Beyond the Lowest Bidder: A Multi-Criteria Framework for EPC Bid Evaluation

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Abstract. Over the past ten years, infrastructure spending in India has increased unlike any other time in the country driven by unprecedented government spending. The government has augmented investments two times and more, and even capital spending by the Union government itself continued to rise as compared to ₹4.4 lakh crore in FY2020 to more than ₹11 lakh crore in FY2024. The release of the National Infrastructure Pipeline (NIP) of estimated expenditure ₹111 lakh crore in FY2020-2025, has provided a systematic roadmap. In this estimated expenditure, the Engineering, Close to 85 percent of expenditure is represented by Procurement, and Construction (EPC) projects highlighting the importance of the EPC project deliveries in the Indian infrastructural context. Despite this dynamism, as per the 456th flash report on central sector projects (Rs.150 crore and above) dated October, 2023, nearly 47 percent of 1,788 projects in the central sector are lagging, slippage on average of 37 months, and cost overruns have risen to above 17.4, or more than ₹4.31 trillion. One of the causes of such inefficiencies is the continuous reliance on the lowest-bidder (L1) system of evaluation, where ability is not considered. This route led to the lack of technical competence, inability to deliver, and never-ending conflicts in contracts. To eliminate these restrictions, this study suggests a shift to a multi-criteria bid assessment framework. This model proposes a shift from the L1 approach to an Economically Most Advantageous Tender (EMAT) framework, which holistically evaluates bids based on multiple criteria including contractor ability, project delivery capabilities, and quality performance.

Keywords: EPC Projects, Bid EVALUATION, Multi-Criteria Decision Making (MCDM), Economically Most Advantageous Tender.

1 Introduction

In the massive infrastructure building of India, procurement plays a critical role purview of the government, and millions of rupees per different government departments per annum on work of construction such as roads, building, port and water works [1]. General Financial Rules (GFR) 2017 and a number of manuals guidelines of the Ministry of Finance, govern the processes of public procurement in sequence to introduce efficiency, economy, transparency and accountability [2]. Despite these simple rules, however, Indian procurement processes, particularly of large size, have many systemic problems still and intricate projects.

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The current systems of procurement in India are often marred by inefficiency, delay in schedules, and high-cost overruns [3] Audit reports, like those from the Comptroller and Auditor General (CAG) reports, have repeatedly brought into the fore the strengthening of bid processing to realize better accountability, transparency, and fairness [4]. Critically, there is a need for manualizing procurement guidelines for every stage, namely pre-qualification, shortlisting, estimation, evaluation of bids, award, and execution of contracts [4]. Lack of documented, detailed procedures, combined with challenges such as finalizing cost estimates upon opening financial bids, has been found to impede transparency and determining the reasonableness of prices [4].

Under the GFR 2017, different procurement modes are utilized in order to manage competition and procedural complexity [2]. These are Open Tender Enquiry (OTE) for procurements of higher values (typically above Rupees Fifty Lakhs for commodities and Rupees Twenty-five Lakhs for consultancies), Limited Tender Enquiry (LTE) for procurements of lower values (up to Rupees Fifty Lakhs for commodities and Rupees Twenty-five Lakhs for consultancies) [2], and Single Tender Enquiry (STE) or nomination basis, reserved for special situations where competitive bidding is not practicable[2].

The dominant practice in Indian public sector construction, on the other hand, is dominated by the Lowest (L1) bidder system of awarding contracts [3]. This system, created with the aim of providing the lowest price as well as preventing fraud and corruption, tends to focus primarily on bid price over other factors. It offers some level of cost transparency but has great weaknesses. Studies show that one is the L1 system among the key schedule delay contributors, general cost increase, and poor quality of construction, which usually causes arbitration and project failure in general. Most of the projects that are carried out by this system are characterized by low efficiency rates, and over half of them only achieve 20 to 50 percent of their planned schedule [3].

There are underlying issues with the L1 system that extend beyond financial implications. It is more likely to establish confrontational relationships among a client, designer, and contractor rather than motivate cooperation and coordination. This can result in inefficiency among the contractors as contractors accept low bids to secure projects, and in the process, they are faced with fighting performance, that causes quality and quality compromises and delays [3]. Also, the current contractor procurement processes do not put much emphasis on the previous work performance of the contractors and hardly assess the capability of a contractor working on multiple projects at a given time straining resources and further impacting the quality and timelines [1]. This culture does not encourage innovation, and the focus is only on the lowest price and not value-added solutions and integrated project delivery skills [3]. Given these obstacles, the EPC contracts are a highly valuable option, particularly to the high-value and complicated infrastructural projects in India. The distinctive feature of EPC contracts is the integrated scope where a single contractor performs the design, procurement, and construction, and the difference is the better allocation of risks and the overall project management [5]. The Public Procurement (Preference to Make in

India) Order 2017, which, in turn, implies their recognition in the national development agenda, includes such items as works [2]. The sophistication and multi-stakeholder complexity of contemporary Indian construction projects require a move towards more advanced contracting paradigms such as EPC that can provide world-class facilities and peak operating performance throughout the life cycle of the project [3]. Worldwide, evolved procurement models for sophisticated projects incorporate advanced techniques to drive value for money.

Global EPC structures typically include tools like centralized bid comparison and multi-criteria decision-making (MCDM) to evaluate contractors on factors other than price [1]. Such methodologies, in contrast to India's conventional L1 model, consciously consider qualities like quoted completion time, guarantee period, and historical performance ratings, in addition to financial proposals [6][1]. In addition, Early Contractor Involvement (ECI) is a common practice in collaborative contract delivery mechanisms such as EPC and Public-Private Partnerships (PPPs), embedding contractor expertise in the pre-construction stage to maximize constructability, increase quality, reduce risks, and ensure collaboration [6]. MCDM tools like the Analytic Hierarchy Process (AHP) and ELECTRE III are used to analyze multiple attributes (both qualitative and quantitative) and avoid compensations among key criteria, an important requirement for projects where deficiencies in one aspect cannot be countered with excellence in another [6]. In spite of the obvious advantages of such multi-criteria and integrated methods, an adequate research gap exists in India that does not have a specialized EPC procurement framework incorporating international best practices systematically.

