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An Evaluation of Project Planning and Implementation Efficiency in the Larsing Basti Water Supply Scheme under PHE, Silchar Division II

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1. Introduction

A project includes various interrelated activities or tasks that are required to be completed on or before a specified set of time period in chronological order with a set quality and minimum cost of using resources such as personnel, money, materials, facilities, and space. In this _ we will take the example of Public Health Engineering (PHE) Project based on Larsing Basti.

Management is a process in which things are done with the help of others or through others. It is done by marshaling man, material, machines and money to get things or tasks done in the best possible way. The quality of performance of a task is determined by the quality of its management.

Project Management is a set of principles, methods, and techniques that people use to effectively manage i.e. plan, control, and review the project work. It provides a strong foundation for proper planning, scheduling, resource allocation , decision making, feedback and adjustments.

2. Project Management

Project management plays a crucial role in ensuring that projects are completed within the allocated budget, timeline, and available resources. It goes beyond these foundational objectives by supporting broader organizational goals such as improved productivity, cost- effectiveness, timely delivery, and quality assurance. In today's dynamic and fast-paced environment, where efficiency and accountability are paramount, project management has emerged as a critical discipline across sectors including business, government, and non-profit organizations.

Modern organizations operate under increasing pressure to deliver results faster, at lower costs, and with higher quality standards. This growing emphasis on speed, quality, and cost control has made project management an essential strategy for competitive advantage. Effective project management enables organizations to shorten time to market, reduce operational expenses, and maintain high service standards—ultimately helping them differentiate their offerings and meet stakeholder expectations.

Given today's limited resources and shrinking timelines, a proactive management approach has become indispensable. Contemporary project environments require managers to deliver more with fewer resources and smaller teams, with minimal tolerance for mistakes. In this context, project management involves multiple layers of responsibility. At the top level, executives such as CEOs, Presidents, and Vice Presidents set the strategic direction. Next, resource providers— including CFOs, CIOs, and department heads—allocate budgets and assign skilled staff. Project managers then coordinate these resources to deliver outcomes, while field-level professionals such as engineers, accountants, and programmers execute the tasks and report progress.

Once a project is sanctioned, a project manager is appointed—either from the project management department or another functional area—depending on the nature and complexity of the project. This manager is tasked with overseeing the project's execution and ensuring that it meets its objectives within the established parameters of cost, time, and quality. Their role is central to the success of the project and includes planning, scheduling, and control.

The planning phase of project management involves identifying all required activities and determining the relationships among them. Key tasks in this phase include resource estimation (covering manpower, materials, machines, and money), assigning responsibilities, estimating costs and timelines, setting performance criteria, and establishing control channels. A network diagram is often developed during this phase to visualize the logical flow of activities and their dependencies.

Following planning, the scheduling phase involves assigning specific responsibilities to individuals, estimating task durations, identifying interdependencies, and developing a project network diagram. This diagram helps in calculating the overall project duration and in pinpointing critical tasks that require close supervision.

The control phase consists of monitoring the project's actual progress against the planned schedule. If any deviations are identified, corrective measures are taken to realign the project with its original objectives. This phase is crucial in ensuring that the project stays on track and meets its expected outcomes.

Project management uses structured techniques such as PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method). PERT is particularly useful in projects with uncertain timelines, as it focuses on the overall project duration using probabilistic time estimates. CPM, on the other hand, is more deterministic and is used to calculate both time and cost, especially in repetitive or well-defined projects.

Both private and public sector organizations apply project management principles, although their priorities often differ. In the private sector, the primary goal is typically profit maximization, whereas public sector projects are oriented toward achieving social and developmental objectives. Public sector projects also consider factors like return on investment, gestation period, decision-making efficiency, and socio-economic impact. However, challenges such as the lack of a program-based approach, limited return analysis, and the complexity of evaluating social costs and benefits often hinder public sector project management effectiveness.

Despite these challenges, project management remains an essential practice across sectors. It provides a systematic approach to planning and execution, improves transparency and accountability, and enhances the overall efficiency and effectiveness of both infrastructure development and service delivery.

3. Statement of the Problem

Despite of Large-Scale investments by the government in Public Health Engineering (PHE) schemes and projects that are aimed at offering safe drinking water, sanitation, and water management but most areas still suffer from poor infrastructure, poor maintenance, irregular water quality, and lack of community participation. These factors are responsible for the lack of sustainability and efficacy of PHE initiatives, especially in rural and underdeveloped regions, resulting in ongoing public health hazards and diminished quality of life.

The Jal Jeevan Mission (JJM) initiated by the Government of India targets to supply functional household tap connections (FHTCs) with safe and sufficient drinking water to all rural households by 2024. Although the mission has sped up water infrastructure development, some challenges still affect its effectiveness. These are inconsistent water source sustainability, project implementation delays, weak operation and maintenance systems, shortages in skilled manpower, and community participation constraints. These are the issues which result in dysfunctional systems, contamination of water and infrastructure delivery, and long-term service assurance shortfall in most places, particularly tribal and rural districts. It is imperative to mitigate these problems so that the mission's vision to provide equitable and sustainable access to safe drinking water for everyone becomes a reality.

4. Objective of the study

- To analyse the project management methodologies applied in PHE water schemes in Larsing Basti.
- To construct and analyze a Gantt Chart for the water supply project to visually represent the timeline, task durations, and interdependencies between different activities.
- To develop a comprehensive project network diagram.
- To examine the application of project scheduling and control methods such as PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) in planning and managing the activities of the water supply scheme.

5. Limitation of the Study

- Access to official project records and schedules was restricted due to bureaucratic constraints, which may have affected the depth of technical analysis related to PERT, CPM, floats, and slack.
- The implementation of tools like PERT and CPM in real-life PHE projects was found to be limited or informal in nature, which constrained the ability to analyze structured schedules or conduct rigorous quantitative modeling.
- Although efforts were made to engage a diverse group of stakeholders, some community members and PHED officials were either unavailable or unwilling to provide detailed responses, potentially limiting the scope of qualitative insights.
- During fieldwork, it was observed that monitoring and evaluation mechanisms were not consistently applied across project phases.

