Admas University

MBA Program

Course Title: Quantitative Analysis for Decision Making

Chapter One
Introduction to Quantitative Analysis

Operations Research = Management Science

- **Alternative Names:**
  - ✓ Operational Research
  - ✓ Operations Analysis
  - ✓ Quantitative Analysis
  - ✓ Quantitative Methods
  - ✓ Systems Analysis
  - ✓ Decision Analysis
  - ✓ Decision Science

The Need for Quantitative Analysis /OR/

- The need for operations research started when man was driven from the Garden of Eden.
- Ever since, he had been confronted with numerous problems, difficulties and challenges which ranging from primitive farming to industrial revolution.
- This is because man's action or decision, no matter well intended will bring-
  - Problem to himself, or
  - To the other people or
  - Even to the society at large.

The Need for Quantitative Analysis /OR/

- Action or decision will bring problem.
- Often new problems arise in an attempt to solve the existing ones.
- **Examples**
  - A person might buy a car to solve the problem of transportation;
  - Complexities in the development of a weapon, such as a bomb, the erection of a large office building or operation of an enterprise producing hundreds of products for diverse customer needs.

The Need for Quantitative Analysis /OR/

- Scheduling of jobs, ordering suppliers, managing inventories, negotiating with contractors, hiring labor, pricing goods and planning production facilities.
- Managers are confronted with uncertainties as the predictable tastes of consumers, the speculative nature of economic forecasts and research and development programs
- They are also constrained by Government policies and actions of their competitors in the market

Brief History of OR/MS

- The field of operations research can be said to have been in existence since the beginning of mankind.
- In ancient times, herdsmen sought methods of avoiding abnormal losses of their cattle.
- The concept of record keeping was believed to have been developed by them. For example,
  - Every morning as the sheep left the field, the herdsmen would drop one pebble into his pocket as each sheep passed out of the gate. On the animals' return in the evening, they would be counted for by the reverse process until no pebbles were left in the pocket. Each pebble left in the pocket represented a lost sheep and action could be taken to find the animal.

Brief History of OR/MS

- **In the 17th century:**
  - Professional gamblers had sought ways of improving the chances of winning during gambling.
  - As a result, they turned to *Mathematicians* to provide optimum strategies for various games of chance.
- **America & Britain:**
- During World War II – Operations Research became as a subject
  - To deploy resource in most economical and efficient ways- military operations

Brief History of OR/MS

- To ensure that this was done, a team of scientists from Britain was drawn together and instructed that they find solutions to pressing operational problems.
- But when America entered the War, both the British and the American Military management called upon a large number of scientists to apply a scientific approach to dealing with military operations.
- In effect they were asked to research into military operations.

Reasons for its expansion today:

- Industry booming,
- Specialization &
- Computers

Definition of QA/MS/OR

1. QA/MS/OR is the application of scientific methods, techniques and tools to problems involving the operations of systems so as to provide those in control of the operations with optimum solutions to the problems.
2. QA/MS/OR is the application of the scientific method to the study of the operations of large, complex organizations or activities.
3. QA/MS/OR is the application of the scientific method to the analysis and solution of managerial decision.

