

Carbon Neutrality with Sustainable Supply Chain Project Management Framework for Affordable Access to Natural Gas in India

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Abstract

The Indian government has set a target of increasing the proportion of natural gas (NG) in India's primary energy consumption mix from 6% to 15% by 2030 in order to transition to a gas-based economy for climate change management, which is a step toward carbon neutrality by 2070. However, schedule and cost overruns in Natural Gas Supply Chain (NGSC) network projects and several taxes on NG hinder its accessibility at a reasonable price. These undermine India's progressive energy strategy and SDG 7 goals for universal access to clean, modern energy affordable access. This article proposes a Sustainable Supply Chain Project Management Framework (SSCPMF) for overcoming obstacles in Natural Gas Supply Chain (NGSC) network projects, as traditional project management (PM) models are unable to resolve complex, sensitive issues that contribute to time and cost overruns. In addition, the mediating role of tax reforms in accelerating India's shift to a gas-based economy is also examined. Through an exploratory approach, this research combines three literature streams to develop a multidisciplinary framework: Supply Chain Management (SCM) strategies (Triple-A, Lean, and Leagile), PM processes, and sustainability. The approach highlights attributes that hierarchically link nine key PM processes with three SCM strategies to manage time and cost overrun, generating economic, environmental, and societal benefits as NG consumption rises. The Triple Bottom Line (TBL) accounting technique quantifies it. Applying DMAIC (Define, Measure, Analyze, Improve, and Control) enhances the dynamic performance of the framework to assure its sustainability. According to empirical evidence, tax reforms that mediate between the delivered price of NG and its consumption are statistically significant in accelerating India's transition to a gas-based economy. The research has practical and policy implications and helps stakeholders at various levels overcome impediments to ensure the on-time delivery of NG at a competitive price. This framework will be a handy strategic instrument in effectively managing time and cost overruns while executing NGSC network projects.

Keywords: Carbon Neutrality, Gas-Based Economy, Natural Gas Supply Chain, Project Management, Sustainability, Triple A, Net Zero

Introduction

Progressive energy policy in India stresses affordable access to clean energy, increased security, and independence for economic growth (NITI Aayog, 2017). Its primary energy consumption is 35.43 exa joules (BP, 2022), ranking it third behind China and the United States. Natural Gas (NG), the most environmentally friendly fuel (Safari et al., 2019), accounts for 24.4% of the global primary energy consumption mix but just 6.2% of India's (BP, 2022). Its consumption gives security, sustainability (Kadam & Kar, 2019), and economic choices for combating climate change, resulting in sustainable socio-economic development (IEA, 2021). In addition, as part of its voluntary commitment to the COP 21 Paris Agreement on Climate Change, India promised to build a low-carbon economy by 2030, for which India aspires to expand NG's primary energy consumption from 6% to 15% by 2030, for transitioning to a gas-based economy (IEA, 2021; MOPNG, 2020b). Consequently, many gas sector reforms have been implemented (CCEA, 2020). A "one nation, one grid" pipeline network, which is the Natural Gas Supply Chain (NGSC), is being completed (PMO, 2021a; PNGRB, 2022). Also, the local distribution network for gas retailing under City Gas Distribution (CGD) projects covering 98 percent countries population in 88 percent of land area (MOPNG, 2022) is under development to increase NG access to reduce energy poverty under SDG 7 (NSO MoSPI, 2021), which seeks to provide everyone with affordable, reliable, sustainable energy. However, pipeline projects encounter various risks and challenges during execution (Prasad, 2011) and the commencement of gas supplies to end consumers (Prasad, 2013). There are barriers which hinder affordable access to NG for such customers ready to switch to this environmentally friendly energy source. These barriers emanate from delays in the completion of pipeline projects resulting in cost overruns which adversely impact delivered gas prices. Moreover, as NG is outside the GST regime, multiple taxes like central excise duty, sales tax, and state value-added tax (VAT) are levied (PTI, 2021). The VAT rates differ from state to state and are very high in

some states, adversely impacting the delivered price of NG, and making it noncompetitive.

The NGSC network comprising interstate pipelines for the transportation and distribution of NG must meet India's energy policy's and SDGs obligations, targets, and objectives. Subterranean welded pipes continuously transport NG from suppliers to consumers. Geographically spread-out NG supply sources and demand centers necessitate the establishment of the SC network to provide NG access. Waterbodies, forests, sensitive zones, utility lines, roads, highways, and railway lines are encountered along the route alignment. They make pipeline building more difficult. Delay in granting statutory permissions for such obstacles by various departments under the union and state governments results in unexpected schedule and cost overruns. Ministry of Statistics and Program Implementation (MoSPI) reported progress on 1679 central sector infrastructure projects with a cost overrun of 19.65 percent (MoSPI, 2022), of which 439 of them had a 64.67 percent cost increase. Because the construction of NG pipeline infrastructure necessitates limited resources, including laborers, machinery, time, and budget, the issue impedes the creation of critical infrastructure. Cost overruns directly increase NG delivery price, undermining the Government of India's SDG 7 objective to provide affordable, sustainable energy. In addition, time overruns delay the start of NG consumption by new customers who are prepared to substitute polluting fuels. Such delay jeopardizes the achievement of climate goals.