6. Research Methodology

The current study is of exploratory in nature. Here the project “A study on Project management of Larsing basti water supply scheme” was studied and analyzed from the perspective of project management. It is meant to explore and understand different aspects of project management in the context of the water supply scheme of Larsing Basti. The study has been undertaken with the intention of identifying fundamental aspects such as planning, execution, monitoring, and evaluation in the context of Public Health Engineering (PHE) activities. The study attempts to explore the application of established project management techniques i.e., PERT (Program Evaluation and Review Technique), CPM (Critical Path Method), floats, and slack within the scheme life cycle or their potential applicability there.

This method enables the overall examination of the use of resources, risk management strategies, and overall efficiency of operations of the scheme. It is not a test of a particular hypothesis but instead seeks to provide enlightenment on the true issues and project management strategies faced in the execution of the water supply scheme in Larsing Basti.

6.1 Data collection Method: -

The following are the methods of collecting the data from the PHE regarding the project management.

- Official project reports, tender documents, and schedules from the PHE department.
- Government publications and policy documents related to water supply and public infrastructure.
- Literature from academic journals on project management in public utility services.
- Observation of site by visiting the PHE in Larsing Basti

6.2 Sources of Data

- Project reports, documents and various official schedule reports from the PHE department.
- Government Publications and various policy documents related to the project.
- Information provided by the website **Jal Jeevan Mission.**

7. Review of Literature

Author(s), Year	**Study Focus**	**Methodology / Approach**	**Key Findings**	**Implications**
Shirle et al., 2022	Project management in a water treatment plant	Interviews with stakeholders	Emphasized planning, resource mgmt., and stakeholder coordination	Highlights best practices for timely project completion
Weibe & Gachengo, 2024	Sustainability of water/sanitation projects in Kenya	Descriptive survey of 17 projects	Planning, monitoring & stakeholder involvement vital	Recommends revised resource management
Rahbaralam et al., 2020	Predictive maintenance in water systems	ML and survival analysis	Pipe geometry, age, material as risk factors	Supports predictive maintenance and resource optimization
Garcia-Herrero et al., 2023	Constructed wetlands for water management	Cost-benefit analysis	Benefits outweigh costs; ecosystem services valuable	Validates green infrastructure for sustainability
Dubey et al., 2023	Tanker-based water distribution under uncertainty	Monte Carlo + scenario tree + Primavera P6	Improves scheduling and monitoring	Promotes planning tools in rural water projects
Maheshwari et al., 2024 (1)	Tanker distribution under uncertainty	Two-stage stochastic model	Optimized delivery, reduced groundwater use	Useful for non-piped water systems
Itani, 2023	Integration of CPM & PERT	Analytical integration	Improved timeline and resource accuracy	Enhances flexibility and delay avoidance
Maheshwari et al., 2024 (2)	Short-term tanker operations	MILP model application	Balanced quality, schedule, logistics	Supports real-time decision models

Author(s), Year	**Study Focus**	**Methodology / Approach**	**Key Findings**	**Implications**
Khajesaeedi et al., 2025	Review of RCPSP advancements	Literature review (2016–2024)	Identifies hybrid and AI-based solutions	Recommends dynamic and decentralized models
Bahroun et al., 2024	Review of MS-RCPSP	Review of 171 articles	Need for flexible, skill-based scheduling	Advocates real-time, skill-sensitive models
Sayah, 2023	Continuous-time MMRCPSP models	Mathematical modeling	Network flow > event-based models	Enhances complex task scheduling accuracy
Holguin Jimenez et al., 2024	Multi-objective production rescheduling	Systematic review	Metaheuristics balance time/cost/resources	Encourages adaptive real-time control
Derbe et al., 2020	Trends in construction scheduling	Scientometric review (332 articles)	Gaps in AI, BIM, IoT use	Advocates digitization of scheduling
Li et al., 2023	Multi-mode, multi-skill scheduling	Mixed-integer model + immune system algorithm	Better labor allocation and delay reduction	Realistic modeling for infrastructure projects
Zohrehvandi, 2022	Scheduling in power plant construction	Heuristic algorithm	Improved leveling and sequencing	Ideal for large-scale, multi-contractor projects
Pimplikar & Salgude, 2021	Evaluation of building project performance	PDSF, PPI, PMCI models	Poor coordination causes failure	Suggests real-time monitoring tools
Shendurkar et al., 2022	Role of automation in risk reduction	Simulations & real data	Tech reduces delays and cost overruns	Supports automated risk detection
Malik et al., 2021	Sustainability in project management	Case-based analysis	Greater stakeholder satisfaction with sustainability	Recommends green practices in public projects
Jain & Malviya, 2019	Adoption of project tools (Primavera, BIM)	Review of Indian projects	Tools improved execution and tracking	Essential for timely & cost-effective execution
Chenchu et al., 2024	NHAI's use of data lakes	Real-time data analysis	Reduced delays and enhanced transparency	Promotes data-driven infrastructure execution
Mittal, 2025	Digital technologies in project execution	Analytical review	AI/cloud enhanced collaboration & resource mgmt.	Recommends real-time digital tools
Yadav et al., 2023	Delay analysis in road projects by contract type	Comparative study	PPP/EPC had fewer delays than item-rate	Highlights contract type's impact
Patil & Vaidya, 2019	Development project issues in India	Theoretical model	Stakeholder misalignment & poor feedback loops	Promotes proactive change management
Chandrachooodan et al., 2021	Govt vs. corporate IT project practices	Comparative analysis	Govt less adaptive; corporates more responsive	Recommends context-specific frameworks
Lakhawat & Agarwal, 2023	Infrastructure tender reforms in India	Critical review	Increased transparency, reduced scope changes	Suggests improved procurement practices
Dixit & Saurabh, 2019	Productivity in construction	Analytical study	Equipment/labor efficiency crucial	Recommends KPI-based change plans

Author(s), Year	**Study Focus**	**Methodology / Approach**	**Key Findings**	**Implications**
Malik & Kumar, 2024	Delay causes in residential construction	Case analysis	Poor planning, resource & communication gaps	Calls for formal monitoring and coordination
Sharma & Trivedi, 2023	Delay causes under Hybrid Annuity Model	Policy-oriented study	Land & finance major issues	Suggests pre-contract readiness
Das, 2024	Real estate project delay factors	Organizational analysis	Poor leadership & delegation cause delays	Supports structured PM methods
Vishal & Myneni, 2021	Delay causes in construction	Empirical study	Manpower/material shortages common	Recommends procurement & skilled workforce
Shrivas & Singla, 2018	Delays in marine construction	Sector-specific study	Environmental & logistics delays dominate	Suggests faster approvals & contingency planning

7.1 Gap in Literature Review

While PERT, CPM, and Gantt charts are widely discussed in project management literature, their practical application in government-led infrastructure projects remains limited. Specifically, there is a lack of studies demonstrating the real-world use of these tools in rural water supply schemes, such as those implemented by the Public Health Engineering (PHE) Department. Gantt charts, though effective for visualizing timelines and task dependencies, are rarely applied using actual project data in public sector contexts. Moreover, existing research often neglects the analysis of individual activity variances and their impact on project delays, limiting the understanding of schedule risks. This study addresses these gaps by applying project scheduling and control techniques to real-world data from the Larsing Basti water supply project.

