of COVID-19 on the construction sector. In *ILO Sectoral Brief*; International Labour Organization: Geneva, Switzerland, 2021; pp. 1–12.
3. Organisation for Economic Co-operation and Development. The global construction sector needs a big push on corporate responsibility. In *OECD Insights*; OECD: Paris, France, 2016; pp. 1–8.
4. Prasad, K.V.; Vasugi, V.; Venkatesan, R.; Bhat, N. Analysis of causes of delay in Indian construction projects and mitigation measures. *J. Financ. Manag. Prop. Constr.* **2019**, *24*, 58–78. [CrossRef]
5. Padala, S.P.S.; Maheswari, J.U.; Hirani, H. Identification and classification of change causes and effects in construction projects. *Int. J. Constr. Manag.* **2020**, *22*, 2788–2807. [CrossRef]
6. McKinsey Global Institute. *Reinventing Construction: A Route to Higher Productivity*; Mckinsey Global Insititute: New York, NY, USA, 2017; p. 168. Available online: http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution (accessed on 15 February 2023).
7. Bhasin, S. Measuring the Leanness of an organisation. *Int. J. Lean Six Sigma* **2011**, *2*, 55–74. [CrossRef]
8. Shafiq, M.; Soratana, K. Lean readiness assessment model—A tool for Humanitarian Organizations' social and economic sustainability. *J. Humanit. Logist. Supply Chain Manag.* **2020**, *10*, 77–99. [CrossRef]
9. Cimermančič, D.; Kušar, J.; Berlec, T. *A Procedure for the Introduction of Leanness into a Company*; Springer: Berlin/Heidelberg, Germany, 2021. [CrossRef]
10. Leite, H.; Radnor, Z.; Bateman, N. Meaningful inhibitors of the lean journey: A systematic review and categorisation of over 20 years of literature. *Prod. Plan. Control* **2022**, *33*, 403–426. [CrossRef]
11. Azalanzazllay, N.N.; Lim, S.A.H.; Abidin, U.F.U.Z.; Anass, C. Uncovering Readiness Factors Influencing the Lean Six Sigma Pre-Implementation Phase in the Food Industry. *Sustainability* **2022**, *14*, 8941. [CrossRef]
12. Narayanamurthy, G.; Gurumurthy, A.; Subramanian, N.; Moser, R. Assessing the readiness to implement lean in healthcare institutions—A case study. *Int. J. Prod. Econ.* **2018**, *197*, 123–142. [CrossRef]
13. Awang, M.; Idris, R.; Zakaria, Z. Lean Readiness Index for Malaysian Hospitals: An Exploratory Study. *Int. J. Ind. Eng. Prod. Res.* **2022**, *33*, 1–11. [CrossRef]
14. Al-Najem, M.; Dhakal, H.; Labib, A.; Bennett, N. Lean readiness level within Kuwaiti manufacturing industries. *Int. J. Lean Six Sigma* **2013**, *4*, 280–320. [CrossRef]
15. Vaishnavi, V.; Suresh, M. Assessment of readiness level for implementing lean six sigma in healthcare organization using fuzzy logic approach. *Int. J. Lean Six Sigma* **2021**, *12*, 175–209. [CrossRef]
16. Alnajem, M.; Garza-Reyes, J.A.; Antony, J. Lean readiness within emergency departments: A conceptual framework. *Benchmarking* **2019**, *26*, 1874–1904. [CrossRef]
17. Sarkar, D. *Lean for Service Organizations: A Holistic Approach for Achieving Operational Excellence and Improvements*; Milwaukee: Brookfield, WI, USA; American Society for Quality: Brookfield, WI, USA; Quality Press: Perth, Australia, 2007.
18. Poole, T.; Mazur, L.M. Assessing readiness for lean change in emergency department. In Proceedings of the IIE Annual Conference and Expo 2010 Proceedings, Expo Cancún, Mexico, 5–9 June 2010.
