International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

A Critical Review of Resource Allocation Optimization in Project Management

Srinivasa Rao Allu[1], Amiya Bhaumik[2*], Akula Ramakrishna[3], Motilal Lakavat[4], Himasri Allu[5], Shaik Chandini[6]*

[1,2]Lincoln University College (LUC), Malaysia.

[3] HSE Planning and Assurance, Senior Field Compliance Coordinator, ARAMCO, Saudi Arabia.

[4] National University of Science and Technology, Al Hail South, Muscat, Oman.

[5]School of Computer Science and Engineering, Vellore Institute of Technology, Vellore, India

[6]Department of Civil Engineering, Gulf American University, UAE.

Emails: *srallu@lincoln.edu.my[1], amiya@lincoln.edu.my[2], akula.ramakrishna@gmail.com[3], motilallakavat@gmail.com[4], alluhimasri@gmail.com[5], eng.shaikchandini@gmail.com[6]*

Abstract

Globalization has led to a competitive market situation, superior quality standards, stringent project delivery schedules, and cost-effectiveness techniques which call for effective resource planning. To compete in the global market and to maintain leadership, India's major construction organisations have formulated various policy measures for effective functionality and executing the projects successfully. As several millions of rupees are being invested in various projects all over the world, the organisation has strong commitments to stakeholders of the organisation. Hence, the organisation is facing a major challenge to execute the projects successfully with maximum return on investment and increase in value addition to the organisation and its shareholders. The objective of an organization is to generate profits by managing social responsibility. One of the major thrust areas to make the business profitable is by improving the operational efficiency, which can be improved by optimizing the resource allocation, and that adds to profits thereby giving a big leverage effect to profitability. Resources are never unlimited in the universe but are available in restricted quantities for any specific project. effective planning, scheduling, and allocating scarce resources, the operational efficiency can be improved. This research paper analyses the improvement in the areas of resource allocation and its subsequent impact on productivity to cut down costs to increase operational efficiency. This study will also highlight the improvements if any; that can be made to the existing system for better and more effective control.

Keywords: *Engineering and Construction (E&C), Engineering, Procurement and Construction (EPC); Operational Efficiency; Productivity; Resource Allocation and Optimization*

1. Introduction

The competitive market environment, superior quality standards, stringent project delivery schedules, and cost-effectiveness techniques present a set of challenges to the Engineering & Construction (E&C) industry [1]. These challenges are particularly pronounced in the execution of projects on time and within budget, which is crucial for achieving an organization's strategic objectives. Traditionally, the focus has been on owner-managed projects, but there has been a significant shift towards contractor-managed projects, transferring the risk of time and cost to E&C organizations. This shift necessitates expertise in engineering design, procurement, material delivery, and construction, especially under

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

the Engineering Procurement and Construction (EPC) contracting model (EPC World Media Group, 2020). The construction phase in EPC projects is often the most critical and riskiest part, constituting 35% to 50% of the project budget(Allu et al. n.d.) [2].Therefore, effective control over this phase is crucial for project success. Optimal resource allocation is essential for improving productivity and ensuring that projects are completed within their defined baselines (Ogunye, S. 2019). Operational efficiency, a key driver of profitability, can be significantly enhanced by optimizing resource allocation. This involves the effective planning, scheduling, and utilization of scarce resources, which in turn improves operational efficiency and profitability (Memon et al. 2006) [3]. Proper resource allocation also supports better project performance by ensuring that labor productivity is monitored and managed effectively. The objective of this research paper is to review and understand the effectiveness of the existing resource allocation system, identifying any inadequacies and proposing improvements for better management decisions. This study also aims to evaluate how well organizations control underutilized resources to enhance efficiency. The research provides an in-depth analysis of the operations of resource departments, and existing systems of resource allocation, and offers recommendations for the optimum allocation of organizational resources. In summary, this paper focuses on the need for stringent control over project activities to avoid project failures. It underscores the importance of productivity norms for project teams and highlights the critical role of effective resource allocation in achieving successful project outcomes (Allu et al. n.d.) [4].

1.1. Importance of Resource Allocation

Resource allocation in projects is essential for enhancing operational efficiency and project performance. Effective planning, scheduling, and allocation of scarce resources improve operational efficiency, thereby supporting project profitability. The productivity norms established help project teams monitor labor productivity, estimate manpower requirements, and ensure timely and cost-effective project delivery.