8. Data Analysis and Interpretation

In project planning, especially in large infrastructure projects such as the Water Supply Scheme at Larsing Basti, falling under the Public Health Engineering (PHE) Department, Silchar Division II, data analysis and interpretation is of primary importance when it comes to ensuring the success of the project. Since infrastructure projects usually comprise many interconnected activities, different timelines, several stakeholders, and fewer resources, it is risky and time- wasting to use instinct or unstructured decision-making techniques. By using data analysis, project managers are able to decompose intricate project activities into workable units, properly schedule them, and track their progress in a methodical and transparent approach.

Analysis techniques like the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) are critical tools for this kind of analysis. CPM assists in determining the order of the most important tasks that dictate the minimum project duration to ensure that project managers concentrate their effort and resources on activities whose delay would immediately result in a delay in project completion. Conversely, PERT accommodates uncertainty in activity duration with the employment of three time estimates ,most likely, optimistic, and pessimistic, to arrive at a more realistic expected time It not only facilitates risk forecasting but also enhances planning accuracy.

In addition, data derived in the form of Gantt charts and network diagrams offer visual clarity on task dependencies and timelines. The visuals aid in inter-departmental coordination, enable better decision-making, and assist in communicating to stakeholders. Finally, computing float and slack indicates which activities possess scheduling flexibility, and thus reallocation of resources to critical activities without altering the overall timeline.

For the Larsing Basti project, more than 30 mutually dependent activities were examined and planned by applying these techniques. CPM was employed for identifying the critical path, whereas tasks containing uncertainty such as procurement of materials and weather-sensitive construction were planned using PERT. Through this analytical method, the project team was able to anticipate delays in advance, deploy resources effectively, and make decisions at each stage of implementation.

Therefore, data interpretation and analysis in project management are more than technical computations, these facilitate a move away from reactive towards proactive control. They offer a basis for efficiency, accountability, and transparency, all of which are vital to successful public infrastructure project delivery. In short, by converting raw scheduling data into usable insights, these techniques greatly improve the potential to complete the project on time, at budget, and to predetermined specifications.

9. Objective wise analysis

Objective 1: - To analyse the project management methodologies applied in PHE water schemes in Larsing Basti.

The study identifies formal and informal processes used by PHE Silchar Division II for the Larsing Basti piped water supply scheme. The study examines documentary evidence (Project Initiation Documents, Detailed Project Reports, Work Breakdown Structures) to determine citations of PMBOK's five process groups (Initiation, Planning, Execution, Monitoring & Control, Closure), PRINCE2 stage gates, or any hybrid customized methodologies. The study will clean workflow diagrams, approval matrices, and governance procedures to determine each methodology's implementation adaptability.

The evaluation examines each life-cycle stage:

Initiation: Project charter and stakeholder register preparation, with focus on the Water User Committee as a pivotal stakeholder in establishing goals and boundaries.

Planning: Use Gantt charts, PERT/CPM diagrams, and slack calculation. Compare cost estimates, resource-loading tables, and procurement schedules against actual data.

Execution: Implement budget-control ledgers, procurement workflows, and quality checklists. Interviews with engineers and contractors show compliance with processes and any unofficial workarounds.

Monitoring & Control: MIS success, frequency of site visit reports, and risk registers in the context of avoiding monsoon-related delays or material shortages.

Closure: Perform post-implementation audits, check variance reports, and formal sign-off, including WUC's handover certificate.

Public Health Engineering (PHE) Department, Silchar Division II, uses a blended approach to managing projects based on combining aspects from the PMBOK's five process groups with the stage-gate approach of PRINCE2, topped off by several context-specific local procedures. This blending offers greater flexibility, organization, and locally responsive approach to public infrastructure project management.

Using both methodologies in tandem, the department is better positioned to improve project governance and oversight. The combined model allows engineers and project officers to track and assess progress in real-time, intervene with corrective action in case of deviations, and minimize the risks of cost overruns and delays. Moreover, the integration of locally designed project controls and checklists guarantees that the methodology is based on the local context, thus more responsive to on-ground issues like resource limitations, administrative bottlenecks, or weather-related problems.

Overall, the integrated approach not only ensures effective project delivery but also accountability, transparency, and cost-effectiveness, as aligns with the overall objectives of sustainable infrastructure development in the region

Objective 2: To construct and analyze a Gantt Chart for the water supply project to visually represent the timeline, task durations, and interdependencies between different activities.

With the aim of visually representing the overall project timeline, task durations, start and end dates, and the interdependence among various activities. The Gantt Chart will serve as a vital tool for project tracking, enabling stakeholders to monitor progress, identify potential scheduling conflicts, and make informed decisions to keep the project on schedule. Through this analysis, the study will assess how effectively the Gantt Chart contributes to communication, coordination, and time management within the project.

Why Gantt Chart?

A Gantt Chart for the Larsing Basti Water Supply Scheme under PHE Silchar Division II was prepared with project activity data derived from the detail project schedule. The table contains the key elements of activity name, predecessor tasks, duration, start date and end date, and dependencies of the critical path, which are critical to project planning and monitoring.

The Gantt Chart graphically charts every stage of the project right from survey and land acquisition to material acquisition, electrical connecting, and execution-related activities such as pipeline trenching, reservoir construction, and final testing. Every task is plotted in the form of a horizontal bar on a time axis so that project managers can visually observe actual progress against planned durations.