19. Al-Balushi, S.; Sohal, A.S.; Singh, P.J.; Al Hajri, A.; Farsi, Y.M.A.; Al Abri, R. Readiness factors for lean implementation in healthcare settings—A literature review. *J. Health Organ. Manag.* **2014**, *28*, 135–153. [CrossRef] [PubMed]
20. Vaishnavi, V.; Suresh, M. Assessment of healthcare organizational readiness for change: A fuzzy logic approach. *J. King Saud Univ. Eng. Sci.* **2022**, *34*, 189–197. [CrossRef]
21. Alnajem, M.; Garza-Reyes, J.A.; Elmelegy, A. Measuring the lean readiness of Kuwaiti manufacturing industries. *Int. J. Bus. Perform. Manag.* **2019**, *20*, 70–92. [CrossRef]
22. Kazancoglu, Y.; Ozkan-Ozen, Y.D. Lean in higher education: A proposed model for lean transformation in a business school with MCDM application. *Qual. Assur. Educ.* **2019**, *27*, 82–102. [CrossRef]
23. Antony, J. Readiness factors for the Lean Six Sigma journey in the higher education sector. *Int. J. Product. Perform. Manag.* **2014**, *63*, 257–264. [CrossRef]

24. Antony, J.; Thomson, S.P. Readiness Factors for the Implementation and Deployment of Lean Six Sigma (or Operational Excellence) in Higher Education. In *Lean Six Sigma in Higher Education*, 1st ed.; Antony, J., Ed.; Emerald Publishing Limited: Bingley, UK, 2020; pp. 53–60.
25. McCord, J.; McCord, M.; Davis, P.T.; Haran, M.; Rodgers, W.J. Understanding delays in housing construction: Evidence from Northern Ireland. *J. Financ. Manag. Prop. Constr.* **2015**, *20*, 286–319. [CrossRef]
26. Koohestani, K.; Poshdar, M.; Gonzalez, V.A. Finding the way to success in implementing lean construction in an unfavourable context. In Proceedings of the IGLC 28—28th Annual Conference of the International Group for Lean Construction, Berkeley, CA, USA, 6–12 July 2020; pp. 373–384. [CrossRef]
27. Prasad, K.V.; Vasugi, V. Lean readiness of organizations: An overview. *AIP Conf. Proc.* **2022**, *2393*, 5–10. [CrossRef]
28. Sohal, A.; de Vass, T.; Singh, P.; Al Balushi, S.; Al Hajri, A.S.; Al Farsi, Y.; Al Arbi, R. Assessing readiness for lean thinking in healthcare settings: The case for Oman. *Ind. Manag. Data Syst.* **2021**, *121*, 2338–2361. [CrossRef]
29. Patri, R.; Suresh, M.; Prasad, R. Modelling the leadership characteristics for organizational readiness: A context of lean implementation in healthcare. *Leadersh. Health Serv.* **2021**, *34*, 181–197. [CrossRef]
30. Vaishnavi, V.; Suresh, M. Modelling of readiness factors for the implementation of Lean Six Sigma in healthcare organizations. *Int. J. Lean Six Sigma* **2020**, *11*, 597–633. [CrossRef]
31. Ajmera, P.; Jain, V. A fuzzy interpretive structural modeling approach for evaluating the factors affecting lean implementation in Indian healthcare industry. *Int. J. Lean Six Sigma* **2020**, *11*, 376–397. [CrossRef]
32. Rees, G.H. Organisational readiness and Lean Thinking implementation: Findings from three emergency department case studies in New Zealand. *Health Serv. Manag. Res.* **2014**, *27*, 1–9. [CrossRef] [PubMed]
33. Allaoui, A.; Benmoussa, R. Employees' attitudes toward change with Lean Higher Education in Moroccan public universities. *J. Organ. Change Manag.* **2020**, *33*, 253–288. [CrossRef]
34. Sunder, V.M.; Antony, J. A conceptual Lean Six Sigma framework for quality excellence in higher education institutions. *Int. J. Qual. Reliab. Manag.* **2018**, *35*, 857–874. [CrossRef]
35. Okfalisa; Insani, F.; Abdillah, R.; Anggraini, W.; Saktioto. Smart Performance Measurement Tool in Measuring the Readiness of Lean Higher Education Institution. In Proceedings of the EECSI 2019, Bandung, Indonesia, 18–20 September 2019; pp. 422–427.