1.2. Challenges in Resource Management

Resource management in construction projects faces several challenges, including the dynamic nature of project demands and the need for realistic labor productivity estimates. Contractors and owners often focus on labor productivity at job sites, measured in units per labor hour for various construction tasks. Establishing industry-accepted productivity norms through data collection and analysis helps in performance measurement and project success (Stiedl et al. 1998) [5].

1.3. Importance of Data in Analysis for Improved Productivity

Data collection and maintenance for benchmarking in the construction industry indeed face several challenges. The construction industry is indeed complex and fragmented, characterized by numerous interconnected processes, diverse stakeholders, and varying project requirements, ranging from contractors and suppliers to engineers and architects. lack of awareness, diverse stakeholders, variability in projects, fragmented data sources limited technical adoption, cost overruns, data quality issues, and cultural resistance are some key issues that limit data collection and maintenance for benchmarking in this sector.The thematic analysis of the discussion highlights seven key factors (Poor Data Management Processes, Data Silos, Integration Needs, Big Data Approaches, Holistic View, Efficiency and Effectiveness, and Strategic Implementation) that influence resource management. The main findings indicate that the majority of the issues stem from inadequate data management processes and the isolation of data in silos. Addressing these challenges necessitates the implementation of big data approaches for resource management. This strategy enables the integration of vast and diverse data forms, fostering a more holistic and efficient resource management system (Kusimo et al. 2019) [6].

1.4. The Construction Industry

The construction industry is the second largest industry after the agriculture industry and will be progressed through an organised process where many labours are getting engaged in accomplishing various tasks. The construction industry works based on a huge number of labours and where remote working is

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

impossible (Sukumar and Kumar 2016) [7]. Construction Productivity labour norms are very important to establish the baselines for the project to have a stringent control mechanism for the execution, and this enables the project team like Managers, Site Engineers, and Planning Engineers to have a robust monitoring and control base to work against the set targets. It should be useful to monitor labour productivity, to estimate the manpower required for a project for planning, controlling, and monitoring purposes or cost estimations. Construction projects are major drives based on manpower productivity. Productivity is the output of workers supported by correct hand tools. Also, the work will be carried out by using machinery. However, it is important to have realistic estimates of expected labour productivity (Stiedl et al. 1998)

1.5. The Construction Productivity

Contractors and owners are frequently worried about the manpower activity at job sites, where labour productivity is a key to success and it is a unit per labour hour for each type of construction task or activity. For specific purposes, different levels of measure may be used for specific tasks depending on the type of work. For example, a cubic meter of concrete poured per hour may be more or less than measure than a kilometer of road paved per hour. Micro-level measurement is more valuable, while high-level measures might be more advantageous for establishing the guidelines of execution. The productivity data collected by various contractors and owners from different project sites are to be correlated and analyzed to develop construction norms for each of the work items of the construction industry. This enables the owner or contractor to use the norms as a basis for performance measurement(Chris Hendrickson n.d.).

1.6. Introduction to Resources Department Operations

The resources department will be located at the centralized location to coordinate all the projects from one common place where the various business departments are located for project coordination.

The resources department operates on two organizational resources those are Men (Staff) and machinery (Plant &Machinery). The prime function of the department is to account for the resources and their allocation among the various business units. And periodical reports also are being generated on productivity and effective utilization

1.7. Functions of Resources Department

The basic function of the Regional Resources department can be summarized as under:

- Allocation of staff by analyzing the skill sets through a skill inventory system.
- Mobilization of Plant &Machinery to the project needs by analyzing the various reports like schedules, utilizations reports, and cash outflow statements.
- Fulfilling the bid stage requirement
- Evaluating P&M acquisition value/book value and hire charges/depreciation.
- Evaluation of P&M hired conveyance vehicle availability and requirement.
- P&M performance reports to identify the utilization.
- Budget Cost Estimates provisions vs actual incurred for staff salaries (OH), conveyance, and plant & machinery hire charges and maintenance.
- Comparison of actual Man months and machine months with Budget Cost Estimate provisions.

2. Objective

The objective of this research paper is to review and understand the effectiveness of the existing resource allocation system and review for its inadequacy if any in considering the optimum allocation among various projects across the organisation. Also is studied how well the organisation has controlled the underutilized resources thereby enhancing efficiency. After a thorough study, this research paper will suggest further improvements and modifications in the existing systems for better management decisions. The objective of this work is focused on:

- The operations of the resources department
- The existing system of resource allocation to various project needs
- Providing an alternative solution/ recommendation for optimum allocation of the organizational resources.