Table 2: Table showing assumed timeline of activities

Sr. No.	Series	Activity Name	Previous Act	Duration	Max Duration	Start Date (Approx.)	End Date (Approx.)
A	A	Survey and Land acquirement	-	21	22	01-09-2021	24-09-2021
B	B	Designing and approving of estimated cost	A	10	13	29-09-2021	11-10-2021
	B1	Approval of work order		3		25-10-2021	27-10-2021
C	C1	Ordering construction materials (sand, bricks,	B	15		01-11-2021	17-11-2021

		stones)					
	C2	Apply for electricity connection		8	15	20-11-2021	29-11-2021
	C3	Ordering of pipeline and ESR material (staging + tank)		10		07-12-2021	17-11-2021
	C4	Raising low sites near the plant site with approved soil		15		07-12-2021	23-12-2021
D	D1	Underground Reservoir Construction	C	30	60	05-01-2022	08-02-2022
	D2	Sedimentation Tank Construction		25		15-02-2022	15-03-2022
	D3	Filtration Bed Construction		20		30-03-2022	21-04-2022
	D4	Pump House (Clear Water) Construction		15		29-04-2022	16-05-2022
	D5	ESR base (pile and pile cap) Construction		45		27-05-2022	29-07-2022
	D6	Boundary wall Construction		7		31-07-2022	08-08-2022
	D7	Pump House (Raw water) Construction		10		10-08-2022	20-08-2022
E	E1	Items Delivered (pipeline & ESR materials)	D	45	60	30-08-2022	20-10-2022
	E2	Transformer installation and charging begins		12		29-10-2022	11-11-2022
F	F1	Providing Pipe connection around the plant	E	12	25	20-11-2022	03-12-2022
	F2	FHTC connection provided (Functional household tap connection)		20		15-12-2022	06-01-2023
G	G	ESR Installation (staging and tank installation)	F	20	25	16-01-2023	07-02-2023
H	H1	Installation of pumps & commissioning	G	15	15	17-02-2023	06-03-2023
	H2	Internal Connection		10		24-03-2023	10-04-2023
I	I	Installation of Service Valve	H	5	5	13-04-2023	18-04-2023
J	J	Trial Run of the connected bodies	I	4	4	22-04-2023	26-04-2023
K	K	Testing & Commissioning of ESR Tank, Pipeline	J	17	17	29-04-2023	18-05-2023
L	L	Site development, gate installation and boundary wall	K	8	8	30-05-2023	07-06-2023
M	M	Handover to WUCs and PRI (Panchayati Raj Institution)	L	7	7	18-09-2023	25-09-2023

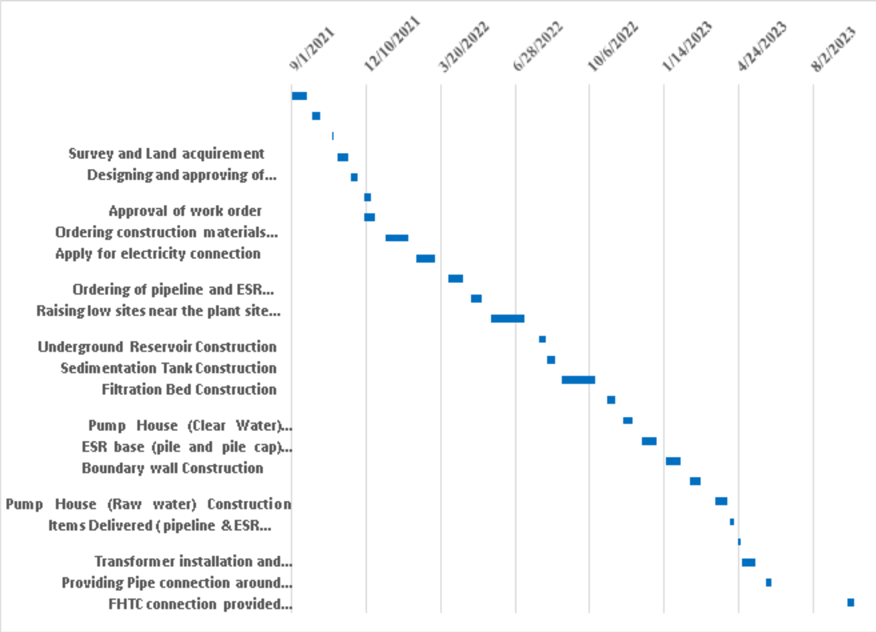

Fig: Chart showing Scheduling of events (Gantt Chart)

Critical Advantages Realized:

Enhanced Scheduling Transparency:

The Gantt Chart gave a clean picture of how activities are planned and how delays in one activity (e.g., approval of estimates) can affect the next activities (e.g., ordering of materials). This assisted in early identification of bottlenecks.

Effective Monitoring and Tracking:

Project engineers and officers could track which activities were on-going, upcoming, or behind schedule using the chart. This helped facilitate real-time decision-making and remedial measures.

Resource Allocation:

By superimposing where possible and visually defining task durations, the chart assisted in best utilization of labor and materials, minimizing idle time and waste.

Identification of Critical Activities:

Those activities with zero slack (on the critical path) were identified, permitting close supervision and management in advance of high-risk parts.

Since various sub-activities (e.g., C1 and C2 under material procurement) were timed parallelly or sequentially, the chart enhanced communications as well as coordination between departments.

Finally, the Gantt Chart was an important tool in the project management of the Larsing Basti water supply scheme. Not only did it allow for improved planning and control but also helped significantly in making the project remain on its intended schedule and cost dimensions.

Interpretation:

The project spans just over two years (Sept 2021 – Sept 2023).

Activities often run sequentially with little overlap, reflecting a tightly controlled schedule. Critical paths involve construction (D series) and commissioning (H–K series).

Final handover to community institutions occurs after all technical work is complete.

Objective 3: To develop a comprehensive project network diagram.

A project network diagram is a basic visual planning aid that formally traces the order of project activities, their relationships to one another, and the logical progression from the initiation to the successful completion of a project. In the case of the Water Supply Scheme at Larsing Basti, carried out under the Public Health Engineering (PHE) Department, Silchar Division II, a complete network diagram was formulated from thorough activity data obtained from the project schedule of the department.