36. Douglas, J.; Muturi, D.; Douglas, A.; Ochieng, J. The role of organisational climate in readiness for change to Lean Six Sigma. *TQM J.* **2017**, *29*, 666–676. [CrossRef]
37. Kallassy, J.; Hamzeh, F. Developing a Lean Culture Index in Construction. In Proceedings of the IGLC 2021—29th Annual Conference of the International Group for Lean Construction—Lean Construction in Crisis Times: Responding to the Post-Pandemic AEC Industry Challenges, Lima, Peru, 12–18 July 2021; pp. 504–513. [CrossRef]
38. Aghayev, H.; Garza-Reyes, J.A.; Nadeem, S.P.; Kumar, A.; Rocha-Lona, L.; Aleu, F.G. Lean Readiness Level of the Azerbaijan Construction Industry. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Dubai, United Arab Emirates, 10–12 March 2020.
39. Abduh, M.; Roza, H.A. Indonesian Contractors' Readiness Towards Lean Construction. In *Proceedings of the Annual Conference of International Group of Lean Construction-14*; International Group for Lean Construction: Santiago, Chile, 2006; pp. 543–549.
40. Suresh, M.; Arun Ram Nathan, R.B. Readiness for lean procurement in construction projects. *Constr. Innov.* **2020**, *20*, 587–608. [CrossRef]
41. Kumar, M.; Murugan, V. *Lean Readiness Index: Assessing Organization Preparedness to Implement Lean*; Springer International Publishing: Berlin/Heidelberg, Germany, 2019. [CrossRef]
42. Fadnavis, S.; Najarzadeh, A.; Badurdeen, F. *An Assessment of Organizational Culture Traits Impacting Problem Solving for Lean Transformation*; Elsevier B.V.: Amsterdam, The Netherlands, 2020; pp. 31–42. [CrossRef]
43. Laubengaier, D.; Hahn, G.J.; Wagner, H.-T.; German Graduate School of Management. Organizational Culture and Knowledge Exchange and Combination: A Systematic Literature Review. In Proceedings of the 52nd Hawaii International Conference on System Sciences, Grand Wailea, HI, USA, 8–11 January 2019; pp. 5498–5507. Available online: https://hdl.handle.net/10125/59986 (accessed on 15 February 2023).
44. Anandh, K.S.; Gunasekaran, K. Constructing a model to examine the influence of quality of work-life on work-life balance—Discernment of civil engineers from construction industry in Chennai. *Indian J. Sci. Technol.* **2016**, *9*, 1–12. [CrossRef]
45. Dinis-Carvalho, J. The role of lean training in lean implementation. *Prod. Plan. Control* **2021**, *32*, 441–442. [CrossRef]
46. Alefari, M.; Almanei, M.; Salonitis, K. Lean manufacturing, leadership and employees: The case of UAE SME manufacturing companies. *Prod. Manuf. Res.* **2020**, *8*, 222–243. [CrossRef]
47. Womack, J.P.; Jones, D.T.; Roos, D. *The Machine that Changed the World*; Rawson Associates, Macmillan Publishing Company: New York, NY, USA, 1990.