3. Method

The methods employed in this study focus on the optimization of resource allocation within

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

Engineering, Procurement, and Construction (EPC) projects. The primary objective is to enhance the utilization of both tangible and intangible resources, namely Men, Machinery, Materials, Money, Methods, and Time (5M+1T). The following steps are involved in the research methodology.

- Library Study – Introduction to Resources department operations.
- Data Requirements – Data requirement for research and the source of the data.
- Schedules – Method of collection of Data
- Period of Study

3.1. Resource Allocation Process

The research analyzed the existing processes for resource allocation in EPC projects, with a particular emphasis on identifying areas for optimal utilization. Resource allocation is typically managed by centralized resource departments, which utilize project schedules to assign manpower and machinery effectively.

3.2. Data Sources

The below (Table 1) information is collected by staff and Plant &Machinery schedules and various organizational reports, and each report will have fixed data requirements.

Table 1 Data Sources

Sl.no	Description	Source
1	Schedules of Staff	Projects
2	Schedules of Plant and machinery	Projects
3	Budget estimates	Project
4	Resources data bank	PMO offices
5	Plant & Machinery Data bank	PMO offices
6	Cash Flow Statements	Projects
7	Hired Vehicle Conveyance statement	Projects
8	Tender stage requirements	PMO offices
9	Month wise sales	PMO offices
10	Staff skill date	PMO offices
11	Plant &Machinery Aqn.Value /Book Value and hire charges	PMO offices

Skill inventory is being collected from the individual employees and will be examined and approved by the concerned in-charge and sector heads confirming the details provided by an individual is correct. And the same will be updated to the data bank at the centralized location by the concerned personnel department. The date is being used on a regular basis to identify the right person for the right job at the right time. With ref to the Plant & machinery schedule reflects the availability and requirements for that particular project. The net requirement will be identified by various projects of regional projects. The remaining requirements will be verified across other projects across the organization. If the machinery is not available then, we must go either for Hiring or procurement. The hiring order is called a Plant Hiring request and Sanction (PHRS) and terminology may defer to each organization. If the particular machinery has to be purchased, the Capital Purchase Request and sanction (CPRS) are to be raised to procure the new asset for the organization. Plant requirement and availability for the region collected for the month, first quarter, and year plotted in s-curve and graph

3.3. Plant Utilization Measurement

To measure plant utilization, the study employed a method of comparing actual production against the rated capacity of the machinery. The analysis was carried out for various deployed plants and machinery across various multiple projects. For example, a 30 Cu.M per hour batching plant operating for 8 hours a day has a rated capacity of 240 Cu.M. The actual production from various projects was measured and compared to this rated capacity to determine utilization rates. This method helps identify areas where machinery can be reallocated to maximize utilization.

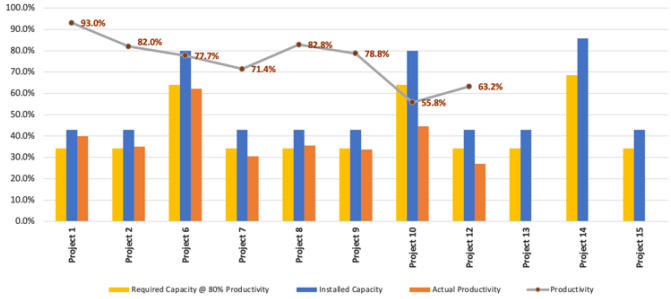

Figure 1 Batching Plant Productivity Analysis

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

From Figure 1, it's evident that the batching plant productivity is very low in Project 10. This underutilization suggests that the batching plant resources could be better utilized if relocated. Considering that Project 14 has a similar requirement and could achieve maximum utilization of these resources, it would be a strategic decision to move the batching plant from Project 10 to Project 14. This relocation would not only enhance productivity but also optimize resource allocation across projects, leading to more efficient operations overall. Similarly, the batching plant productivity in Project 12 is low. To optimize resource utilization, it would be beneficial to relocate the batching plant from Project 12 to either Project 13 or Project 15. The choice between Project 13 and Project 15 should be based on the priority and specific requirements of these projects. By reallocating the batching plant to the project with the highest priority or greatest need, overall productivity and efficiency can be significantly improved.

3.4. Staff Productivity Analysis

Calculated using the ratio of spent man-hours to earned man-hours. Earned man-hours were derived by multiplying the percentage progress with the budgeted man-hours. This metric allows for the assessment of productivity across different disciplines and helps in identifying areas where staff resources can be better utilized.