Table 3: List of activities and their respective dependent (preceding) tasks

Sr. No.	**Series**	**Activity Name**	**Previous Act**
A	A	Survey and Land acquirement	-
B	B1	Designing and approving of estimated cost	A
	B2	Approval of work order	A
C	C1	Ordering construction materials (sand, bricks,stones)	B1
	C2	Apply for electricity connection	B1
	C3	Ordering of pipeline and ESR material (staging +tank)	B2
	C4	Raising low sites near the plant site with approved soil	B2
D	D1	Underground Reservoir Construction	C1
	D2	Sedimentation Tank Construction	C1
	D3	Filtration Bed Construction	C1
	D4	Pump House (Clear Water) Construction	C1
	D5	ESR base (pile and pile cap) Construction	C3
	D6	Boundary wall Construction	C4
	D7	Pump House (Raw water) Construction	C3
E	E1	Items Delivered (pipeline & ESR materials)	D5
	E2	Transformer installation and charging begins	D6, C2
F	F1	Providing Pipe connection around the plant	E1, E2
	F2	FHTC connection provided (Functional household tap connection)	E1, E2
G	G	ESR Installation (staging and tank installation)	F, D7
H	H1	Installation of pumps & commissioning	G, D’
	H2	Internal Connection	G, D’
I	I	Installation of Service Valve	H
J	J	Trial Run of the connected bodies	I
K	K	Testing & Commissioning of ESR Tank, Pipeline	J
L	L	Site development, gate installation and boundary wall	K
M	M	Handover to WUCs and PRI (Panchayati Raj Institution)	L

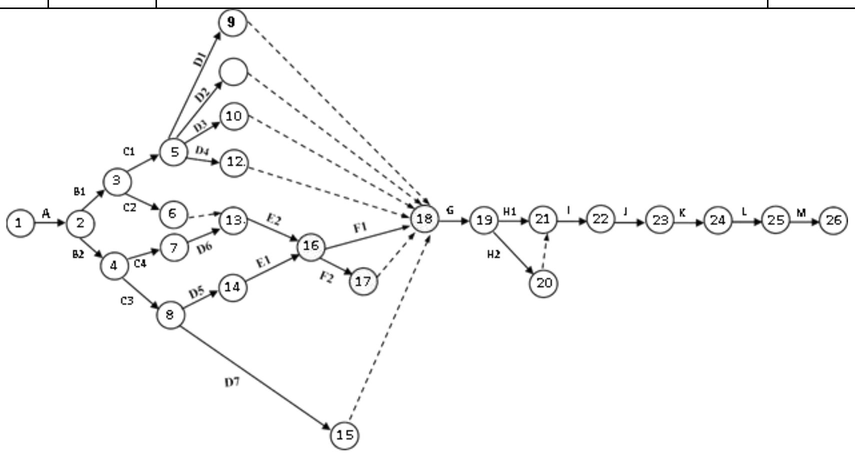

Fig: Network diagram of the activities

Interpretation

Critical chains like C3 → D5 → E1 → F2 → G → H1 determine the project duration and require close monitoring.

Parallel activities (e.g., D1 to D4) allow for resource optimization and flexibility. Convergence points (e.g., E2, F1) require strong coordination across departments.

The network structure helps visualize dependencies, prevent delays, and improve planning.

Structure and Activity Dependency Analysis

The project's water supply activity schedule consists of more than 30 dependent activities, grouped into activity series A to M. Each of the series is a major functional stage, i.e.:

A–B: Preliminary work including survey, estimation, and administrative approvals

C: Procurement and site preparation

D: Core construction work

E–F: Utility Installations and Equipment Delivery

G–H: Infrastructure commissioning

I–M: Trial run, testing, and handover completion

These activities are associated with logical dependencies, and they form a network flow required to model using Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM). Some of the most significant dependency relationships are:

- Activity B depends on the successful completion of Activity A (Survey and Land Acquisition).
- Procurement activities (C1–C4) are a follow-up to design approval (Activity B).
- Construction activities (D1-D7) depend on procurement developments.
- Installation and test phases (G to K) are sequenced to ensure that there is no disruption in technical synchronization.
- Handover (M) is scheduled only after completion of all functional trials and testing.

Application and Advantage of Network Diagram in PHE Project Management

The application of a network diagram in the project at Larsing Basti was a very powerful catalyst for strategic planning, as well as operational execution. The practical benefits are outlined below:

1. Increased Visualization of Workflow The chart acted like a pictorial map, marking each activity, its time, and how it was connected to other activities. This made it easier for each project team, ranging from site managers and engineers to administrative officers, to understand.
2. Identification and Management of the Critical Path With the inclusion of CPM, the network diagram facilitated the identification of the critical path, a sequence of activities whose contribution directly affects the overall project duration. Critical activities such as reservoir construction (D1), ESR installation (G), and final commissioning (K) were carefully tracked to avoid any slippage.
3. Streamlined Resource Planning and Coordination The graphic arrangement revealed windows of opportunity for simultaneous tasking, such as the overlap of civil site work with material acquisition. Project managers were able to reduce downtime, use resources more effectively, and maintain project momentum.
4. Real-Time Delay Management and Risk Control With the project environment beset by labour shortages, adverse weather, delayed funding, and local cooperation, the network diagram enabled the team to simulate delay scenarios and make dynamic adjustments to timelines and resources to prevent cascading delays.
5. Better Communication, Cooperation, and Responsibility. The network diagram was a shared point of reference at weekly status reviews, site visits, and cross-departmental meetings. This ensured open decision-making, brought everyone on the same page, and promoted accountability culture at all project execution levels.

Conclusion

Development and utilization of the network diagram for the PHE water supply project at Larsing Basti played a crucial role in facilitating systematic and disciplined project implementation. Not only did it chart the technical sequence of activities, but also improved control over operations, resource utilization, and stakeholder coordination. A tool like this becomes indispensible in public sector projects where delay cost is high and popular perception is high.

By integrating formal project management methods such as CPM and PERT within visual models, the PHE department showed the operational utility of formal project management approaches in government service delivery. It aligns with an emerging demand for building capacity in planning public department projects and is a model for subsequent water supply and sanitation projects in Assam and elsewhere.