MoSPI has reported exogenous influences. Direct control by the NG transporter setting up the NGSC network is challenging. The typical Project Management (PM) methodology (MoSPI, 2010) alone does not address the difficulties. Neither PM field practitioners nor literature present empirical models, methods, and approaches for managing such complex problems. MoSPI created a monthly monitoring mechanism, a reactive intervention, which failed to address the issue. Cost and schedule overrun are a concern for the GoI as it plans to spend USD 60 billion on new NG infrastructure (MOPNG, 2021b) while advancing its commitment in COP 26 to achieve Net Zero by 2070 (PMO, 2021b). As a result, there is a growing need to find a mechanism to manage time and cost overruns resulting from delays in granting statutory permissions and introduce

tax reform to enhance the delivered gas price affordability. Developing empirical models, methods, and approaches to deal with this complex problem is essential to complete NGSC network projects within schedule and budget to optimize the NG transportation tariff and keep delivered NG prices within reasonable limits to enhance affordability and increase NG consumption to achieve the committed goal of a gas-based economy by 2030. Considering the critical role of NG in the transition to a gas-based economy, ultimately contributing to carbon neutrality by 2070 (PMO, 2021b), the research aims to find an implementable practical solution to provide affordable access to benign NG, the global choice for the Indian population.

Literature Review and Theory Building

The researcher conducted a concept-centric literature review to comprehend the underlying theory for developing an integrated framework to address time and cost overrun issues in NGSC network project execution, integrating concepts like SCM strategies, PM processes, sustainability, DMAIC cyclic processes, and Triple Bottom Line (TBL) accounting. These concepts have been known to solve business problems successfully. The consumer tax component on NG, which is crucial for its affordability, is analyzed to establish tax reforms' mediation effect in boosting NG usage and traditional PM model constraints that must be eliminated.

Traditional Project Management Model and Issues

The traditional project management (PM) model includes budgeting, funding, planning, scheduling, cost management, contract management, material management, risk management, course correction, startup, and commissioning (MoSPI, 2010). Emerging difficulties include land acquisition, rehabilitation, and compensation complicate project execution. Interference from stakeholders and lengthy legislative permissions are challenges (MOPNG, 2021a). The traditional PM model is static and doesn't handle these difficulties. MoSPI monitors central sector projects to increase effectiveness, fix difficulties, improve the system, and implement the best management practices, but the monitoring is inefficient due to ongoing cost and time overruns. Secondary data analysis (MoSPI, 2016, 2017, 2018, 2019, 2020, 2021, 2022) shows the severe cost and time overruns in many infrastructure sectors. MoSPI doesn't mention NGSC network projects exclusively. Because railways, road transport, and highways require ROUs, permanent land, and legislative clearances, like NGSC network projects, Table 1 analyses these MoSPI-reported projects to estimate cost and schedule overruns.

Table-1. Cost and Time Overrun

Sl.	Report Year	Total Number of Projects	Cost Overrun in percentage w.r.t. original cost	Projects with Cost Overrun	Cost Overrun in percentage w.r.t. original cost	Number of Projects with Time Overrun	Time Overrun range in months
Railways							
1	2021-22	285	54.52	202	105.49	141	2 to 324
2	2020-21	311	51.23	209	108.93	159	2 to 324
3	2019-20	315	44.05	187	120.11	146	1 to 324
4	2018-19	366	43.69	207	129.66	99	1 to 324
5	2017-18	353	28.27	213	133.14	36	12 to 261
Road Transport and Highways							
1	2021-22	889	2.97	120	25.18	134	5 to 134
2	2020-21	858	3.73	126	28.19	146	1 to 152
3	2019-20	856	4.16	92	39.3	225	1 to 149
4	2018-19	605	3.46	49	50.58	104	1 to 131
5	2017-18	482	2.01	43	27.57	74	5 to 116

Source: (MoSPI, 2018, 2019, 2020, 2021, 2022)

Exogenous factors (MoSPI, 2022) attributed to time and cost overruns in NGSC network projects which are tabulated in Table 2a and Table 2b, respectively.

Table 2a: Reasons for Time Overrun

Issues with	
Union Ministries	
1	Environment, Forest, Wildlife, Eco-Sensitive Zone Clearances, Tree Cutting Permission
2	Railway permission
3	Road Crossing of Pipelines/Transmission lines permission
4	Grant of Right of Way (ROW) for Right of Use (ROU)
5	Shifting of Utilities
State Governments	
1	Land Acquisition, removal of encroachments, transfer of government land, ROW permission
2	No Objection Certificates from various departments
3	Law and Order
4	Diversion of forest land

Table 2b: Reasons for Cost Overrun

Reasons	
1	Time Overrun
2	Increase in rates of foreign exchange and statutory duties
3	High cost of environmental safeguards and rehabilitation measures
4	High land acquisition costs

MoSPI's monitoring technique is a reactive intervention initiated after the risk event (IPMD, 2021). Recent projects have reported ROW and compensation issues, delaying project completion, and doubling project costs (Line, 2020), due to the reasons attributed to the government departments. The financial loss is unaffordable for a developing country like India, so proactive sustainable techniques to manage these are required.