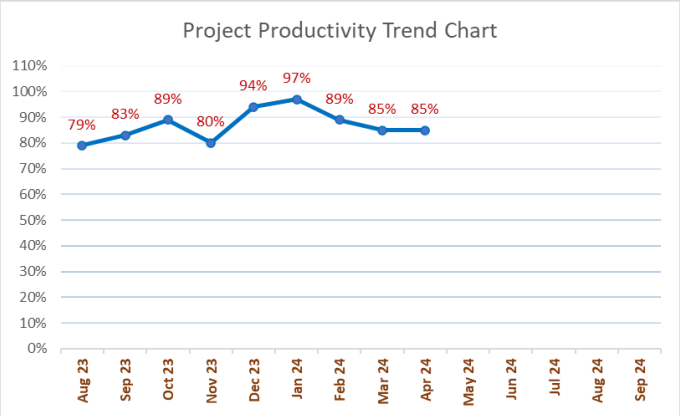

Figure 2 Productivity Trend Analysis

From Figure 2, it's clear where productivity is dropping. This serves as a crucial alert for the project management team to take action. To improve productivity, they need to address bottlenecks by identifying and resolving the issues causing delays. Optimizing resource allocation by relocating or demobilizing underutilized resources can enhance efficiency. Additionally, providing further training to the workforce can improve their skills and effectiveness. Better planning and scheduling are essential to ensure tasks are managed efficiently, avoiding delays and overlaps. Finally, improving communication within the team will facilitate smoother workflows and quicker resolution of issues. Implementing these strategies will increase operational efficiency and overall productivity.

3.5. Data Analysis Technique

The study utilized various data analysis techniques to evaluate resource allocation efficiency. This included trend analysis of productivity over time and comparative analysis across different projects. The data collected was used to identify patterns and anomalies in resource utilization, providing insights into potential improvements.

3.6. Technological Integration

An important aspect of the study was the emphasis on upgrading integrated IT systems, such as ERP systems, to facilitate better decision-making. These systems allow for real-time access to relevant information, enabling more effective allocation of resources by identifying and addressing pitfalls in the current processes.

4. Results and Discussion

4.1. Results

The study investigated the allocation of resources in project management with a focus on manpower productivity in various projects. The primary data was collected from one of the Plant projects and analysed to understand the effectiveness of resource allocation. The projects covered various disciplines, including civil and structural, commissioning, and electrical. However, certain disciplines are lagging and need to get focused on improved practices and might have been focused on the right resource allocation by having a centralised resources department.

4.2. Manpower Productivity

Productivity metrics were collected and analysed for different departments (refer to Figure 3). For

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

example, the civil and structural department showed fluctuations in manpower hours allocated over the period, with a significant increase in November 2023 and a peak in January 2024. Similar trends were observed in other departments:

- **Civil & Structural:** The highest allocation was in January 2024 with 4117 hours, reflecting a major phase of construction activities.
- **Commissioning:** A notable peak in activities was observed in November 2023 with 430 hours.
- **Electrical:** The department experienced the highest allocation in November 2023 with 2044 hours, indicating a phase of intensive electrical installations.

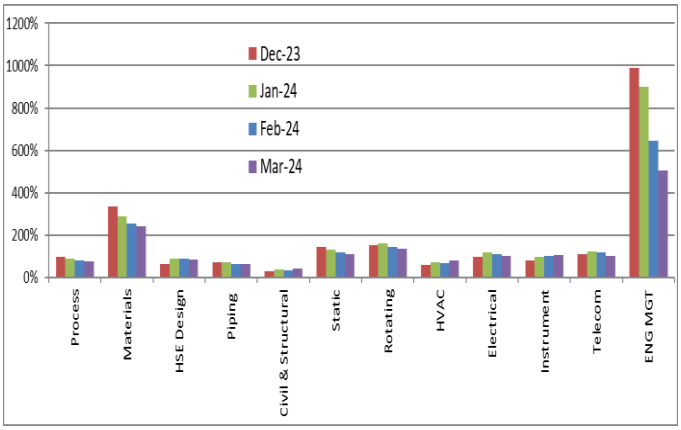

Figure 3 Productivity at the Discipline Level

4.3. Resource Allocation Efficiency

The efficiency of resource allocation was measured by comparing planned and actual hours worked across different tasks. The analysis revealed a consistent alignment between planned and actual hours, indicating effective resource planning and management. The overall project showed a high degree of completion with tasks reaching nearly 100% by April 2024, demonstrating efficient project management practices.