Objective 4: To examine the application of project scheduling and control methods such as PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) in planning and managing the activities of the water supply scheme

In government schemes such as the Water Supply Scheme of Larsing Basti, delays, cost escalation, and inefficient use of resources are typical problems that may affect the effectiveness of the project and citizen satisfaction. These are averted by utilizing contemporary project management techniques like the Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM) for systematic scheduling, efficient time management, and forehand risk control.

Both CPM and PERT are network-based methods employed to graph the logical flow of activities, approximate project duration, and track the progress. These tools assist project managers in visualizing the work flow, recognizing dependencies, assigning resources appropriately, and implementing corrective measures in a timely manner.

PERT (Program Evaluation and Review Technique)

PERT is a probabilistic method applied mainly to projects whose activity durations are uncertain or subject to external variables like weather, logistics delays, or procurement lead times. PERT adds three-time estimates:

Optimistic Time (O): The minimum time to finish an activity.

Most Likely Time (M): The best possible estimate under ideal working conditions. Pessimistic Time (P): The maximum time an activity may take in poor conditions. The Expected Duration (TE) of a task is determined by the weighted average formula:

$$\text{Expected Duration} = \frac{O+4M+P}{6}$$

This allows planners to estimate timelines more realistically and incorporate uncertainty directly into the project plan.

Table 4 : Table showing the Expected time of each activity to complete

Series	Activity Name	Most Likely(Days)	Pessimistic Time(Days)	Optimistic Time(Days)	Expected Time(Days)	Variance
A	Survey and Land acquirement	21	22	15	20.17	1.36
B	Designing and approving of estimated cost	10	13	8	10.17	0.69
B1	Approval of work order	3	13	1	4.33	4
C1	Ordering construction materials (sand, bricks, stones)	15	15	10	14.17	0.69
C2	Apply for electricity connection	8	15	7	9	1.77
C3	Ordering of pipeline and ESR material (staging + tank)	10	15	9	10.67	1
C4	Raising low sites near the plant site with approved soil	15	15	13	14.67	0.11
D1	Underground Reservoir Construction	30	60	20	33.33	44.44
D2	Sedimentation Tank Construction	25	60	18	29.67	49
D3	Filtration Bed Construction	20	60	15	25.83	56.25
D4	Pump House (Clear Water) Construction	15	60	10	21.67	69.44
D5	ESR base (pile and pile cap) Construction	45	60	30	45	25
D6	Boundary wall Construction	7	60	2	15	93.44
D7	Pump House (Raw water) Construction	10	60	8	18	75.11
E1	Items Delivered (pipeline & ESR materials)	45	60	40	46.67	11.11
E2	Transformer installation and charging begins	12	60	11	19.83	66.69

F1	Providing Pipe connection around the plant	12	25	10	13.83	6.25
F2	FHTC connection provided (Functional household tap connection)	20	25	18	20.5	1.36
G	ESR Installation (staging and tank installation)	20	25	13	19.67	4
H1	Installation of pumps & commissioning	15	15	10	14.17	0.69
H2	Internal Connection	15	15	10	14.17	0.69
I	Installation of Service Valve	5	5	3	4.67	0.11
J	Trial Run of the connected bodies	4	4	2	3.67	0.11
K	Testing & Commissioning of ESR Tank, Pipeline	17	17	15	16.67	0.11
L	Site development, gate installation and boundary wall	8	8	7	7.83	0.02
M	Handover to WUCs and PRI (Panchayati Raj Institution)	7	7	5	6.67	0.11

After determining the expected project duration and variances using the PERT method, a probabilistic analysis was conducted to:

- Assess the probability of completing the Larsing Basti Water Supply Scheme within the target timeframe.
- Identify activities with the highest risk, based on their variability (measured by standard deviation)

This is done using the Z-score formula, which helps us understand how likely it is to meet a specific deadline.

Z- score formula:

$$Z = \frac{(X-\mu)}{\sigma}$$

Where,

X = Target completion time (e.g., 240 days) μ = Expected project duration = 220 days

σ = Standard deviation of the critical path.

Let’s assume the standard deviation σ = 22.66 days (based on the variance values in the activity chart of PERT table.

Probability of the Project finishing in 240 days

Using the z- score formula :

$$Z = \frac{240-220}{22.66} = 0.88.$$

A Z-score of 0.88 indicates a cumulative probability of 88.45%, meaning there is an 88.45% chance that the project will be completed within 240 days.

Activities with the Highest Schedule Risk (Ranked by Variance)

Activity	Activity Name	Variance	Interpretation
D6	Boundary wall Construction	**93.44**	Extremely high uncertainty; large difference between optimistic and pessimistic times.
D7	Pump House (Raw Water) Construction	**75.11**	Very high risk; wide time range implies potential major delays.
D4	Pump House (Clear Water) Construction	**69.44**	High fluctuation in duration; critical in physical infrastructure.
E2	Transformer Installation and	**66.69**	Highly uncertain; utility coordination can cause delays.

	Charging Begins		
D3	Filtration Bed Construction	**56.25**	Complex civil task with variable completion likelihood.
D2	Sedimentation Tank Construction	**49.00**	Likely dependent on site-specific conditions; high schedule risk.
D1	Underground Reservoir Construction	**44.44**	Large-scale excavation may face delays due to weather, soil, labor.
D5	ESR Base (Pile and Pile Cap) Construction	**25.00**	Structural complexity adds moderate-high risk.
E1	Material Delivery (Pipeline & ESR)	**11.11**	Procurement/logistics issues may lead to delivery delays.

Interpretations and Implication

1. Activities in the D series (D1–D7), particularly D6 and D7, carry the highest schedule risk. These are mostly core civil works like pump house construction, boundary walls, and reservoirs — elements that are often impacted by environmental factors, manpower shortages, and delays in approvals or supplies.
2. E2 (Transformer installation) is another high-risk activity, likely due to coordination required with electricity boards and utility providers.
3. High-risk activities tend to be on or near the critical path and must be monitored closely as they can impact the entire project duration if delayed.

