

# **Resource Project Planning System (RPPS)**

**MS (Data Science Project Report) | VIT (Vellore Institute Of Technology)**

**LITERATURE REVIEW**

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# Table of Contents

Section No	Title
<b>1</b>	Introduction Overview of Resource Project Planning Systems Enterprise Resource Planning (ERP) Systems Human Resource Planning and Workforce Optimization Resource Planning and Project Scheduling Techniques
<b>2</b>	Artificial Intelligence in Project Resource Management Machine Learning in Resource Allocation Natural Language Processing (NLP) for Profile Building Skill-Based Project Recommendation Systems Candidate–Project Matching and Resource Optimization
<b>3</b>	Employee Bench Management and Workforce Utilisation Predictive Analytics and Workforce Forecasting Performance Management and Employee Analytics Business Intelligence and Dashboard Visualisation Comparative Analysis of Existing Resource Planning Systems
<b>4</b>	Research Gap Proposed Research Framework Summary

## 2.1 Introduction

Resource allocation has become one of the most critical challenges in modern organizations, particularly in Information Technology (IT), consulting, engineering, healthcare, and research-based industries. Organisations often experience inefficient workforce utilization because employees remain unallocated ("bench employees"), while project managers simultaneously struggle to find suitable resources with the required skills. Recent advances in Artificial Intelligence (AI), Machine Learning (ML), Enterprise Resource Planning (ERP), and Predictive Analytics provide opportunities to automate project planning and workforce optimization.

The Resource Project Planning System (RPPS) aims to bridge this gap by integrating employee skill profiling, project requirement analysis, recommendation systems, optimisation algorithms, and performance analytics into a single intelligent platform.

## 2.2 Enterprise Resource Planning Systems

Modern ERP systems integrate multiple organizational departments through centralized databases that provide real-time access to operational information.

Recent ERP research explains that organizations benefit from:

- Centralised workforce information
- Real-time resource visibility
- Improved decision making
- Better project coordination
- Reduced operational delays
- Improved reporting capabilities

However, traditional ERP systems primarily manage employee records and project information without providing intelligent recommendations regarding project allocation or skill-gap analysis.

Therefore, ERP systems require AI-based extensions capable of performing dynamic workforce planning.

## 2.3 Resource Planning and Workforce Optimization

Resource planning ensures that the right employee is assigned to the right project at the right time while maintaining balanced organizational workload.

Previous studies indicate that successful organizations focus on:

- Workforce availability
- Employee competencies
- Training management
- Capacity planning
- Project forecasting
- Resource utilization

Poor resource planning results in:

- Increased bench time
- Project delays
- Employee dissatisfaction
- Revenue loss
- Higher operational costs

## 2.4 Project Scheduling Techniques

Traditional project scheduling techniques include:

- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
- Critical Chain Project Management (CCPM)
- Resource Leveling
- Resource Smoothing

Although these techniques effectively schedule project activities, they generally assume static resource availability.

Recent studies suggest that modern organizations require adaptive scheduling techniques capable of responding to changing employee skills, project priorities, and resource constraints.

Artificial Intelligence enables dynamic scheduling by continuously evaluating project demands against workforce capabilities.

## 2.5 Artificial Intelligence in Project Resource Management

Artificial Intelligence provides predictive capabilities beyond traditional management systems.

AI contributes through:

- Demand forecasting
- Workforce prediction
- Performance analytics
- Recommendation engines
- Intelligent dashboards
- Automated decision support

Modern organizations increasingly employ AI to reduce human bias during resource allocation while improving productivity.

## 2.6 Machine Learning in Resource Allocation

Machine Learning has significantly transformed workforce management by enabling automated prediction and recommendation systems.

Common ML applications include:

- Employee recommendation
- Skill matching
- Workforce forecasting
- Project success prediction
- Performance evaluation
- Employee clustering
- Workforce segmentation

Algorithms frequently applied include:

- Cosine Similarity
- TF-IDF
- K-Means Clustering
- Linear Regression
- Decision Trees
- Random Forest
- Neural Networks

These techniques improve allocation accuracy while reducing manual intervention.

## 2.7 Natural Language Processing (NLP) for Profile Building

Natural Language Processing (NLP) is a branch of Artificial Intelligence that enables computers to understand, process, and analyze human language in textual form. In the context of a Resource Project Planning System (RPPS), NLP is used to automatically extract relevant information from employee resumes, project descriptions, and organizational documents. Instead of manually reviewing resumes, NLP identifies important attributes such as technical skills, programming languages, tools and technologies, educational qualifications, certifications, domain expertise, and professional experience. This automated extraction process reduces manual effort, improves data accuracy, and standardizes information for further analysis.

