OPERATIONS MANAGEMENT

Master of Business Management
First Semester

INSTITUTE OF DISTANCE EDUCATION IDE
Rajiv Gandhi University

RAJIV GANDHI UNIVERSITY

Arunachal Pradesh, INDIA - 791112

About the University

Rajiv Gandhi University (formerly Arunachal University) is a premier institution for higher education in the state of Arunachal Pradesh. Late Smt. Indira Gandhi, the then Prime Minister of India, laid the foundation stone of the university on 4th February, 1984 at Rono Hills, where the present campus is located.

Ever since its inception, the university has been trying to achieve excellence and fulfill the objectives as envisaged in the University Act. The university received academic recognition under Section 2(f) from the University Grants Commission on 28th March, 1985 and started functioning from 1st April, 1985. It got financial recognition under section 12-B of the UGC on 25th March, 1994. Since then, Rajiv Gandhi University, (then Arunachal University) has carved a niche for itself in the educational scenario of the country following its selection as a university with potential for excellence by a high-level expert committee of the University Grants Commission from among universities in India.

The University was converted into a Central University with effect from 9th April, 2007 as per notificationof the Ministry of Human Resource Development, Government of India.

The University is located at top Rono Hills on a picturesque tableland of 302 acres overlooking the river Dikrong. It is 6.5 km from the National Highway 52-A and 25 km from Itanagar, the State capital. The campus islinked with the National Highway by the Dikrong Bridge.

The teaching and research programmes of the University are designed with a view to play a positive role in the socio-economic and cultural development of the State. The University offers Undergraduate, Post- graduate, M. Phil and Ph.D. programmes. The Department of Education also offers the B.Ed. and M.Ed. programme.

There are 37 (Thirty-seven) colleges affiliated to the University. The University has been extending educational facilities to students from the neighbouring states, particularly Assam. The strength of students in different departments of the University and in affiliated colleges has been steadily increasing.

The faculty members have been actively engaged in research activities with financial support from UGC and other funding agencies. Since inception, a number of proposals on research projects have been sanctioned by various funding agencies to the University. Various departments have organized numerous seminars, workshops and conferences. Many faculty members have participated in national and international conferences and seminars held within the country and abroad. Eminent scholars and distinguished personalities have visited the University and delivered lectures on various disciplines.

The academic year 2000-2001 was a year of consolidation for the University. The switch over from the annualto the semester system took off smoothly and the performance of the students registered a marked improvement. Various syllabi designed by Boards of Post-graduate Studies (BPGS) have been implemented. VSAT facility installed by the ERNET India, New Delhi under the UGC-Infonet program, provides Internet access.

In spite of infrastructural constraints, the University has been maintaining its academic excellence. The University has strictly adhered to the academic calendar, conducted the examinations and declared the results on time. The students from the University have found placements not only in State and Central Government Services, but also in various institutions, industries and organizations. Many students have emerged successfulin the National Eligibility Test (NET).

Since inception, the University has made significant progress in teaching, research, innovations in curriculum development and developing infrastructure.

About IDE

The formal system of higher education in our country is facing the problems of access, limitation of seats, lack of facilities and infrastructure. Academicians from various disciplines opine that it is learning which is more important and not the channel of education. The education through distance mode is an alternative mode of imparting instruction to overcome the problems of access, infrastructure and socio-economic barriers. This will meet the demand for qualitative higher education of millions of people who cannot get admission in the regular system and wish to pursue their education. It also helps interested employed and unemployed men and women to continue with their higher education. Distance education is a distinct approach to impart education to learners who remained away in the space and/or time from the teachers and teaching institutions on account of economic, social and other considerations. Our main aim is to provide higher education opportunities to those who are unable to join regular academic and Vocational education programmes in the affiliated colleges of the University and make higher education reach to the doorsteps in rural and geographically remote areas of Arunachal Pradesh particular and North-eastern part of India in general. In 2008, the Centre for Distance Education has been renamed as "Institute of Distance Education (IDE)." Continuing the endeavour to expand e-learning opportunities for distant learners, IDE has introduced Post Graduate Courses in 5 subjects (Education, English, Hindi, History and Political Science) from the Academic Session 2013-14 and Economics & Sociology from the Academic Session-2018-19. Subsequently a Post Graduate Diploma in Mass Communication and other certificate courses also have been introduced in the University.

Outstanding Features of Institute of Distance Education:

1. **At Par with Regular Mode**

   Eligibility requirements, curricular content, mode of examination and the award of degrees are on par with the colleges affiliated to the Rajiv Gandhi University and the Department(s) of the University.

2. **Self-Instructional Study Material (SISM)**

   The students are provided SISM prepared by the Institute and approved by Distance Education Council (DEC), New Delhi. This will be provided at the time of admission at the IDE or its Study Centres SISM is provided only in English except Hindi subject.

3. **Contact and Counselling Programme (CCP)**

   The course curriculum of every programme involves counselling in the form of personal contact programme of duration of approximately 7-15 days. The CCP shall not be compulsory for BA. However, for professional (a) courses and MA the attendance in CCP will be mandatory.

4. **Field Training and Project**

   For professional course(s) there shall be provision of field training and project writing in the concerned subject.

5. **Medium of Instruction and Examination**

   The medium of instruction and examination will be English for all the subjects except for those subjects where the learners will need to write in the respective languages.

6. **Subject Counselling Coordinators**

   For developing study material, the IDE appoints subject coordinators from within and outside the University In order to run the PCCP effectively Counselling Coordinators are engaged from the Departments of the University, The Counselling Coordinators do necessary coordination for involving resource persons in contact and counselling programme and assignment evaluation. The learners can also contact them for clarifying their difficulties in then respective subjects.

Syllabi – Book Mapping Table

OPERATIONS MANAGEMENT

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Unit – II	Facilities Location Decisions.
Unit – III	Capacity Analysis, Design of Manufacturing Process, Plant Layout Planning.
Unit – IV	Total Quality Management, Material Resources Planning (MRP), Operations Scheduling.

C O N T E N T

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UNIT – I

Introduction to Operations Management (OM)

Structure

1.0 Objectives

2.0 Introduction

- 2.1 Operations management as a systems perspective
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- 2.3 Challenges in operations management
- 2.4 Current priorities for operations management

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4.0 Let us sum up

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1.0 Objectives

After reading this unit a student should be able to:

- Understand what operations management (OM) is.
- Recognise the role of OM in various types of organisations (manufacturing, service, etc.).
- Learn about the historical development of OM, including key milestones and influential figures.
- Identify common challenges and issues faced by operations managers, such as supply chain disruptions, quality control issues, and demand forecasting.
- Understand the impact of global trends, technological advancements, and regulatory changes on operations.
- Explore emerging trends and future directions in OM, such as automation, AI, sustainability, and lean operations.
- Understand the implications of these trends for operations managers and organisations.

2.0 Introduction

Operations Management (OM) is a crucial discipline that transforms resources into goods and services, impacting productivity, quality, and overall performance. It involves designing, overseeing, and improving processes to convert inputs like raw materials, labour, and technology into outputs. OM has evolved from traditional manufacturing practices to incorporate advanced technologies and methodologies, encompassing supply chain management, logistics, quality control, and process improvement. It aligns with strategic goals, emphasises sustainability, and is the backbone of any organisation.

2.1 Operations management as a systems perspective

Operations Management (OM) viewed from a systems perspective involves understanding and managing the interconnected processes and activities within an organisation as a cohesive whole. This holistic approach recognises that every part of the

operations system impacts and is impacted by other parts, necessitating a comprehensive and integrated management strategy.

Key aspects of the systems perspective in operations management include:

a. Interconnected Processes:
   - Integration: Operations management considers the end-to-end processes that span from suppliers to customers. Each stage, from procurement of raw materials to production, distribution, and customer service, is interconnected.
   - Dependencies: Changes in one part of the system can affect others. For example, a delay in raw material supply can impact production schedules and, consequently, delivery timelines.

b. Holistic Optimisation:
   - System Efficiency: Rather than optimising individual components, the systems perspective focuses on optimising the entire process. This ensures that improvements in one area do not inadvertently cause issues in another.
   - Balanced Performance: Key performance indicators (KPIs) and metrics are evaluated in the context of overall system performance, ensuring that goals such as efficiency, quality, and customer satisfaction are balanced.

c. Feedback Loops:
   - Continuous Improvement: Feedback from various stages of the operation is used to continually refine and improve processes. Techniques such as Total Quality Management (TQM) and Six Sigma rely on constant feedback for process enhancement.
   - Adaptive Systems: Operations management systems must be adaptable to changes in demand, technology, and market conditions, utilising feedback loops to stay responsive and flexible.

d. Cross-Functional Collaboration:
   - Interdepartmental Coordination: Effective operations management requires collaboration across departments such as procurement, production, marketing, and finance. Each function must align its objectives and processes with the overall system goals.

- Integrated Decision-Making: Decisions are made with an understanding of their impact on the entire system, fostering a culture of collaboration and shared responsibility.

e. Resource Management:
   - Efficient Utilization: Resources, including materials, labour, and technology, are managed to maximise their utility across the entire system. This involves strategic planning and real-time adjustments.
   - Sustainability: Emphasis is placed on sustainable practices, ensuring that resource utilisation does not negatively impact the environment or future operations.

f. Customer-Centric Focus:
   - Value Delivery: The ultimate goal of the system is to deliver value to the customer. Operations management ensures that every process and activity is aligned with meeting customer needs and expectations.
   - Feedback Integration: Customer feedback is integrated into the system to drive improvements and innovation.

g. Technology Integration:
   - Advanced Tools: Modern operations management utilizes technology such as Enterprise Resource Planning (ERP) systems, Internet of Things (IoT), and data analytics to enhance system integration and efficiency.
   - Real-Time Data: Real-time data collection and analysis enable proactive management and swift response to issues, further enhancing system coherence.

Viewing operations management from a systems perspective enables organisations to achieve a higher level of efficiency, adaptability, and customer satisfaction. By understanding and managing the interdependencies within the entire operations system, organisations can optimise their processes, respond effectively to changes, and deliver superior value to their customers. This holistic approach is essential for sustained success in today's complex and dynamic business environment.

2.2 Operations management functions

Operations Management (OM) encompasses a wide array of functions that collectively ensure the efficient and effective transformation of resources into goods and services. Each function plays a critical role in maintaining smooth operations, optimising performance, and achieving strategic organisational goals. Here is an elaborative note on the primary functions of operations management:

a. Process Design and Improvement
   - Process Design: This involves creating efficient workflows and processes for producing goods or delivering services. It includes determining the sequence of operations, selecting appropriate technologies, and laying out physical or virtual spaces to maximize efficiency.
   - Process Improvement: Continuous improvement methodologies such as Lean, Six Sigma, and Total Quality Management (TQM) are employed to enhance process efficiency, reduce waste, and improve quality.

b. Capacity Planning
   - Capacity Analysis: Understanding the maximum output that an operation can achieve under normal conditions. This involves analyzing current capabilities and forecasting future demands to ensure that capacity aligns with market needs.
   - Capacity Adjustment: Implementing strategies to adjust capacity based on demand fluctuations. This can involve scaling up operations during peak periods or scaling down during low-demand periods.

c. Supply Chain Management
   - Supply Chain Design: Structuring the supply chain to ensure the smooth flow of materials, information, and finances from suppliers to customers. This involves selecting suppliers, determining logistics routes, and establishing distribution networks.
   - Inventory Management: Balancing inventory levels to meet customer demand while minimizing holding costs. Techniques such as Just-In-Time (JIT) inventory and Economic Order Quantity (EOQ) are used to optimise inventory.

d. Production Planning and Control
    - Production Scheduling: Creating detailed schedules that dictate when and where production activities will take place. This ensures that resources are used efficiently, and that production meets demand.
    - Workflow Management: Monitoring and controlling the flow of work through the production process to ensure it is completed on time and meets quality standards.
e. Quality Management
    - Quality Assurance (QA): Establishing systems and processes to ensure that products or services meet specified quality standards. This involves developing quality policies, setting standards, and training employees.
    - Quality Control (QC): Monitoring and inspecting products or services to identify and correct defects. Techniques such as statistical process control (SPC) and inspection plans are used to maintain quality.
f. Logistics and Distribution
    - Logistics Planning: Managing the transportation and storage of goods. This includes route optimisation, selecting transportation modes, and managing warehousing.
    - Distribution Management: Ensuring that products are delivered to customers efficiently and on time. This involves managing relationships with distributors, retailers, and third-party logistics providers.
g. Facilities Management
    - Facility Layout: Designing the physical arrangement of operations facilities to optimise workflow and efficiency. This includes layout planning for factories, warehouses, and service centres.
    - Maintenance Management: Ensuring that facilities and equipment are maintained in good working condition to prevent downtime and extend their useful life.

h. Human Resources in Operations
    - Workforce Planning: Determining the number and types of employees needed to meet operational goals. This includes recruiting, training, and scheduling staff.
    - Performance Management: Monitoring and evaluating employee performance to ensure it meets organisational standards. This involves setting performance metrics, providing feedback, and implementing reward systems.

i. Technology Management
    - Technology Integration: Implementing and managing technology solutions that enhance operational efficiency. This includes enterprise resource planning (ERP) systems, manufacturing execution systems (MES), and automation technologies.
    - Innovation Management: Encouraging and managing innovations that can improve operational processes. This involves research and development (R&D), prototyping, and scaling new technologies.

j. Sustainability and Ethical Considerations
    - Sustainable Operations: Implementing practices that minimise environmental impact and promote sustainability. This includes reducing waste, recycling, and using renewable resources.
    - Ethical Practices: Ensuring that operations are conducted in an ethical manner. This involves fair labour practices, responsible sourcing, and compliance with regulations.

The functions of operations management are multifaceted and interrelated, collectively ensuring that organisations can produce and deliver goods and services efficiently, effectively, and sustainably. Each function requires careful planning, execution, and continuous improvement to adapt to changing market conditions and technological advancements. By mastering these functions, operations managers can drive organisational success, enhance customer satisfaction, and achieve strategic goals.

2.3 Challenges in operations management

Industry 4.0 is founded on the incorporation of cutting-edge information and communication technologies into the value chain through the interlinking and computerisation of conventional operations. This innovative and revolutionary approach seeks to promote a smart integration of products and processes to simplify operations and enhance efficiency and effectiveness, resulting in long-term cost savings and process improvement.

Digitisation plays a crucial role in the fourth industrial revolution. By incorporating the Internet of Everything (IoE) into industrial operations, organisations can develop various strategies and examine the benefits and problems associated with this digital transformation. Moreover, the escalating competition among organisations results in the need for corporate procedures to be streamlined to achieve optimal efficiency. In this regard, the combination of advanced methods of manufacturing with digital information and communication technologies holds the potential for significantly enhancing operational efficiency.

The topic of operations management offers ample opportunities for study in light of the advancements in Industry 4.0, as it enables the formulation of operations strategies tailored to the market. By considering intricate scenarios, it enables the construction of resource-based models that are more efficient. Given that these strategies are implemented through processes that establish how tasks are carried out, it is crucial to ensure that these processes are conducted with efficiency while satisfying operational objectives and criteria. Therefore, the implementation of Industry 4.0 not only presents challenges at the local level inside the shop floor, but also has far-reaching consequences throughout the global supply chain. Although the practical ramifications of globalisation on operations management are significant, it is widely acknowledged that researchers have not yet extensively examined this area.

Impacts of industry 4.0 on operations management

Operations are a crucial aspect of any organisation, as they involve the creation and delivery of goods and/or the provision of services to clients. Operations management

(OM) involves the management of various processes and the resources related to them. Operations is a crucial factor for firms to acquire a competitive edge and enhance their growth. Operations Management (OM) can be defined as the collection of activities involved in creating value by transforming resources into goods or services within a business model.

- **Steering Operations and Processes:** The operations function possesses a strategic aspect, overseeing the overarching strategy that guides the course of the operation and influences all other decisions related to operations. Directing includes the establishment of an operations strategy, the determination of performance objectives, the decision-making process for product and service design and innovation, and the management of the operation's scope. The marketplace exerts a significant influence on these strategic decisions, especially through the dynamic changes in customers and competitors. Therefore, it is imperative for organisations to implement a streamlined procedure that enables swift response to market fluctuations, facilitates agile strategy adaption, and expedites operational improvements. Hence, it would be crucial to establish connections across all operations in this process and enhance the transmission of information. Given the principles and trends of Industry 4.0, it is crucial to examine the possibilities of Operations Management (OM) in determining the most effective strategy for organisations. This is especially pertinent in the present market conditions, as it is crucial to make rapid and adaptable operational adjustments, which are heavily influenced by the rapidly changing market needs and competitive pressures.
- **Shaping Operations and Processes:** The design of the transformation process involves identifying the physical characteristics, structure, and composition of activities and processes, as well as the resources involved, that are responsible for producing products and services. Design includes the activities of process design, layout definition, and the selection of technology and personnel. Each of these tasks is categorised based on the organization's strategy, namely the type of operation and performance targets. These activities sometimes involve making structural changes and substantial investments. Therefore, alterations in the design of operations and processes, which arise from shifts in the marketplace,

can occur at a sluggish pace and occasionally become unattainable. Thus, firms can get a competitive edge by employing a flexible, dynamic, and decentralised transformation process, along with the ability to test designs prior to deployment. Industry 4.0 principles can significantly contribute by promoting decentralisation and enabling the adaptability of real-world systems. However, digital transformation enables the timely provision of context-aware real-time information regarding crucial operational variables. There is still uncertainty on whether the present OM models are appropriate for incorporating the Industry 4.0 paradigm.

- **Planning and Controlling Operations:** After the design of operations and procedures, the production and delivery of products and services to clients must take place. To ensure the efficacy of this procedure, it is imperative to plan and control all actions inside the supply chain operation. The process's efficiency is ensured by capacity management, which involves optimising the reaction to demand fluctuations. Additionally, the supply chain is analysed to determine the influence of all supply chain actions on profitability. Furthermore, inventory management applies models to balance costs. The execution of delivery tasks is facilitated by methodologies and procedures that require the processing of data and information. The data and information are typically gathered with a time lag and occasionally in varying settings, pertaining to the decision-making stage, and relying on statistical analysis. This approach has the potential to undermine the accuracy and dependability of the decisions. Therefore, companies have the potential to enhance their delivery services by collecting and integrating real-time data into the decision-making process. Nevertheless, the present OM models must undergo testing to determine their ability to process real-time data.
- **Improving Operations:** The responsibilities of operations management extend beyond the completion of delivery. The process is dynamic and offers chances for growth and enhancement. The chain of value process is not always able to maintain consistent standards due to changing variables, such as evolving customer wants, and the supply offered by competitors. Therefore, it is imperative for firms to have a well-defined approach for enhancing their operations, whether through significant or gradual changes. This can be achieved by implementing

methodologies such as quality management to reduce errors and project management to enhance project activities. Similar to delivery activities, performance improvement activities rely on precise and current process data. Regarding the aforementioned matter, it is necessary to thoroughly examine the existing OM models to determine their appropriateness for meeting these specific requirements.