SCM Strategies

SCM has evolved into a new academic subject. While recently promoting the process view of SCM, some authors have defined it differently (Mukhamedjanova, 2020). This article describes SCM as "the integration of important business operations and collaboration, with two main aspects: the intensity of partner connections and the degree of cooperation throughout the supply chain" (Desai & Rai, 2016). The NGSC demands SCM-like strategies and distinguishing attributes for the transportation, distribution, and delivery of NG in a variety of market and business situations. These strategies are (i) the Triple-A (Feizabadi et al., 2019; Lee, 2004) (ii) Lean (López & Ruiz-Benítez,

2020) (iii) Le-agile (Bhamra et al., 2020).

Triple-A : Hua L. Lee established the Triple-A strategy: Agility, Adaptability, and Alignment (Lee, 2004). Agility is speedy, cost-effective response. Real-time information flow, contingency preparations, and collaboration are used to achieve this. This method aids project planning and control in uncertain environments like the NGSC network project. Adaptability means adapting the SC to market shifts (Lee, 2004) for long-term focus. The adaption strategy with a flexible design method is significant in constructing NGSC network to accommodate local conditions. Hau L. Lee (2004) defines alignment as "creating incentives for supply chain partners to improve performance of the entire chain". Free information and knowledge exchange between vendors and consumers; clear roles and responsibilities; sharing risk, cost, and rewards are ways to establish alignment. All guiding concepts add value when applied to NGSC network initiatives. Due to project startup uncertainties, the approach must be agile and adaptable to local realities. Real-time information and strategic alignment are crucial

for speedy decision-making. Thus, the Triple-A strategy enables the management of unforeseen challenges that jeopardize the project's schedule, resulting in time overruns.

Lean : Lean means creating a value stream to reduce any waste, including Time (Ben Naylor et al., 1999). This technique eliminates waste or Muda, reduces inventory and lead Time, and maximizes profit without meeting precise needs rapidly (Agarwal et al., 2006). The lean strategy optimizes pipeline route alignment to decrease the length and avoid statutory approvals. During the design process, it reduces project costs and removes Time wasters. The strategy manages time and cost overruns while optimizing resource use and supporting sustainability.

Leagile : Leagile combines lean and agile strategies (Ben Naylor et al., 1999; Mason-Jones et al., 2000; Mason-Jones & Towill, 1999). Lean capabilities are the foundation for any agile SC. Therefore, this strategy enables SC design and operation at the lowest competitive cost and speedy execution of NGSC network projects to maximize end-customer satisfaction. Leagile strategies manage risk with a rapid response at a low cost (Fadaki et al., 2020). Market knowledge, value stream, lead time compression, waste elimination, and quick reconfiguration identify leanness and agility (Purvis et al., 2014). The analysis shows that this technique provides value to the NGSC network design, which must be lean to save costs and nimble to establish the SC onsite.

Project Management Processes

PMI, (2017) defines Project Management as the "application of knowledge, skills, tools, and techniques to project activities to achieve project requirements". There are five PM process groups, initiating, planning, executing, monitoring, and controlling, and closing (PMI, 2017a). The NGSC network project applies several processes to accomplish its objectives and goals. The initiating process group identifies project stakeholders. The project plan is developed by integrating 20 subprocess plans. The project execution process group has eight subprocesses. The project monitoring and controlling process have 10 subprocesses. The closing group has two sub-processes. All

these processes are vital to establishing the NGSC network within defined parameters.

DMAIC Cyclic Process

Define, Measure, Analyze, Improve, and Control (DMAIC) is a six sigma data-driven performance benchmarking technique for optimizing, improving, and stabilizing business processes and designs (Toit & Vlok, 2014). DMAIC improves the quality of the typical PM methods used to establish the NGSC network. In addition, the technique minimizes inefficiencies and time-wasting activities, reducing the NGSC network's project and operating expenses. As a result, the cost of delivering NG decreases, making it more attractive for growing NG use and allowing the government to accomplish its stated goals and commitments.

Sustainability

Sustainability requires meeting current demands without endangering the ability of future generations to meet theirs (Brundtland, 1987). Three pillars support sustainable development: the environment, the economy, and society (Birla, 2021). As global concerns about climate change have amplified, environmental health and social justice have received more attention leading to sustainability accounting during economic growth (John, 1998) measured through the TBL method (Martens & Carvalho, 2016). As a result, SDG disclosure by commercial organizations worldwide has dramatically increased, manifesting increased responsibility toward becoming environmentally friendly (Kalra, 2022). The ultimate target is globally achieving net zero carbon emissions, reiterated at COP 26 Glasgow summit (Ahluwalia & Patel, 2021; Elsevier's Analytical Services, 2021; Nations, 2021).

Taxation on NG

As the NG custody passes from the gas producers or importers to end consumers, many indirect taxes are levied (PTI, 2021) comprising producer and consumer taxes (Phoumin et al., 2019), detailed in Table 3a and 3b, respectively.