The extracted information is then preprocessed using techniques such as text cleaning, tokenization, stop-word removal, stemming or lemmatization, and feature engineering before being converted into numerical representations using methods like TF-IDF. These processed features enable the machine learning model to compare employee profiles with project requirements effectively. By leveraging NLP, the proposed RPPS can generate accurate skill-based project recommendations, identify skill gaps, support intelligent resource allocation, and improve overall workforce utilization while minimizing bench time.

**Key Points:**

- Automatically extracts skills and information from resumes and project descriptions.
- Identifies technical skills, tools, certifications, experience, and domain knowledge.
- Reduces manual data entry and improves consistency and accuracy.
- Performs text preprocessing, including cleaning, tokenization, and stop-word removal.
- Converts textual data into numerical features using techniques such as TF-IDF.
- Enables intelligent comparison between employee skills and project requirements.
- Supports skill-based project recommendation and optimized resource allocation.
- Helps identify skill gaps and recommends suitable projects for employees.
- Improves workforce utilization and reduces employee bench time.
- Provides high-quality input for machine learning models used in the RPPS.

## 2.8 Skill-Based Project Recommendation Systems

Skill-based recommendation systems compare employee competencies with project requirements.

Typical recommendation workflow includes:

1. Resume parsing
2. Skill extraction
3. Data preprocessing
4. Feature engineering
5. Similarity calculation
6. Candidate ranking
7. Allocation recommendation

Natural Language Processing (NLP) enables extraction of technical skills from resumes and project descriptions.

Recommendation systems reduce recruitment effort while increasing project success rates.

## 2.9 Candidate–Project Matching and Resource Optimization

Candidate–Project Matching is the process of identifying the most suitable employee for a project by comparing employee profiles with project requirements. The matching process considers multiple factors such as technical skills, experience level, domain expertise, tools and technologies, job roles, certifications, and project complexity. Instead of relying solely on manual decision-making, intelligent matching algorithms evaluate the similarity between employee competencies and project requirements to generate the most appropriate recommendations. This approach improves project success rates, reduces employee bench time, and ensures efficient utilization of organizational resources.

Resource Optimization extends the matching process by ensuring that available employees are allocated across multiple projects in the most efficient manner. After similarity scores are generated, optimization techniques are applied to maximize overall organizational productivity while minimizing resource conflicts and workload imbalance. In the proposed Resource Project Planning System (RPPS), the Hungarian Algorithm is employed to determine the optimal one-to-one assignment between employees and projects based on maximum matching scores. This enables fair, balanced, and cost-effective project allocation while improving workforce utilization and supporting strategic resource planning.

**Key Points:**

- Matches employee profiles with project requirements based on multiple attributes.
- Considers technical skills, experience, domain knowledge, tools, and job roles.
- Uses intelligent matching algorithms to calculate candidate–project compatibility.
- Generates similarity scores to rank the most suitable project recommendations.
- Employs the Hungarian Algorithm for optimal employee–project assignment.
- Maximizes overall resource utilization while minimizing allocation conflicts.
- Balances employee workload across multiple projects.
- Reduces manual allocation efforts and improves decision-making accuracy.
- Supports efficient resource optimization through AI-driven allocation strategies.
- Increases project success rates and minimizes employee bench duration.

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## Matching Algorithms

Matching algorithms are computational techniques used to determine the degree of compatibility between employee profiles and project requirements. These algorithms analyze structured and unstructured data, including technical skills, experience, certifications, domain expertise, and project descriptions, to calculate similarity scores. In AI-driven resource planning systems, matching algorithms help automate the decision-making process by ranking employees according to their suitability for specific projects, thereby reducing manual effort and improving allocation accuracy.

Different matching algorithms use various similarity measures such as cosine similarity, Euclidean distance, Jaccard similarity, and semantic matching to evaluate candidate-project compatibility. In the proposed RPPS, TF-IDF combined with Cosine Similarity is utilized to compare employee skill profiles with project requirements, generating a ranked list of the most suitable projects or candidates for allocation.