Operations management is a critical function in any organization, aimed at ensuring efficient and effective production and delivery of goods and services. However, operations managers face numerous challenges that can impact productivity, quality, and overall organisational success. Below is a brief discussion on some of the key challenges in the field of operations management.

a. Globalisation
   - Complex Supply Chains: As businesses operate on a global scale, supply chains have become more complex. Managing these extended supply chains involves coordinating with multiple suppliers, manufacturers, and logistics providers across different countries.
   - Cultural and Regulatory Differences: Navigating various cultural norms, business practices, and regulatory environments can be challenging. Operations managers must ensure compliance with local laws while maintaining global standards.

b. Technological Advancements
   - Keeping Up with Technology: Rapid advancements in technology require constant updates to processes and systems. Staying abreast of the latest technologies and integrating them effectively can be daunting.
   - Cybersecurity Threats: As operations become increasingly digitized, the risk of cyber-attacks grows. Protecting sensitive data and maintaining system integrity are critical concerns.

c. Quality Management
    - Maintaining Consistency: Ensuring consistent quality across all products and services, especially in global operations, is challenging. Variations in raw materials, manufacturing processes, and human skills can affect quality.
    - Customer Expectations: With rising customer expectations, maintaining high quality while managing costs is increasingly difficult. Customers demand flawless products and services, pushing quality standards higher.
d. Sustainability and Environmental Impact
    - Eco-Friendly Practices: Implementing sustainable practices can be costly and complex. Balancing environmental responsibilities with economic goals requires innovative approaches and significant investments.
    - Regulatory Compliance: Meeting environmental regulations and standards adds another layer of complexity. Operations managers must stay updated on evolving regulations and ensure compliance to avoid penalties.
e. Supply Chain Disruptions
    - Natural Disasters and Pandemics: Events such as natural disasters, pandemics, and geopolitical conflicts can severely disrupt supply chains. Contingency planning and risk management strategies are essential but challenging to implement effectively.
    - Supplier Reliability: Ensuring reliable and consistent supply from multiple suppliers can be difficult. Issues such as supplier bankruptcy, quality failures, and logistical challenges must be managed proactively.
f. Cost Management
    - Rising Costs: Fluctuations in raw material prices, labour costs, and energy prices can impact overall operational costs. Managing these costs while maintaining profitability is a significant challenge.
    - Efficiency Improvements: Continuously improving operational efficiency to reduce costs without compromising quality or service levels requires constant innovation and process optimisation.

g. Human Resource Management
    - Skill Shortages: Finding and retaining skilled labour is a persistent challenge, particularly in specialised fields. Investing in training and development is crucial but can be resource intensive.
    - Employee Engagement: Maintaining high levels of employee engagement and motivation is essential for productivity. Addressing issues such as job satisfaction, work-life balance, and career development requires strategic focus.
h. Demand Forecasting
    - Accuracy in Forecasting: Predicting customer demand accurately is challenging due to market volatility and changing consumer preferences. Inaccurate forecasts can lead to overproduction or stockouts, both of which have significant financial implications.
    - Data Management: Leveraging big data and analytics to improve forecasting accuracy involves managing large volumes of data and extracting actionable insights, which can be complex and resource intensive.
i. Innovation and Product Development
    - Speed to Market: Accelerating product development cycles to meet market demands without compromising quality is challenging. This requires efficient collaboration across different functions and departments.
    - Balancing Innovation and Risk: Encouraging innovation while managing the inherent risks is a delicate balance. Investments in R&D need to be weighed against potential returns and market acceptance.
j. Customer Satisfaction and Service
    - Meeting Diverse Needs: Catering to diverse customer needs and preferences requires a high degree of flexibility and customisation. This can complicate operations and increase costs.
    - Handling Complaints: Efficiently addressing customer complaints and feedback is crucial for maintaining customer satisfaction and loyalty. Developing effective customer service processes is essential but challenging.

The field of operations management is fraught with challenges that require strategic foresight, innovative thinking, and meticulous execution. Operations managers must navigate complexities in globalisation, technology, quality management, sustainability, supply chain disruptions, cost management, human resources, demand forecasting, innovation, and customer satisfaction. By addressing these challenges effectively, organisations can achieve operational excellence, enhance competitiveness, and ensure long-term success.

2.4 Current priorities for operations management

In today's dynamic and competitive business environment, operations management priorities are continuously evolving to address new challenges and leverage emerging opportunities. Here are some of the current priorities for operations management:

a. Digital Transformation and Technology Integration
   - Automation: Implementing robotic process automation (RPA), artificial intelligence (AI), and machine learning (ML) to streamline operations, reduce errors, and enhance productivity.
   - Internet of Things (IoT): Utilising IoT devices to collect real-time data for better monitoring and management of operations, leading to improved decision-making and operational efficiency.
   - Data Analytics: Leveraging big data and advanced analytics to gain insights into operational performance, optimise processes, and predict future trends.

b. Sustainability and Green Operations
   - Environmental Responsibility: Reducing carbon footprints, minimising waste, and implementing sustainable practices throughout the supply chain.
   - Circular Economy: The circular economy is an economic system aimed at eliminating waste and the continual use of resources. It represents a shift from the traditional linear economy, which follows a "take-make-dispose" model, to a more sustainable approach that focuses on "reduce-reuse-recycle." The core principles of the circular economy are designed to create a closed-loop system, minimising the input of resources and the creation of waste, pollution,

and carbon emissions. Adopting circular economy principles extend product lifecycle and reduce environmental impact.

- Sustainable Sourcing: Ensuring that raw materials and components are sourced from environmentally and socially responsible suppliers.

c. Resilience and Risk Management
   - Supply Chain Resilience: Building robust and flexible supply chains that can withstand disruptions such as natural disasters, geopolitical tensions, and pandemics.
   - Risk Mitigation: Developing comprehensive risk management strategies to identify, assess, and mitigate potential risks in operations.

d. Customer-Centric Operations
   - Personalisation: Tailoring products and services to meet individual customer preferences and needs, enhancing customer satisfaction and loyalty.
   - Customer Feedback: Integrating customer feedback into the operational process to drive continuous improvement and innovation.

e. Lean and Agile Operations
   - Lean Management: Implementing lean principles to eliminate waste, streamline processes, and improve efficiency.
   - Agility: Developing agile operations that can quickly adapt to changing market conditions and customer demands.

f. Quality Management and Continuous Improvement
   - Total Quality Management (TQM): Ensuring that every aspect of the operation meets high-quality standards through a company-wide commitment to quality.
   - Continuous Improvement: Employing methodologies such as Six Sigma and Kaizen to drive ongoing enhancements in processes and products.

g. Workforce Management and Development
   - Skill Development: Investing in training and development programs to equip employees with the necessary skills to operate advanced technologies and adapt to changing operational needs.

- Employee Engagement: Fostering a positive work environment that promotes employee engagement, satisfaction, and retention.

h. Cost Efficiency
   - Cost Reduction: Identifying areas where costs can be reduced without compromising quality or service levels. This includes optimising resource utilisation and improving operational efficiency.
   - Cost Management: Implementing effective cost management practices to maintain profitability while delivering value to customers.

i. Globalisation and Localisation
   - Global Supply Chain Management: Managing global supply chains effectively to balance cost efficiency with the ability to respond quickly to local market needs.
   - Localisation: Adapting operations to meet local regulations, cultural preferences, and market conditions while maintaining global standards.

j. Innovation and Product Development
   - Rapid Prototyping: Using technologies such as 3D printing to accelerate product development cycles and bring new products to market faster.
   - Collaborative Innovation: Encouraging cross-functional collaboration and open innovation to drive creativity and the development of innovative products and services.

k. Ethical Operations
   - Corporate Social Responsibility (CSR): Implementing CSR initiatives to ensure that operations are conducted ethically and contribute positively to society.
   - Ethical Sourcing: Ensuring that all suppliers adhere to ethical standards regarding labour practices, environmental impact, and business integrity.

l. Advanced Manufacturing Techniques
   - Industry 4.0: Embracing the fourth industrial revolution technologies, such as smart manufacturing, cyber-physical systems, and advanced robotics, to enhance operational capabilities.

- Additive Manufacturing: Incorporating 3D printing and other additive manufacturing techniques to reduce waste, improve customisation, and speed up production.

The priorities for operations management today are cantered around leveraging technology, enhancing sustainability, building resilience, maintaining customer focus, and fostering continuous improvement. By addressing these priorities, organisations can achieve greater efficiency, adaptability, and competitiveness in an increasingly complex and dynamic business environment. Operations managers play a crucial role in navigating these challenges and driving the strategic objectives of their organisations.

Check your Progress – I

1. Operations management needs to be understood as a systems perspective. Explain why?
2. What are the key functions that are undertaken by an operations manager?
3. What is Industry 4.0? What changes do businesses need to bring in this era?
4. What are the new dimensions that every business unit needs to take care of to succeed in the contemporary era?

3.0 Sustainability in Operations

Sustainability in operations management involves integrating eco-friendly practices and principles into the production, distribution, and logistics processes of an organisation. The goal is to meet current needs without compromising the ability of future generations to meet theirs, ensuring long-term ecological balance and economic viability. OM techniques and research should be adapted to meet the requirements of addressing sustainability. This response is prompted by climate change and other environmental issues, as well as the welfare of workers and communities, and other wide-ranging societal demands. Sustainable operations management (OM) is the practice of pursuing social, economic, and environmental goals, known as the triple bottom line (TBL), within a company's operations. This includes considering the supply chain and communities that are connected to the company. Various facets of OM can be examined via the lens

of sustainability. These components include product design and eco-design, the implementation of environmental and social standards, process improvement and efficient operations, purchasing, supply chain management (SCM), logistics including recycling and closed-loop systems, performance monitoring, and risk management.

Over the past two decades, there has been a significant increase in sustainable operations management (OM) research, which is a result of several transformations in both the business world and society as a whole. During the 1990s, there was a significant emphasis on resource productivity, aiming to decrease resource use and enhance their efficiency. The primary issue was that if humans persist in consuming resources at the present rates, we will require more than three times the amount of resources available on a single planet. An interest in resource productivity was characterised by the aspiration to be environmentally sustainable and economically competitive, aiming to generate profits or achieve a competitive edge through enhancing environmental performance. The interest in environmental performance has persisted, namely targeting green products and processes, waste reduction, CO_2 emission reduction, recycling, and reverse logistics or closed-loop supply chains.

Simultaneously, a more comprehensive and thorough investigation of social and humanitarian concerns in operations has enhanced this environmental research. For instance, there has been a growing fascination in the corporate social responsibility (CSR) actions of companies, and voluntary programmes like the Global Reporting Initiative (GRI) have demonstrated this expansion. Furthermore, there has been an increase in study regarding health and safety and employee wellbeing, specifically in relation to global supply chains. This research has coincided with the implementation of standards and codes of behaviour within and across companies. Research on ethical products and fair trade demonstrates a growing customer concern over the origins of products. The ethicality of purchasing behaviour within businesses has been subject to investigation. Furthermore, attention is given to the behavioural and psychological elements of OM. Humanitarian aid is an expanding area of study in logistics, focusing on the delivery of goods to populations during disaster situations. In recent times, researchers have endeavoured to explore the interconnectedness of social, economic,

and environmental concerns, enabling the analysis of the Triple Bottom Line (TBL) of sustainability.

Regrettably, the past ten years have been marked by a worldwide economic downturn, partly attributable to questionable ethical conduct within the financial sector. At the same time, as social media has grown, there has been an increase in the coverage and discussion of prominent incidents where firms have engaged in unethical behaviour. Consumers possess a medium via which they may express their problems, and corporations are experiencing pressure to provide a response. This phenomenon has been observed in a growing body of research on risk management and sustainable operations management and supply chain management.

3.1 Notion of sustainability

Sustainability refers to the capacity of our society to thrive and progress without exhausting the essential natural resources required for future survival. Sustainable development facilitates the achievement of this objective over a prolonged period by implementing systems, frameworks, and receiving support from global, national, and local institutions. The concept of sustainability is based on the understanding that the natural resources available on Earth are limited. Therefore, promoting sustainable behaviours is crucial for preserving a harmonious relationship between the environment, economy, and social fairness. The concept revolves around the dynamic force and vitality required to ensure the sustainability of Earth, while simultaneously managing and mitigating the depletion of resources. Preserving our world and its natural resources, such as water and air, is crucial for ensuring sustainability. Promoting the development of a sustainable future and fostering sustainable lifestyles can effectively mitigate pollution and save the habitats of flora and fauna.

Sustainability encompasses sustainable business practices and economic development, which encompass green technology, eco-friendly supply chains, and other related factors. When businesses and government adhere to sustainable practices, it has a cascading impact on individuals and communities, leading to a reduction in greenhouse gas emissions and reliance on fossil fuels. All these factors contribute to an

enhanced quality of life. The concept of sustainability emerged from the movement that originated from the ideas of social justice, ecological conservation, and globalism in the late 20th century.

In 1983, the United Nations appointed Gro Harlem Brundtland, the former prime minister of Norway, to lead the World Commission on Environment and Development. Despite decades of industrialisation, many countries remained impoverished, with negative consequences for both social fairness and the environment. The study "Our Common Future" by the Brundtland Commission establishes the necessity of sustainable development, which is a comprehensive approach that takes into account the environment, economics, and equity. Sustainable development necessitates a comprehensive approach that incorporates environmental considerations alongside economic advancement.

The United Nations Brundtland Commission, in 1987, provided a definition of sustainability as the act of satisfying the requirements of the current generation while ensuring that future generations can also fulfil their own needs without any hindrance. Currently, there are about 140 developing nations worldwide that are actively searching for strategies to fulfil their development requirements. However, due to the growing menace of climate change, it is imperative to take tangible actions to ensure that present-day progress does not have adverse consequences for future generations.

The Sustainable Development Goals provide a comprehensive framework for enhancing the well-being of global populations and addressing the adverse anthropogenic impacts of climate change. SDG 13, often known as Climate Action, emphasises the need to incorporate strategies for mitigating climate change within development frameworks. SDG 14, which focuses on Life Below Water, and SDG 15, which focuses on Life on Land, both advocate for the adoption of more sustainable approaches in utilising the earth's natural resources. A summary of all the SDGs can be visualised from Figure 1 below.

Figure 1. Sustainable Development Goals of the United Nations.
Source: https://commons.wikimedia.org/wiki/File:Sustainable_Development_Goals_text_only.png

SGD 9 and 12 particularly need to be given due consideration and prime focus while taking production and service delivery decisions by any organisation. Although it is a global endeavour, the SDGs can only be realised in the true spirit if every business unit and the industries as a whole ensure policies in accordance with SDGs 9 and 12.

The trinity of sustainability

The three fundamental principles of sustainability, namely environmental, economic, and social, can guide us in creating a pathway towards a future that is sustainable.

- Environmental sustainability refers to the practice of preserving the ecological balance of Earth's environmental systems as humans consume natural resources such as air, water, soil, forests, and animals.
- Economic sustainability refers to the objective of individuals on Earth to achieve self-reliance and get employment or obtain other necessary resources to fulfil their needs. It is imperative to establish and provide universal access to economic systems.
- Social sustainability refers to the notion of guaranteeing universal access to basic human needs and maintaining equitable distribution of resources within a community. Robust social institutions can guarantee the well-being and contentment of communities, where fundamental human rights such as labour, healthcare, and equality are upheld.

Sustainable Operations Management (SOM) refers to the use of skills and principles that enable a company to effectively execute its business processes while maintaining

competitiveness and without causing negative impacts on social, economic, or environmental aspects. The SOM method strives to meet the demands of the present generation while also considering the needs of future generations, without making any compromises. It guarantees a harmonious equilibrium among financial profitability, ecological responsibility, and societal welfare. It is essential for all operational units of a corporation to adhere to the principles of sustainability. Production units should be organised in a manner that encourages the reduction of energy consumption, gas emissions, liquid and solid waste, and ensures efficient use of resources. Promoting the incorporation of production optimisation techniques, use of green energy, and minimising the number of processes is advisable. SOM approaches should be integrated into distribution and logistics processes, including packaging and choice of delivery mode.

3.2 Challenges in creating sustainable operations

Creating sustainable operations management in contemporary business is fraught with challenges that span economic, social, and environmental dimensions. These challenges require businesses to rethink traditional practices and adopt innovative solutions. Some of the major challenges faced by organisations striving to achieve sustainability in their operations are discussed below:

a. High Initial Costs
    - Investment in Technology: Implementing sustainable technologies such as renewable energy systems, energy-efficient machinery, and waste treatment facilities often require significant upfront investment.
    - Research and Development: Developing new sustainable products and processes necessitates investment in research and development, which can be costly.
b. Complex Supply Chains
    - Supply Chain Visibility: Achieving transparency and traceability throughout the supply chain to ensure sustainable practices is complex and resource intensive.

- Supplier Compliance: Ensuring that all suppliers and partners adhere to sustainable practices and ethical standards can be challenging, especially in global supply chains with diverse regulatory environments.

c. Regulatory and Compliance Issues
   - Varying Regulations: Navigating different environmental regulations and standards across countries can be complicated, requiring businesses to adapt their practices to comply with local laws. There are international regulatory bodies such as United Nations Environment Programme (UNEP) and UN Framework Convention on Climate Change (UNFCCC) whose sustainability guidelines and policies must be adhered to by business organisations.
   - Frequent Changes: Keeping up with the rapidly evolving regulatory landscape and ensuring continuous compliance can be a significant challenge.

d. Consumer Awareness and Demand
   - Consumer Education: Educating consumers about the benefits of sustainable products and practices is crucial but challenging. Consumer preferences are varied, and not all are willing to pay a premium for sustainability.
   - Market Demand: Balancing sustainability with consumer demand and preferences can be difficult, especially if sustainable products are more expensive or perceived as lower quality.

e. Operational Integration
   - Process Redesign: Integrating sustainability into existing operations often requires a complete redesign of processes, which can disrupt normal business activities and require extensive training and change management.
   - Cultural Change: Fostering a culture of sustainability within an organisation requires changing mindsets and behaviours, which can be met with resistance from employees accustomed to traditional practices.

f. Measurement and Reporting
   - Data Collection: Collecting accurate and comprehensive data on sustainability metrics across the entire supply chain and operations is challenging.

- Standardisation: There is a lack of standardised metrics and reporting frameworks for sustainability, making it difficult to measure and compare performance.

g. Resource Constraints
   - Material Scarcity: Ensuring a consistent supply of sustainable materials can be challenging due to scarcity and competition for these resources.
   - Energy Consumption: Transitioning to renewable energy sources while maintaining reliable and sufficient energy supply is often complex and costly.

h. Innovation and Technological Barriers
   - Technology Adoption: Adopting new, sustainable technologies requires significant changes to existing systems and processes, which can be met with resistance and technical challenges.
   - Scalability: Scaling sustainable solutions to match the size and scope of operations without compromising efficiency or quality is often challenging.

i. Economic Pressures
   - Cost Competitiveness: Maintaining cost competitiveness while investing in sustainable practices is a major challenge, particularly for small and medium-sized enterprises (SMEs) with limited financial resources.
   - Short-Term vs. Long-Term Goals: Balancing the short-term financial pressures with long-term sustainability goals requires a strategic approach that may not always align with immediate business objectives.

j. Global Disparities
   - Developing vs. Developed Countries: Implementing sustainability practices can be more challenging in developing countries due to limited access to technology, infrastructure, and financial resources.
   - Economic Inequality: Addressing sustainability in a manner that also tackles economic inequality and promotes inclusive growth is a complex challenge.

Check your Progress – II

1. What is the notion of Triple Bottom Line (TBL)? How is it significant?
2. Briefly discuss the contribution of Brundtland Commission.

3. What is sustainable operations management?
4. List down the major challenges in developing and managing a sustainable operations management environment?

4.0 Let us sum up

Operations management (OM) is all about running the engine of a business. It involves planning, organising, and controlling the activities that turn raw materials and labour into finished goods or services. The ultimate goal is to enhance the efficiency of the business with which it converts resources into finished goods and services. OM professionals strive to deliver high-quality products or services at the lowest possible cost, keeping customers happy and the company profitable.

Sustainability in operations management takes things a step further. It recognises the impact business operations have on the environment and society. Sustainable OM aims to balance three key areas:

- Economic viability: Making a profit and staying competitive.
- Environmental responsibility: Minimising waste, reducing pollution, and conserving resources.
- Social well-being: Ensuring fair labour practices, supporting communities, and upholding ethical standards.

By adopting sustainable practices, companies can reduce costs through resource efficiency, improve brand reputation and attract environmentally conscious customers, and mitigate risks associated with climate change and resource depletion. In short, sustainable operations management is about creating a win-win situation for businesses, the environment, and society.

5.0 Keywords

Goods	Goods are tangible, demand-driven items that can be owned and transferred between institutions through market transactions.
Operations	Operations refers to the activities involved in managing the internal processes of a business to maximise efficiency.
Product	A product is a purchasable item, service, or item, either physical or virtual, with production costs and a specific price based on market conditions, product quality, marketing effectiveness, and target consumer category.