Table 3a.:Producer taxes on NG

Sl.	Producer Tax	Levied by
1	Excise Duties	Central Government
2	Customs duties on LNG import	Central Government
3	Central Sales Tax	Central Government
4	GST on pipeline transmission service	Central Government
5	Royalty, on the production of NG from offshore regions	Central Government
6	Royalty, on the production of NG from onshore regions	State Government

Table 3b.:Consumer taxes on NG

Sl.	Consumer Tax	Levied by
1	VAT	State Government
2	Octroi, duties including electricity duty	State Government
3	Entry taxes	State Government

Multiple taxations increase the delivered price of NG, impacting its affordability. In importing Liquefied Natural Gas (LNG), additional taxes like a customs duty of 2.5 percent is levied (PTI, 2022). Further, states levy VAT on NG sales at different rates, as detailed in Table 4. Therefore, tax reforms like bringing NG into the ambit of the GST regime will eliminate legacy taxes making NG more competitive and enhancing its affordability. This will

positively impact NG consumption, accelerating the transition towards a gas-based economy in India (PTI, 2022). Accordingly, it is hypothesized that:

H1: Tax reforms in the NG sector mediate the relationship between delivered NG price and increasing NG consumption to accelerate the transition to a gas-based economy

Table 4: VAT rate in percentage

Sl.	State	Vat Rate in percentage	Sl.	State	Vat Rate in percentage
1	Andhra Pradesh	24.5	9	Maharashtra	3
2	Bihar	12.5	10	New Delhi	5
3	Goa	12.5	11	Punjab	3
4	Gujarat	15	12	Rajasthan	10
5	Jharkhand	14	13	Tamil Nadu	5
6	Karnataka	12.5	14	Uttar Pradesh	14.5
7	Kerala	5	15	West Bengal	5 (NG when used as fuel), 14.5 (NG use except fuel)
8	Madhya Pradesh	14			

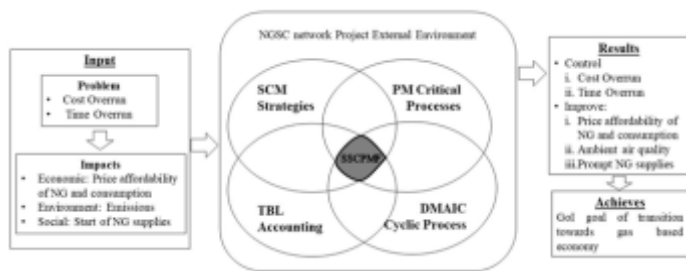
Source: Authors Analysis

Conceptual and Mediating Models

The review above aids the development of a conceptual model theorized by synthesizing diverse concepts to find solutions to the emergent problem, making it a one-of-a-kind contribution with practical applications. The

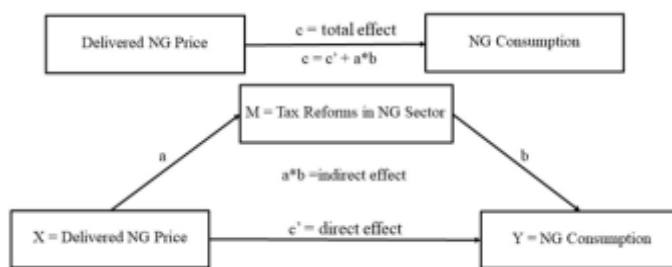
conceptual Supply Chain Project Management (SCPM) model is in Figure 1, while the mediation model (Hayes, 2013) on the role of tax reforms is in Figure 2. The Sustainable Supply Chain Project Management Framework (SSCPMF) is at the intersection.

Figure 1: Conceptual SCPM Model



Source: Author's analysis

Figure2: Tax Reform Mediation Model



Source: Author's analysis

Research Gap and Objective

Literature on applying SCM concepts to the PM body of knowledge is scant except in a few instances detailed in

Table 5. Frameworks and models for improving project management processes, practices, and outcomes on infrastructure projects in the Indian context are also lacking. Also, literature on research problems related to finding solutions to cost and time overruns caused by delays in granting statutory permissions and ROU acquisition in emerging economies is limited. Providing affordable NG access to enhance its consumption for accelerating the transition to a gas-based economy is the immediate target for 2030 for tackling climate change. However, cost, time overrun in NGSC network projects, and multiple taxations on NG sales adversely impact delivered prices. In this context, the current research attempts to fulfill these gaps by aiming to:

1. Propose a Sustainable Supply Chain Project Management Framework (SSCPMF) providing systematic direction for establishing NGSC network projects within cost and time restrictions to provide affordable NG delivery to end users
2. Propose a model by statistically examining the mediating role of tax reforms to enhance NG consumption, with multiple taxes on NG sales being a deterrent.

Table 5: Brief on PM areas

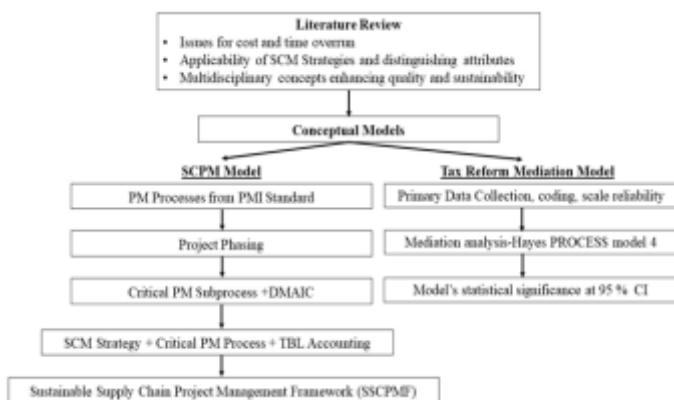
Sl.	Reference	Detail	PM Area
1.	(Ghosh & Hamad, 2021)	Development of a risk exposure model in the supply chain to manage operational risk. Causes of supply chain disruption	Risk Management
2.	(Kan & Khalid, 2021)	As part of their quality assurance and control methods, public procurement procedures should combine accountability, experience, and past knowledge.	Tendering and Procurement
3.	(Rehman & Ishak, 2021)	Government acts, regulations, and policies, with team competencies and skills, influence construction risk management positively.	Construction risk management
4.	(Chidambaram et al., 2021)	Project team integration positively impacts construction outcome	Project soft skills
5.	(Rompoti et al., 2020)	Effective contracting conceptual framework to manage the complex interactions and risks in construction supplier chains.	Construction SC risk management
6.	(Amade et al., 2017)	Implementation of construction projects using SCM approach	Construction Management
7.	(Sanchez-Cazorla et al., 2016)	Risk Management in Mega Projects	Risk Management
8.	(Ramanayaka & Rotimi, 2011)	Strategies for the delivery of construction projects successfully	Construction Management