48. Amin, M.A.; Alam, M.R.; Alidrisi, H.; Karim, M.A. A fuzzy-based leanness evaluation model for manufacturing organisations. *Prod. Plan. Control* **2020**, *32*, 959–974. [CrossRef]
49. Albliwi, S.; Antony, J.; Halim-Lim, S.A.; van der Wiele, T. Critical failure factors of Lean Six Sigma: A systematic literature review. *Eletronic Libr.* **2014**, *31*, 1012–1030. [CrossRef]
50. Antony, J.; Downey-Ennis, K.; Antony, F.; Seow, C. Can Six Sigma be the 'cure' for our 'ailing' NHS? *Leadersh. Health Serv.* **2007**, *20*, 242–253. [CrossRef]
51. Ballard, G. The lean project delivery system: An update. *Lean Constr. J.* **2008**, 1–19.

52. Herrera, R.F.; Mourgues, C.; Alarcón, L.F.; Pellicer, E. An assessment of lean design management practices in construction projects. *Sustainability* **2020**, *12*, 19. [CrossRef]
53. Ballard, H.G. *The Last Planner System of Production Control*; The University of Birmingham, Edgbaston: Birmingham, UK, 2000.
54. Sterzi, M.P.; Isatto, E.L.; Formoso, C.T. Integrating strategic project supply chain members in production planning and control. In Proceedings of the Lean Construction: A New Paradigm for Managing Capital Projects—15th IGLC Conference, East Lansing, MI, USA, 18–20 July 2007; pp. 159–169.
55. Viana, D.D.; Mota, B.; Formoso, C.T.; Echeveste, M.; Peixoto, M.; Rodrigues, C.L. A survey on the last planner system: Impacts and difficulties for implementation in brazilian companies. In Proceedings of the 18th Annual Conference of the International Group for Lean Construction, IGLC 18, Haifa, Israel, 14–16 July 2010; pp. 497–507.
56. Ballard, G.; Tommelein, I.D. *2020 Current Process Benchmark for the Last Planner® System of Project Planning and Control*; University of California, Berkeley: Berkeley, CA, USA, 2021.
57. Arbulu, R.; Ballard, G. Lean Supply Systems in Construction. In Proceedings of the 12th Annual Conference of the International Group for Lean Construction, Helsingør, Denmark, 3–5 August 2004; p. 13. Available online: http://iglc.net/Papers/Details/291/pdf%5Cnhttp://iglc.net/Papers/Details/291 (accessed on 15 February 2023).
58. Dakhli, Z.; Lafhaj, Z. Considering Materials Management in Construction: An Exploratory Study. *Logistics* **2018**, *2*, 7. [CrossRef]
59. Sivaraman, A.; Varghese, K. Pull Planning System to Coordinate the Engineering Procurement and Construction on Process Plant Projects. In Proceedings of the Construction Research Congress, San Juan, Puerto Rico, 31 May–2 June 2016; pp. 2039–2049. [CrossRef]
60. Young, B.K.; Hosseini, A.; Lædre, O. Project alliances and lean construction principles. In Proceedings of the IGLC 2016—24th Annual Conference of the International Group for Lean Construction, Boston, MA, USA, 20–22 July 2016; pp. 33–42.
61. Lamming, R.C.; Caldwell, N.D.; Harrison, D.A.; Phillips, W. Transparency in supply relationships: Concept and practice. *J. Supply Chain Manag.* **2001**, *37*, 4–10. [CrossRef]
62. Chan, D.W.M.; Chan, J.H.L. Developing a Performance Measurement Index (PMI) for Target Cost Contracts in Construction: A Delphi Study. *Constr. Law J. (CLJ)* **2012**, *28*, 590–613.
63. Garza-Reyes, J.A.; Ates, E.M.; Kumar, V. Measuring lean readiness through the understanding of quality practices in the Turkish automotive suppliers industry. *Int. J. Product. Perform. Manag.* **2015**, *64*, 1092–1112. [CrossRef]
64. Raghavan, V.A.; Testani, M.; Lam, S.S.; Srihari, K.; Ramakrishnan, S.; Testani, M.V. A Methodology for Assessing the Adoption Rates of an Organization's Lean Transformation. 2013. Available online: https://www.researchgate.net/publication/289296761 (accessed on 15 February 2023).