System	A set of things working together as parts of a mechanism or an interconnecting network or a complex whole.
Service	A service is an intangible commodity that is both created and consumed at the same time. This can be juxtaposed with a material commodity, which is a palpable item that is manufactured and subsequently utilised at a later point in time.
Sustainability	The amalgamation of environmental health, social fairness, and economic vitality aims to establish flourishing, robust, diversified, and resilient communities for both the present and future generations.
Sustainable Development Goals	An urgent call for action by all countries - developed and developing - in a global partnership.

6.0 Check your learning

i. What is Operations Management?

ii. What is the difference between goods and services in the context of operations management?

iii. What is the role of an operations manager?

iv. What is the importance of process design in operations management?

v. What is the significance of quality management in operations?

vi. What is the role of technology in operations management?

vii. What are the challenges in managing global operations?

viii. How is sustainability integrated into operations management?

7.0 Suggested readings

Robert Jacobs and Richard B. Chase:	*Operations and Supply Chain Management: The Core*. 6th Edition. McGraw Hill, India.
Jay Heizer and Barry Render:	*Principles of Operations Management: Sustainability and Supply Chain Management*. 12th Edition. Pearson, India.
S N Chary:	*Production and Operations Management*. 6th Edition. McGraw Hill, India.
W J Stevenson:	*Operations Management*. 13th Edition. McGraw Hill, India.
B. Mahadevan:	*Operations Management: Theory and Practice*. 3rd Edition. Pearson, India.

UNIT – II

Facilities Location Decisions

Structure

1.0 Objectives

2.0 Introduction to facility location

3.0 Factors affecting factor location decisions

- 3.1 Proximity to the source of supply
- 3.2 Proximity to the customer or the market
- 3.3 Proximity to the source of labour
- 3.4 Community considerations
- 3.5 Site considerations

4.0 Effects of globalisation on location decisions

5.0 Facility location decision-making

- 5.1 Factor rating method
- 5.2 Centre of gravity method
- 5.3 Load-distance method

6.0 Let us sum up

7.0 Keywords

8.0 Check your learning

9.0 Suggested readings

1.0 Objectives

After reading this unit a student should be able to:

- Define meaning of facility location and understand its significance in operations management.
- Understand the Importance of facility location decisions.
- Analyse key factors influencing facility location.
- Apply location decision models and techniques.

2.0 Introduction to facility location

According to the Cambridge dictionary, a facility is described as a location, typically consisting of structures, where a specific activity takes place. A facility encompasses more than just a physical location or structure; it also includes the many equipment and individuals associated with it. Additionally, it encompasses hospitals, food processing facilities, and petrol stations, among other establishments. Plant location refers to the process of selecting the optimal position for a plant in order to achieve the highest level of operational efficiency and effectiveness.

The process of choosing a suitable location for establishing a factory is a crucial challenge that entrepreneurs have when initiating a new business venture. Choosing based only on economic factors will guarantee a consistent and reliable supply of raw materials, a skilled workforce, an optimised factory layout, efficient use of production capacity, and lower production costs. While a great site alone may not ensure success, it undeniably enhances the efficiency and effectiveness of an organisation. An unfavourable site, however, poses a significant disadvantage for any business and ultimately leads to its financial ruin. Therefore, it is crucial to exercise great caution in the early phases while choosing an appropriate location. Once an error is made in the placement of a plant, rectifying it becomes exceedingly challenging and expensive.

The location of a facility is a crucial element in the supply chain, as it has a considerable influence on the efficiency and efficacy of various supply networks and the overall organisation. Location decisions are strategic, long-term, and non-repetitive. In the

absence of effective and comprehensive site planning from the beginning, the new facilities may encounter persistent operational problems in the future. An unfavourable location choice not only hampers the expansion of the company but also hinders the progress and advancement of the nation. The location decision should be made meticulously, as any mistake that leads to an unfavourable location can lead to persistent issues such as increased costs, higher investments, challenging marketing and transportation, discontented employees and consumers, frequent production interruptions, excessive wastage, delays, and subpar quality, among other consequences.

The location of a facility has a substantial impact on revenue, costs, and service levels provided to consumers. Therefore, it is a traditional optimisation problem that involves identifying the most suitable locations for factories, service outlets, and warehouses. The facility placement selection is determined by choosing the optimal choice from a range of potential sites, based on the specific characteristics or category of the firm. The selection of a facility location is strategically driven by the goal of maximising profits or minimising all costs related to the location choice.

Facility location planning

The decision on the location of a facility is closely linked to decisions regarding its capacity. When considering expanding capacity, it is important to choose where to grow to properly connect with the distribution network of the facility location. The facility location of operations is a strategic decision that requires significant and enduring commitment to geographically fixed elements that impact commercial organisations. The choice of location is a crucial decision for production and operations management due to the significant expenditure involved in constructing plant and gear.

Importance of facility location decisions

Location analysis is a process that aims to determine the most advantageous position for an organization's building or factory. The geographical location of a company significantly influences its ability to attract and retain top-tier staff, providing a competitive advantage over its competitors. An optimal site decision prevents the

squandering of expenditures made in plant and industrial equipment. An effective location decision enhances the firm's performance by minimising its overall production costs. Additionally, it guarantees the well-being and security of its employees. Strategically positioning a facility can provide the company with client accessibility and the opportunity to benefit from government incentives. The selection of a business's location has always been a crucial factor. The location of a workplace significantly influences the ability to attract and retain top-notch personnel, many of whom carefully consider the geographical setting to enhance their work-life balance.

Strategic location choices can greatly enhance a company's overall performance in the long run. Inefficient individuals can result in significant financial losses due to decreased skill, production, and capital. It is common to encounter companies that have long-lasting implications due to their decision-making processes about their presence of site. One corporation made the decision to decentralise to reduce expenses. The reduction in real estate expenses did occur, but it also led to the departure of skilled employees and clients, resulting in significant financial losses for the company, amounting to millions of dollars.

Besides mitigating potential calamities, there exist seven crucial factors reasons why location decisions are strategically important for a modern-day business:

1. **Acquiring and retaining skilled individuals:** Typically, this will entail a placement in the heart of a city. Urban areas attract a growing population of young individuals and foreigners. These locations also become reachable.

2. **Expenses related to property ownership:** Real estate efficiency is crucial as it is the second highest expenditure after labour costs.

3. **Groupings:** Establishing a network of interconnected firms can provide corporations with enhanced access to a more extensive and superior talent pool, regulatory bodies, investors, and economies of scale. Nevertheless, this could incur significant costs;

carefully evaluate the advantages and disadvantages and determine what is crucial for your organisation.

4. **Government oversight and taxation:** Considering the possibility of regulatory changes, it is advisable to consult with your C-suite executives and reach a consensus on whether your preference is to establish your operations in a country with lower tax rates or in one with less restrictions.

5. **Expansion or a shift in corporate strategy, technology, or leadership:** Various organisational frameworks are suitable for different enterprises. Occasionally, I have observed corporations choosing a central hub equipped with meeting places, while being supplemented by several smaller spokes located elsewhere. Meanwhile, some individuals or organisations are upholding the existence of expansive, strategically positioned corporate offices. Once again, contemplate the optimal approach for the functionality of your organisation.

6. **Urban vibrancy:** Several European governments are decentralising authority to regions and cities, perhaps providing financial assistance and incentives to enterprises. Take note of emerging urban hubs that offer incentives to firms, since this might be highly beneficial.

7. **Ease of access:** Transportation plays a vital role in facilitating successful movement for both your employees and other those you collaborate with, enabling access to new markets, clients, and resources.

Location considerations can often involve a significant amount of time. The process entails determining the specific needs of the company, engaging with relevant parties, evaluating possible sites, performing on-site visits, and negotiating the most favourable agreement.

3.0 Factors affecting factor location decisions

When deciding on the location of a facility, it is important to carefully analyse many elements. The elements can be classified into two categories: controllable and uncontrollable factors.

Controllable factors are those that a business can influence or manage to a significant extent. These factors typically involve internal considerations and strategic decisions that can be adjusted based on the company's goals, resources, and operational needs. Uncontrollable factors are external conditions and circumstances that a business cannot influence or control directly. These factors often involve broader economic, political, and environmental considerations that must be accounted for in the location decision process. The major factors affecting location decisions can be discussed as follows:

3.1 Proximity to the source of supply

Proximity to the source of supply is a crucial factor in determining the location of a facility, whether it is a manufacturing plant, warehouse, or distribution centre. This factor significantly impacts operational efficiency, cost management, supply chain reliability, and overall competitiveness. Here are the key roles and benefits associated with being close to suppliers:

Cost Reduction

- Transportation Costs: One of the most immediate benefits of proximity to suppliers is the reduction in transportation costs. Shorter distances mean lower fuel expenses, fewer transportation fees, and reduced wear and tear on vehicles.
- Handling Costs: Fewer handling stages and shorter transit times minimise the costs associated with loading, unloading, and storage during transit.

Supply Chain Efficiency

- Reduced Lead Times: Being close to suppliers shortens lead times, allowing for quicker replenishment of raw materials and components. This enhances the ability to respond rapidly to production needs and market demand.

- Inventory Management: Shorter supply chains facilitate just-in-time (JIT) inventory systems, reducing the need for large inventory buffers and thereby decreasing inventory holding costs.

Improved Reliability and Risk Management

- Supply Chain Reliability: Proximity to suppliers can lead to more reliable and predictable supply chains, with fewer delays caused by long-distance transportation or geopolitical issues.
- Risk Mitigation: Shorter supply chains reduce exposure to risks such as transportation strikes, border delays, and customs issues. This enhances continuity and reduces the likelihood of production stoppages.

Quality Control and Collaboration

- Quality Assurance: Close proximity allows for more frequent and easier quality inspections of materials and components, ensuring higher standards and reducing defects.
- Collaboration: Geographic closeness fosters stronger relationships and better communication with suppliers. It facilitates collaboration on product development, process improvements, and problem-solving.

Flexibility and Responsiveness

- Agility: Proximity to suppliers enables quicker adjustments to changes in production schedules, product designs, and customer requirements. This agility is crucial in dynamic markets where demand can be unpredictable.
- Custom Orders: Manufacturers can more easily accommodate custom orders or modifications with rapid access to necessary materials and components.

Sustainability and Environmental Impact

- Reduced Carbon Footprint: Shorter transportation distances contribute to lower greenhouse gas emissions and a reduced environmental footprint, aligning with sustainability goals and regulatory requirements.

- Sustainable Practices: Proximity can facilitate the adoption of more sustainable practices, such as using local materials and reducing the overall environmental impact of the supply chain.

Economic and Social Benefits

- Local Economy: Sourcing materials locally supports the regional economy, potentially leading to positive community relationships and local government incentives.
- Job Creation: Increased local business activity can lead to job creation and economic development within the community.

Proximity to the source of supply plays a pivotal role in the location decision-making process. It offers substantial advantages in terms of cost savings, supply chain efficiency, reliability, quality control, flexibility, sustainability, and economic impact. By carefully considering this factor, businesses can enhance their operational performance, reduce risks, and achieve a competitive edge in the market.

3.2 Proximity to the customer or the market

Proximity to the customer is a vital factor in determining the optimal location for various types of facilities, such as manufacturing plants, distribution centres, retail outlets, and service centres. This factor significantly impacts customer satisfaction, cost efficiency, and overall competitiveness. Here are the key roles and benefits associated with being close to customers:

Enhanced Customer Service

- Reduced Delivery Times: Locating facilities close to customers helps ensure faster delivery of products and services, which enhances customer satisfaction and loyalty.
- Quick Response: Proximity allows for quicker response times to customer orders, inquiries, and issues, leading to improved service levels and customer experience.

Cost Efficiency

- Lower Transportation Costs: Shorter distances to customers result in reduced transportation costs, including fuel, labour, and vehicle maintenance expenses.
- Reduced Logistics Costs: Proximity to customers can lower overall logistics costs, including warehousing and inventory holding costs, by enabling more efficient distribution networks.

Market Responsiveness

- Agility: Being close to customers allows businesses to be more agile in responding to changes in market demand, customer preferences, and competitive actions.
- Customisation: Facilities near customers can more easily offer customized products or services tailored to local needs and preferences, enhancing customer satisfaction and differentiation.

Competitive Advantage

- Market Penetration: Proximity to customers can enhance market penetration by making products and services more accessible, convenient, and attractive to local consumers.
- Brand Image: Being present in key customer markets can strengthen brand visibility and reputation, creating a competitive edge in those regions.

Improved Inventory Management

- Reduced Inventory Levels: Proximity to customers allows for just-in-time delivery, reducing the need for large inventory buffers and minimizing inventory holding costs.
- Efficient Replenishment: Shorter distances enable more frequent and reliable replenishment of stock, ensuring better inventory turnover and availability.

Sustainability and Environmental Impact

- Lower Emissions: Reducing transportation distances decreases carbon emissions and the environmental footprint of logistics operations, aligning with sustainability goals and regulatory requirements.

- Local Sourcing: Proximity can facilitate local sourcing of materials and products, further reducing the environmental impact and supporting local economies.

Risk Management

- Reduced Risk of Disruptions: Shorter supply chains are less susceptible to disruptions caused by long-distance transportation issues, such as weather conditions, geopolitical events, and transportation strikes.
- Better Control: Proximity allows for better control over the end-to-end supply chain, enhancing reliability and consistency in meeting customer demands.

Economic and Social Benefits

- Support for Local Economy: Locating facilities near customers supports the local economy by creating jobs and stimulating economic activity.
- Community Relations: Being present in local markets can foster positive relationships with communities, leading to better customer trust and loyalty.

Proximity to the customer is a critical factor in location decisions that directly affects customer satisfaction, cost efficiency, market responsiveness, competitive advantage, and sustainability. By strategically choosing locations that bring them closer to their customers, businesses can improve service levels, reduce costs, enhance market presence, and contribute positively to the environment and local economies. This approach not only meets immediate operational needs but also supports long-term strategic goals and growth.

3.3 Proximity to the source of labour

Proximity to the source of labour is a crucial factor in determining the optimal location for various types of facilities, including manufacturing plants, service centres, and corporate offices. This factor significantly influences operational efficiency, cost management, productivity, and overall competitiveness of the business. The key roles and benefits associated with being close to a suitable labour source can be discussed as follows:

Access to Skilled Workforce

- Skill Availability: Locating facilities in areas with a high concentration of skilled labour ensures access to employees with the necessary qualifications, experience, and expertise required for the job.
- Training and Development: Proximity to educational institutions and training centres can facilitate continuous employee development and skill enhancement, contributing to higher productivity and innovation.

Cost Efficiency

- Labor Costs: Choosing a location with favourable wage rates can significantly reduce labour costs, which is a major component of operational expenses.
- Lower Recruitment Costs: Proximity to a dense labour market can reduce recruitment costs and time, as there is a larger pool of potential employees to choose from.

Operational Efficiency

- Reduced Absenteeism and Turnover: Locating facilities near where employees live can reduce commuting times and costs, leading to lower absenteeism and higher employee retention.
- Work-Life Balance: Proximity to labour sources can improve employees' work-life balance, enhancing job satisfaction and overall morale, which positively impacts productivity.

Flexibility and Scalability

- Easier Hiring: A nearby labour pool allows businesses to quickly scale up or down their workforce in response to changing demands, providing operational flexibility.
- Temporary and Seasonal Labor: In regions with a readily available labour force, businesses can easily hire temporary or seasonal workers to manage peak periods without long-term commitments.

Competitive Advantage

- Speed to Market: Proximity to a skilled labour force enables faster ramp-up of operations, reducing the time needed to achieve full production capacity and speed to market.
- Innovation and Quality: Access to talented and innovative employees can drive improvements in product quality, processes, and services, providing a competitive edge.

Community and Economic Impact

- Local Economic Development: By locating near labour sources, businesses contribute to local economic development through job creation and increased economic activity.
- Positive Community Relations: Establishing facilities in areas with high unemployment or underemployment can foster positive relationships with the community, enhancing the company's reputation and social responsibility profile.

Risk Management

- Labor Market Stability: Proximity to stable and diverse labour markets reduces the risk of labour shortages and ensures a continuous supply of workers.
- Union Relations: Understanding the local labour environment, including union presence and dynamics, helps in managing labour relations more effectively.

Sustainability and Environmental Impact

- Reduced Commuting Impact: Locating facilities near the labour force reduces commuting distances, lowering the environmental impact associated with employee travel and contributing to sustainability goals.
- Local Sourcing: Encouraging local employment can align with broader sustainability and corporate social responsibility initiatives.

Proximity to the source of labour plays a vital role in the location decision-making process, impacting access to skilled workers, cost efficiency, operational productivity, flexibility, and competitive advantage. By strategically positioning facilities near a

suitable labour force, businesses can enhance their operational performance, reduce costs, and contribute positively to local economies and communities. This approach not only addresses immediate labour needs but also supports long-term strategic objectives and sustainable growth.

3.4 Community considerations

Community considerations encompass a range of factors related to the social, economic, and cultural environment of a potential location. These considerations play a critical role in determining the optimal site for business operations, impacting the company's relationship with the local community, regulatory compliance, employee satisfaction, and overall sustainability. Community considerations are a critical factor in the location decision-making process, encompassing a wide range of social, economic, cultural, and environmental aspects. By carefully evaluating these factors, businesses can ensure they choose locations that not only meet operational and strategic needs but also support positive relationships with the local community, regulatory compliance, employee satisfaction, and sustainability goals. This comprehensive approach contributes to the long-term success and resilience of the business in its chosen location.

Understanding the demographic profile of the community helps businesses gauge the availability of a skilled and qualified workforce. Proximity to educational institutions and vocational training centres can enhance the quality and readiness of the local labour pool. Each community has its own set of regulations and compliance requirements related to zoning, environmental protection, labour laws, and business operations. Navigating the local regulatory landscape efficiently can expedite the establishment and expansion of facilities. Many communities offer financial incentives such as tax breaks, grants, and subsidies to attract businesses and stimulate local economic growth. Participation in local economic development programs can provide additional support and resources for new businesses. The quality and affordability of housing, along with access to amenities such as healthcare, education, recreation, and retail, influence employee satisfaction and retention. Community safety and low crime rates also contribute to the well-being of employees and their families.

3.5 Site considerations

Site considerations refer to the specific characteristics and attributes of a particular piece of land or location where a facility or business operation is planned. These considerations are crucial in determining the suitability, feasibility, and long-term success of the site for operational needs.

The size and shape of the land must accommodate current and future operational requirements, including buildings, parking, and potential expansions. The physical landscape, including elevation, slope, and natural features, affects construction costs, drainage, and overall site usability. Whereas, the soil quality and geological conditions influence foundation stability, construction methods, and costs. Proximity to major roads, highways, railways, ports, and airports ensures efficient logistics and transportation of goods and materials.

Reliable access to essential utilities such as electricity, water, gas, and sewage systems is critical for uninterrupted operations. High-quality telecommunications and internet connectivity are also necessary for modern business operations and communications. The site should be compatible with surrounding land uses to avoid conflicts and ensure harmonious integration with the community. There are several other site-specific factors such as legal and regulatory compliance, proximity to key resources, future growth and scalability, and community impact that must be given serious attention for efficient business operations.

4.0 Effects of globalisation on location decisions

Globalisation has profoundly impacted the way businesses make facility location decisions. It has introduced both opportunities and challenges that influence how companies choose locations for their manufacturing plants, distribution centres, service hubs, and offices. Globalisation has transformed facility location decisions by broadening the scope of factors businesses must consider. Companies now evaluate a complex mix of cost efficiencies, market access, supply chain optimisation, technological advancements, regulatory environments, political stability, cultural

compatibility, sustainability, and infrastructure when choosing locations for their facilities. The ability to strategically navigate these factors in a global context is crucial for achieving operational success and competitive advantage in today's interconnected world.

Some of the key effects of globalisation on facility location decisions can be discussed:

Access to Global Markets

- Market Expansion: Globalisation enables businesses to access new markets, increasing their customer base and revenue potential. Companies often choose locations that provide strategic access to emerging and established markets.
- Local Presence: Establishing facilities in key international markets can enhance brand visibility, customer relationships, and market penetration.