Source: Authors Analysis

Research Design

The researcher adopted an exploratory design merging three streams of literature: SCM strategies (Triple-A, Lean, and Leagile), PM processes, and sustainability to create a multidisciplinary framework where the application of DMAIC improves process outcomes while the TBL quantifies sustainability. A quantitative method was adopted using a closed-ended questionnaire containing independent, dependent, and mediating variables on the transition to a gas-based economy to collect primary data on the mediating effect of tax reforms. The respondents were randomly selected from professions associated with the NG sector. After encoding the primary data, regression assumptions were examined (Jum C. Nunnally, 1978). Cronbach Alpha was within the acceptable range (Taber, 2018) with a value of 0.828, indicating that the internal consistency of the survey was acceptable. The mediation model was analyzed utilizing model 4 of Hayes PROCESS (Hayes, 2012) for IBM SPSS 26 and 5000 bootstrap samples. At the 95% confidence interval, the statistical significance of the conceptual mediation model was determined by testing the hypothesis. The results are represented diagrammatically and tabulated. The research methodology is in Figure 3.

Figure-3. Research Methodology



Source: Author's analysis

Project Management of the Natural Gas Supply Chain network

Natural Gas Supply Chain (NGSC)

NGSC network is an underground pipeline system linking the NG source to the gas market. Pipeline entities build, own, and operate the pipeline system (PNGRB, 2008). Operations involve upstream NG suppliers and downstream customers. The pipeline entity has contractual agreements with companies, including:

- (i) the project management consultants (PMC) responsible for the network design, engineering, procurement, construction, and commissioning
- (ii) contractors for construction work and vendors for supplying different materials
- (iii) third-party inspection agency for conducting quality checks

Project Management Processes to establish NGSC network project

Building a pipeline system for NG transportation and distribution uses several PM processes, including initiation, planning, execution, monitoring, control, and closure (PMI, 2017a), by integrating successor and predecessor activities. Per the project charter, each process is adapted to site-specific requirements, costs, and schedules. The following is the execution order for critical subprocesses:

- (i) Stakeholders Management

The key stakeholder (PMI, 2017b) role, their varying demands, and expectations from the NGSC network during execution are in Table 6.

Table-6. Stakeholders Management

S.No.	Stakeholder	Role	Demand/Expectation
1.	Government, in instant case Ministry of Petroleum and Natural Gas (MoPNG)	Provide ROU	Project Completion within cost and time
2.	Petroleum & Natural Gas Regulatory Board (PNGRB)	Grant Authorization to lay pipelines	Project completion adhering to design standards, authorized schedule, and approved cost

S.No.	Stakeholder	Role	Demand/Expectation
3.	Statutory Authorities/ Departments	Grant obstacle-crossing permissions expeditiously	Adherence to their design and safety standards during pipeline construction
4.	Land Owners	Allow laying pipelines through their stretch of land.	Fair compensation, quick restoration of land, timely rehabilitation
5.	Press / Media	Report progress status to the public in general	Periodic progress status from the pipeline entity
6.	Local /state government	Resolve ROU issues and fix the compensation rate	Timely disbursement of fair compensation
7.	NG Customers	Generate NG demand	Deliver NG at an affordable price, as per the contractual schedule

Source: Authors Analysis

(ii) Project Management Plan Development

This procedure necessitates the creation of a comprehensive PM plan document outlining planning, execution, monitoring, control, closure, and knowledge management processes. The project team regularly refers to this document. Each accomplished step is checked off the list, and the strategy is evaluated. Major components include scheduling, communications, budgeting, resource management, contracts, quality, and risk management. Plans for stakeholders and management of human resources are intertwined. A momentum rolling wave plan outlines the steps in minute detail to enhance control.

(iii) Project decomposition

Work Breakdown Structure (WBS) is a hierarchical

breakdown of the NGSC network project (PMI, 2017b). After the preparation of the WBS, the organizational, resource, and risk levels are developed. These are the organizational breakdown structure (OBS), the resource breakdown structure (ReBS), and the risk breakdown structure (RBS) structure, respectively. For each WBS level, the risk is identified, and resources are allocated. CPM is used to develop a project model that includes a detailed task list for project completion, while PERT is used to schedule the project. Individual and total float is determined by examining the network schedule for predecessor and successor relationships, early start, early finish, late start, and late finish dates. Normally project planners use enterprise PM software for these. The WBS elements are detailed in Table 7.