Whereas current manuals and regulations allow general guidelines for procurement [2], there isn't a specific framework in place for the complexities of EPC and so there remains the reliance on imperfect systems such as L1. This essay contends that through the adoption of global best practices like centralized, multi-criteria bid analysis, expert categorization, consensus-building processes, and early contractor involvement, India can solve most systemic problems in its public procurement, resulting in more effective, transparent, and efficient delivery of its strategic infrastructure projects [1]. Yet as EPC contracts increasingly become the centerpiece of India's infrastructure delivery, their procurement model is still based on the lowest-bidder system. For clarity in identifying this gap, it is helpful to contrast India's bid evaluation practices against global procurement standards.

2 Overview of EPC Market

Understanding the EPC delivery method - its benefits and challenges

2.1 Definition of EPC Project Delivery Method

To meet the different requirements of stakeholders, a number of project delivery systems have been designed to deliver facilities through the design and construction of facilities to meet the various needs of the clients/owners. These are mostly Design-Bid-Build (DBB), Design-Build (DB), Engineering-Procurement-Construction (EPC), Fast-track construction, Partnering and Relational Contracting/Lean project delivery. Such delivery methods are not new and have been adopted by many years with some levels of success depending on the kind of project being dealt with and the skills that are needed [7].

The KPMG Global Construction Survey 2023 - India edition is the source that gives a comprehensive information about the Indian EPC (Engineering, Procurement, and Construction) projects environment. The survey, of 119 India-based construction leaders, comprising of project owners and E&C firms, indicates that there is an overall optimistic outlook of the construction business in India with 84 per cent of those surveyed indicating positive sentiments on the growth of the market. The most important results are the importance of integrated project management systems, prefabrication technologies, and Building Information Modelling (BIM) as the most important innovations that contributed to reducing project execution, stoppage of time and cost overruns by at least 10% in half of the respondents. The survey also highlights the increasing significance of Environmental, Social, and Governance (ESG) principles in the development of infrastructure as close to 60 percent of the surveyed individuals are actively seeking ESG maturity considering it a way of improving reputation, safety, and project success. Overall, the Indian EPC companies and project owners have been resilient despite such challenges as the acquisition of land, regulatory delays, and disruptions in supply chains, which facilitate profitability and leadership in the industry due to strong risk management practices. The information gathered in this survey is a valuable resource in the research and policy development in EPC contracts evaluation and infrastructure development as it gives a rich dataset to study the trends of EPC in India in terms of digital adoption, integration of sustainability, and projections of capital expenditure in the next few years [8].

3 India vs International

Public procurement, a key function to national development, shows stark divergence in bid evaluation techniques between India and worldwide standards. The procurement environment in India is regulated primarily through the General Financial Rules (GFR) of 2005 and 2017, supported by elaborate directions in manuals like the Procurement of Goods Manual (2017), the Procurement of Consultancy & Services Manual (2017), and the CPWD Works Manual 2014. The GFRs have been a collection of general financial rules for Government of India offices [9]. GFR 2017, for example, requires public procurement processes to meet criteria of fairness, transparency, and reasonableness to ensure that the chosen offers are up to requirements and acceptable

in terms of quality [10]. Rule 173(xvi) of GFR 2017 also clarifies that contracts are "ordinarily" to be entrusted to the "lowest evaluated bidder" who is responsive, eligible, and capable of performing the contract to satisfactory standards [11]It is this focus on the lowest bid (L1 system) that pervades all different procurement methods, ranging from direct buying, advertised tenders, and restricted tender enquiries [9][11]. While the Procurement of Goods Manual (2017) makes transparency, fairness, and accountability its key positions, it also recognizes that "price alone may not necessarily represent VfM" (Value for Money) [11]. Also, in case of non-consultancy services, Manual for Procurement of Consultancy & Other Services (2017) ensures that selection is generally made on the basis of the lowest price of technically responsive offers, following the procurement recommendations for goods [2]. Even in contracts for works, according to CPWD Works Manual 2014, it has been a general practice to accept the lowest tender [12]. Even with good intentions on transparency, the prevalence of the L1 system in India has been severely criticized.

Though GFR 2017 provides factors such as time of delivery, performance, efficiency, environmental characteristics, payment terms, guarantees, price, and life-cycle costs for bid evaluation [11], the primary emphasis on the lowest price usually tends to overlook these qualitative elements. Such cost-oriented strategy is often linked with project delays, resulting in lost revenues and cost overruns [11]. It can also incite conflicts, requiring effective dispute settlement provisions. In addition, seeking the lowest price can trade off against quality since contractors seek to minimize costs at the expense of quality, which may result in poor performance. The CPWD Works Manual 2014, for instance, firmly provides that there must be "no compromise on the quality of work"[12]. In addition, the L1 system is generally regarded as hampering innovation, since it gives minimal incentive to bidders to put forward better, even if more costly, solutions. While Quality and Cost Based Selection (QCBS) is an accepted means of consultancy services in that quality can be given up to 80% [11], the use of the same for goods and works is not common, with Least Cost Selection (LCS) generally considered to be suitable for ordinary tasks where price is the only distinguishing factor among technically qualified bids [11].

By contrast, global public procurement regulations, as represented by the EU Directive 2014/24/EU, the UK Public Contracts Regulations 2015, and Scotland's 2015 regulations, require a value-driven approach. Such regulations demand contracts being issued based on the "Most Economically Advantageous Tender" (MEAT). MEAT is not defined in terms of price but through determining the "best price-quality ratio," which involves cost-effectiveness methodology, including life-cycle costing. This overall assessment considers a wide variety of criteria, including qualitative, environmental, and social ones directly related to the matter of the contract. It also enables one to consider such aspects as the conditions of production and delivery, in spite of the fact that they are not mentioned in the material quality of the goods or services. Interestingly, the Member States are expressly permitted by these international guidelines to forbid or limit application of price only or cost only when examining MEAT in way that it forbids do not make awards on the principle of lowest price alone. The structures encourage flexibility via mechanisms like competitive negotiation and competitive dialogue in order to procure authorities are able to select

solutions that most appropriately fitted their respective needs including innovative ones, and at the same time promise equal treatment and transparency. Such an approach naturally promotes efficiency and sustainability by focusing on long-term benefits and in general social advantages more than the expenditure of first purchase.