Cost Considerations

- Labor Costs: Globalisation allows companies to take advantage of lower labour costs in different regions. Many businesses relocate facilities to countries with competitive wage rates to reduce operational costs.
- Resource Costs: Proximity to raw materials and suppliers in different parts of the world can reduce costs associated with transportation and procurement.

Supply Chain Efficiency

- Optimised Logistics: Globalization enables the optimization of supply chains by strategically placing facilities to minimize transportation costs, reduce lead times, and improve service levels.
- Global Sourcing: Companies can source materials and components from the most cost-effective locations, improving overall supply chain efficiency and competitiveness.

Technological Advancements

- Digital Infrastructure: Advances in technology and global communications facilitate remote management and coordination of facilities, making it easier to operate across multiple countries.

- Automation and Innovation: Access to advanced manufacturing technologies and innovation hubs can influence location decisions, as companies seek to stay competitive and leverage new technologies.

Regulatory Environment

- Trade Agreements: Free trade agreements and regional economic blocs (such as the European Union, NAFTA, ASEAN) influence location decisions by reducing tariffs and trade barriers, making it easier to do business across borders.
- Regulatory Compliance: Companies must consider the regulatory environment in different countries, including labour laws, environmental regulations, and tax policies. Favourable regulatory conditions can attract business investment.

Political and Economic Stability

- Risk Management: Political and economic stability is a critical factor in location decisions. Companies often prefer locations with stable governments, predictable economic policies, and low risks of political unrest or economic instability.
- Diversification: To mitigate risks, businesses may diversify their locations across multiple countries and regions, ensuring continuity in operations even if one location faces political or economic challenges.

Cultural and Social Factors

- Cultural Compatibility: Understanding local cultures, languages, and business practices is essential for successful operations. Companies may choose locations where cultural and social norms align with their corporate values and operational practices.
- Community Relations: Building positive relationships with local communities can enhance a company's reputation and facilitate smoother operations.

Environmental and Sustainability Considerations

- Sustainable Practices: Globalization encourages companies to adopt sustainable practices by locating facilities in regions with stringent environmental standards or abundant renewable resources.
- Environmental Impact: Companies must consider the environmental impact of their location decisions, including carbon footprint, waste management, and resource utilization, to meet global sustainability goals.

Infrastructure and Connectivity

- Transportation Networks: Access to robust transportation infrastructure (ports, airports, highways, railways) is critical for efficient logistics and distribution.
- Digital Connectivity: High-quality digital infrastructure and telecommunications are essential for managing global operations, ensuring seamless communication and data exchange.

All these aspects of globalisation have immense impact on the usual operations of a business unit. The factors become even more significant when the businesses go overseas as multinational corporations.

5.0 Facility location decision-making

Facility location decision-making is the process of selecting a geographic site for a company's operations, such as manufacturing plants, distribution centres, retail stores, or service centres. This strategic decision has long-term implications for a business's operational efficiency, cost structure, customer service, and overall competitiveness. Facility location decision-making is a complex and multifaceted process that requires careful consideration of various strategic, operational, financial, and environmental factors. By systematically evaluating these elements, businesses can choose locations that optimise their operations, reduce costs, and support long-term growth and success.

5.1 Factor rating method

It is the most commonly employed analytical technique. The technique is widely popular because it allows for the inclusion of a diverse range of factors in the study. It is beneficial for the placement of services and industries. In this approach for combining quantitative and qualitative elements, weights are assigned to factors based on their relative relevance. A weightage score is then computed for each site using a preference matrix. The site with the highest weighted score is chosen as the optimal selection.

Steps of factor rating method

i. List relevant factors.
ii. Assign importance weight to each factor.
iii. Develop scale for each factor (0-1, etc.)
iv. Score each location using factor scale.
v. Multiply scores by weights for each factor & total.
vi. Select location with maximum total score.

Illustration:

Key Success Factor	Weight	Scores (out of 100) France	Denmark	Weighted Scores France	Denmark
Labor availability and attitude	.25	70	60	(.25)(70) = 17.5	(.25)(60) = 15.0
People-to-car ratio	.05	50	60	(.05)(50) = 2.5	(.05)(60) = 3.0
Per capita income	.10	85	80	(.10)(85) = 8.5	(.10)(80) = 8.0
Tax structure	.39	75	70	(.39)(75) = 29.3	(.39)(70) = 27.3
Education and health	.21	60	70	(.21)(60) = 12.6	(.21)(70) = 14.7
Totals	1.00			70.4	68.0

After evaluating the firm's needs, the managers have narrowed the list of Important Selection Criteria down into major factors. Then weights reflecting the relative importance of each factor have been assigned. Based on these criteria, the alternative sites were scored between 0 and 100 points. Now each score is multiplied by its corresponding factor weight. The weighted scores are calculated as:

(Site Score) × (Factor Weight)

From these results, the largest total weight is for site France. It appears to be the best location.

5.2 Centre of gravity method

The Centre of Gravity Method is a mathematical technique used for finding the location of a distribution centre that will minimise distribution costs. The method considers the location of markets, the volume of goods shipped to those markets, and shipping costs in finding the best location for a distribution centre.

The first step in the centre of gravity method is to place the locations on a coordinate system. The origin of the coordinate system and the scale used are arbitrary, just as long as the relative distances are correctly represented. This can be done easily by placing a grid over an ordinary map.

The centre of gravity is determined using the following equations:

$$x - coordinate\ of\ the\ centre\ of\ gravity = \sum_i d_{ix}Q_i / \sum_I Q_i$$

$$y - coordinate\ of\ the\ centre\ of\ gravity = \sum_i d_{iy}Q_i / \sum_I Q_i$$

where,

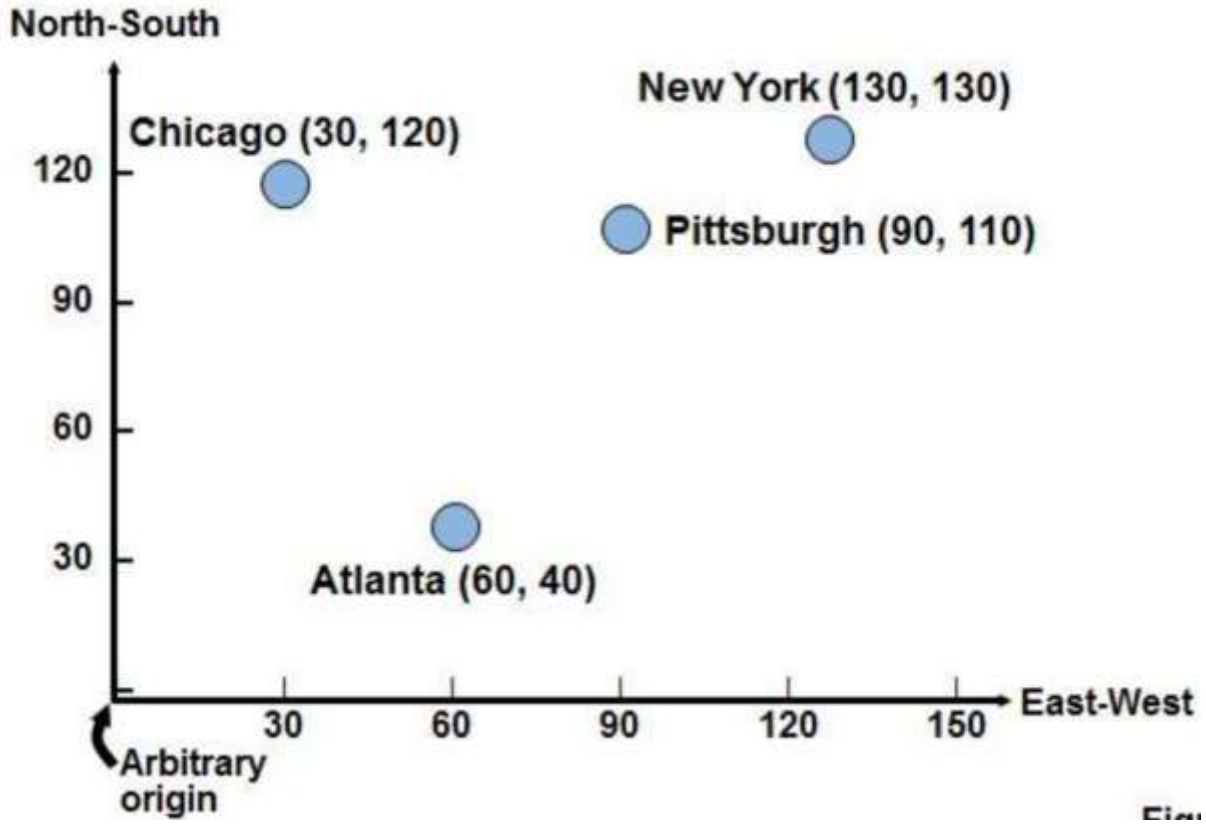
d_{ix} = x-coordinate of location i

d_{iy} = y-coordinate of location i

Q_i = quantity of goods moved to or from location i

Since the number of containers shipped each month affects costs, distance alone should not be the principal criterion. The centre of gravity method assumes that cost is directly proportional to both distance and volume shipped. The ideal location is that which minimises the weighted distance between the warehouse and its retail outlets, where the distance is weighted by the number of containers shipped.

Illustration



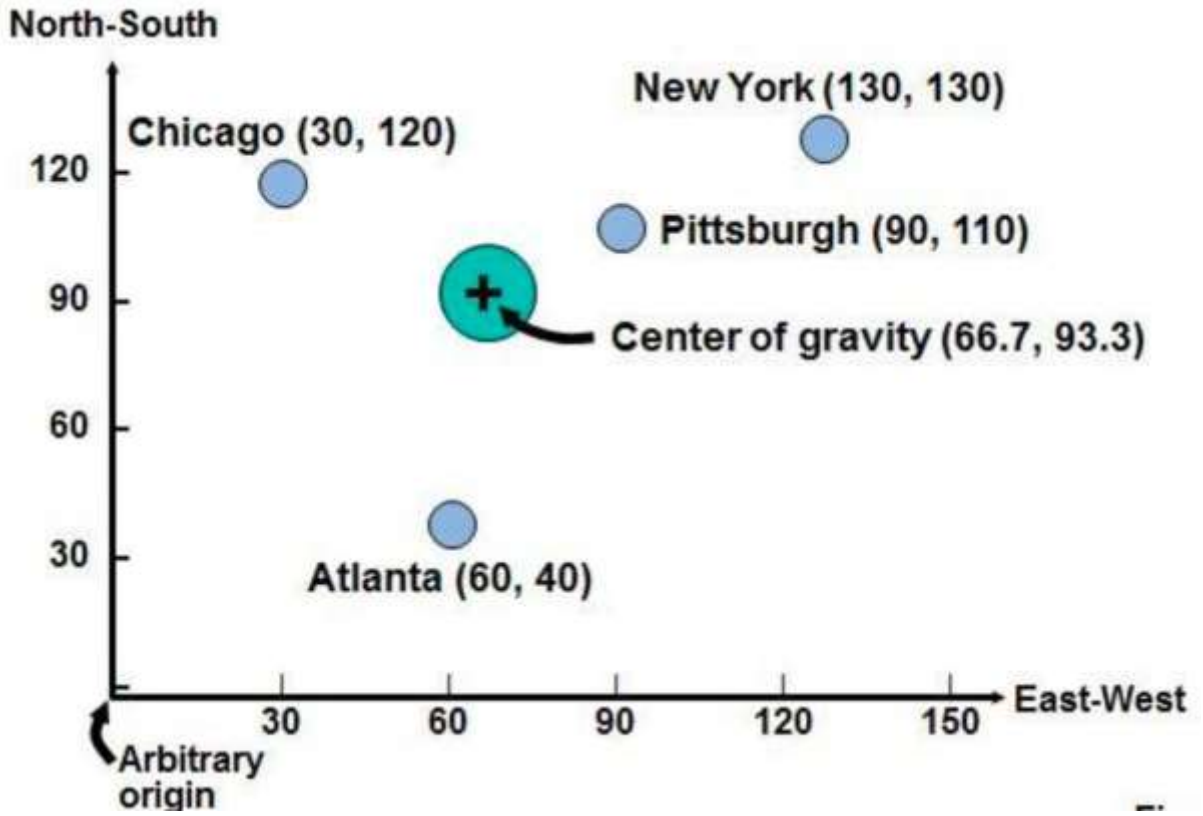
Store Location	Number of Containers Shipped per Month
Chicago (30, 120)	2,000
Pittsburgh (90, 110)	1,000
New York (130, 130)	1,000
Atlanta (60, 40)	2,000

$$x\text{-coordinate} = \frac{(30)(2000) + (90)(1000) + (130)(1000) + (60)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 66.7$$

$$y\text{-coordinate} = \frac{(120)(2000) + (110)(1000) + (130)(1000) + (40)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 93.3$$



Result

The firm will be located at:

- x-coordinate 66.7
- y-coordinate 93.3

5.3 Load-distance method

The load–distance model is a method used to assess several site options by considering the distance between them. The distance to be measured may refer to the proximity to markets, suppliers, or other essential resources, as well as the proximity to any other significant facility. The goal of the model is to choose a location that minimises the overall quantity of loads transported, considering the distance travelled. A load refers to the amount of work or weight that is placed on a structure, system, or device. It can also refer to the electrical power consumed by a device, or the data transferred over a network. A load refers to the commodities that are transported into or out of a facility, or the number of times goods are transferred between different facilities.

For instance, when 200 units of Kellogg's cereal are transported from the nearby storage facility to a grocery store, that is the shipment between the warehouse and the grocery store. The concept is to minimise the distance between facilities that have a significant workload between them. The comparison of relative locations involves the calculation of the load-distance, or ld, score for each place. The ld score for a specific location is calculated by multiplying the load (represented by l) for each place by the distance travelled (represented by d), and then adding together the results for all locations. This score serves as a proxy indicator for the transportation of commodities, the management of materials, or even the exchange of information. Our objective is to minimise the ld score by decreasing the distance that the heavy loads need to travel.

The load-distance model

ld score for a location = $\sum l_{ij}d_{ij}$

where l_{ij} = load between locations i and j

d_{ij} = distance between locations i and j

Illustration

Matrix Manufacturing Corporation is considering where to locate its warehouse to service its four stores located in four Ohio cities: Cleveland, Columbus, Cincinnati, and Dayton. Two possible sites for the warehouse are being considered. One is in Mansfield, Ohio, and the other is in Springfield, Ohio. Use the load–distance model to select the best location for the warehouse.

Solution:

STEP 1 Identify Distances. The distances between the locations can be seen in figure below shows a map of the cities with grid coordinates. The coordinates allow us to compute the distances between the cities. To compute the specific distances, we use the rectilinear distance measure.

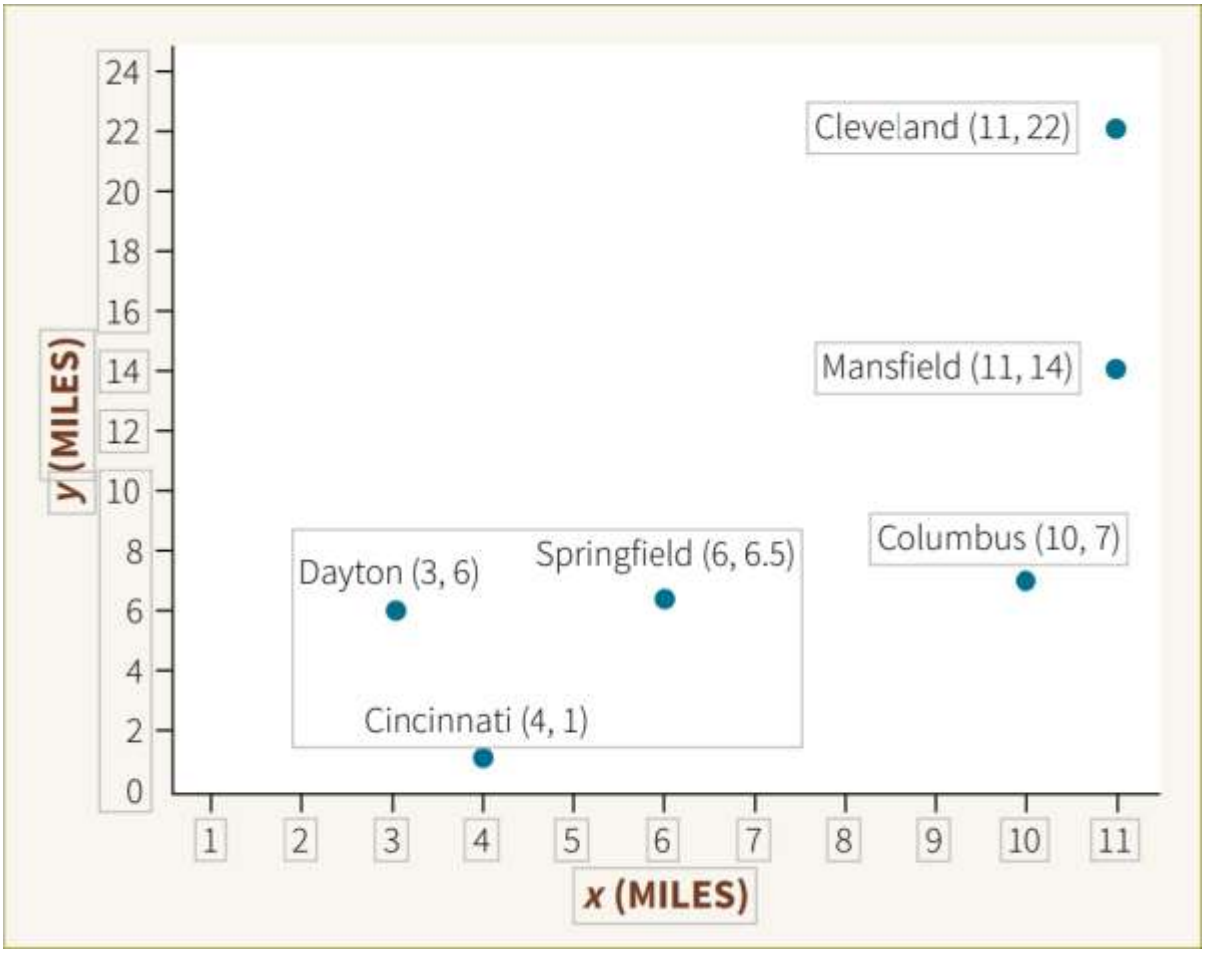


Figure 2. Location map for Matrix Manufacturing.

From Figure 2 we can compute the distances between the four cities and the Springfield site as follows:

City	Distance to Springfield
Cleveland	$\|11 - 6\| + \|22 - 6.5\| = 20.5$
Columbus	$\|10 - 6\| + \|7 - 6.5\| = 4.5$
Cincinnati	$\|4 - 6\| + \|1 - 6.5\| = 7.5$
Dayton	$\|3 - 6\| + \|6 - 6.5\| = 3.5$

Similarly, we can compute the distances between the four cities and the Mansfield site as follows:

City	Distance to Mansfield
Cleveland	$\|11 - 11\| + \|22 - 14\| = 8$
Columbus	$\|10 - 11\| + \|7 - 14\| = 8$
Cincinnati	$\|4 - 11\| + \|1 - 14\| = 20$
Dayton	$\|3 - 11\| + \|6 - 14\| = 16$

STEP 2 Identify Loads. The next step is to identify the loads between the four cities and the warehouse. Remember that these loads will be the same regardless of where the warehouse is

located. For this reason, we want to locate the warehouse at a place that will minimise the amount of distance large loads will have to travel.

City	Load between city and warehouse
Cleveland	15
Columbus	10
Cincinnati	12
Dayton	4

STEP 3 Calculate the Load–Distance Score for Each Location. The final step is to calculate the load–distance score for each location. The computation for Springfield is shown in Table below.