Table 7: WBS elements

WBS Element and Weightage	Detail
WBS-1: Pre-Project Activities (W1)	This involves appointing PMC, third-party inspection and survey agencies, establishing project and site offices, finalizing the route alignment, RoU acquisition, seeking statutory permissions, land acquisition, baseline project plan preparation, and stakeholder's analysis.
WBS-2: Design and Engineering (W2)	This involves designing the pipeline system as per standard codes and practices adhering to lean strategy
WBS-3: Tendering and Ordering (W3)	This involves the procurement of different line materials to construct the pipeline system. Contractors are awarded work for pipeline construction
WBS-4: Manufacturing and Delivery (W4)	This involves expediting the various vendors to manufacture and deliver the ordered materials at the designated site following an agile strategy.
WBS-5: Construction and Commissioning (W5)	This involves laying the pipeline system and establishing the different stations along the route through lean strategy.
WBS-6: Project Closeout (W5)	This phase involves closing completed project activities.

Source: Authors Analysis

The project's progression is measured by weighing each WBS element. Each WBS element's monthly and cumulative incremental schedules are merged into a master project schedule. When project activities are finished, the progress made against each activity within the different WBSs is recorded. The actual progress is calculated and compared to the schedule to determine the project's overall physical performance. Likewise, a financial plan is developed, and progress is monitored (Prasad, 2012). These data generate a "S" curve depicting the overall physical and financial schedule. Together, they provide a snapshot of the project's real-time health.

(iv) Risk management

The NGSC network project involves internal and external risks (ISO, 2019) that have a negative effect on the project's objectives, budget, and timeline. Risks can arise from any of the issues discussed earlier, as well as issues such as changes to the project's scope during execution, non-cooperation by key stakeholders, natural disasters, and epidemics. When the project is launched, not all risks are identified in the baseline risk management plan (RMP). Consequently, RBS is prepared for the risk associated with key activities. As risks become more evident, the RMP is revised. At the hierarchical level, risk management responsibilities are delegated. There is resource allocation for each risk. A contingency plan is created to mitigate risk by including a contingency reserve in the project's cost. Catch-up programs compensate for any time lost during the allotted duration of an activity. The league strategy mitigates risk in an uncertain environment because it enables rapid response and cost-effective project operations.

(v) RoU and land acquisition, statutory permissions

Permanent land is acquired to build intermediate stations and terminals for NG receiving and dispatch. Further, laying pipelines requires permission for impediments like roads, railways, water bodies, and forests. Any delay in land acquisition or permission causes time overrun, resulting in financial loss.

(vi) Contracting and Procurement

Contracting, procurement, and delivery of all supplies at the site are essential to mobilize all requisite resources to achieve the construction schedule.

(vii) Project execution

Construction begins after ROU clearance, material delivery, and contractor mobilization. Daily progress is monitored, and delays are analyzed to limit risk. Onsite periodic meetings with stakeholders to review milestones, progress, exceptions, and next steps are done. Mechanical completion and commissioning bring execution to a close

(viii) Project Closeout

Closeout entails the closure of all open orders, the evaluation of vendors' contractors' performance, and the release of any outstanding payments. The actual cost and duration of the project are compared to the estimated costs and timeline. The sponsor is presented with a comprehensive project closeout report.

(ix) Knowledge Leverage

The final critical process is knowledge leverage, in which lessons learned are presented to stakeholders to improve future projects. Additionally, brainstorming sessions address issues that impact the project's cost, schedule, and quality to ensure that similar risks do not recur.

The processes outlined above are continuous, mutually reinforcing, and result in a compounding effect. As a result, knowledge leverage ensures its sustainability for improvement and enhancement, resulting in cost and schedule optimization.

Supply Chain Strategic Fit

The ultimate goal is to construct the NGSC network within the original cost and schedule constraints while maintaining design standards to provide NG to customers at a reasonable cost. The customers specify when they want to use NG, and the pipeline entity determines how long it will take to establish connectivity. The pipeline entity and the customers settle on a mutually agreeable NG delivery schedule by signing a bilateral contract. The project plan is carried out at three levels, strategic, tactical, and

operational. The long-term strategic plan aligns with the ultimate goal—the tactical plans carry out the strategy in the medium term. Operational plans are short-term plans for completing tasks daily. The pipeline entity maintains a strategic fit (Chopra and Meindl, 2013) by aligning its SCM and competitive business strategies. Nonetheless, NGSC's

strategic fit is best demonstrated when it manages external risk efficiently and effectively, avoiding cost and time overrun.

Distinguishing attributes for SCM strategy

The distinguishing attributes of the SCM strategy with the associated NGSC objectives are in Table 8.