India is to a great extent operating by the price model where the best price would normally be awarded the contract, despite the provisions on the same quality in place. This is likely to lead to the inefficiency ridden procurement outcomes problems with contracts, the low quality, and lack of innovations. In contrast, international value focused models, particularly in the EU and UK, have an inherent nature. They emphasize a coherent selection of tenders taken up by the MEAT principle, holistic assessment of prices and quality, environmental, innovative, social and life-cycle cost factors. This value-based approach will lead to more sustainable, efficient and quality results in public expenditure. The term landscape today means that there is a great research gap concerning the subject of public procurement in India. One can note an apparent absence of a comprehensive MEAT-style solution which is sound reward and examines bids in an even measure of price and diverse value characteristics. The integration of international best practices as the case with EU Directive and the UK/ Scotland laws, can precipitate a revolution in Indian government purchasing. This would shift the system from the prevailing cost-based model towards an advanced value-based approach, promoting higher quality, more sustainability, and very important innovation in public sector initiatives.

The L1 system fundamentally views procurement as a transactional cost-minimization exercise. In contrast, the MEAT approach treats procurement as a strategic investment, seeking the best long-term value by balancing cost with quality, innovation, and lifecycle performance.

Table 1. Understanding The EPC, Its Process, Benefits and Drawbacks

Author /Organization	EPC Definitions
Iskandar, I., Hardjomuljadi, S., & Sulistio, H. (2021).	EPC is a project management concept that delegates responsibility for design activities (Engineering), procurement of materials/equipment (Procurement), and implementation of construction (Construction) to EPC contractors.
NurSholeh, M., Fauziyah, S.	EPC is a construction model that integrates the work between engineering, procurement, and construction, often applied in petroleum work.
Zhang, S., Zhang, S., Wu, Z., Wang, C., Jiang, Z., & Wang, X. (2025)	EPC is a widely adopted project delivery method that centralizes responsibility but faces challenges related to fragmented documentation in projects like pumped storage hydropower

Author /Organization	EPC Definitions
Boccasini, B.	EPC effort focuses on the final commissioning and delivery where validation occurs for the earlier project effort, beginning with a preliminary engineering phase.
Mehta, J.	EPC strategy "Design One, Build Many" involves designing standard components that can be replicated in multiple projects for cost savings and efficiency.
Dei, G., Trucco, P., Locatelli, G., Scaini, C.	EPC companies develop and adopt new technologies to foster energy transition, requiring a novel technological risk management approach.
Jordan, A., Selway, M., Grossmann, G., (...), Stumptner, M.	EPC companies are responsible for designing industrial plants, often facing interoperability issues due to different information formats.
Kim, M.-H., Lee, E.-B., Choi, H.-S.	EPC contractors with lump-sum turnkey contracts face profit losses due to re-works and schedule delays, necessitating a detail engineering completion rating index system (DECRIS).
Li, Y., & Pei, Z. (n.d.)	EPC general contracting model is a management model for integrated management of project design, procurement, and construction, aligning with the development of prefabricated buildings.

Turnkey and EPC are also synonymous with Design-Build (DB), although there are some significant differences. The contractor in both Turnkey and EPC projects is not only involved in designing and construction as opposed to a normal DB arrangement. In Turnkey project, the contractor must provide a fully functioning plant, which is ready to be used as soon as the owner turns the key. In this case, project funding and bearing the risk to its completion is usually organized by the contractor. After making the finished asset operational, the owner there upon buys it conversely, the owner or the lenders often fund EPC projects, and not the contractor himself. The EPC contractor is responsible for engineering, procurement and construction but without responsibility to fund the project.

Table 2. EPC / Db / Turnkey-Definitions

Type	Definition	Project types
Turnkey	The Turnkey method usually involves a single contractor being responsible for the total project life cycle from design through post-construction functions such as commissioning and handover. The client signs the contract and expects that 'turning the key' is the only function to open a fully functional facility. This option shifts some risk to the developer. It reduces the economic return to the facility owner or limits the types of technologies or equipment - very similar to client procuring a completed project.	Most common in building and industrial projects

Type	Definition	Project types
DB	Design build/Construct system is an integrated approach that delivers design and construction services under one contract with a single point of responsibility. Owner selects a DB contractor to develop a construction project, which is governed by architectural designs.	Most common in building and infrastructure projects

BOT (Build-Operate-Transfer), BOOT (Build-Own-Operate-Transfer), BOO (Build-Own-Operate), and BLT (Build-Lease-Transfer) are some of the variants of the EPC model, according to some researchers. As a matter of fact, they are more of financial arrangements. Within this type of model, the contractor not only designs and constructs the project, but also finances, operates or leases the facility and finally transfers to the client ownership at the expiry of the contract. The models have been termed as types of Turnkey contracts which are normally used when the project owner does not want to or is not able to fund the project.

In the larger EPC system, there are other subcategories, including EPCI (Engineering, Procurement, Construction, Installation), EPCC (Engineering, Procurement, Construction, Commissioning), EPCIC (Engineering, Procurement, Construction, Installation, Commissioning) and EPCM (Engineering, Procurement and Construction Management). Both emphasize various phases of contractor participation and areas of responsibility.

To understand, this paper will identify EPC as a project delivery process whereby, the designers and contractors work together in order to provide a fully functional industrial facility. The EPC contractor undertakes the single point responsibility of design and construction taking care of delivery at an assured cost, within a stipulated scale of time, and to a predetermined quality- whilst dealing with all the project risks involved.

The EPC project delivery method is generally split into two major stages, namely, the development stage and implementation stage. The research stage is the time when such critical activities as investigations, scope definition, work packaging, and contract award occur. These operations provide the base of the project and normally take a period of two-three years. The client/ owner starts by specifying the scope of the project and the performance requirements and conveying the same to in-house engineers, external consultants or prospective EPC contractors. This gives rise to the creation of Front-End Engineering Design (FEED) which consists of feasibility, process design as well as initial cost and schedule estimates. After the FEED is done, the client has a choice of either assigning the same contractor to execute it or allowing others to place competitive bids. After the bidding process, EPC contractors are usually hired via lump-sum contracts or fixed-price contracts.

After awarding the contract, the implementation process starts which is normally three years or more. At this level, the EPC contractor takes the entire charge of detailed engineering, procuring equipment and materials, and building of the facility. The project cuts across various fields including civil, mechanical, electrical, piping, and instrumentation and may include many different specialists and subcontractors.

Primary cost and schedule risks are borne by the EPC contractor with approval by the owner who may also track progress either by having an in-house project management team or by contracting a separate consultant.