City	Load (l_{ij})	Distance (D_{ij})	$l_{ij} D_{ij}$
Cleveland	15	20.5	307.5
Columbus	10	4.5	45
Cincinnati	12	7.5	90
Dayton	4	3.5	14
Total	**Load-Distance Score**		**456.5**

The load–distance score computed for Springfield does not tell us very much by itself. This number is useful only when comparing relative locations—that is, when we compare it to another load–distance score. The load–distance score for Mansfield is shown in Table below:

City	Load (l_{ij})	Distance (D_{ij})	$l_{ij} D_{ij}$
Cleveland	15	8	120
Columbus	10	8	80
Cincinnati	12	20	240
Dayton	4	16	64
Total	**Load-Distance Score**		**504**

The load–distance score for Mansfield is higher than the score for Springfield. Therefore, Matrix Manufacturing should locate its warehouse in Springfield. Note in the computation for the load–distance score for Mansfield that the load between the city and the warehouse did not change. What changed was the distance. Through the load–distance model we select a location that will minimise the distance large loads travel.

6.0 Let us sum up

Facility location is a critical aspect of a business, affecting revenue, costs, and service levels. It is a strategic, long-term, and non-repetitive decision that can lead to persistent operational problems and financial ruin. Location analysis is a process that aims to determine the most advantageous position for an organization's building or factory. Seven crucial factors make location decisions important for modern-day businesses: acquiring and retaining skilled individuals, expenses related to property ownership, groupings, government oversight and taxation, expansion or a shift in corporate strategy, technology, or leadership, urban vibrancy, and ease of access.

Location considerations involve determining the company's specific needs, engaging with relevant parties, evaluating possible sites, performing on-site visits, and negotiating the most favourable agreement. Controllable factors involve internal considerations and strategic decisions, while uncontrollable factors are external conditions and circumstances. Proximity to the source of supply is a crucial factor in determining the optimal location of a facility, as it impacts operational efficiency, cost management, supply chain reliability, and overall competitiveness. Key benefits include cost reduction, improved reliability, quality control, flexibility, sustainability, and local economy support.

Community and site considerations are crucial for businesses when choosing a location for their operations. Community factors include the social, economic, and cultural environment, while site factors include the size, shape, physical landscape, soil quality, and proximity to major roads, highways, railways, ports, and airports. Legal and regulatory compliance, proximity to key resources, future growth and scalability, and community impact are also important. Globalisation has significantly influenced facility location decisions, introducing opportunities and challenges. Key effects of globalisation include market expansion, local presence, cost considerations, supply chain efficiency, digital infrastructure, automation, regulatory environment, political stability, cultural compatibility, community relations, environmental and sustainability considerations, and infrastructure.

Facility location decision-making is a complex process that requires careful consideration of strategic, operational, financial, and environmental factors. The Centre of Gravity Method and Load-Distance Model are essential tools for determining the optimal location for a distribution centre. By considering factors such as market proximity, volume of goods shipped, and shipping costs, companies can find the most cost-effective and efficient distribution centre for their operations.

7.0 Keywords

Community	A group of people living in the same place or having a particular characteristic in common.
Competitive Advantage	A condition or circumstance that puts a company in a favourable or superior business position.
Facility location	A facility is a physical location or site where business operations take place. This encompasses a wide range of structures and places essential for the production, storage, and distribution of goods and services.
Market	The place where two or more parties interact to exchange goods or services is called the market.

8.0 Check your learning

i. What are the primary factors that influence facility location decisions?

ii. How do labour costs and availability impact the choice of facility location?

iii. What are the advantages and disadvantages of locating a facility near the market/customer versus near the supply?

iv. What are some common methods used to evaluate potential facility locations?

v. Explain how globalization has changed the approach to facility location decisions.

9.0 Suggested readings

R. Dan Reid and Nada R. Sanders — *Operations Management: An Integrated Approach*. 8th Edition. Wiley, India.

Jay Heizer and Barry Render: — *Principles of Operations Management: Sustainability and Supply Chain Management*. 12th Edition. Pearson, India.

S N Chary: — *Production and Operations Management*. 6th Edition. McGraw Hill, India.

UNIT – III

Capacity Analysis and Facility Layout Planning

Structure

1.0 Objectives

2.0 Introduction to capacity analysis

- 2.1 Definition and types of capacity
- 2.2 Measuring capacity
- 2.3 Capacity planning
- 2.4 Importance of capacity planning

3.0 Plant layout planning

- 3.1 What is plant layout?
- 3.2 Objectives of a good plant layout
- 3.3 Types of plant layout

4.0 Let us sum up

5.0 Keywords

6.0 Check your learning

7.0 Suggested readings

1.0 Objectives

After completing this lesson, the students will be able to:

- Explain the meaning of capacity.
- Identify the system of capacity measurement and its effectiveness Meaning of capacity planning.
- Identify the capacity planning activities.
- Discuss the importance of capacity planning.

2.0 Introduction to capacity analysis

Capacity analysis or planning is crucial in operations management. Capacity refers to the speed at which a facility can produce goods or services. Capacity decisions require meticulous and diligent consideration by all involved, as nearly all aspects of operations are interconnected with capacity. It is crucial because it establishes the most efficient level of production and ensures a continuous manufacturing process. Entrepreneurs and managers must handle capacity decisions for several additional significant causes. This unit has intentionally attempted to introduce significant concepts related to these matters. This section covers topics such as capacity, capacity planning, and the significance of capacity decision-making. It also includes discussions on capacity requirements, factors that determine effective capacity, and capacity strategies.

The most crucial determination of every organisation pertains to the products and services it provides. These decisions are determined by factors like as capacity, process, facilities, location, and other relevant considerations, all of which are influenced by product and service choices. Therefore, choosing to manufacture a high-quality product will require specific types of processing equipment and specialised labour skills, as well as a particular arrangement of facilities. The size and kind of the structure, as well as the location of the plant, will be affected by it. Capacity selections can vary in frequency, with some being made occasionally and others being made routinely as part of a continuing process. The frequency is primarily influenced by factors such as demand stability, technological change rate in equipment, product design change rate, and competitive forces.

2.1 Definition and types of capacity

What is the definition of capacity?

The maximum load that an operational unit can handle is referred to as its capacity. Capacity refers to the speed at which a facility can produce goods or services. The operating unit can encompass several entities such as a plant, department, machine, store, or worker. The load can be defined in relation to either inputs or outputs. To comprehend these concepts, please examine the following illustrations.

- Capacity in respect of capability: Airlines quantify their capacity by calculating the number of Available Seat Miles (ASMs) they offer throughout a year. Hospitals may quantify their capacity by the number of beds they have available. Nevertheless, this assessment is flawed as it fails to consider the hospital's outpatient treatments.
- Capacity in respect of inputs: The machine has an input capacity of 120 pounds per hour, meaning it can process 120 pounds of raw materials in every working hour.
- Capacity in respect of outputs: A machine has a production rate of 20 units per hour, resulting in an output capacity of 20 units/hour.

The previously presented definition is a preliminary definition of capacity; while it serves its purpose, it can be further developed into three practical definitions:

- Design Capacity: The maximum output that can possibly be attained.
- Effective Capacity: The maximum possible output given a product mix, scheduling difficulties, machine maintenance, quality factors, and so on.
- Actual Output: The rate of output achieved. It cannot exceed effective capacity and is often less than effective capacity due to breakdowns, defective outputs, shortage of materials, and similar factors.

2.2 Measuring capacity

There is no one measure of capacity that will be suitable for every case. The measure of capacity should be customised to fit the specific situation. The table below presents a selection of frequently utilised capacity measures.

Table. Common measures of capacity

Business	Inputs	Outputs
Auto manufacturer	• Labor hours • Machine hours	Number of cars per shift
Steel Mill	• Furnace size	Tons of steel per day
Oil refinery	• Refinery size	Gallons of fuel per day
Farming	• Number of acres • Number of cows	Bushel of grain per acre per year, Gallons of milk per day
Restaurant	• Number of tables • Seating capacity	Number of meals served per day
Theatre	• Number of seats	Number of tickets sold per performance
Retail sales	• Square feet of floor space	Revenue generated per day

Metrics for Evaluating System Efficiency

The different metrics included in the table below are valuable for determining two key indicators of system performance: *Efficiency* and *Utilisation*.

Efficiency is defined as the ratio of the actual output to the effective capacity, expressed as (Actual output / Effective capacity). Utilisation, on the other hand, is the ratio of the actual output to the design capacity, expressed as Actual output / Design capacity). Managers often prioritise efficiency, yet this emphasis can be incorrect in many cases. This occurs when the actual capacity is significantly lower than the intended capacity. In such instances, the appearance of great efficiency may falsely suggest the optimal use of resources. Here is an example that demonstrates this point:

Example:

Design capacity = 50 trucks per day

Effective capacity = 40 trucks per day

Actual output = 36 units per day

Efficiency = Actual output / Effective capacity

= 36 units per day/ 40 units per day

= 90%

Utilisation = Actual output / Design capacity

= 36 units per day/ 50 units per day

= 72%

Thus, compared with the effective capacity of 40 units per day, 36 units per day (90%) looks pretty good. However, compared with design capacity of 50 units per day, 36 units per day (72%) is much less impressive although probably more meaningful.

Because effective capacity acts as a lid on the actual output, the real key to improving capacity utilisation is to increase the effective capacity. Now assume that Mr. Bharat wants to travel from his home in Kanpur to his sister's home in Tundla, 125 miles away. He could borrow his son's bicycle or his motorbike. Instead of using the bicycle and concerning himself with pedalling as efficiently as possible, he could make the trip in less time (same output in a shorter time) by using the motorbike. Hence, increasing utilisation depends on being able to increase effective capacity, and this requires knowledge of what is constraining effective capacity.

Check your progress – I

Why term efficiency and utilization are important to measure the capacity of any business-related issue? Choose any business issue of your choice and based on that justify your argument.

2.3 Capacity planning

Capacity Planning, also known as Aggregate Planning, refers to the process of consolidating and grouping all the capacity requirements for each time in the intermediate horizon. It involves selecting the most effective approach to meet the required capacity. The primary goals of capacity planning are to ensure feasibility, meaning that the internal requirements are within the capabilities of the operations system, and optimality, which involves determining the most cost-effective approach to meet the capacity needs.

Aggregate planning involves analysing the factors that can be utilised to modify the capacity in the medium-term timeframe. The primary variables that can be adjusted to modify capacity are the size of the workforce, the production rate in terms of hours worked per day or week (which may involve the use of overtime or idle time), and the utilisation of inventory to store capacity in one period for later use in meeting demand

(although this is typically not applicable to service industries). Occasionally, the practices of back-ordering and subcontracting are employed. The term "pure strategy" refers to the modification of a single variable to address a non-uniform demand within the planning horizon. On the other hand, when multiple variables are modified, it is referred to as a "mixed strategy".

The operational capability of a unit is a crucial piece of information for the purpose of planning. Managers can use it to measure the production capacity in terms of inputs and outputs, allowing them to make informed decisions and plans based on these quantities. The fundamental inquiries in capacity planning of any kind are:

- What type of capacity is required?
- What is the required amount?
- At what point is it necessary?

The question of the required capacity is directly related to the specific products and services that management plans to create or offer. Therefore, capacity planning is essentially determined by those decisions.

Activities related to capacity planning

Capacity planning is the initial stage in which an organisation determines the necessary resources and capabilities required to increase production of a new or existing product. After assessing capacity, if there is a requirement for additional or larger facilities, the tasks of determining facility site and process technology take place. If there is an excessive amount of capacity, it would be necessary to consider methods of decreasing capacity, such as temporarily shutting down, selling, or consolidating. This may include relocating, integrating technologies, or reorganising equipment and processes. Capacity planning often encompasses the subsequent activities:

- Evaluating current capabilities.
- Anticipating future capacity requirements.
- Exploring alternate methods for adjusting capacity.
- Assessing options for financial, economic, and technological capabilities.
- Choosing the most appropriate capacity option to fulfil the strategic mission.

a. Evaluating current capabilities and needs

Evaluating begins with quantification. There is no specific measurement technique tailored for such decisions; instead, a combination of many approaches is used as needed. There are two distinct methods for measuring the effectiveness of a system: efficiency and utilisation. Efficiency is defined as the proportion of real production achieved in relation to the effective capacity, while utilisation refers to the proportion of actual output achieved in relation to the design capacity.

b. Anticipating future capacity requirements

Capacity requirements can be assessed from two contrasting viewpoints - immediate and long-term capacity demands:

- Short-term requirements: Managers frequently utilise product demand projections to estimate the immediate workload that the facility has to manage. When managers look ahead up to 12 months, they predict the output needs for various products or services. They then assess the requirements in relation to the current capacity and identify when adjustments are needed.
- Long-term requirements: Forecasting long-term capacity requirements is challenging due to the uncertainty surrounding future demand and technologies. Predicting events or outcomes five or ten years in advance is a challenging and uncertain endeavour. Crucial inquiries revolve around the firm's future production of products and services, as the products that are currently in existence may become obsolete in the future. Long-term capacity requirements are contingent upon marketing objectives, product development, and the life cycle of products. Anticipating changes in process technology is also necessary. Although the items themselves may stay unaltered, the processes used to produce them can undergo significant changes. Capacity planning must include predictions of both technological advancements and product demand.

c. Identifying methods to alter capacity

Once the existing and future capacity requirements have been evaluated, it is necessary to identify different methods of adjusting capacity, whether in the short

term or the long term. Immediate reactions to capacity adjustment involve the Table.

Table. Temporary Capacity Changes

Type	Actions
Inventories	Stockpile of finished goods should be built during slack periods to meet later demand.
Backlogs	During peak demand periods, willing customers may be requested to wait some time before receiving their product. Their orders may be filed and be fulfilled after the peak demand period.
Employment levels	Additional employees be hired or be laid-off as demand for output increases or decreases.
Workforce utilisation	Employees may be asked to work overtime during peaks and can be allowed to work fewer hours during slack demand periods.
Employee training	Instead of having employees specialised in one task, each of them should be trained in several tasks. Then as skill requirement changes employees be rotated among different tasks. This is an alternative to hiring and layoffs for getting needed skills.
Process design	Job contents may be changed at each workstation to increase productivity. Work methods analysis and redesign of jobs are suggested there.
Subcontracting	During peak periods, temporarily another firm might be hired to make the product or some of its components.
Maintenance	Routine preventive maintenance programs on facilities and equipment be discontinued temporarily so that during peak periods the facility can be operated when it would otherwise be idle.

However, while evaluating the long-term effects of capacity modification management in organisations, it is crucial to not only focus on expanding their resource bases, but also to carefully analyse the most efficient methods of contracting it. The costs, benefits, and hazards of expansion present a compelling decision dilemma. Constructing the complete extension at present allows the company to circumvent elevated construction expenses, the perils of rapid inflation (which could lead to even higher future building costs), and the potential loss of future business due to insufficient capacity. However, there may also be drawbacks associated with this prospective option. Initially, the organisation may lack the necessary financial resources to make the required

investment. Furthermore, should the organisation choose to expand at this time, there is a possibility that it may discover in the future that its initial demand projections were inaccurate. If the actual demand turns out to be lower than anticipated, the organisation will have constructed more than necessary. Ultimately, the projected demand, even if it is correct, may not be fully realised until the conclusion of the five-year planning period. If this is the case, the organisation will have made an investment in a building that has more capacity than is now needed, and no profit will be generated from it for several years. By choosing to invest in this method, the corporation has missed out on the chance to earn returns from alternative investments.

Contraction and constant capacity: Capacity contraction typically entails the divestment of current facilities, equipment, and inventory, as well as the termination of staff. If there is a significant decrease in demand, we may progressively cease operations. Permanent capacity reduction or shutdown is only implemented as a final option. Efforts are being made to find other methods to preserve and utilise the current capacity, as a significant amount of work, capital, and human expertise invested in developing these technologies would otherwise be squandered. Frequently, these technological and skill foundations can be used to different products or services. As a product enters the decline phase of its life cycle, it can be substituted with alternative products without the need to increase production capacity (refer to the table below). The deliberate alternation between new and old products is not coincidental. The staff responsible for product research & development and market research engages in strategic planning to assess how the current capacity may be utilised and modified to meet future demand.

Check your progress – II

From the point of current market trends of the Indian IT sector, do you think they should think about the modification of their capacity of production? Why or why not? Discuss.

d. Evaluating financial, economic, and technological capacity alternatives

For evaluation purposes of capacity planning activities different modelling alternatives are available. These are:

- Present Value Analysis is helpful whenever the time value of capital investments, and fund flows are considered.
- Aggregate Planning Models are useful for examining how best to use existing capacity in the short term.
- Breakeven Analysis can identify the minimum breakeven volumes when comparing projected costs and revenues. In the short–term capacity utilization: linear programming and computer simulations are very useful.
- Decision Tree Analysis is useful to the long-term capacity problems of facility expansion.

e. Selecting a capacity alternative most suited to achieving strategic mission

As previously stated, the three types of modelling - decision tree analysis, linear programming, and computer simulation - must be employed strategically to discover the most appropriate capacity alternatives. The optimal selection among them is contingent upon the nature of the capacity issue. Additionally, other models can also be advantageous. Effective utilisation of capacity management models necessitates a comprehensive comprehension of the organisational context, encompassing the present demands on current operations as well as a foresight into future business situations.

2.4 Importance of capacity planning

Capacity decisions are crucial design decisions that managers must make due to various causes. The following items are included:

- The significance of capacity decisions lies in their potential to affect the organization's ability to meet future demand for products and services. Capacity effectively determines the maximum rate of output achievable.
- The significance of capacity arises from the correlation between capacity and operational expenses. Optimally, the capacity and demand requirements will be aligned, resulting in a reduction of operational expenses.
- The significance of capacity decisions also resides in the initial cost incurred, in which capacity typically plays a crucial role. Generally, the larger the capacity of a productive unit, the higher its costs. This does not necessarily indicate a direct

correlation; larger units often have a lower proportional cost compared to smaller units.

- The significance of capacity decisions arises from the frequently necessary long-term allocation of resources and the fact that once they are put into effect, it may be challenging or impossible to alter such decisions without paying substantial expenses.

Managers must make judgements on the capacity of their operating units, which is crucial due to various reasons:

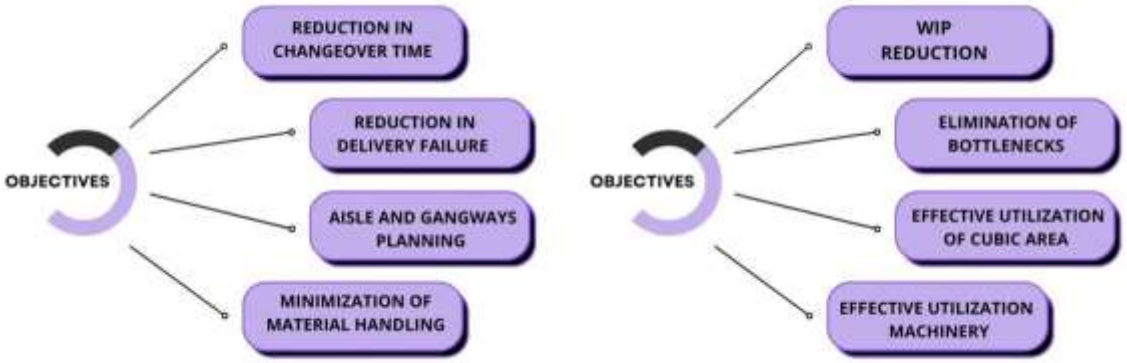
- In the current competitive landscape, every for-profit organisation aims to retain its current customer base while also acquiring new customers. If there are deficiencies in the capacity decision, the sales team may strongly desire to accept a specific order, while the operations team may face difficulties in fulfilling the demand. Therefore, failing to meet consumers' demands can result in losing them. Consider a scenario where you take your automobile to a car service centre and are informed that, because of constraints in equipment and personnel, it will take about one week for your car to be serviced.
- Capacity planning encompasses several cost factors. One category of such expenses is operational costs. Assuming that the capacity of the ABC footwear factory is 100,000 units per year and the demand for their product is 50,000 units for the same period, it can be inferred that the operational cost of the factory will be greater compared to a scenario where the capacity and demand are equal. Another category of expenses is the cost associated with constructing the operational facility. Once the cost is determined and the unit is constructed, there is no possibility of changing it, as it becomes a fixed cost. If management discovers that the capacity of the unit is either lower or larger than what is needed, any modifications are likely to result in significant expenses.