### Key Points:

- Measures compatibility between employee profiles and project requirements.
- Uses structured and unstructured organizational data.
- Calculates similarity scores for intelligent decision-making.
- Supports automated candidate ranking and project recommendation.
- Reduces manual errors during resource allocation.
- Improves matching accuracy using AI techniques.
- Utilizes TF-IDF and Cosine Similarity in the proposed RPPS.
- Enables scalable and efficient workforce planning.

- Assists in identifying the best-fit employee for each project.
- Enhances organizational productivity through intelligent matching.

## Hungarian Algorithm

The Hungarian Algorithm is an optimization algorithm used to solve assignment problems by identifying the optimal one-to-one mapping between two sets, such as employees and projects. The algorithm minimizes total assignment cost or maximizes overall matching efficiency by systematically evaluating all possible assignments without exhaustive computation. It guarantees an optimal solution within polynomial time, making it suitable for large-scale workforce allocation problems.

In the proposed RPPS, the Hungarian Algorithm uses the similarity matrix generated by the machine learning recommendation model to assign employees to projects with the highest compatibility scores. This ensures that each employee is assigned to the most appropriate project while avoiding duplicate allocations and maximizing overall workforce utilization.

### Key Points:

- Solves optimal assignment problems efficiently.
- Provides one-to-one employee–project allocation.
- Maximizes compatibility scores across all assignments.
- Minimizes allocation conflicts and resource wastage.
- Operates with polynomial-time computational complexity.
- Uses similarity matrices generated by recommendation models.
- Ensures fair and balanced resource distribution.
- Prevents duplicate employee assignments.
- Improves organizational efficiency and productivity.
- Forms the optimization backbone of the proposed RPPS.

## Optimization Techniques

Optimization techniques are mathematical and computational methods used to achieve the best possible allocation of organizational resources while satisfying predefined constraints. In project management, these techniques aim to maximize employee utilization, minimize project delays, reduce operational costs, and improve overall productivity. Optimization considers multiple constraints such as employee availability, project deadlines, workload balance, skill compatibility, and business priorities.

The proposed RPPS combines machine learning-based similarity scoring with optimization algorithms to generate efficient resource allocation decisions. By integrating predictive analytics and optimization techniques, the system continuously improves allocation quality while adapting to changing organizational requirements and workforce availability.

### Key Points:

- Optimizes resource allocation under organizational constraints.
- Maximizes employee utilization and project efficiency.
- Minimizes operational costs and project delays.
- Balances workloads across available employees.
- Considers availability, skills, deadlines, and business priorities.
- Integrates optimization with machine learning recommendations.
- Supports dynamic and adaptive workforce planning.
- Enhances organizational decision-making.
- Improves resource allocation accuracy.
- Enables efficient utilization of human resources.

## Allocation Strategies

Allocation strategies define the methods and policies used to assign employees to projects while ensuring organizational objectives are achieved effectively. Traditional allocation strategies often depend on managerial judgment and manual scheduling, which may introduce bias and inefficiencies. Modern AI-driven allocation strategies utilize employee competencies, project requirements, historical performance, availability, and optimization algorithms to make objective and data-driven allocation decisions.

In the proposed RPPS, allocation strategies integrate skill-based project recommendation, candidate-project matching, optimization algorithms, and performance analytics to ensure that the right employee is assigned to the right project at the right time. This intelligent allocation approach enhances productivity, reduces bench time, supports employee development, and improves overall project success.

### Key Points:

- Defines systematic methods for assigning employees to projects.
- Considers employee skills, experience, and availability.
- Incorporates project requirements and organizational priorities.
- Uses AI-driven decision-making instead of manual scheduling.
- Integrates recommendation and optimization algorithms.
- Promotes fair and unbiased project allocation.
- Improves employee utilization and productivity.
- Reduces bench time and allocation delays.
- Supports long-term workforce planning.
- Contributes to higher project success rates and organizational performance.

## 3.1 Employee Bench Management and Workforce Utilisation

Employee Bench Management refers to the systematic process of monitoring and managing employees who are temporarily unassigned to active projects. In project-based organizations, especially in the IT industry, employees may remain on the bench due to project completion, skill mismatches, market fluctuations, or delays in new project acquisition. Effective bench management ensures that employees are productively engaged through project recommendations, training programs, certification courses, or internal assignments, thereby minimizing idle time and improving workforce productivity.

Workforce Utilisation measures how effectively an organization uses its available human resources to achieve business objectives. It evaluates employee allocation, productivity, workload distribution, and project participation. In the proposed Resource Project Planning System (RPPS), Artificial Intelligence and Machine Learning are utilized to monitor employee availability, analyze skills, identify suitable project opportunities, and recommend optimal assignments. This intelligent approach helps organizations reduce bench duration, maximize employee utilization, improve operational efficiency, and enhance overall organizational performance.