EPC has emerged as an ideal means of delivery on large industrial projects because of the technical and commercial merits. It facilitates easy coordination of activities between design and construction and aids in reduction of delays and cost overruns. Co-operation among designers and contractors promotes innovation and specific procurement of long-lead materials which would go a long way in reducing the project timelines. Additionally, the sole point of responsibility also minimizes the administrative burden on the owner and enables them to concentrate more on the operations of the business. EPC also leads to more positive communication between all parties and allows integrated risk management- a critical consideration when lenders consider financing projects.

Even though EPC contract has its benefits, it also possesses significant shortcomings. These include:

- EPC contracts present a significant financial risk to the contractors driven by fixed-price contracts, the exposure to unanticipated site and regulatory conditions and fines levied on the schedule delay or performance shortfall [13].
- Contract claims and disputes are prone within EPC contracts due to vague contractual terms and lump sum contract payments which tend to end up into long drawn litigation, escalation of costs and project delays [14].
- Poor contract management may trigger time delays, cost increase, and quality improvement. The complexity of distribution of overlapping stages of a project and adaptation to the unique needs of various industrial sectors often adds complications to these issues [15].

There is also high level of technical complexity involved in EPC projects due to the numerous engineering disciplines that will have to work in harmony. As an example, oil and gas projects depend on the experience in process, mechanical, electrical, civil, structural (onshore/offshore), subsea, and instrumentation engineering, telecommunications and IT. This inter-disciplinary integration increases the risk and the challenges of coordinating.

Moreover, the implementation of EPC is usually characterized by a large number of international and local subcontractors, which has led to a high level of demand on supply chain management. The contractual arrangements, working practices and the risk distribution in EPC are very different compared to the traditional ones, and this can cause the project owners to struggle with the execution of the project. Consequently, as much as EPC is efficient and accountable, it involves a high level of planning, competent contractors and clear governance that oversee its complexity and risk.

The construction industry in India is also a pillar of economic growth and it has significant national contribution to economic Gross Domestic Product (GDP) and employment just like other industries around the globe. National Infrastructure Pipeline

(NIP) statistics show that the infrastructure investments will lead to transformative growth between 2020-2025 with the capital expenditure of over 4 lakh crore and construction of infrastructure in transport (roads and railways), petroleum and urban sectors. The use of the Engineering, Procurement and Construction (EPC) contract model is especially significant in this environment, as EPC takes up over fifty percent of the proportion of implementation in projects, year-after-year, outcompeting hybrid annuity (HAM), PPP, and other systems, as found in combined NIP data and industry rainbow maps. With a global investment of ground-breaking growth, such as the development of energy infrastructure, multi-modal transport connections, the EPC market has become an indispensable channel through which nations are migrating their projects, in some years making up more than 50% of the yearly infrastructure expenditure. Similar to mining and energy-based booms in Australia, the EPC growth in India has been fuelled by demand in the oil, gas, roads, railways, and industrial corridors- where the government and the masses appreciate EPC turnkey benefits of timeliness, distribution of risks, and cost predictability. Such activity is supported by NIP figures (See figures 1 and 2), as well as recent studies of the sector, and proves EPC to be the key to transforming capital investments into tangible assets and jobs, and supplying ancillary industries such as manufacture, logistics, and professional services. The trends of the industry development, however, were not all positive- patterns of fiscal strain, regulatory lags, and supply chain shocks toned down expansion during a few years, as it is reflected by NIP outlay curves and mode-of-implementation plots. However, the future of the EPC construction sector in India is expected to grow steadily, backed by a strategic government vision, increasing urbanization, and continuous collaboration between the private and the government sector in energy, urban and logistic development projects which will offer a strong analogy to the cyclical sectors and structural contribution as are documented in the mature markets of the world. The sector, based on utilizing the power of the public money, competence of the private sector, and progressive models of delivery, supports the physical infrastructure of the country, including highways and railways, energy, and urban resources. According to the insights made by the National Infrastructure Pipeline (NIP), the planned infrastructure outlays were projected over 2020-2025 to be more than 4 lakh crore, with a clear prevalence of the Engineering, Procurement, and Construction (EPC) contracts as the preferred mode of project delivery. Recent NIP statistics and multi-year capital allocation graphics demonstrate how EPC has been the centerpiece of infrastructure construction in India, often taking over a majority of the total investments in the sector, in roads, railways and oil. This reflects the sectoral booms experienced in the mature construction economies where EPC contracts supported the growth of mining, oil and gas, and heavy industry projects- converting the inflows of capital into physical assets and pervasive economic returns. In the same way that the Australian mining-oriented growth led to the rapid adoption of EPC in the country, the expansion hindered in the oil, gas, power, and logistics corridors in the Indian market has also been supported by the single-point responsibility benefit of EPC that de-risks both the schedule and quality of work by the public authorities. The pattern of the EPC industry in India, too, is one of fiscally stressed and regulatory dynamic cycles, in terms of rising and falling multi-year outlays and shifting project forms. A continuous growth is supported by strategic government vision, growing urbanization, and a partnership between the private and the government and now EPC contracts are placed as

imperative tools of efficient, responsible delivery and driving affiliated production, professional services and employment creation. As the pipeline of the projects gets longer and more diversified, the EPC ecosystem in India mirrors the trends in the global infrastructure market with distinct challenges and opportunities for innovation that relate to the domestic setting.

Mode of implementation	2020	2021	2022	2023	2024	2025
EPC	2,69,191	4,02,317	4,63,507	3,65,966	2,37,113	1,51,001
HAM	1,06,607	1,10,077	91,881	79,905	1,22,954	2,51,183
PPP	18,106	38,204	40,397	31,781	30,928	13,696
JV - CGD	3,933	4,546	5,829	5,608	5,969	2,400
Railway	3,000	4,670	3,617	750	20	20
Item rate	2,935	599	613	210	139	0
TOLL	1,520	1,661	535	0	0	0
NA	1,473	1,354	539	1,749	16,825	38,967
SPV	496	149	0	0	0	0
Annuity	69	277	277	69	0	0
BOT	0	0	0	0	0	0
Total	**4,07,330**	**5,63,854**	**6,07,195**	**4,86,038**	**4,13,948**	**4,57,267**

Fig.1. Mode-Wise Infrastructure Investment Breakdown (FY2020–FY2025) Source: Volume-3B Report-of-the Task-Force-National-Infrastructure-Pipeline-(NIP)

The table presents a detailed summary of the annual investment figures distributed among various modes of implementation in India's NIP.