3.0 Plant layout planning

3.1 What is plant layout?

Plant layout refers to the systematic arrangement of all components of the production process to maximise space efficiency, reduce manufacturing costs, and ensure a smooth and uninterrupted production cycle. This configuration encompasses the necessary area for the transportation of materials, storage, auxiliary labour, and all other supplementary activities or services. Plant layout refers to a strategic plan that optimises the use of resources in the production of goods. It involves organising machinery, materials, workers, storage space, and other supporting services in the most efficient and cost-effective way possible, given the available floor space. A plant layout is a comprehensive plan that optimises the utilisation of machinery, workforce, and materials to coordinate all activities within a factory, with the goal of enhancing overall productivity. The complexity of plant layout arises from the integration of various disciplines, including engineering, architecture, economics, and business management.

3.2 Objectives of a good plant layout



The following is a list of main objectives of a good plant layout:

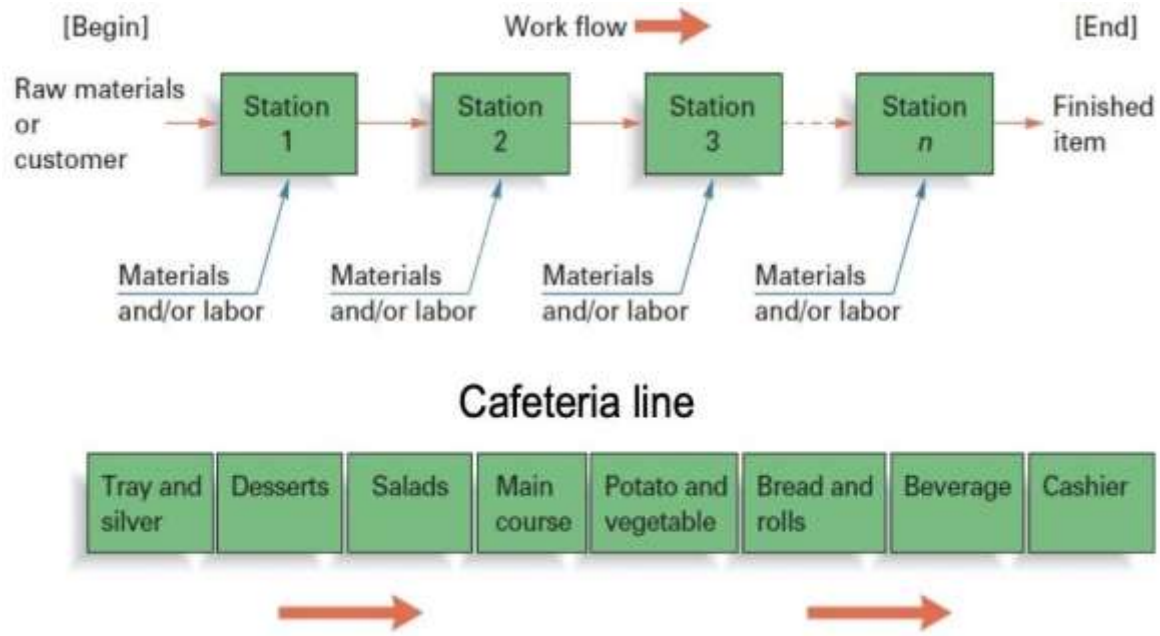
- Effective utilisation of installed machinery and workforce.
- Minimisation of material handling.
- Elimination of bottlenecks through the line balancing.
- Elimination of physical efforts with low-cost automation.
- High turnover with reduction in delivery failure.
- WIP (work-in-progress) reduction between processes.

- Natural light, ventilation, control of noise and vibrations for better ergonomics and energy cost reduction.
- Sufficient workspace for a better work environment.
- Aisle and gangways planning for better accessibility and monitoring.
- Store designed based on better flow, accessibility, capacity of storage and traceability of materials.
- Dust control based on different types of clean rooms/ ISO norms.
- Distance travel reduction of material and manpower.
- Reduction in labour cost.
- Reduction in manufacturing time.
- Increased flexibility.
- Scope for future expansion of operations.

3.3 Types of plant layout?

Product or line layout

Product or Line Layout refers to the arrangement of machines in a sequential line based on the order of operations for the products. In this configuration, each subsequent machine or section is organised to carry out the subsequent operation accomplished by its preceding machine or section. In other words, the raw material begins at one end of the production lines and progresses from one machine to the next in a sequential path, with storage and material handling, and with minimal labour in process. This arrangement is ideal for large-scale production and for items with consistent demand. This configuration is also suitable for the continuous production system, particularly when the products consist of small components that are highly standardised and can be easily interchanged.



The grouping of machines should be done keeping in mind the following general principles:

a) All the machine tools or other items of equipment must be placed at the point demanded by the sequence of operations.

b) There should no points where one line crossed another line.

c) Materials may be fed where they are required for assembly but not necessarily at one point.

d) All the operations including assembly, testing, packing, must be included in the line.

Advantages	Disadvantages
Low material handling cost	No flexibility
Less WIP (Work in progress)	Breakdown of any machine in the line may shut down the whole production line
Better utilisation of Machine and Manpower	Difficulty in increase the production beyond the capacities of the production lines
Lesser time in Production	If the output rate of one machine is slower than the other machine, overall production rate decreases
Less space requirements	High initial capital investment in special purpose machine
Minimum possible cost of manufacturing	Heavy overhead charges

Therefore, the manufacturing units involving continuous manufacturing process, producing few standardised products continuously on the firm's own specifications and in anticipation of sales would prefer product layout, e.g., chemicals, sugar, paper, rubber, refineries, cement, automobiles, food processing, and electronics, etc.

Process layout

This plan involves the grouping of machines of the same type in a single location. For example, drilling machines are organised in the drilling department, whereas casting machines are gathered in the casting department. Consequently, the equipment is installed in the factories that adhere to the process pattern. Therefore, these layouts generally consist of a drilling department, milling department, welding department, heating department, and painting department, among others. The process or functional layout has been adopted from ancient times. It originated from the manual way of production. The task must be distributed among each department in a manner that minimises the selection of machines for multiple jobs, with an emphasis on utilising general-purpose machines. The work is assigned to the machines based on loading schedules to ensure that each unit is fully utilised. The graphic below illustrates the process layout.

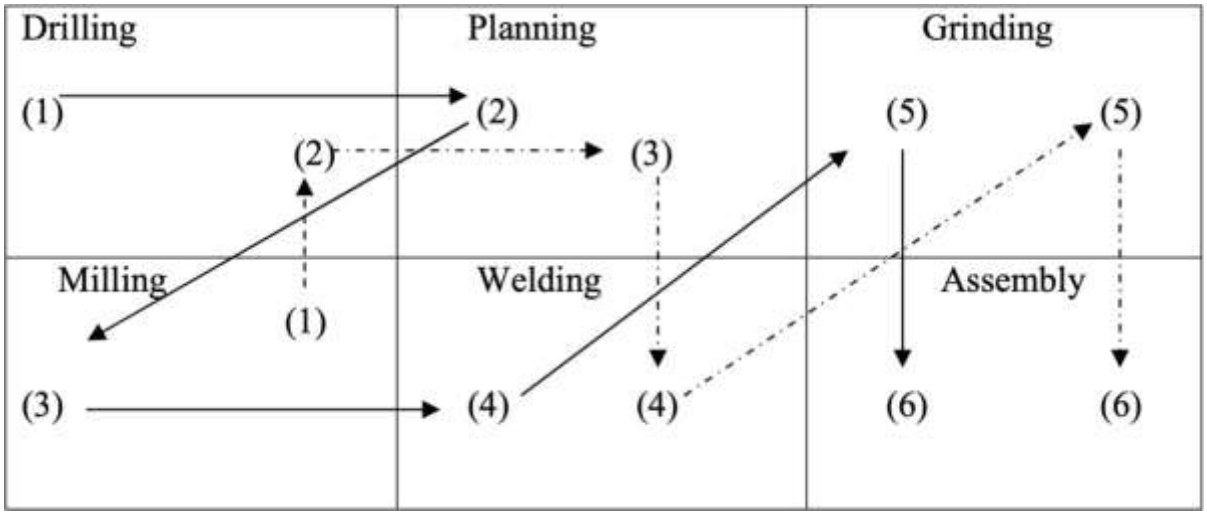


Figure. Process layout showing movement of two products

Product A ——————→

Product B – · – · – · – · –→

The grouping of machines according to the process must be done keeping in mind the following principles.

a) The distance between departments should be as short as possible for avoiding long distance movement of materials.
b) The departments should be in sequence of operations.
c) The arrangement should be convenient for inspection and supervision.

Advantages:

Process layout provides the following benefits

a) Lower initial capital investment in machines and equipment. There is high degree of machine utilisation, as a machine is not blocked for a single product.
b) The overhead costs are relatively low.
c) Change in output design and volume can be more easily adapted to the output of variety of products.
d) Breakdown of one machine does not result in complete work stoppage.
e) Supervision can be more effective and specialised.
f) There is a greater flexibility of scope for expansion.

Disadvantages:

Product layout suffers from following drawbacks:

a. Material handling costs are high due to backtracking.
b. More skilled labour is required resulting in higher cost.
c. Time gap or lag in production is higher.
d. Work in progress inventory is high needing greater storage space.
e. More frequent inspection is needed which results in costly supervision.

Suitability:

Process layout is adopted when:

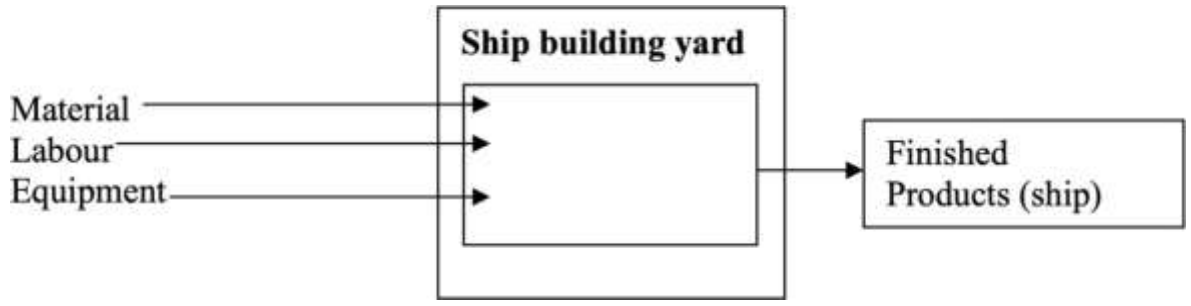
a. Products are not standardised.
b. Quantity produced is small.
c. There are frequent changes in design and style of product.
d. Job shop type of work is done.

e. Machines are very expensive.

Thus, process layout or functional layout is suitable for job order production involving non-repetitive processes and customer specifications and non- standardised products, e.g., tailoring, light and heavy engineering products, made to order furniture industries, jewellery.

Fixed Position or Location Layout

In this configuration, the primary commodity being manufactured is situated in a fixed position at a specific site. The equipment, labour, and components are relocated to that specific place. All facilities are procured and organised around a central work centre. This layout is not applicable for small-scale entrepreneurs. The image below illustrates a shipbuilding layout that is fixed in position.



Advantages:

Fixed position layout provides the following benefits:

a) It saves time and cost involved on the movement of work from one workstation to another.
b) The layout is flexible as change in job design and operation sequence can be easily incorporated.
c) It is more economical when several orders in different stages of progress are being executed simultaneously.
d) Adjustments can be made to meet shortage of materials or absence of workers by changing the sequence of operations.

Disadvantages:

Fixed position layout has the following drawbacks:

a. Production period being very long, capital investment is very heavy.

b. Very large space is required for storage of material and equipment near the product.

c. As several operations is often carried out simultaneously, there is possibility of confusion and conflicts among different workgroups.

Suitability:

The fixed position layout is followed in following conditions

1. Manufacture of bulky and heavy products such as locomotives, ships, boilers, generators, wagon building, aircraft manufacturing, etc.
2. Construction of building, flyovers, dams.
3. Hospital, the medicines, doctors and nurses are taken to the patient (product).

Combined layout

Some manufacturing units may necessitate the utilisation of all three processes, namely intermittent process (job shops), continuous process (mass production shops), and representative process combined process (miscellaneous shops). Within most industries, it is uncommon to find a sole reliance on a product layout, process layout, or permanent site layout. Therefore, in manufacturing companies where multiple goods are produced in large quantities without the possibility of continuous production, a combined layout is implemented. In practice, companies that involve the production of parts and assembly typically use a combination of the product and process architecture. Specifically, the fabrication process tends to employ the process plan, while the assembly sections often use the product layout. The soap manufacturing facility follows a product line method for arranging the machinery involved in soap production. However, supplementary services such as heating, glycerine manufacturing, power generation, and water treatment are organised based on their specific functions.

4.0 Let us sum up

Capacity planning is a crucial aspect of operations management focused on determining the production capacity needed by an organization to meet changing demands for its products. In business, capacity planning is like preparing for a party. You want to have enough food and drinks (resources) for your guests (demand) without having too much leftover or running out. The goal is to match a business's ability to produce (capacity) with what your customers need (demand). Managers should acknowledge the wider ramifications that capacity decisions have on the entire organisation.

Common tactics in capacity management include proactive capacity planning, where capacity is proactively raised to align with anticipated demand, and reactive capacity planning, where organisations wait for actual demand increases before extending their capacities. Another strategy is capacity tracking, when additional capacity is gradually added to meet increasing demand. The two primary functions of capacity planning are design capacity and effective capacity. Design capacity is the highest planned capacity or output rate, whereas effective capacity is the design capacity minus allowances for personnel and other factors. These two capacity functions can be employed to determine the efficiency and utilisation.

Plant layout refers to the arrangement of physical facilities such as machinery, equipment, and furniture within a manufacturing plant or service facility. It aims to ensure a smooth flow of work, materials, and information through the system. Plant layout is the organisation and positioning of machinery, workspaces, and service areas within a manufacturing facility. Plant layout refers to the process of establishing a strategic arrangement of buildings, equipment, and production procedures to facilitate efficient manufacturing. Product layout, process layout, combined layout, and fixed layout are the main types of product layouts that various industries use for their operations.

5.0 Keywords

Capacity Utilisation	The extent to which a firm or nation employs its installed productive capacity.
Bottleneck Analysis	The process step (station) in the flow diagram with the lowest capacity (the "weakest link"). Although the bottleneck is often the process step with the longest processing time, it is important to always look at the capacities for making a judgement.
Overcapacity	A situation where the firm's production capacities of goods and services exceed its demand in the market. This surplus can lead to various challenges for businesses and industries, impacting their financial performance. Overcapacity often results in increased competition among businesses, leading to price wars and reduced profit margins.
Plant layout	The optimum physical arrangement of the economic activity centres so that they are easily manageable. It aims at finding the quickest route for efficient material flow at minimum cost.
Ergonomics	The process of designing or arranging workplaces, products and systems so that they fit the people who use them.

6.0 Check your learning

i. Define the plant layout.

ii. What are the various factors influencing the layout of grocery store?

iii. Explain process layout? State its advantages and disadvantages in brief.

iv. Distinguish between product layout and process layout?

vi. Explain the suitability of fixed position layout

7.0 Suggested readings

R. Dan Reid and Nada R. Sanders — *Operations Management: An Integrated Approach*. 8th Edition. Wiley, India.

Muhlemann, Oakland, Lockyer, Sudhir, & Katyayani — *Production and Operations Management*. 6th Edition. Pearson, India.

S N Chary: — *Production and Operations Management*. 6th Edition. McGraw Hill, India.

UNIT – IV

Quality Management and Operations Scheduling

Structure

1.0 Objectives

2.0 Quality management

- 2.1 Quality definitions
- 2.2 Total quality management (TQM)
- 2.3 Just-in-time and lean management

3.0 Operations scheduling

- 3.1 Basic scheduling concepts
- 3.2 Developing a schedule of operations
- 3.3 Scheduling issues in a service organisation

4.0 Let us sum up

5.0 Keywords

6.0 Check your learning

7.0 Suggested readings

1.0 Objectives

The objective of operations management is to enhance value. A business can enhance value by increasing net profits, enhancing the client experience, or augmenting the product's quality. Quality is understood and defined in many ways in different contexts by different experts.

2.0 Quality management

2.1 Quality definitions

Quality can be defined as an inherent measure of excellence in a product or service. According to another meaning in Webster's Dictionary, quality is described as the level of perfection possessed by anything. Both the definitions fail to provide a clear understanding of what quality means in operations management, as well as the effects of quality on the outcomes of operations. According to the American Society for Quality, quality is defined as the complete set of attributes and traits that fulfil requirements. Even this definition is somewhat inadequate when examining operations management.

The fitness for use of the product is determined by its ability to fulfil its intended purpose. Utilising a screwdriver as a chisel may lead the client to see the screwdriver as lacking in quality, as the handle of the screwdriver fractures upon being struck with a hammer. On the other hand, if a chisel is used as a screwdriver, it is quite probable that the client will perceive the chisel as an inferior screwdriver. Attempting to use a shoe as a tool to hammer a nail will certainly lead to the shoe being harmed. The shoe's user may mistakenly see it as a subpar product, but it is important to note that the shoe is not intended for use as a hammer. A US Navy acquaintance of mine articulates this point more well. The Navy possesses vessels specifically engineered to detect and neutralise underwater mines. These vessels are commonly referred to as minesweepers. While not all ships are specifically equipped for this task, it is possible to utilise any ship as a mine sweeper at least once.

Dimensions of quality

To comprehensively analyse quality, it is crucial to examine the many aspects of quality in the context of operations management. The characteristics of quality mentioned here are interconnected with the definition provided by APICS. According to APICS, the dimensions of quality are defined as aspects that are specifically identified to improve the ability to describe quality.

The primary aspect of a product's quality is its reliability. This reliability encompasses the system's availability. During my initial involvement in the Research and Development phase for the US Army, the primary criterion for evaluating a system was its reliability. The item's reliability was often assessed by the Mean Time Between Failures (MTBF) metric. The Mean Time Between Failures (MTBF) refers to the average duration between instances of product breakdown or failure. When employing the Mean Time Between Failures (MTBF) as a metric for assessing dependability, the testing technique involved calculating the average duration between system failures.

Responsiveness is the second dimension of quality. This aspect of quality is commonly linked to a service, or the customer assistance offered by the company following the purchase of the goods. What is the level of responsiveness of the organisation towards consumer needs following the sale of the product? Customer service appears to be diminishing in most contemporary organisations. The assessment of the product includes not only its physical attributes, but also the level of customer service provided by the company in case of any product-related issues.

The third component of product or service quality is assessed based on the company's ability to resolve issues or deliver services. Does the company demonstrate empathy and concern towards the customer, or does it behave as if it is doing the customer a favour? A corporation that prioritises quality will demonstrate a genuine commitment to fulfilling the customer's requirements. How frequently have you visited a restaurant or retail store where the servers or salespersons exhibit an attitude of superiority, as if their presence is a favour to you? Alternatively, must one resort to disparaging the company on social media to resolve the issue?

The fourth dimension of quality pertains to the company's expertise in assisting customers with the utilisation of their product or service. Can the customer care representative in the service and retail industry sufficiently provide the consumer with the necessary information to make an informed decision? Bass Pro Shops/Cabela's serves as a commendable illustration of this. Cabela's proudly claims to be the preeminent supplier of outdoor gear and equipment worldwide. To fulfil this claim, Cabela's provides comprehensive training to its workers, equipping them with the essential expertise to assist customers in selecting the appropriate equipment for their desired outdoor pursuits. The absence of commission-based incentives for Cabela's sales team enables them to provide unbiased recommendations to customers, without any perception of a motive to promote certain products for personal gain. This is also crucial in the food service sector. When entering a restaurant, it is reasonable to anticipate that the server possesses comprehensive knowledge of every item listed on the menu, in case you have any inquiries. This is an indicator of the service's calibre.