Table 8: Distinguishing attributes

S.No.	Attribute	Associated NGSC Objective
Distinguishing attributes for lean, agile, and leagile strategy(Agarwal et al., 2006)		
1.	Customer Drivers	Cost price affordability, NG delivery schedule
2.	Dominant Cost	Project cost
3.	Purchasing Policy	Project cost, quality
4.	Lead Time Compression	Project schedule, NG delivery schedule
5.	Eliminate Muda	Project cost, schedule, quality
6.	Service Level	NG delivery price, NG delivery schedule
Distinguishing attributes for adaptability and alignment strategy (Feizabadi et al., 2019)		
1.	Structural Shift	Project schedule, quality
2.	Market Changes	NG delivery price, NG delivery schedule
3.	Visibility	Project schedule, NG delivery schedule
4.	Flexibility	Project schedule
5.	Innovation	NG delivery price, NG delivery schedule, quality
6.	Performance	Project schedule, NG delivery price

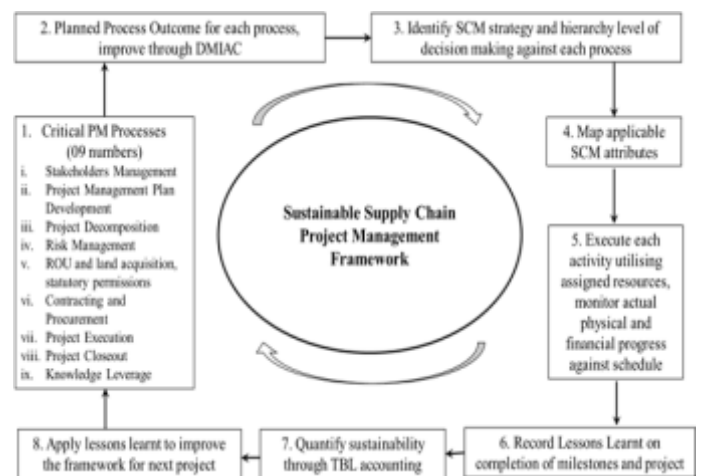
Source: Authors Analysis

Results and Analysis

Sustainable Supply Chain Project Management Framework (SSCPMF)

The SSCPMF depicted in Figure 4 is an eight-step guiding framework that assists the pipeline entity in creating the NGSC network within the parameters specified in the project charter. The framework encourages proactive response by continuously monitoring the external operating environment and aligning agile execution strategies with a lean design. It integrates SCM strategies and project management processes, assessing WBS outcomes regularly against DMAIC to ensure process sustainability. Table 9 lists each essential process targeted outcome, hierarchical-level strategy, and functional attributes.

Figure-4. Sustainable Supply Chain Project Management Framework (SSCPMF)



Source: Authors Analysis

Table 9: Critical Process and Outcome

S.No.	Critical Process	Planned Process Outcome	SCM Strategy/ [Hierarchy Level]	Functional attributes
1.	Stakeholders Management	Stakeholder identification, classification(internal/external), role definition, demand/expectation	Adaptability, Alignment / [Strategic]	Visibility, Flexibility
2.	Project Management Plan Development	Project Schedule to monitor physical and financial progress, major milestones, and interrelationships	Leagile, Adaptability, Alignment / [Tactical, Operational]	Lead time compression, Structural Shift, Market changes, performance
3.	Project Decomposition	Identification of WBS elements and activities within each WBS	Lean, Adaptability, Alignment/ [Tactical]	Eliminate Muda, Dominant Cost, Flexibility, Innovation
4.	Risk Management	RBS, Risk mapping with WBS, and resource identification for mitigation	Agile, Adaptability, Alignment / [Strategic, Tactical]	Customer drivers, Lead time compression, performance
5.	ROU and land acquisition, statutory permissions	Timely acquisition of ROU and receipt of all permissions	Agile, Adaptability, Alignment / [Tactical, Operational]	Structural Shift, Lead Time Compression, Flexibility
6.	Contracting and Procurement	Orders placement within schedule and budgeted cost	Lean, Alignment / [Tactical, Operational]	Purchasing Policy, Eliminate Muda, Structural shift, Market changes, Innovation
7.	Project Execution	Completion of pipeline laying within cost, schedule, and quality	Leagile, Adaptability, Alignment / [Tactical, Operational]	Service Level, Flexibility, Innovation, Performance
8.	Project Closeout	Performance appraisal of all vendors, and contractors, the release of final payment	Agile, Alignment / [Operational]	Dominant Cost, Service Level
9.	Knowledge Leverage	Implementation of lessons learned in the subsequent project will ensure the sustainability of the process towards continuous improvement.	Leagile, Adaptability, Alignment / [Operational]	Service Level, Structural Shift, Market changes, performance

Source: Authors Analysis

Mediation analysis

A mediation analysis was undertaken to comprehend and determine the role of tax reforms (M) as a mediator between the NG-delivered price (X) and NG consumption (Y). The respondents comprised professionals associated with the Indian NG sector, the majority being male. According to Table 10, the total effect of NG delivered price on rising NG

consumption is statistically significant (H1: $c=0.304$, $p=0.000$). However, when the tax reforms were included, the direct and indirect effects remained significant ($a*b=0.125$, $LBCI=0.018$, $UBCI=0.229$), indicating that tax reform partially mediates the relationship between NG-delivered price and rising NG consumption, supporting the hypothesis.