### Key Points:

- Manages employees who are temporarily unassigned to projects.
- Monitors bench duration and employee availability.
- Identifies skill mismatches causing prolonged bench periods.
- Recommends suitable projects using AI-driven allocation models.
- Supports employee upskilling during bench periods.
- Improves workforce utilization and productivity.
- Reduces operational costs associated with idle employees.
- Balances workload across available organizational resources.
- Enhances employee engagement and career development.
- Contributes to better organizational resource planning.

## 3.2 Predictive Analytics and Workforce Forecasting

Predictive Analytics is the process of using historical and real-time organizational data to predict future workforce requirements and project demands. By applying statistical models and machine learning algorithms, organizations can anticipate resource shortages, identify hiring needs, forecast project workloads, and estimate employee availability. Predictive analytics enables proactive decision-making, allowing managers to allocate resources efficiently before potential challenges arise.

Workforce Forecasting extends predictive analytics by estimating future employee demand based on organizational growth, project pipelines, business objectives, and historical performance trends. In the proposed RPPS, forecasting models such as Linear Regression and ARIMA analyze workforce utilization patterns to predict future resource requirements. These forecasts assist organizations in strategic workforce planning, minimizing bench time, improving project readiness, and ensuring that skilled employees are available when new opportunities emerge.

#### **Key Points:**

- Predicts future workforce demand using historical organizational data.
- Supports proactive planning for upcoming projects.
- Estimates employee availability and resource requirements.
- Uses machine learning and statistical forecasting techniques.
- Applies Linear Regression and ARIMA models for prediction.
- Identifies future skill shortages and hiring requirements.
- Improves organizational planning and resource allocation.
- Reduces project delays caused by resource shortages.
- Enhances business decision-making through data-driven forecasting.
- Supports long-term workforce and capacity planning.

### **3.3 Performance Management and Employee Analytics**

Performance Management is the continuous process of evaluating employee performance to ensure that organizational goals are achieved efficiently. It involves measuring various performance indicators such as task completion, execution accuracy, productivity, work quality, and project contribution. Continuous performance monitoring enables organizations to recognize high-performing employees, identify areas for improvement, and support professional development through data-driven feedback.

Employee Analytics complements performance management by analyzing workforce data to generate meaningful insights into employee productivity, efficiency, and utilization trends. In the proposed RPPS, employee performance metrics are continuously collected and analyzed to improve future project recommendations and resource allocation decisions. By integrating performance analytics with machine learning models, the system ensures that historical employee performance contributes to more accurate and effective project assignments.

#### **Key Points:**

- Continuously evaluates employee performance and productivity.
- Measures execution accuracy, task completion, and work quality.
- Tracks employee contribution across multiple projects.
- Generates performance insights using analytical techniques.
- Supports objective and data-driven employee evaluations.
- Integrates historical performance into project recommendation models.
- Identifies high-performing employees and skill improvement areas.
- Enhances employee development and organizational productivity.
- Improves future resource allocation decisions.
- Enables continuous organizational performance monitoring.

### **3.4 Business Intelligence and Dashboard Visualisation**

Business Intelligence (BI) refers to the technologies and analytical processes used to transform organizational data into meaningful information for strategic decision-making. BI systems collect, process, and visualize data from multiple organizational sources, enabling managers to monitor workforce performance, project progress, resource utilization, and operational efficiency in real time. Interactive dashboards simplify complex datasets into easily understandable charts, graphs, and reports that support informed business decisions.

Dashboard Visualisation enhances Business Intelligence by presenting key organizational metrics through interactive graphical interfaces. In the proposed RPPS, dashboards display resource allocation, project recommendations, employee utilization, bench analysis, performance indicators, forecasting results, and workforce trends using tools such as Power BI, Tableau, and Python-based visualizations. These dashboards provide executives, project managers, and HR professionals with real-time insights for efficient workforce planning and organizational management.

## Key Points:

- Converts organizational data into meaningful business insights.
- Provides real-time monitoring of workforce and project performance.
- Displays interactive charts, graphs, and KPI dashboards.
- Supports strategic and operational decision-making.
- Visualizes employee utilization and bench management metrics.
- Monitors project allocation and recommendation outcomes.
- Presents forecasting and performance analytics effectively.
- Integrates with Power BI, Tableau, and Python visualization tools.
- Improves organizational transparency and reporting.
- Enables data-driven workforce management.