5.1 Conclusion

- The study found that PHE Silchar Division II does not follow a single standardized project management framework.
- Instead, it employs a hybrid model, integrating structured elements from PMBOK (Initiation, Planning, Execution, Monitoring & Control, Closure) with PRINCE2's features such as stage-gate reviews and defined roles.
- This global framework is enhanced with locally adapted practices, such as manual contractor coordination logs, junior engineer supervision, weekly field reviews, and informal reporting.
- The hybrid approach ensures flexibility, adaptability, and real-time responsiveness, which are essential in rural project environments where uncertainty is frequent.
- A detailed Gantt chart was developed, capturing over 30 interconnected activities across various phases—surveying, planning, procurement, construction, testing, and commissioning.
- The chart allowed for visual representation of task durations, dependencies, overlaps, and slack times.
- It helped in resource scheduling, labor allocation, and task prioritization.
- Weekly updates using the Gantt chart improved communication between field staff and project managers, thus supporting active tracking and control.
- A project network diagram was created to visualize logical sequences and interdependencies between activities.

The critical path identified was:

A → B2 → C3 → D5 → E1 → F2 → G → H1 → I → J → K → L → M, establishing a minimum project duration of 220 days.

- The diagram revealed parallel paths (e.g., D1–D4) that could proceed independently, enhancing schedule flexibility.
- Key convergence points like E2 and F2 were flagged as potential bottlenecks requiring focused attention.
- This visual tool allowed for better resource optimization, bottleneck anticipation, and what-if analysis to plan for delays.
- The study applied both CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) to evaluate scheduling efficiency.
- CPM helped identify critical activities with zero slack, ensuring these were tightly managed to avoid overall project delays.
- PERT accounted for uncertainties in task durations using three-time estimates (Optimistic, Most Likely, and Pessimistic), providing a probabilistic view of project timelines.

- The expected project completion time was calculated at 220 days, with a standard deviation of 22.66 days and an 88.45% probability of completing the project within 240 days.

These variances should inform resource allocation, buffer planning, and risk mitigation strategies in the project management plan.

Critical Path Method

CPM is a deterministic method applied when the durations of the activities are known and established. This determines the critical path, the longest chain of dependent activities that will give the shortest project duration. CPM also estimates float or slack, which measures the amount by which a non-critical activity can be delayed without extending the project finish date.

In the project of the Water Supply Scheme at Larsing Basti carried out by Public Health Engineering (PHE) Department, Silchar Division II, the Critical Path Method (CPM) was the key to controlling the life cycle of the project. CPM is a deterministic, logic-based approach to project scheduling and aids in determining the critical sequence of dependent tasks influencing the duration of the project. Its use allowed the department to better plan, predict delays, assign resources, and keep overall project discipline.

Learning the Critical Path Method (CPM)

The Critical Path Method is a project modeling method that was designed to schedule project activities systematically. It assumes that activity times are fixed and certain and applies to projects with well-delineated activities and quantifiable outputs, like the construction and inauguration of water facilities.

Critical path is the longest list of dependent activities responsible for determining the shortest project duration. A delay in any task on this path will have a direct effect on the overall project completion time.

Steps Involved in CPM Application

The Critical Path Method is utilized following a step-by-step process:

1. Activity Identification

The project is divided into separate activities or work packages. In this project, some of the activities were land acquisition, design approvals, material procurement, construction of ESR base, pipeline laying, testing, and handover.

2. Sequencing Activities

The task sequence is logical by establishing predecessor-successor relationships. In our example, construction (D5) cannot begin until pipeline material procurement (C3) is finished.

3. Creating the Network Diagram

Nodes are represented by activities, and arrows are used to indicate dependencies in a network diagram. This gives a graphical representation of the workflow of the project as well as interdependencies.

4. Duration Estimating

Every activity receives a predetermined duration, estimated or derived from past experience. These are fed into the CPM model.

5. Selecting Critical Path

The path that takes the longest is known as the critical path, any changes in the duration of other activities will delay the completion of the project and increase the project cost.

Table 5: Table showing Activities and Duration required by the activities to complete

Sr. No.	Series	Activity Name	Previous Act	Duration
A	A	Survey and Land acquirement	-	21
B	B1	Designing and approving of estimated cost	A	10
	B2	Approval of work order	A	3
C	C1	Ordering construction materials (sand, bricks,stones)	B1	15
	C2	Apply for electricity connection	B1	8
	C3	Ordering of pipeline and ESR material (staging +tank)	B2	10
	C4	Raising low sites near the plant site with approved soil	B2	15
D	D1	Underground Reservoir Construction	C1	30

	D2	Sedimentation Tank Construction	C1	25
	D3	Filtration Bed Construction	C1	20
	D4	Pump House (Clear Water) Construction	C1	15
	D5	ESR base (pile and pile cap) Construction	C3	45
	D6	Boundary wall Construction	C4	7
	D7	Pump House (Raw water) Construction	C3	10
E	E1	Items Delivered (pipeline & ESR materials)	D5	45
	E2	Transformer installation and charging begins	D6, C2	12
F	F1	Providing Pipe connection around the plant	E1, E2	12
	F2	FHTC connection provided (Functional household tap connection)	E1, E2	20
G	G	ESR Installation (staging and tank installation)	F, D7	20
H	H1	Installation of pumps & commissioning	G, D’	15
	H2	Internal Connection	G, D’	10
I	I	Installation of Service Valve	H	5
J	J	Trial Run of the connected bodies	I	4
K	K	Testing & Commissioning of ESR Tank,Pipeline	J	17
L	L	Site development, gate installation and boundary wall	K	8
M	M	Handover to WUCs and PRI (Panchayati Raj Institution)	L	7