Table 10: Mediation between NG delivered price and NG consumption

Hypothesis	Total effect (c)	Direct effect (c')	Indirect effect (a*b)	95 percent Confidence Interval (CI)		Conclusion
				Lower Bound(LB)	Upper Bound(UB)	
H1 _d	0.304 (0.000)	0.179 (0.009)	0.125	0.018	0.229	Partial Mediation

Source: Author's calculations

Contribution to Sustainability

India's first choice for moving towards carbon neutrality with enhanced NG consumption is economical compared to liquid alternatives such as gasoline and diesel in the transportation segment (IGL, 2021a). NG produces 50% less carbon dioxide than coal and 25% less than oil. When used in NG vehicles with the same engine power as gasoline, Compressed NG (CNG) emits 70% less carbon monoxide, 89% less non-methane organic gas, 87% less nitrogen oxides, and minimal greenhouse gases and pollutants (Demirbas, 2012). Thus NG enhances efficiency and economic performance, resulting in environmental benefits (Zhang et al., 2020). In addition, the NGSC network offers individuals access to NG for cooking, displacing high-polluting conventional fuels like coal and kerosene, decreasing health risks, and thereby providing social and economic advantages by addressing fundamental necessities supporting SDG 3. Thus, the NGSC network permits affordable access to clean NG, offering several benefits (IGL, 2021c, 2021a, 2021b), promoting economic, environmental health, and social well-being as defined by the TBL accounting approach aiding India in achieving its SDG 7 objectives.

Discussion and Research Implications

Unique for NGSC project execution, the SSCPM framework incorporates mature multidisciplinary diverse concepts that have never been deployed in conjunction with any SC network infrastructure projects. The framework (Fig 4) is superior to the traditional PM model (MoSPI, 2010) in a number of ways, including its dynamic, aligned, and proactive adaptation to the project environment,

promotion of lean design and agile execution, and application of the PM process from global standards with a data-driven DMAIC cyclical process to benchmark quality and enhance process sustainability. The results in Table 9 indicate which proven SCM strategies at the hierarchy level should be applied to the nine critical PM processes to capitalize on functional attributes and achieve NGSC project objectives. The results support the recommendations for implementing SCM strategies in the PM body of knowledge (Wei et al., 2021) and in construction projects (Amade et al., 2017). In the stakeholder management process, for instance, an adaptable SCM strategy that leverages the visibility and flexibility features will meet the demands and expectations of influential strategic-level stakeholders. Similarly, when applied to the ROU and land acquisition process at the tactical and operational levels, an agile, adaptive alignment strategy will manage the structural transition by shortening the lead time for the timely acquisition of ROU and receipt of clearances.

India is a developing nation, and eradicating energy poverty among the common masses is one of the national energy policy objectives underpinning affordable access (Aayog, 2017). Quantitative results revealed that tax reforms mediating role is significant at a 95% confidence interval to enhance NG consumption which is required to accelerate the transition to a gas-based economy. Thus the SSCPMF, coupled with tax reforms, will have a compounding effect on fulfilling the GOI vision for a gas-based economy by 2030. The diverse research implications are listed in Table 10, necessitating action on emerging issues by associated stakeholders.

Table 10: Research Implications

S.No.	Implication for action	Dimension	Explanation	Criticality of Implication	Interested Party
1.	Socio-Economic - Sustainable Development	Increase in the share of NG in the primary energy mix	Provides thrust to the GoI objective for achieving a transition towards a gas-based economy	High: Enhanced use of NG arrests climate change	GoI, Citizens
2.	Financial	Cost and Time Overrun Phenomena	The proposed framework adopts DMAIC cyclic process for its continuous improvement	High: Manage cost and time overrun	GoI, Pipeline Entity, NG Customers

S.No.	Implication for action	Dimension	Explanation	Criticality of Implication	Interested Party
3.	Academic	New Research Area	Provides an opportunity to explore PM issues through SCM and Sustainability lens	High: Future research will provide empirical models with more effective solutions	Academicians, Researchers
4.	Practical	New Framework	Onsite applications in real-world settings will test the framework's effectiveness by comparing completion cost and schedule with similar results of earlier projects implemented using the traditional model.	High: Cost and Schedule Optimization	Project Management field Professionals, GoI, NG customers
5.	Policy	Review the current monitoring mechanism of MoSPI, guidelines for granting statutory approvals, land acquisition	The current MoSPI monitoring mechanism is reactive and requires refurbishing to support GoI aspirations under SDGs. Time-consuming lengthy policy guidelines for statutory approvals, land acquisition need review along with guidelines for compensation	High: An emerging economy like India cannot afford financial loss attributed to issues causing time and cost overruns.	GoI, Citizens

Source: Authors Analysis

Conclusions, Limitations, and Research Directions

This research is the first step toward developing a practice-driven sustainable framework for proactive cost and schedule management in NGSC network projects while ensuring continuous improvement in the critical PM processes outcome. The findings solve a real-time business problem that impacts NG sector in an emerging economy. Results contribute to all forms of sustainability by expanding NG access to common masses via NGSC. However, if cost and schedule overruns are to be managed, the GoI's guidelines for statutory approvals, ROU acquisition, and equitable compensation must be immediately reviewed, as these influence construction risk management (Rehman & Ishak, 2021). Unforeseen delays due to lengthy processes increase the budgeted cost at completion and adversely impact delivered gas prices. Concurrently multiple taxations on NG contrast the energy policy and SDG 7 objective for affordable energy access (IEA, 2022). Therefore, implementing tax reforms like bringing NG sales under the GST regime is necessary to

make NG competitively priced. While the scope of the research is limited to NGSC, it can be expanded to include other network projects related to laying railway lines and building National Highways that face similar challenges during ROU acquisition and statutory permissions. Field testing will improve the framework's credibility enhancing robustness, while TBL accounting will quantify the multidimensional sustainable benefits accrued to the stakeholders. The results can be applied to any emerging economy where the NGSC faces similar barriers and challenges.

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