## 3.5 Comparative Analysis of Existing Resource Planning Systems

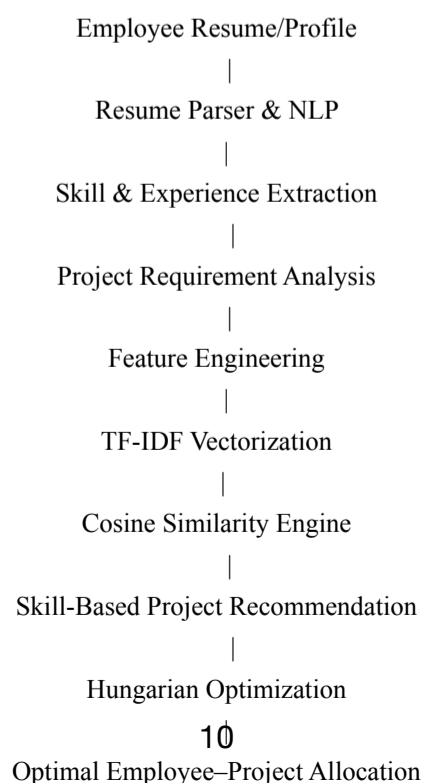
Comparative analysis involves evaluating existing resource planning systems to understand their capabilities, strengths, and limitations. Traditional Enterprise Resource Planning (ERP) systems primarily focus on managing organizational operations such as finance, human resources, procurement, and inventory. While these systems provide centralized data management and reporting capabilities, they generally lack intelligent project recommendation, AI-driven workforce optimization, predictive analytics, and automated resource allocation functionalities required by modern organizations.

The proposed Resource Project Planning System (RPPS) extends conventional resource planning by integrating Artificial Intelligence, Machine Learning, Natural Language Processing, optimization algorithms, predictive analytics, and business intelligence into a unified platform. Unlike existing systems, RPPS not only manages organizational data but also provides intelligent skill-based project recommendations, candidate–project matching, workforce forecasting, performance analytics, and bench management. This comprehensive approach improves workforce utilization, minimizes resource wastage, and supports strategic organizational decision-making.

## Key Points:

- Compares traditional ERP systems with intelligent resource planning solutions.
- Evaluates strengths and limitations of existing workforce management systems.
- Highlights the lack of AI-driven project recommendation in conventional systems.
- Identifies limitations in bench management and workforce optimization.
- Compares forecasting and predictive analytics capabilities.
- Examines automation in employee–project allocation.
- Demonstrates the advantages of integrating AI and Machine Learning.
- Highlights RPPS features such as NLP, recommendation systems, and optimization algorithms.
- Supports intelligent, data-driven workforce planning.
- Justifies the need for the proposed AI-powered Resource Project Planning System (RPPS).

## 3.7 Proposed Research Framework



### 3.8 Research Gap

The reviewed literature demonstrates considerable progress in ERP systems, workforce planning, project scheduling, and machine learning. However, several important research gaps remain:

1. Existing ERP systems primarily manage employee and project information but lack intelligent **skill-based project recommendation** capabilities.
2. Most workforce management solutions emphasize project scheduling rather than recommending the most appropriate projects for available employees based on their technical competencies and experience.
3. Current resource planning tools rarely integrate resume parsing, Natural Language Processing (NLP), project recommendation, optimization algorithms, forecasting, performance analytics, and business intelligence within a single platform.
4. Most existing studies focus on allocating employees to predefined tasks instead of developing AI-driven systems that dynamically recommend projects based on employee skills, domain expertise, tools, experience, and organizational priorities.
5. There is limited research on intelligent Resource Project Planning Systems capable of providing **real-time skill-based project recommendations**, identifying skill gaps, recommending upskilling opportunities, forecasting workforce demand, and continuously improving allocation decisions through machine learning and optimization algorithms.

### 3.9 Summary

The reviewed literature indicates that intelligent workforce management has become essential for organizations operating in dynamic environments. Although ERP systems, project scheduling methodologies, and machine learning techniques have significantly improved resource planning, existing solutions remain fragmented and often fail to address bench employee utilization comprehensively. The proposed Resource Project Planning System integrates AI-based recommendation, optimization algorithms, predictive analytics, performance management, and business intelligence into a unified platform, thereby addressing key limitations identified in previous studies and contributing to more efficient workforce utilization and project success.