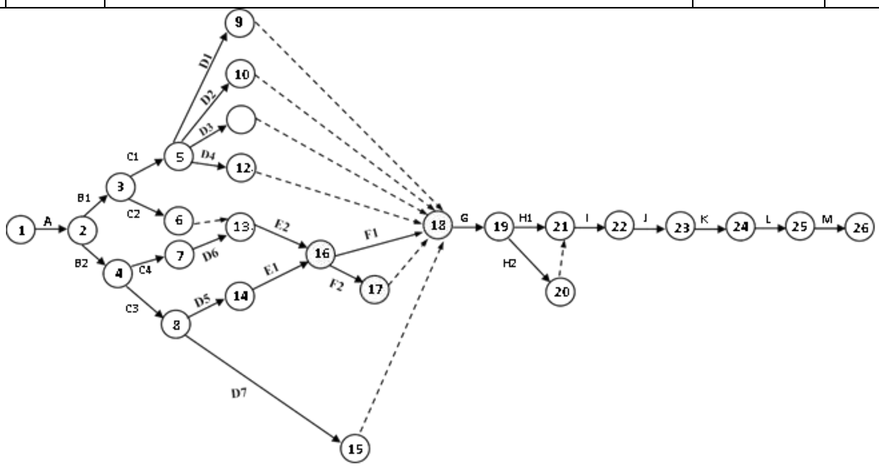

Fig: Network diagram to find out the critical path of the project

Table 6: Table showing all the duration taken by the various paths

Path No.	Activities Sequence	Total Duration (Days)
1	A → B1 → C1 → D1 → G → H1 → I → J → K → L → M	145
2	A → B1 → C1 → D2 → G → H1 → I → J → K → L → M	140
3	A → B1 → C1 → D3 → G → H1 → I → J → K → L → M	135
4	A → B1 → C1 → D4 → G → H1 → I → J → K → L → M	130
5	A → B1 → C2 → E2 → F1 → G → H1 → I → J → K → L → M	132
6	A → B2 → C4 → D6 → E2 → F1 → G → H1 → I → J → K → L → M	146
7	A → B2 → C3 → D5 → E1 → F1 → G → H1 → I → J → K → L → M	212

8	A → B2 → C3 → D5 → E1 → F2 → G → H1 → I → J → K → L → M	220
9	A → B2 → C3 → D7 → G → H1 → I → J → K → L → M	120
10	A → B1 → C1 → D1 → G → H2 → I → J → K → L → M	140
11	A → B1 → C1 → D2 → G → H2 → I → J → K → L → M	135
12	A → B1 → C1 → D3 → G → H2 → I → J → K → L → M	130
13	A → B1 → C1 → D4 → G → H2 → I → J → K → L → M	125
14	A → B1 → C2 → E2 → F1 → G → H2 → I → J → K → L → M	127
15	A → B2 → C4 → D6 → E2 → F1 → G → H2 → I → J → K → L → M	141
16	A → B2 → C3 → D5 → E1 → F1 → G → H2 → I → J → K → L → M	207
17	A → B2 → C3 → D5 → E1 → F2 → G → H2 → I → J → K → L → M	215
18	A → B2 → C3 → D7 → G → H2 → I → J → K → L → M	115

Interpretation: - From the data in Table, we observe multiple activity sequences (paths) with different total durations. The critical path in project management is the longest duration path through the project network, and it determines the minimum time required to complete the entire project. Delays in any activity on the critical path will directly cause a delay in the project completion.

A → B2 → C3 → D5 → E1 → F2 → G → H1 → I → J → K → L → M 220 Days

For government-run projects such as PHE schemes, where transparency, efficiency, and punctual completion are expectations from the public, CPM is an extremely useful project control system. It enhances communication among departments, increases accountability, and facilitates adherence to funding and policy schedules.

The Larsing Basti project had such challenges as material procurement delays, seasonality constraints, and co-ordination problems. Nonetheless, the application of CPM served to reduce these by ensuring concentration on key activities, and that changes were made with full clarity of the activity dependencies.

Objective 5: To calculate the float (slack) values of project activities in order to determine the permissible delay for each task without affecting the overall project completion time.

Overview

This objective focuses on enhancing the scheduling efficiency and time management of the water supply scheme at Larsing Basti by calculating critical scheduling parameters—Earliest Start (ES), Latest Start (LS), and Total Float for each activity. These parameters are essential to understanding the project's timing structure, as they reveal which tasks are flexible and which lie on the critical path. Activities with zero float represent the most time-sensitive parts of the project, requiring close monitoring to avoid delays in overall project completion. On the other hand, tasks with significant float offer scheduling flexibility, enabling efficient resource reallocation and delay management.

By analyzing these scheduling indicators, the study provides a detailed view of the project's internal timeline logic, supports strategic planning, and strengthens execution control. This kind of analysis is especially valuable in public infrastructure projects like those managed by the PHE Department, where delays can lead to cost escalations and public dissatisfaction. The findings derived from this objective contribute directly to improving project governance, efficiency, and on-time delivery.

Table 7: Table showing activities with Total Float/Slack

Activity	**Earliest Start (ES)**	**Latest Start (LS)**	**Total Float**
A	0	0	0
B1	21	21	0
B2	21	21	0
C1	31	31	0
C2	31	104	73
C3	24	24	0
C4	24	90	66

D1	46	46	0
D2	46	46	0
D3	46	46	0
D4	46	46	0
D5	34	34	0
D6	39	105	66
D7	34	55	21
E1	79	79	0
E2	112	112	0
F1	124	124	0
F2	124	124	0
G	136	136	0
H1	156	156	0
H2	156	161	5
I	171	171	0
J	176	176	0

Interpretation

The scheduling table provides valuable insight into the time flexibility and criticality of each task in the Water Supply Scheme project under PHE Silchar Division II. By calculating the Earliest Start (ES), Latest Start (LS), and Total Float, we can determine which tasks are on the critical path and which have scheduling flexibility.

1. Critical Path Activities (Zero Float)

Activities such as A, B1, B2, C1, C3, D1–D5, E1, E2, F1, F2, G, H1, I, J, K, L, and M all have a total float of 0.

These are critical path activities, meaning any delay in these tasks will directly delay the overall project competion.

These tasks require strict scheduling, resource allocation, and continuous monitoring.

2. Non-Critical Activities with Float

Activities such as C2 (Float: 73 days), C4 (Float: 66 days), D6 (Float: 66 days), D7 (Float: 21 days), and H2 (Float: 5 days) have positive float values.

These tasks are not on the critical path and can be delayed by the number of float days without affecting the project's finish date.

For example:C2 can start as late as 104 days, even though it's ready to start by day 31. D6, which depends on C4, has a generous window for scheduling without causing project delay.

3. Strategic Implications

The float values allow the project manager to identify which tasks have flexibility and can be rescheduled or slowed down without disrupting project completion.

This enables resource optimization—critical tasks can be prioritized for manpower, machinery, or funding, while float-heavy tasks can be deferred or used as buffers during unforeseen delays.

Activities like D6, C4, and C2 can be used to absorb delays in case resources need to be diverted to critical path activities.

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