Infra Type	2020	2021	2022	2023	2024	2025
Petrol & Natural Gas	22,306	37,202	40,246	33,301	14,125	6,911
Railways	1,13,209	2,19,347	2,65,409	2,42,120	1,76,588	1,18,848
Roads	1,33,676	1,45,768	1,57,852	90,545	46,400	25,242
Total	**2,69,191**	**4,02,317**	**4,63,507**	**3,65,966**	**2,37,113**	**1,51,001**

Fig.2. Sectoral Distribution of EPC Infrastructure Investment (FY2020–FY2025) Source: Volume-3B Report-of-the Task-Force-National-Infrastructure-Pipeline-(NIP)

This table displays yearly infrastructure investments segmented by core sectors: Petrol & Natural Gas, Railways, and Roads, for EPC contracts.

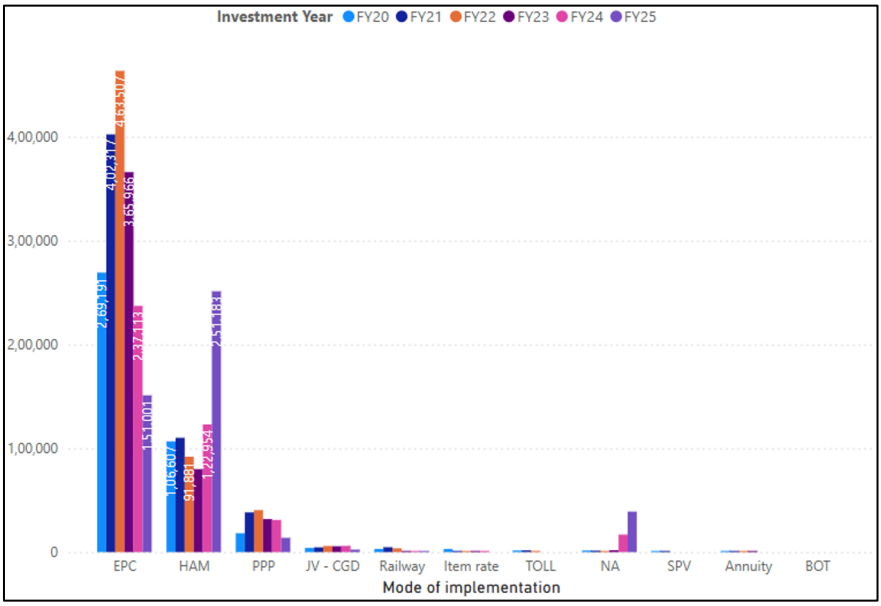

Fig.3. Annual Investment in Infrastructure by Mode of Implementation (FY2020–FY2025)
Source: Volume-3B Report-of-the Task-Force-National-Infrastructure-Pipeline-(NIP)

This chart visualizes capital outlay trends across different project delivery models, highlighting EPC, HAM, PPP, and others, by fiscal year (See figure 3).

4 Literature Review

This review of literature seeks to state the characteristics frequently utilized in Multi-Criteria Decision-Making (MCDM) for contractor selection and to record the major limitations associated with the conventional Lowest Bidder (L1) approach to construction projects [16][17]. Through the synthesis of current literature, this review determines major contractor selection factors, ranging from core economic drivers to intricate risk and sustainability issues in Engineering, Procurement, and Construction (EPC) environments and enumerates the reported L1 system failures.

Conventionally, selection of the contractor has been mostly based on cost, time, and quality as the three broad conceptual dimensions for project success. These basic parameters are the foundation upon which the contractor's ability to provide acceptable standards of work within budget and on schedule is measured. Nevertheless, early research also appreciated the importance of a more advanced measurement beyond these elementary parameters.

The development of contractor selection has resulted in extended multi-criteria frameworks, particularly in pre-qualification processes, intended to reduce the risk and failure by developing minimum capacities for contractors. Prequalification is by its

very nature a multi-criteria decision-making (MCDM) problem. The major prequalification requirements noted are financial capability, which evaluates a contractor's ability to undertake a project; technical capability, which includes their knowledge and facilities such as plant and equipment; management and organizational skill, indicating their proficiency in planning, organizing, and control of projects, in addition to their management style and commitment to continuous improvement; occupational health and safety records and programs; and past performance, which analyzes a contractor's history in time, cost, quality, and regulatory compliance, in addition to past non-performance, claims, and litigations. These specifications are intended to screen responsive, responsible, and capable contractors prior to the bid stage, hence encouraging sound competition among suitable companies and maximizing selection for improved price-performance equilibrium [17].

Within the professional field of Engineering, Procurement, and Construction (EPC) projects, contractor choice is even more crucial considering the inherent high risks and uncertainties. EPC contracts entail a great transfer of responsibility from the client to the contractor, including every detail of design, construction, erection, and commissioning, along with related interface risks. Recurrent types of risks, and their origin causes, such as contract related, design related, execution related, sub-contractor related, systems-related and equipment-related is critical towards minimization of adverse effects on project quality, time and budget goals. Key Performance Indicators (KPIs) of EPC. Such aspects like change orders initiated by the owners, communication failures are likely to become a factor within design teams, time lag in decision making, as well as consultant and client satisfaction on project cost performance and schedule [16]. Moreover, the sophistication of design engineering, the fixed price, and fixed time nature of the majority of EPC contracts and the need of collaborative work between designers and contractors is emphasized in need to have good contractor prequalification. To address the inaccuracy and imprecision fuzzy Multi-Criteria Decision-Making (MCDM) which is usually found in these assessments. There is increased use of models and hybrid models, since crisp models are likely to provide reliable results when affected by inaccurate data and subjective choices. These models combine fuzzy logic expert judgments to give a more reliable classification and choice of EPC contractors.