65. Alkhoraif, A.A.; McLaughlin, P.; Rashid, H. A framework to improve lean implementation by review leveraging aspects of organisational culture: The case of Saudi Arabia. *Int. J. Agil. Syst. Manag.* **2019**, *12*, 124–179. [CrossRef]
66. Cherrafi, A.; Garza-Reyes, J.A.; Belhadi, A.; Kamble, S.S.; Elbaz, J. A readiness self-assessment model for implementing green lean initiatives. *J. Clean Prod.* **2021**, *309*, 127401. [CrossRef]
67. Sreedharan, R.V.; Raju, R.; Sunder, V.M.; Antony, J. Assessment of Lean Six Sigma Readiness (LESIRE) for manufacturing industries using fuzzy logic. *Int. J. Qual. Reliab. Manag.* **2019**, *36*, 137–161. [CrossRef]
68. Baskaran, S.M.; Lakshmanan, A.R. A framework for lean readiness evaluation using a hierarchical fuzzy system. *South Afr. J. Ind. Eng.* **2019**, *30*, 220–234. [CrossRef]
69. Alefari, M.; Salonitis, K.; Xu, Y. The Role of Leadership in Implementing Lean Manufacturing. *Procedia CIRP* **2017**, *63*, 756–761. [CrossRef]
70. Qian, X.; Zhang, M.; Jiang, Q. Leader humility, and subordinates' organizational citizenship behavior and withdrawal behavior: Exploring the mediating mechanisms of subordinates' psychological capital. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2544. [CrossRef]
71. Dogan, O.N.; Yagli, S.B. Value Stream Mapping: A Method That Makes the Waste in the Process Visible. In *Lean Manufacturing and Six Sigma—Behind the Mask*; IntechOpen: London, UK, 2020; pp. 1–17. [CrossRef]
72. García-Palao, C.; Oltra-Mestre, M.J. Lean-Teams Characterization. *J. Econ. Bus. Organ. Res.* **2020**, *2*, 226–237.
73. Hamzeh, F.; Zankoul, E.; El Sakka, F. Removing Constraints to Make Tasks Ready in Weekly Work Planning. *Procedia Eng.* **2016**, *164*, 68–74. [CrossRef]
74. Alieva, J.; Powell, D.J. The significance of employee behaviours and soft management practices to avoid digital waste during a digital transformation. *Int. J. Lean Six Sigma* **2022**, *14*, 1–32. [CrossRef]
75. Fakher, R.A.; Anandh, K.S. An Exploratory Study to Utilize Construction 4.0 Technologies in Enhancing Communication to Get Quality Human Resources. In *Lecture Notes in Civil Engineering*; Springer Science and Business Media Deutschland GmbH: Berlin/Heidelberg, Germany, 2022; pp. 465–479. [CrossRef]
76. Alnajem, M.N.; Dhakal, H.N. The role of culture and leadership in lean trasnformation: A review and assessment model. *Int. J. Lean Think.* **2012**, *3*, 119–138.
77. Shaffer, J. Using Communication to Make Lean Transformations Stick. 2011. Available online: http://jimshaffergroup.com/wp-content/uploads/Jim-Shaffer-Lean-Article.pdf (accessed on 15 February 2023).
78. Tracey, M.W.; Flinchbaugh, J. *HR's Role in the Lean Organizational Journey*; WorldatWork: Scottsdale, AZ, USA, 2006; pp. 49–58.
79. Mujumdar, P.; Maheswari, J.U. Design iteration in construction projects—Review and directions. *Alex. Eng. J.* **2018**, *57*, 321–329. [CrossRef]

80. Peter, E.; Love, D.; Heng, L.I. Quantifying the causes and costs of rework in construction. *Constr. Manag. Econ.* **2000**, *18*, 479–490. [CrossRef]
81. Tawfek, H.S.; Mohammed, H.E.-D.H.; Abdel Razek, M.E. Assessment of the expected cost of quality (COQ) in construction projects in Egypt using artificial neural network model. *HBRC J.* **2012**, *8*, 132–143. [CrossRef]
82. Prasad, K.V.; Vasugi, V. Experiences from the implementation of last planner system® in construction project. *Indian J. Eng. Mater. Sci.* **2021**, *28*, 125–141.