2.2 Total quality management (TQM)

The notion of quality has endured for numerous years, yet its significance has undergone transformation and development during time. During the early twentieth century, quality management referred to the practice of examining items to verify that they conformed to predetermined requirements. During World War II in the 1940s, there was a shift towards a more statistical approach to measuring quality. Statistical sampling methods were employed to assess quality, while quality control charts were utilised to oversee the production process. During the 1960s, the concept gained a more expansive interpretation with the assistance of individuals known as quality gurus.

The concept of quality became to be perceived as something that included the entire organisation, rather than just the production process. Given that every function had a role in ensuring product quality and collectively bore the expenses of subpar quality, quality was perceived as a notion that impacted the entire organisation. The definition of quality for corporations underwent a significant transformation in the late 1970s. Prior to that time, quality was still perceived as something that required inspection and rectification. However, during the 1970s and 1980s, numerous industries in the United States

experienced a decline in their market share due to competition from foreign countries. In the automotive sector, companies like Toyota and Honda emerged as prominent contenders. Toshiba and Sony were the frontrunners in the consumer products sector. These international rivals were manufacturing products at a lesser cost while maintaining significantly better quality. To endure, corporations were had to implement significant modifications to their quality programmes. Numerous organisations have employed consultants and implemented quality training programmes for their staff. A novel paradigm of quality was beginning to emerge. Consequently, quality acquired a strategic significance. In the present day, prosperous corporations comprehend that quality confers a competitive edge. Their priority is client satisfaction, and they define quality as the ability to meet or beyond consumer expectations.

Since the 1970s, the significance of competition centred around quality has increased and has sparked immense interest, worry, and enthusiasm. Companies across all industries are prioritising the enhancement of quality to enhance their competitiveness. Quality excellence has become a prevailing benchmark in most areas for conducting business. Companies that fail to reach these criteria will not survive. The significance of quality is exemplified by national quality awards and sought quality certificates, as will be discussed later in this chapter.

Prominent Quality Gurus

Quality Guru	Salient Contribution
Walter A. Shewhart	• Contributed to understanding of process variability. • Developed concept of statistical control charts.
W. Edwards Deming	• Stressed management's responsibility for quality. • Developed "14 Points" to guide companies in quality improvement.
Joseph M. Juran	• Defined quality as "fitness for use." • Developed concept of cost of quality.
Armand V. Feigenbaum	• Introduced concept of total quality control.
Philip B. Crosby	• Coined phrase "quality is free." • Introduced concept of zero defects.
Kaoru Ishikawa	• Developed cause-and-effect diagrams. • Identified concept of "internal customer."
Genichi Taguchi	• Focused on product design quality. • Developed Taguchi loss function.

The TQM Philosophy

Total Quality Management (TQM) is a management strategy that focuses on integrating a strong emphasis on quality throughout all aspects of an organization's procedures. Total Quality Management (TQM) has found extensive application in several sectors such as manufacturing, education, government, and service industries. It has also been implemented in NASA's space and science programmes.

Total Quality Management primarily focuses on the ongoing enhancement of all operational and functional operations inside an organisation. It is a form of strategic planning that focuses on long-term goals and objectives. The quality consistently improves. It is an ongoing and perpetual process. This text outlines a managerial strategy that aims to achieve long-term success by prioritising customer satisfaction. In a Total Quality Management (TQM) initiative, every member of an organisation actively participates in enhancing processes, products, services, and fostering a collaborative culture inside the workplace. The effectiveness of Total Quality Management (TQM) relies on substantial modifications in organisational structure, operational procedures, and cultural norms. Multiple methodologies exist for implementing Total Quality Management (TQM). Certain organisations prioritise the implementation of quality programmes such as statistical process control, while others prioritise the utilisation of tools like quality function deployments. Organisations often struggle to achieve quality improvements due to a lack of comprehensive grasp of the quality tools or concepts across the entire organisation.

Total quality management is a comprehensive organisational philosophy aimed at meeting the needs and expectations of consumers. The company is consistently enhancing the quality of its products, services, and procedures. The primary objective is to fulfil and surpass customers' intended expectations. Total Quality Management (TQM) is a responsibility that extends to all members of the organisation, regardless of their position within the hierarchy. Collaboration is essential for ensuring the high standard of products, services, and procedures. All stakeholders, including suppliers and customers, are integral components of the quality improvement process. The principles of total quality management include top management involvement, customer

satisfaction, establishment of an optimal TQM environment, employee engagement and dedication, integrated system approach, and ongoing quality improvements.

The Customer Focus

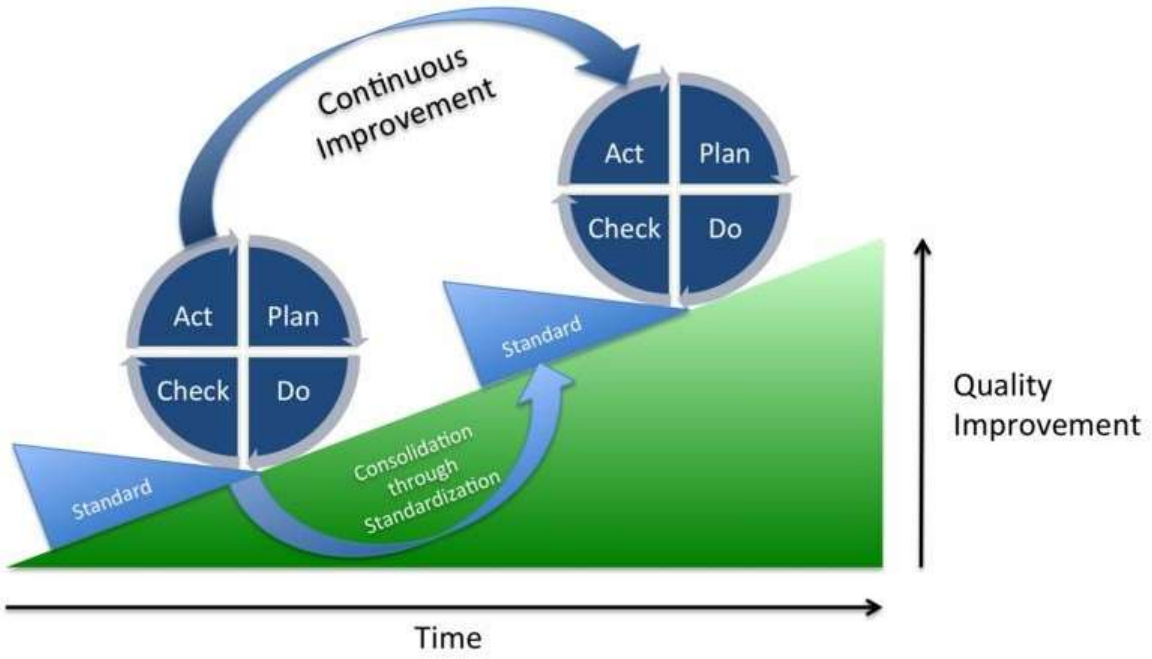
The primary and dominant characteristic of Total Quality Management (TQM) is the company's unwavering emphasis on its customers. Quality is the state of fulfilling or surpassing the expectations of customers. The objective is to initially ascertain and subsequently fulfil the requirements of the customer. Total Quality Management (TQM) acknowledges that a product that is flawlessly manufactured holds less significance if it does not align with the customer's preferences and requirements. Thus, it may be asserted that quality is determined by the preferences and demands of the client. Nevertheless, discerning the customer's desires might be challenging due to the ever-changing nature of tastes and preferences. Furthermore, client expectations can differ across individual customers. As an illustration, in the automotive business, trends undergo rapid changes, transitioning from compact cars to sports utility vehicles and then reverting to compact cars. This also applies to the retail sector, where trends and fashion have a short lifespan. Companies must consistently acquire information through focus groups, market surveys, and customer interviews to remain attuned to client preferences. It is imperative for them to constantly bear in mind that their existence as a corporate entity is solely dependent on their clients.

Continuous Improvement

Another fundamental principle of the TQM philosophy is the emphasis on perpetual enhancement. Traditional methods operated under the premise that if a company reached a specific standard of quality, it was considered successful and did not require any additional enhancements. Improvement is often conceptualised as reaching specific milestones, such as successfully completing a certification exam or decreasing the number of faults to a predetermined threshold. Traditionally, American managers perceive change as including significant scales, such as substantial organisational upheaval. In contrast, the Japanese hold the belief that the most effective and enduring transformations are achieved through incremental enhancements. By way of analogy, they hold the belief that it is more

advantageous to consume regular modest amounts of medication rather than a single high dosage. Kaizen, a concept embraced by the Japanese, entails the ongoing pursuit of improvement through continuous learning and problem-solving within the firm. Given the impossibility of attaining perfection, it is imperative that we consistently assess our performance and implement strategies to enhance it. Now, we will examine two strategies that might assist firms in achieving continuous improvement: the plan–do–study–act (PDSA) cycle and benchmarking.

The Plan–Do–Check–Act Cycle



The plan-do-check-act (PDCA) cycle outlines the necessary steps that a corporation must undertake to integrate continuous improvement into its operations. The cycle seen in the figure above is commonly known as the *Shewhart cycle* or the *Deming wheel*. The cyclical nature of this process demonstrates that continuous development is an ongoing and perpetual endeavour. Now, let's examine the precise stages in the cycle.

— **Plan** The initial stage of the PDCA cycle involves planning. Managers are required to assess the existing process and develop strategies based on any identified issues. It is necessary to systematically record all existing procedures, gather data, and pinpoint any issues. Subsequently, this data must be analysed and

utilised to build a strategy for enhancement, together with precise benchmarks to assess effectiveness.

- **Do** Perform The subsequent phase in the cycle is executing the plan (do). Throughout the implementation process, it is imperative for managers to meticulously record any modifications and gather data for assessment purposes. Academic pursuit
- **Check** The third phase involves analysing the data gathered in the previous stage. The data are assessed to determine if the strategy is successfully attaining the objectives set during the planning phase.
- **Act** Perform The final stage of the cycle involves taking action based on the outcomes of the initial three stages.

The most effective approach to achieve this objective is to disseminate the findings to fellow colleagues inside the organisation and thereafter execute the new protocol if it has proven to be successful. It is important to understand that this process is cyclical, meaning that after completing one stage, the following step is to plan again. Once we have taken action, it is necessary to persistently assess the process, strategise, and then restart the cycle.

Benchmarking

Organisations can also achieve continuous improvement by analysing and adopting the business practices of organisations that are recognised as leaders in their field. This process is commonly referred to as benchmarking. Gaining the capacity to acquire knowledge and analyse the methods employed by others is a crucial component of ongoing enhancement. The benchmark company does not necessarily need to operate in the same industry, as long as it demonstrates exceptional performance in an area that the company doing the study aims to replicate. For example, Amazon has been increasing the number of its exclusive fashion brands by using electronic catalogues and is currently one of the most rapidly expanding enterprises in this field. Therefore, numerous organisations who are developing e-catalogue businesses compare

themselves to Amazon. Likewise, numerous firms have utilised American Express as a standard for evaluating conflict resolution.

Empowering Employees

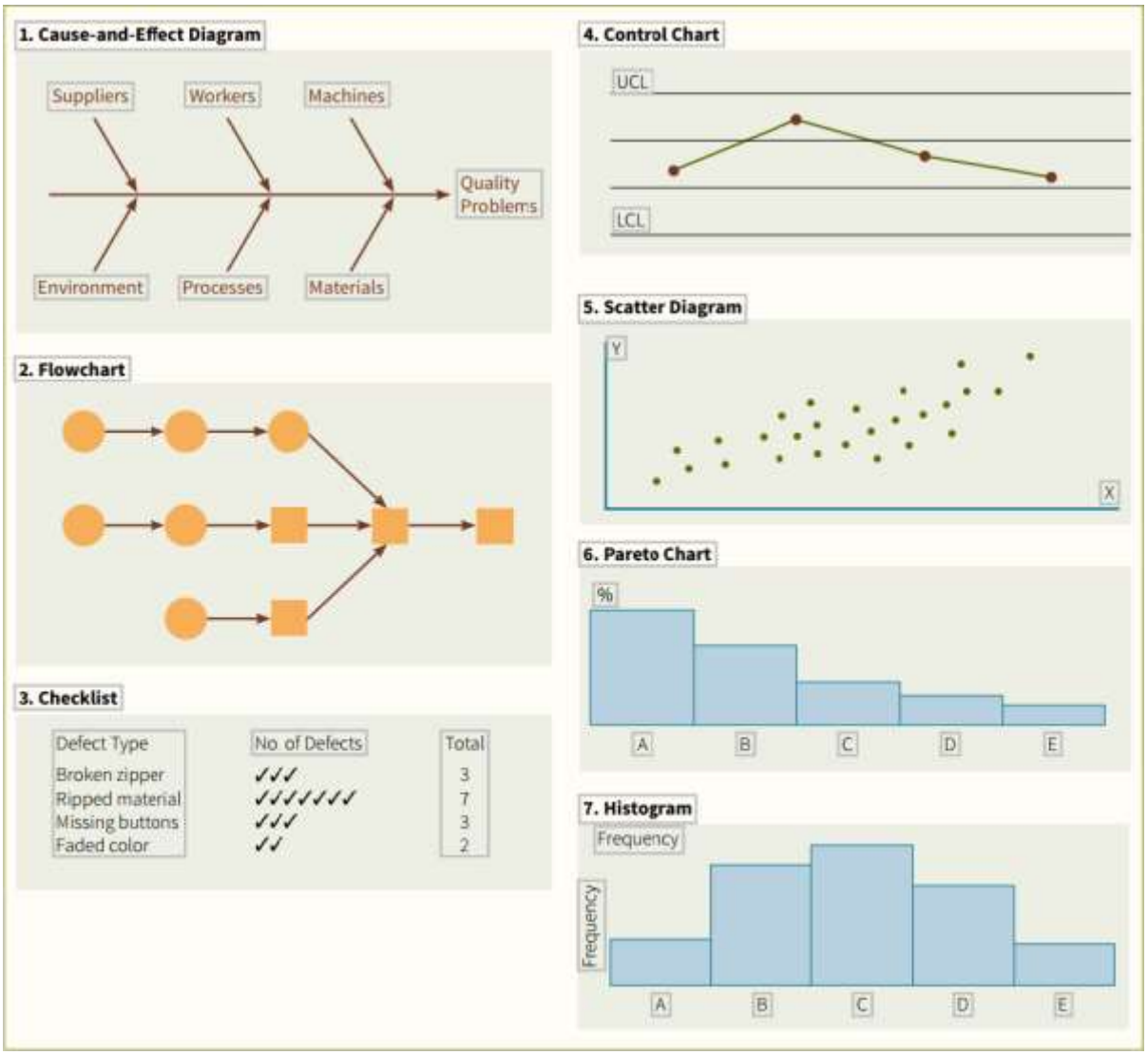
Another aspect of the TQM philosophy is to grant all employees the authority to proactively identify and rectify quality issues. Under the previous paradigm of quality, employees were hesitant to identify issues due to the apprehension of facing disciplinary action. Frequently, substandard quality was transferred to another individual with the intention of shifting the responsibility onto them. The emerging idea of Total Quality Management (TQM) offers incentives to employees to detect and address quality issues. Employees are incentivized for identifying quality issues, rather than being penalised. Within the framework of TQM, the responsibilities and functions of employees undergo significant changes compared to those in older systems. Workers have the authority to make judgements regarding the quality of the production process. They are regarded as an essential component in the endeavour to attain superior quality. Their contributions are well esteemed, and their proposals are put into effect. Employees receive ongoing and comprehensive training on quality measuring tools to carry out this function.

To emphasise the importance of people in ensuring quality, TQM distinguishes between external and internal consumers. External clients refer to individuals or organisations who buy the products or services offered by the company. Internal customers refer to the employees inside an organisation who receive goods or services from other individuals or departments within the same company. As an illustration, the assembly department of an organisation has the packaging department as its internal customer. Like how a faulty item would not be given to an outside consumer, a faulty item should not be given to an internal customer.

Quality tools

For staff to effectively recognise and rectify quality issues, it is imperative that they receive enough training. It is essential for them to comprehend the process of evaluating quality using diverse quality control methods, interpreting the results, and rectifying any

issues that arise. This section examines seven distinct quality tools, sometimes referred to as the seven instruments of quality control (Figure below). These concepts are easily comprehensible, yet highly valuable for recognising and analysing issues related to quality. Occasionally, workers utilise a single tool, but frequently a combination of instruments proves to be the most beneficial.



1. Cause-and-effect diagrams

Cause-and-effect diagrams are used to discover potential causes of specific quality concerns. They are commonly referred to as fishbone diagrams due to their resemblance to the skeletal structure of a fish (figure above). The "head" of the fish refers to the primary issue or problem, such as the presence of damaged zippers on a garment or broken valves on a tyre. The diagram is illustrated with the intention of linking the "spine" of the

fish to the potential cause of the problem, hence connecting the "head". These causes may be interconnected with other factors such as machinery, labour, measurement, suppliers, materials, and other elements of the production process. Each of these potential causes can thereafter be broken down into smaller components that specifically address the concerns related to each cause. For instance, issues with machines may arise from the requirement for calibration, outdated machinery, or difficulties with tooling. Likewise, an issue with employees may stem from insufficient training, inadequate supervision, or weariness. Cause-and-effect diagrams are frequently employed by quality control teams as problem-solving instruments. Brainstorming can be used to investigate the precise reasons of difficulties. The creation of a cause-and-effect diagram necessitates the team to thoroughly consider all potential factors contributing to subpar quality.

2. Flowcharts

A flowchart is a visual representation that illustrates the sequential steps of an activity or process. It offers a user-friendly and comprehensible graphic tool. By seeing the sequential stages of an operation or process, individuals acquire a lucid understanding of its functioning and identify potential areas of difficulty.

3. Checklist

A checklist is a compilation of typical flaws together with the corresponding frequency of their occurrence. The tool provides a straightforward and efficient method for gathering precise information about observed problems. The checklist depicted in figure above displays four instances of flaws along with their corresponding frequencies of occurrence. The primary issue is evidently torn fabric. This implies that the factory should prioritise addressing this particular issue, such as investigating the origin of the supply or examining if the material tears during a specific stage of production. Additionally, a checklist might be utilised to concentrate on alternative aspects, such as geographical position or temporal factors. For instance, in cases where a problem is being regularly detected, it is possible to create a checklist that quantifies the frequency of occurrences per shift, per machine, or per operator.

By employing this method, we may effectively pinpoint the precise position of the specific flaw and thereafter concentrate our efforts on rectifying the issue.

4. Control charts

Control charts are a vital quality control tool. In the next chapter, we will extensively examine the application of control charts. These charts are utilised to assess whether a process is functioning within anticipated parameters in relation to a measurable attribute, such as weight, width, or volume. As an illustration, we can quantify the mass of a bag of flour, the diameter of a tyre, or the capacity of a bottle of soda. When the production process is functioning according to anticipated standards, we describe it as being "in control".

To assess the stability of a process, we routinely measure the variable of interest and graph it on a control chart. The chart features a horizontal line positioned at the midpoint, symbolising the mean value of the variable under consideration. There are two lines, known as the upper control limit (UCL) and the lower control limit (LCL), positioned above and below the centre line. If the observed values remain within the upper and lower control limits, it indicates that the process is stable and there are no quality issues. If a measured observation exceeds certain limitations, it indicates a problem.

5. Scatter diagrams

Scatter diagrams are graphical representations that illustrate the relationship between two variables. They are especially valuable in determining the level of correlation, or the extent of linear association, between two variables. Increased production speed and the number of faults have a positive correlation. As production speed increases, the number of defects also increases. Two variables may exhibit a negative correlation, meaning that an increase in one variable is accompanied by a drop in the other. For instance, a correlation may exist between enhanced worker training and a reduction in the quantity of observed defects.