4.4. Discussion

The results demonstrate the critical role of proper resource allocation in achieving project success. The data highlights that:

- **Fluctuations in Manpower Allocation:** The variations in manpower allocation across different months suggest adaptive resource planning in response to project demands. For instance, the spike in January 2024 for the civil and structural department aligns with a significant phase of construction activities.
- **Resource Utilization Efficiency:** The alignment between planned and actual hours worked indicates that the projects were effectively managed, minimizing resource wastage and ensuring timely completion of tasks. This suggests that the project management team was adept at forecasting resource needs and adjusting allocations as necessary.
- **Impact on Project Timelines:** Efficient resource allocation positively impacted project timelines, with most tasks reaching completion as planned. This underscores the importance of proactive planning and real-time adjustments in resource management.

The study reaffirms the necessity of strategic resource allocation in project management. Properly allocated resources not only enhance productivity but also ensure project milestones are met without significant delays. Future projects can benefit from adopting similar resource management strategies, emphasizing the need for dynamic allocation models that respond to real-time project needs. Overall, the findings suggest that the key to successful project management lies in the continuous monitoring and adjustment of resource allocation, ensuring optimal use of manpower, plant, and other resources throughout the project lifecycle.

Conclusion

The conclusion confirms the problem analysed in the Results and Discussion section. The primary problem addressed was the optimization of resource allocation in Engineering, Procurement, and Construction (EPC) projects to enhance operational efficiency. The study revealed that resources such as men, machinery, methods, materials, money, and time (collectively referred to as 5M+1T) are often underutilized due to improper data availability and ineffective allocation strategies. Resources are never unlimited in the universe but are available in restricted quantities to any specific project. Effective planning, scheduling, and allocating scarce

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1855- 1861
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0255

resources, operational efficiency can be improved. By implementing effective planning, scheduling, and allocating scarce resources, operational efficiency can be significantly improved. The study emphasized the need for an integrated IT system to facilitate better decision-making and resource allocation. This system would enable decision-makers to access relevant information quickly and identify existing pitfalls in projects. The research confirmed that optimum resource allocation is achievable by identifying areas of maximum utilization and monitoring productivity. The findings suggest that improving the productivity of staff and the utilization of plant and machinery can lead to enhanced operational efficiency. Thus, the study concludes that the existing resources allocation system requires improvements and modifications to ensure better management decisions through a centralised resources department to add value to project success.

Acknowledgements

The list of scholars, friends, and acquaintances, who have contributed to this work in a diverse way, is extensive. While I am thankful to all of them, I restrict myself to mention a few of them who have helped in a special way. My guide and supervisor Dr. Amiya Bhaumik, Vice Chancellor of Lincoln University, and my Co-Supervisor Dr. Rama Krishna Akula helped in every way and was the moving force behind this work. He has given constant cooperation, valuable advises, and encouragement throughout this work. I remain indebted to all of them. Even a faulty memory cannot suppress the long list of friends and my wife Lakshmi Devi Allu and my daughter Himasri Allu who were generous with their time and effort. I thank them for all they have been with me.

References

[1]. Allu, Srinivasa Rao et al. “Tec Empresarial.” :1056–71.

[2]. Chris Hendrickson. “No Title.” Project Management for Construction Version 2. https://www.cmu.edu/cee/projects/PMbook/04_Labor,_Material,_And_Equipment_Utilization.html.

[3]. Kusimo, Habeeb et al. 2019. “Optimisation of Resource Management in Construction Projects: A Big Data Approach.” World Journal of Science, Technology and Sustainable Development 16(2): 82–93. https://doi.org/10.1108/WJSTSD-05-2018-0044.

[4]. Memon, Zubair Ahmed, Muhd Zaimi, Abd Majid, and Mushairry Mustaffar. 2006. “A Systematic Approach for Monitoring and Evaluating the Construction Project Progress.” Journal-The Institution of Engineers 67(3): 26.

[5]. Ogunye, S., Praxair. 2019. “EPC/Construction Contracting—Start with the End in Mind.” https://www.hydrocarbonprocessing.com/magazine/2019/february-2019/project-management/epcconstruction-contracting-start-with-the-end-in-mind.

[6]. Stiedl, David, Ulf Brudefors, Mike Shone, and International Labour Organisation. Advisory Support Information Services and Training. 1998. “Productivity Norms for Labour-Based Construction.” ILO/ASIST technical brief (no 2): 51, 6 leaves.

[7]. Sukumar, D., and R. Kumar. 2016. “A Study of Various Factors Affecting Labour Productivity In Road Construction and Suggestions to Improve It.” International Journal of Scientific & Engineering Research 7(4): 98–102. http://www.ijser.org.