Despite the evident advantages of the MCDM techniques, the L1 (lowest bid) system continues to be popular vogue to the selection of contractors in most countries such as India in the case of government and privately sector projects. This regime is harshly condemned as its negative effects. It has been found out that L1 system can often lead to inefficiency, unrealistic bidding, conflict, and low quality. To be awarded, contractors will place unrealistic and purposeful bids contracts, which will turn costly and issue projects disagreements. Such moves will reduce the profit margin of the contractors, and this can be a motivator to the use of inefficient equipment and poor-quality materials hence affecting project quality and general efficiency. Further, the focus on bid price alone may lead to extensive late projects, cost increase and increased litigation. Contractor controversy is a concern in other parts of the world and consultant procurement approaches also support such worries [17]. Whereas others prefer competitive (price-based) selection to reduce expenditures from public coffers, others

prefer that for professional services such as architectural and engineering (A/E) design, quality and trust be more important, like medical practice. Issues raised are the possibility of minimal design fees negatively impacting design document quality and costing clients' money in the long term. Foreign examples also highlight such issues. For instance, in Israel, a move to a competitive consultant selection process for curbing bureaucratic overload inadvertently decreased costs but also raised issues over contractors seeking lower-calibre consultants to maximize profits, which could have a knock-on effect on project quality. Likewise, in Sweden, public clients tended not to use uncertainty in selecting control modes for engineering services, thus compromising on creativity, raising the financial risks to service providers, and confusing responsibilities, especially where uncertainty was high [18]. The US, among other countries, has embraced qualifications-based selection (QBS) for A/E services, whereby competence is evaluated prior to fee negotiation, as compared to pure competitive bidding. There are other overseas options available, such as the average-bid approach, which serves to guard against owner interests from unrealistically low bids [19]. However, even the competitive selection processes when not adequately handled have the possibility to give rise to issues like underpricing costs by the contractors and then bringing claims in order to get additional payments, a "pendulum effect. A study has shown that overemphasis on cost can weaken creativity of service providers, increase their financial risks, and cause uncertain responsibilities [19].

Overall, it can be concluded that a shift toward historical cost-time-quality is easily described in the literature reflections to broader multi-criteria models and sophisticated EPC-related risk and performance criteria. The failures of L1 system reported outline its natural inabilities to achieve perfect project results, and the vast majority of international environments have adopted more high-end, quality or qualification-based methods of contractor and consultant selections coupled with MCDM. The big gap that has been identified is that India has continued to use the L1 methodology which is far apart to the best practices in the world which involve holistic MCDM strategies. The wisdom of these studies, combined, is the powerful foundation of the development of a new India-oriented EPC purchasing system capable of making good use of multi-criteria decision making to counteract the known failures of the lowest bidder system. From this integration, there is a collection of features that can be grouped into the proposed framework denoted in the Findings." This will add strength to the transition. This disparity in price in India shows the need to research the based practices and global value-based model's traits that are applied in multi-criteria decision-making procedures applied in contractor selection. These characteristics are incorporated in the following literature review, and the reviews are conducted has been recorded restriction to the use of lowest-bidder method, alone [20]

5 Synthesis of Key Selection Attributes

This study conducts a thorough study of the available literature on procurement system weaknesses, L1 system, multi-criteria decision-making (MCDM) and practices. Whereas Indian procurement is very keen on having the lowest bid, international academic literature husbands have a bigger and larger perspective. Out of this review,

a set of attributes is proposed to evaluate subcontractors in the Indian Engineering, Procurement, and Construction (EPC) environment thematically arranged to make procurement decisions based on cost, quality take into consideration long-term value, risk and risk, and value.

Traditional Criteria: Cost, Time, and Quality: In all, the evaluation used to be the main characteristic by cost, time, and quality procurement systems. The responsibility of Cost remains to be a key factor wise application of the national resources at the cost of taxpayers; but, exclusive care in cost may cause unrealistic bidding and inefficiency [3]. Prompt project it is also important to complete it to avoid economic risks and reputation related risks. While measuring quality is difficult, it has significant effect on infrastructure operability throughout its lifetime. These are not enough basic parameters to be dealt with the complexity of EPC projects and thus need to be complemented with additional ones generalised qualities [17].

Capability and Resources: Contractor capability extends beyond price to a successful mobilisation of resources. Literature emphasizes on technical capability, financial health, and track record as contractor ability measures [21]. Financial strength lessens the chances of the project being abandoned; technical competence, it overcomes Engineering opportunities; and previous history of performance serves as a measure of trustworthiness. Moreover, Also organizational systems through which safety procedures and quality control mechanisms are found critical to the long-term performance [22]. All this would ensure that only viable contractors reach the shortlist and risks of poor performances are reduced bidders.

Risk and Uncertainty Management: EPC projects are also risky and uncertain with chances of disruption of supply chain, scope modifications, and matters touching on finance. The traditional methods of assessment, of which the most prominent is these risks are not addressed appropriately by L1 method [18]. Modern approaches suggest looking at the ability of a contractor to manage risk and this includes subcontractors monitoring, flexibility, and contingency planning [13]. As With EPC contracts the Engineering, Procurement and Construction are responsibility of a single party, risk management ability of bidders is good as their price.

Sustainability and Innovation: International best practice increasingly places a focus on sustainability and innovation as critical procurement qualities. Models like the MEAT (Most Economically Advantageous Tender) criterion [10] put emphasis on lifecycle expenses, environmental performance, and social responsibility. Sustainable procurement in EPC projects encompasses resource efficiency, energy performance, and lifecycle cost reduction. Innovation, through the introduction of new construction methods or digital technologies, can potentially reduce risks and improve efficiency. Empirical data suggests combining innovative solutions has a positive effect on cost and schedule performance [16]. These considerations ensure procurement is aligned with societal and environmental goals.

Organizational and Behavioral Factors: In addition to technical and economic aspects, organizational culture and contractor behavior significantly determine project success.

Research emphasizes the need for cooperation, communication, and flexibility Contractors that have a strong safety culture, open communication systems, and collaborative practices stand a better chance of success in EPC contracts because of the collaborative nature of the phases of a project. Evaluation of these intangible factors might require other evaluation tools like performance scoring, but they are crucial for building partnership-based relationships instead of adversarial relationships.

EPC Procurement Framework Attributes:

Synthesizing the above themes, the study proposes that an Indian EPC procurement framework should be built around the following categories of attributes:

i. Traditional Criteria: Cost, time, and quality.
ii. Capability and Resources: Technical expertise, financial stability, management systems, safety culture, and past performance.
iii. Risk and Uncertainty Management: Supply chain risk-handling capabilities, management of subcontractors, flexibility, and mitigation strategies.
iv. Sustainability and Innovation: Lifecycle costing, environmental responsibility, and adoption of innovative practices.
v. Organizational and Behavioral Factors: Communication, collaboration, safety culture, and transparency.

The combining of these categories is intended to create a framework that addresses the weakness of the L1 system and aligns with global best practices in MCDM. Whilst cost remains an overarching concern, it is considered along with qualitative and strategic considerations to increase the potential for long-term success of a project.