The level of correlation is directly proportional to the linearity of the observations in the scatter diagram. Conversely, if the observations in the figure are more widely dispersed, it indicates a lower level of correlation between the variables. Additionally, a scatter diagram can display several types of relationships, including an inverted U shape. When examining the correlation between two variables, such as oven temperature and the number of faults, it is possible to observe that both temperatures below and beyond the optimal range might result in flaws.

6. Pareto Analysis

Pareto analysis is a method employed to discover quality issues by assessing their level of significance. Pareto analysis is based on the premise that a small number of quality issues hold significant importance, while the majority of other issues are not of vital significance. The approach was coined in honour of Vilfredo Pareto, an Italian economist from the nineteenth century who observed that a minority of individuals possessed the majority of the wealth. This principle is commonly referred to as the 80–20 rule and has been applied to various domains. Pareto's principle in quality management is based on the notion that the majority of quality issues stem from a small number of root causes. The key is to pinpoint these reasons.

An effective use of Pareto analysis involves creating a chart that arranges the sources of substandard quality in descending order, according to the proportion of defects attributed to each cause. For instance, one can create a count of the quantity of flaws that arise from various origins, such as human mistake, faulty components, or imprecise machine calibrations. The percentages of flaws can be calculated based on the tally and displayed in a chart, similar to the one depicted in figure above. Typically, we observe that a small number of factors are responsible for the majority of the faults.

7. Histograms

A histogram is a graphical representation that displays the frequency distribution of observed values for a given variable. The plot allows us to determine the sort of

distribution exhibited by a specific variable, including whether it follows a normal distribution and if the distribution is symmetrical.

Quality control tools are crucial in the food service business for recognising quality issues. It is necessary for grocery store chains, such as Kroger and Meijer, to document and supervise the calibre of incoming produce, such as tomatoes and lettuce. Quality tools are utilised to assess the acceptance of product quality and to oversee product quality from particular suppliers. Additionally, they can be utilised to assess the underlying factors contributing to quality issues, such as extended transportation duration or inadequate refrigeration. Restaurants employ quality control technologies to assess and oversee the quality of received items, such as meats, veggies, or baked goods.

2.3 Just-in-time and lean management

Waste significantly hampers the operational efficiency of a firm, leading to substantial expenses and the loss of consumers. In order to address these issues, numerous firms have adopted Just-in-Time (JIT) practices. Currently, the whole automotive sector universally employs Just-in-Time (JIT) as the normal operating procedure. Ford Motor Company's operations employ Just-in-Time (JIT) concepts to maintain minimal amounts of inventory for raw materials and parts. Toyota utilises Just-in-Time (JIT) concepts to maintain a consistent and uninterrupted flow of parts from its suppliers. BMW is implementing Just-in-Time (JIT) concepts to provide a streamlined vehicle-ordering system for consumers and a highly adaptable operation capable of promptly meeting client requests. Nevertheless, JIT principles are not exclusively employed in the realm of manufacturing. These principles are also relevant in the service industry and may be observed in companies like McDonald’s, Wendy’s, Pizza Hut, and FedEx.

Just-in-time philosophy

Just-in-time (JIT) refers to the efficient procurement of commodities, ensuring the correct quantity is delivered to the appropriate location precisely when needed. The merchandise is delivered precisely when needed, hence the origin of the phrase JIT.

Contrary to popular belief, JIT is not just an inventory reduction programme or a production process; it encompasses much more than that. JIT, or Just-in-Time, is a comprehensive philosophy that is based on the principle of removing inefficiencies and unnecessary resources. The term "waste" may evoke thoughts of rubbish, paper, or surplus stock. However, JIT categorises anything that does not contribute value as waste.

The whole perspective of JIT is frequently referred to as lean production or lean systems. The implementation of this has significantly contributed to the success of numerous organisations and is widely utilised by corporations globally. The advantages that may be achieved by JIT are so remarkable that JIT has become a widely adopted practice in various industries, such as the automotive and computer sectors. Nevertheless, Just-in-Time (JIT) can be implemented not only in manufacturing but also in service organisations and can even be applied in several aspects of daily life. JIT encompasses multiple factors, including quality, inventory, and efficiency. It represents a completely distinct perspective on matters. JIT, or Just-in-Time, is a comprehensive philosophy that encompasses all areas of an organisation, including administration, manufacturing, labour management, supplier management, and housekeeping. The application of this system, known as the Toyota Production System (TPS) in the case of Toyota and "the Honda Way" in the case of Honda, has played a significant role in the success of these firms. Moreover, it has the potential to contribute to success in one's personal life as well.

The concept of Just-in-Time (JIT) was first developed in Japan. Following World War II, the Japanese established a goal of enhancing their economic foundation, encompassing achieving full employment and maintaining a favourable trade balance. Just-in-time (JIT) emerged as a response to the nation's imperative to endure in the aftermath of the war's destruction. While some authors suggest that the beginnings of JIT may be traced back to the early 1900s, it is widely acknowledged that the theory achieved global prominence in the 1970s. The development of the system took place at the Toyota Motor firm, with Taiichi Ohno, a vice president of the firm, being widely acknowledged as its primary developer. Just-in-Time (JIT) methodology played a crucial role in driving Toyota to a dominant position in terms of quality and delivery. Since its inception, Just-in-Time (JIT) has gained widespread acceptance across various industries and has been recognised

for its remarkable advantages, such as substantial reductions in operational expenses, enhanced product quality, and heightened customer responsiveness. Companies such as Honda, GE, Ford, Boeing, Lockheed Martin, Hewlett-Packard, and IBM have incorporated Just-in-Time (JIT) into their operations. The retailer Zara also employs Just-in-Time (JIT) inventory management.

The core tenet of the JIT philosophy is the eradication of inefficiency, although there exist additional defining principles within this philosophy. These factors encompass a comprehensive perspective on operations, a focus on simplicity, ongoing enhancement, clear visibility, and adaptability. Subsequently, we will examine each of these ideas in further detail.

Just-in-Time Manufacturing

Just-in-Time (JIT) is a philosophy that focuses on waste reduction and value-added production, enabling large-scale manufacturing of top-notch, cost-effective products that cater to customer requirements. JIT manufacturing is a pull system that uses a master production schedule to ensure equal production of each product in the same order every day. This system differs from conventional operations, which usually generate a large volume of a single product within a single day, leading to elevated inventory expenses.

JIT manufacturing uses a coordinating mechanism, kanban cards, to facilitate the movement of necessary products across the production system. Traditional systems often manufacture significant quantities of one type of product before converting to production of another due to substantial setup costs. JIT systems have proven effective in minimizing setup costs, resulting in shorter production lead times and a focus on manufacturing products in a batch size of one.

JIT manufacturing also considers inventory as a superfluous resource that should be eradicated to mitigate issues such as subpar quality, delayed delivery, inefficiency, lack of coordination, and uncertainty in demand. Inventory incurs expenses and does not

contribute any value, but JIT methodology aims to identify and eliminate problems by eliminating it.

In summary, JIT manufacturing is a highly efficient production strategy that enables timely delivery of the correct quantity of products to designated locations.

3.0 Operations scheduling

3.1 Basic scheduling concepts

A company's overarching strategy serves as the foundation for decision-making across many operational domains. Companies distinguish themselves by the quantity and diversity of their products. This divergence has an impact on the company's organisational structure. A company that offers a high-volume, standardised, consistent-quality, lower-margin product or service, such as a commercial bakery or a fast-food restaurant, prioritises product and layout. This operation requires specialised equipment, personnel with lower levels of experience, and a continuous or repetitive process flow. Companies that offer customised, high-margin products or services in small quantities, such as a bespoke furniture manufacturer or a high-end restaurant, prioritise their operational procedures. They require versatile equipment, a workforce with advanced expertise, and adaptable operational procedures. Each type of operation requires a distinct scheduling approach. Now, let's examine operations that include a large volume of work or activity.

High-Volume Operations Scheduling

High-volume operations, also known as flow operations, refer to repetitive procedures involving discrete products such as autos, appliances, or bread, as well as services like licence renewals at the Division of Motor Vehicles. Alternatively, they can be ongoing processes to produce things in a continual manner, such as petrol, or for the provision of services like waste treatment. Standard items with high sales volume, whether they are discrete or continuous, typically have narrower profit margins, making cost optimisation crucial. Cost efficiency in a high-volume operation is achieved by maximising labour and equipment utilisation. The design of the work environment guarantees a seamless

movement of products or consumers within the system. Flow operations possess the subsequent attributes.

Flow operations employ predetermined routings, where the product or service is consistently executed in the same manner, following the same sequence and utilising the same workstations. The workstations are grouped in a sequential manner based on the routing. Uniform processing times are required at each workstation to achieve a balanced line. Workstations are specifically designated for the use of a single product or a narrow range of items. They utilise specialised equipment and tooling. In a service operation, personnel who undertake a specific but limited task might be considered as analogous to specialised equipment. When you go to the theatre, you encounter several stages of processing. Initially, you acquire the tickets from the box office. Next, you pass the ticket to the ticket taker. Subsequently, an usher guides you to your designated seat. Every individual who attends the performance undergoes the identical sequence of processing stages.

Automated systems can facilitate the movement of materials between workstations. Nowadays, there are numerous software applications that efficiently assist in identifying the most optimal layout and style for workspaces. Some notable examples include Apache OpenOffice Draw, SmartDraw, EDraw, and SketchUp. An optimally designed system minimises the amount of inventory in progress and decreases the time it takes for a product or service to be completed. The capacity of the flow system is determined by the design of the production line. The workstation or processing point that requires the most time is referred to as the system's bottleneck. The bottleneck determines the maximum number of products or services that the system can complete. Hence, the objective is to arrange the operations in a manner that requires little control. An important issue regarding flow operations is the potential for employee ennui due to monotonous duties. Companies employ strategies such as job enrichment, job enlargement, and job rotation to alleviate monotony and optimise productivity.

Low-Volume Operations Scheduling

Low-volume or job-shop operations are employed to produce high-quality, tailor-made products such as bespoke stereo systems or custom automotive paint jobs. They are also utilised for services such as personal fitness, which yield better profit margins. Companies that have modest production volumes typically use highly skilled workers, utilise versatile equipment, and adopt a process plan. The goal is to achieve flexibility in terms of both product variety and production volume. The equipment is versatile and may be used for any job, rather than being limited to certain tasks. Products are manufactured on demand in low-volume businesses. Every individual product or service can be assigned a specific path through a distinct series of workstations, processes, materials, or configurations. Consequently, the process of scheduling is intricate. The allocation of the workload must be evenly dispersed across the various work centres or service people. A Gantt chart is a valuable tool for visualising and managing schedules and workloads.

Now, let's examine the practical application of a Gantt chart. Gantt charts were created by Henry Gantt in the early 1900s. A Gantt chart is a graphical depiction of a timetable or schedule that shows the progression of activities over a specific period. There are two types of Gantt charts: the load chart and the progress chart.

3.2 Developing a schedule of operations

Operation sequencing, also known as job sequencing, is a method used for short-term planning of specific tasks to be executed in each work centre. This planning is based on considerations of capacity and priority. In order to determine the order in which jobs will be processed, it is anticipated that a work centre will have many jobs awaiting processing. Operation sequencing determines the planned start and end timings of tasks, as well as the anticipated waiting times. The priority of a job refers to its relative position in the sequence.

Using priority rules

Job priority is often determined by a predefined rule. Refer to Table 15.1 for descriptions of frequently utilised priority rules. Priority rules are commonly categorised as either local or global. A local priority rule is a method of assigning priority to jobs based solely on the jobs that are already waiting in a specific work centre. For instance, the utmost importance could be assigned to the work that arrives earliest or the project that can be completed most quickly. Global priority criteria, such as crucial ratio or slack per remaining operations, assign precedence based on parameters such as the workload scheduled at the remaining work centres that the job needs to go through.

A work centre requires priority rules in situations where there are several works waiting for processing, but not when there is only a single job that needs to be processed. Priority rules operate under the assumption that there is no variation in either the time required to prepare for a task or the time it takes to complete the task. Now, let's examine the utilisation of priority rules. Applying priority rules is simple. Simply adhere to these instructions.

Step 1: Determine the priority rule to be utilised. Various priority rules yield distinct outcomes. We will address this matter throughout our examination of performance metrics.

STEP 2: Enumerate all the pending jobs at the work centre together with their respective job duration. The duration of the job encompasses both the time required for setting up and the time needed for processing.

STEP 3: Apply your priority rule to determine the job with the highest priority, which should be addressed first, followed by the second, third, and so on.

3.3 Scheduling issues in a service organisation

Methods for scheduling requested services vary and include options such as making appointments, requesting reservations, utilising a publicly available schedule, or deferring the service to a later time or placing it on back-order. Let’s examine each of these separately.

Scheduling Techniques for Service Organisations

Appointments

Appointment systems allocate a specific time for the customer to avail the service. For instance, students schedule appointments with teachers to discuss coursework. Appointments optimise client waiting time and efficiently utilise the service provider's capacity. Appointment systems are utilised by medical practitioners, legal professionals, automotive repair or service establishments, and hair salons. The common characteristic of all these services is that they typically do not involve physical inventory. The drawbacks of an appointment system encompass the issue of "no-shows" - those who fail to attend their appointments - as well as inadequate time allocated for customers. If a customer fails to show up for their appointment, the service provider may have to wait idly until the next scheduled appointment, resulting in a loss of money.

When there is not enough time available, the service provider frequently fails to meet deadlines and causes customers to wait. Current research is investigating the process of scheduling outpatients in a dynamic and multiperiod context. The goals are to minimise the time lag between a patient's appointment request and their actual appointment, as well as to identify the optimal time windows for unscheduled appointments throughout the day. The unscheduled slots are reserved for urgent-care patients who require immediate attention from the physician.

Reservations

A reservation system allows customers to gain temporary custody or management of an asset, such as a hotel room, car, or banquet facility. A reservation system offers prior notification regarding the required time and duration for an item. Deposits typically mitigate the issue of last-minute cancellations or instances where individuals fail to show up.

Posted schedules

Several service providers display a timetable that indicates the availability of their services. Movie theatres, universities, airlines, trains, buses, retail stores, museums,

concerts, and athletic events are all instances of services that display schedules. The provided schedule informs the customer of the specific day and time of the event.

Delayed Services or Backlogs

Delayed services or backlogs are another strategy employed to schedule client demand. Restaurants that do not accept bookings are a prime illustration. The restaurant places guests on a waiting list until a table becomes vacant. Additional illustrations include financial institutions, supermarkets, commercial establishments, maintenance facilities, and hair salons. Typically, these organisations prioritise consumers based on their arrival time. These strategies are designed to enhance the service organization's capacity management. An alternate approach to capacity management involves the scheduling of the workforce.

Scheduling Employees

Given that organisations may encounter difficulties in scheduling demand, they can instead focus on effectively managing capacity by scheduling their staff. Organisations have the option to adopt many strategies to meet peak demand, such as hiring additional staff, utilising floating personnel, having employees available on call, or employing temporary, seasonal, or part-time workers, or any combination thereof.

Staffing for Peak Demand

By using this approach, the organisation ensures that it has a sufficient number of service providers to meet the highest degree of client demand. The evident drawback of this situation is the issue of expenses. The staff is completely utilised exclusively during periods of high demand. Alternatively, a segment of the labour force is unoccupied. Organisations usually hire more staff during periods of high demand when the service providers possess extensive expertise, and the workforce cannot be easily adjusted. An illustration would be your nearby fire or police station.

Floating Employees

Employees who are not permanently assigned to a specific location or department. Organisations leverage floating staff to their advantage when there is a daily fluctuation in client demand for services. Mobile staff provide a variety of services and are allocated to different locations based on daily requirements. Hospitals utilise floating staff members to accommodate the fluctuating number of patients and the varying level of care required on a daily basis. One drawback of this method for certain individuals is the lack of assurance regarding their work location and the temporary nature of short-term employment.

On-call employees

Certain organisations use on-call staff during designated time periods each week. Physicians in a hospital may be on standby for emergencies, but they are not physically present unless their presence is required. Maintenance personnel may also be available for immediate response in the event of emergencies. While being on call limits an employee's regular leisure time, it also allows the person to be absent from the business within the designated timeframe.

Temporary Workers

Employing temporary workers is an additional method for an organisation to modify its staff size. An organisation has the ability to recruit temporary personnel with a wide range of skill sets by utilising the services of a temporary agency. The agency supplies the staff and invoices the organisation.

Seasonal employees

Seasonal employees are hired by service organisations, such as merchants, to meet the temporary increase in client demand during specific seasons. These individuals are temporary employees who anticipate the conclusion of their employment at the end of the season. Agricultural producers, such as growers, hire seasonal workers to handle the processing of things when they reach maturity. These organisations require a temporary

increase in their personnel and cannot rationalise the recruitment of more permanent employees.

Part-Time Employees

Certain organisations see fluctuations in client demand, with higher levels during specific periods of the day and lower levels during other periods. At a fast-food establishment, such as a restaurant, there is a significant increase in customer demand at mealtimes, namely breakfast, lunch, and dinner, whereas demand decreases throughout the remaining hours of the day. To optimise its resources, the organisation employs part-time workers instead of committing to full eight-hour shifts.

Organisations have the ability to successfully control their service capacity by combining any of these strategies. While these strategies offer the ability to handle capacity, organisations must still create staff schedules that adhere to regulatory standards and contractual commitments. Legal mandates may specify the minimum quantity of employees required to be physically present and actively working at a fire station, as an illustration. Contractual obligations are established by labour agreements. These responsibilities may restrict the amount of extra work hours and pertain to the frequency of consecutive days off per week.

4.0 Let us sum up

Scheduling in operations management is the process of organizing, assigning, and timing tasks, activities, or jobs to resources (like machines, workers, or workstations) to ensure the efficient and timely completion of production goals. Effective scheduling is essential for optimising resource use, meeting deadlines, and enhancing overall operational efficiency. Scheduling in operations management is a vital function that ensures tasks are efficiently and timely executed by optimally allocating resources and sequencing activities. Addressing the key elements and challenges of scheduling helps businesses achieve greater operational efficiency, reduce costs, and improve overall production outcomes. Effective scheduling practices are crucial for maintaining a competitive edge and ensuring smooth, reliable operations.

5.0 Keywords

Quality	The measure of excellence of a product.
Quality control	Quality control involves testing units and determining if they are within the specifications for the final product.
Kaizen	Kaizen, also known as quick improvement processes, is often regarded as the fundamental element of all lean production methods. Kaizen is a methodology that aims to eliminate inefficiencies, enhance efficiency, and achieve ongoing and consistent improvement in specific activities and processes within an organisation.
Cost of Quality	The cost of quality includes all costs associated with the quality of a product from preventive costs intended to reduce or eliminate failures, cost of process controls to maintain quality levels and the costs related to failures both internal and external.
Gantt Charts	A Gantt chart is a project management tool assisting in the planning and scheduling of projects of all sizes; they are particularly useful for visualising projects.
Sequencing	It is to plan the order of the operation by process, regarding the fixed orders through the Operation Order Release Planning. It is to grasp the progress status of the operation, to consider the priority, setup time, etc., and to make an operation sequencing list.
Just-In-Time (JIT)	Just-in-time, or JIT, is an inventory management method in which goods are received from suppliers only as they are needed. The main objective of this method is to reduce inventory holding costs and increase inventory turnover.

6.0 Check your learning

i. What is Total Quality Management (TQM) and how does it benefit an organization?

ii. Why is customer satisfaction crucial in quality management?

iii. What role does continuous improvement play in quality management?

iv. How does lean manufacturing enhance quality management processes?

v. Discuss the role of employee involvement in the success of quality management initiatives.

8.0 Suggested readings

R. Dan Reid and Nada R. Sanders *Operations Management: An Integrated Approach*. 8th Edition. Wiley, India.

Muhlemann, Oakland, Lockyer, Sudhir, & Katyayani — *Production and Operations Management*. 6th Edition. Pearson, India.

S N Chary: — *Production and Operations Management*. 6th Edition. McGraw Hill, India.