The results of this research indicate an extensive range of parameters to take into consideration for the assessment of contractors in Engineering, Procurement, and Construction (EPC) projects. To convert them into a practical instrument, the parameters are grouped into a formal framework that assists decision-making within the Multi-Criteria Decision-Making (MCDM) setting. This model reconciles classical performance measures with wider qualitative, organizational, and risk-based criteria in order to provide a balanced, all-around evaluation model that transcends the shortcomings of the lowest bidder (L1) method.

6 Contractor Selection Framework for EPC Projects in India

The choice of the contractors forms one of the most crucial determining factors of the temporal, financial, qualitative and the holistically focused project outcome in the Engineering Procurement and Construction i.e. EPC infrastructure related activity in India. The delivery paradigm of EPC combines engineering, procurement and construction under one single contractual arrangement and thus enhances the complexity of project execution and requires contractors with strong multidisciplinary skills. In view of the magnitude of investment required, technical complexity and

coordination among the stakeholders that is needed for such undertakings, EPC contractors must demonstrate not only fiscal robustness, but also rigor in their technical and managerial acumen along with an adherence to innovation and sustainability.

Within the ambit of India's increasingly competitive playing field in infrastructure sector and the growing significance on digitalization and sustainable project implementation, contractor selection can no longer be based solely on bid price or narrow parameters of capability, including past experience. Technical assessment should go beyond experience to include accounting for design and engineering capability, construction methodology, availability of key human resources, adequacy of plant and equipment, quality management systems, health and safety performance, procurement and supply chains competence and digital capacities (for example, Building Information Modeling-enabled planning and monitoring). Likewise, managerial capacity includes planning, risk management, coordination, governance structures and decision-making efficiency.

Conventional procurement methodologies that unduly append performance objectives to the lowest bid or mis limited pre- qualification criteria often lack the ability to capture these multi facet performance attributes, and thus contribute to schedule delays, cost overruns, quality deficits and contractual conflicts. To overcome these limitations, the following chapter proposes a structured Contractor Selection Framework which is suitable for EPC projects in India. The framework synthesizes empirical evidence that was Defense gleaned from an industry wide survey using a multi-criteria decision making (MCDM) methodologies. Contractor selection factors are categorized into four evaluative domains of Technical, Managerial, Financial/Legal, and Sustainability whose relative importance is ranked by using Relative Importance Index (RII) and Mean Score Analysis. The proposed framework provides a transparent, systematic and reproducible methodology to support informed decisions during the evaluation of EPC tenders.

6.1 Survey Results and Data Interpretation

A survey questionnaire in a structured form was sent to EPC professionals in a diverse range of sectors of transport, urban development, oil and gas as well as industrial construction to build the framework. The questionnaire involved project managers, procurement experts, engineers, and consultants who are very experienced in the assessment of contractors. The respondents were requested to specify the importance of thirteen attributes of selection using a five-point Likert scale (1 = Least Important, 5 = Most Important).

We computed the gathered data using the Mean Score and Relative Importance Index (RII) methods. The formula used in calculating the RII was the following:

$$RII = \sum W / (A*N)$$

Were,
(W) = weighting given to each factor by respondents,
(A) = highest possible weight (5 in this case),
(N) = total number of responses.

The attributes were ranked according to their RII and mean values to determine their relative significance in EPC contractor selection.

Table 3: Attributes analysis according to RII and mean values.

Attribute	Mean Score (1–5)	RII (0–1)	Rank
Technical Capability	4.68	0.94	1
Financial Capability	4.62	0.92	2
Management and Organizational Capability	4.60	0.91	3
Experience and Past Performance	4.55	0.90	4
Quality Management	4.50	0.89	5
Health, Safety, and Environment (HSE)	4.48	0.88	6
Resources and Human Capital	4.42	0.87	7
Bid Responsiveness and Documentation	4.35	0.86	8
Schedule and Time Performance	4.32	0.85	9
Legal and Regulatory Compliance	4.25	0.84	10
Innovation and Strategic Alignment	4.20	0.83	11
ESG (Environmental, Social, Governance)	4.18	0.82	12
Digital Tools and Technological Integration	4.10	0.81	13

Interpretation

The findings reveal that Technical Capability, Financial Capability and Management and Organizational Capability are viewed to be the most powerful determinants in the selection of contractors on EPC. Experience and Past Performance were also high, with the need to underline the ability to deliver. Surprisingly, the new features, like ESG and Digital Tools, which are ranked lower, portray the continuous shift of the evaluation priorities to the global trends on sustainability and digitalization of tools.

"While traditional capabilities remain paramount, the inclusion and ranking of ESG and Digital Tools, even at the lower end, signal a crucial evolution in the industry. An effective framework must therefore be robust enough to value established criteria while being flexible enough to accommodate these emerging priorities."

Proposed EPC Contractor Selection Framework

Following the survey findings and the literature used, the 13 attributes could be divided into four key dimensions in the proposed framework, each of which reflects an area of evaluation.

I. Dimension 1: Technical

Interests itself in whether the contractor will execute the scope of the project in an efficient, safe, and desired quality.

i. Technical Capability
ii. Quality Management
iii. Schedule and Time Performance

II. Dimension 2: Managerial

Focuses on organizational, human resource, and operational capabilities which affect coordination, supervision and site execution.

i. Management and Organizational Capability
ii. Resources and Human Capital
iii. Health, Safety, and Environment (HSE)
iv. Experience & Past Performance

III. Dimension 3: Financial and Legal

Meets financial stability, solidity, and legal/regulatory requirements.

i. Financial Capability
ii. Legal and Regulatory Compliance
iii. Bid Responsiveness and Documentation

IV. Dimension 4: Sustainability and Strategic

Reflects future-oriented guidelines associated with the performance of large-term projects, innovation, and sustainable construction.

i. ESG (Environmental, Social, and Governance)
ii. Innovation and Strategic Alignment
iii. Digital Tools and Technological Integration

Framework Formula:

$$CSI = \sum(Wi \times Si)$$

Where:

(Wi) = Normalized weight (derived from RII value) of each attribute

(Si) = Contractor's score for the attribute during evaluation

The Contractor Selection Index (CSI) is an index that gives the overall weighted score and enables the decision-makers to rank and compare EPC contractors objectively.

Hierarchical Representation:

EPC Contractor Selection Framework

→ Dimension 1: Technical (3 attributes)

→ Dimension 2: Managerial (4 attributes)

→ Dimension 3: Financial & Legal (3 attributes)

→ Dimension 4: Sustainability & Strategic (3 attributes)

Application and Implementation Strategy

The suggested framework may be used both during pre-qualification and post-bid evaluation stages.

Stage 1: Pre-qualification Screening.

In this phase, the contractors will be compared to minimum requirements in the following main dimensions:

i. Financial: Net worth, liquidity ratio and credit rating.

ii. Technical: Analogous experience of the project, plant and equipment volume.

iii. Managerial: Employee skillfulness, corporate resiliency.

iv. Legal/HSE: Statutory requirements and safety records.

Contractors that succeed in the initial level receive an opportunity into the next phase in case they can match the minimum standards.

Stage 2: Detailed Evaluation

At the second step, shortlisted contractors are rated on the 13 attributes through the weighted RII values. A Typical scoring sheet can also be used as illustrated below:

Table 4. Typical scoring sheet

Dimension	Attribute	Weight (RII)	Contractor Score (1–5)	Weighted Score
Technical	Technical Capability	0.94	4	3.76
Financial & Legal	Financial Capability	0.92	5	4.60
Managerial	Management & Organizational Capability	0.91	4	3.64
Sustainability	ESG	0.82	3	2.46

The total Contractor Selection Index (CSI) is the sum of all weighted scores. The contractor with the highest CSI is deemed most suitable, subject to final financial and risk review.

i. Benefits of Implementation
ii. Reduces subjectivity in contractor evaluation
iii. Ensures consistency across tendering processes
iv. Facilitates transparent and auditable selection
v. Allows flexibility to adjust weights based on project-specific priorities

The given framework is associated with the principles of Multi-Criteria Decision-Making (MCDM) that is commonly used in the construction management research [23] [24]. It is a synthesis of objective or subjective evaluation factors thereby permitting a balanced decision-making process.

A number of researchers such as Holt [25] and Alhazmi and McCaffer [26] note that cost-based selection in most cases leads to poor quality and project delivery. The combination of such dimensions like management capability, quality, HSE, and innovation creates more sustainable results.

The introduction of the ESG and Digital Tools criteria is a big step. Contractors who use BIM (Building Information Modelling), digital scheduling, and environmental reporting to support the results of the Indian infrastructure projects have shown the best outcomes of the projects. Introduction of digital tools will enhance the transparency of data, whereas the integration of ESG will help to maintain the standards of environmental and societal governance that are required by regulatory organs and financiers. On the part of managers, this framework will motivate both clients and consultants to abandon old prequalification forms. It offers a systematic, evidence-based framework that can be used in diverse EPC projects - metro, highways, industrial complexes, and power plants.

In this chapter, an extensive contractor selection Framework was offered in EPC projects in India. It has been developed because of the empirical analysis conducted by surveys which identify 13 major attributes that are classified in the four dimensions, such as Technical, Managerial, Financial/Legal, and Sustainability and Strategic. The weighting of RII guarantees a statistically justified prioritization of assessment criteria.

The framework provides a coherent and clear solution that decision-makers can use to evaluate EPC contractors on a holistic approach. It creates a link between theoretical models of contractor evaluation and the actual realities of the Indian construction environment. Further studies can also be done on this framework to incorporate techniques like AHP-TOPSIS hybrid model or even checking the weights using case studies of completed EPC projects. With the construction industry moving toward digital transformation and the sustainability requirements, this framework offers a strong basis of more resilient and value-oriented contractors selection processes in India.

7 Limitations

Although the proposed multi-criteria framework is a structured alternative to the L1 approach, there are significant limitations associated with this approach. The selection of attributes and their weights in particular are first, situation-specific and can change depending on the project, sector, delivery risks, and client priorities; the weights obtained here will only be valid to the cohort being surveyed at a single point in time and should not be generalized without being re-elicited. Second, in the additive scoring model ($CSI = \sum w_i s_i$) criteria are assumed to be independent and fully compensatory. In practice, non-compensatory rules and floor scores (e.g. legal compliance, HSE) are often used and can change rankings. Third, survey responses and self-reporting-performance may pose response and availability bias, and the framework is yet to be tried on completed EPC procurements to evaluate predictive validity or rank permanence with real-tender conditions and rules (e.g. GFR/CPWD). Lastly, procurement landscapes change regulatory changes, tech usage (BIM, digital tools), and ESG demands may reset priorities to ensure a given set of attributes is redefined and weightings re-evaluated periodically before it can be operationalized.

8 Conclusion

The current reliance of India on the L1 system in the EPC procurement has been a major challenge in allowing timely, economical, and quality infrastructure delivery. The data collected during this study support the idea that most practitioners already feel: the contracts with references to the lowest price frequently attract unrealistic bids, conflicts, and poor performance. In contrast, global systems are becoming more dependent on relevance-based assessment frameworks prioritizing cost, quality, risk management, sustainability and innovation. A broad range of evaluation attributes is obtained based on the literature. They include financial stability and technical capability, human resources, equipment, QHSE, performance history and the capability of handling risks. All these attributes can be clustered, creating a framework through which contractor assessment can take five groupings: traditional criteria, capability and resources, risk and uncertainty management, sustainability and innovation, and organizational and behavioral factors. Instead of eliminating cost, this model puts cost next to other contractor efficiency and reliability indicators. To have such a framework functioning,

reforms are required. Institutional capacity and training will also be required, whereby procurement officials should be equipped more robustly to exercise qualitative judgment regularly, and policies should promote balanced judgments rather than rewarding the lowest price only. Through enablers, Indian procurement can move beyond short-term cost savings and towards longer-term value creation. There are larger implications of implementing this kind of model. It would potentially remove chronic inefficiencies, incentivize contractors to be innovative, and promote sustainable and high-quality infrastructure. First and foremost, it would bring Indian procurement nearer to international best practice, assuring the audience of the veracity of the proposed innovations, and bearing in mind the details of EPC delivery. This will make it simpler for the country to align the procurement approach with its overall developmental objectives, to have a more efficient, innovative, and sustainable infrastructure procurement process.

Declaration of Generative AI in Scientific Writing

Generative AI tools were partially helpful to correct the grammar, clarity, and flow of the manuscript text. The authors had full analysis, scientific interpretation of results, and conclusions and gave their approval before any conclusion. There was no AI tool that was used to derive or modify data or research findings.

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