Definition

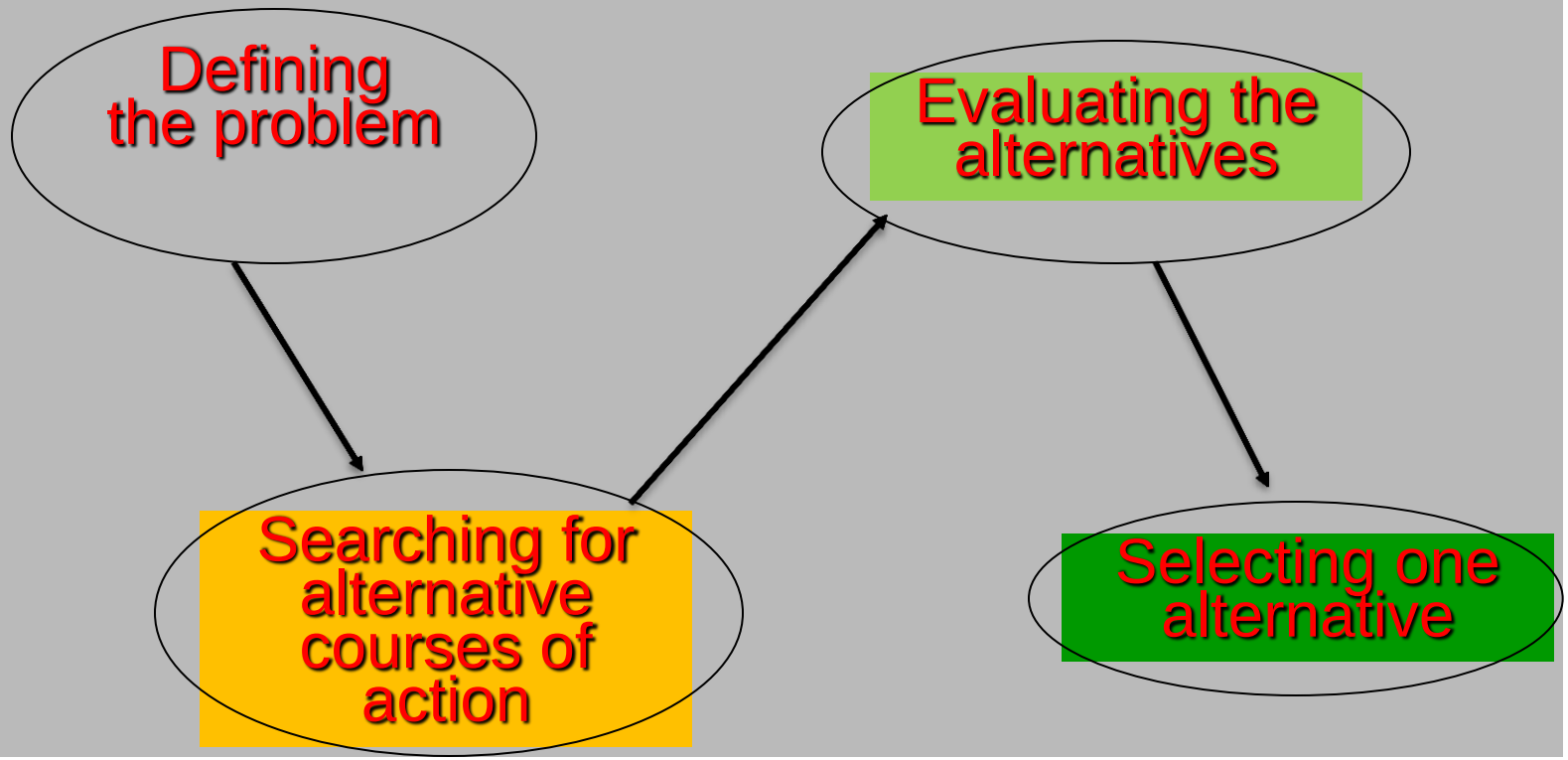
- In general, QA/MS/OR can be defined as the:
  - Application of SCIENTIFIC METHOD
  - Study of LARGE & COMPLEX SYSTEMS
  - Analysis of MANAGERIAL PROBLEMS, or
  - Process of Finding OPTIMAL SOLUTION

- From the definitions we found that some certain key words keep coming up.
- These are *"scientific method", "system", "model", "comparison", and "decision making".*
- That is, these definitions tell us several essential features of O/R and they are:
  - ✓ Assistance to managerial decision making and control
  - ✓ Application of model-based Scientific approach
  - ✓ System approach to organizations
  - ✓ Recognition of risk and uncertainty

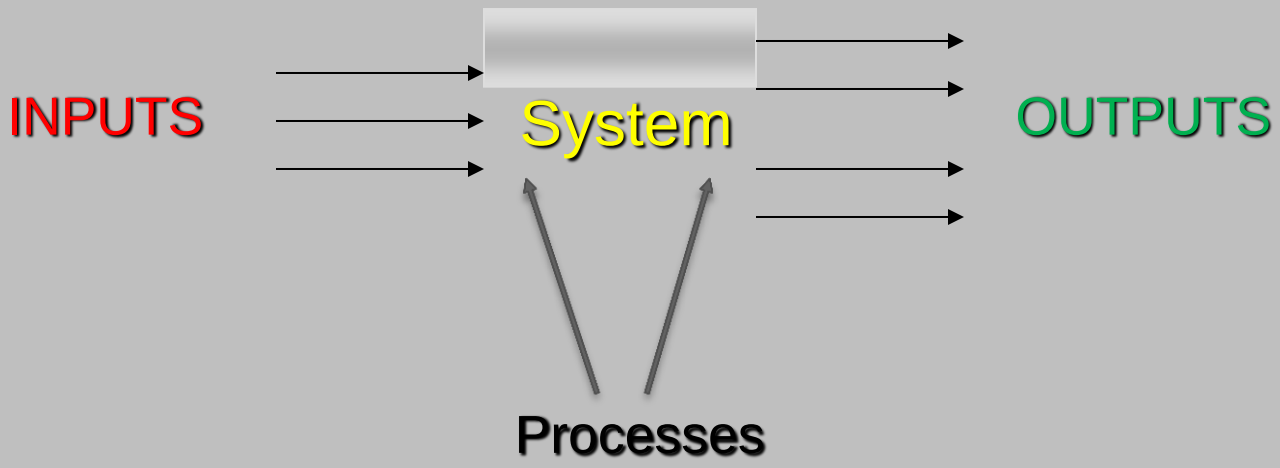
Decision Making

- 2 or more alternatives
- Conclusion = Decision
- Systematic process

Systematic Process Sample

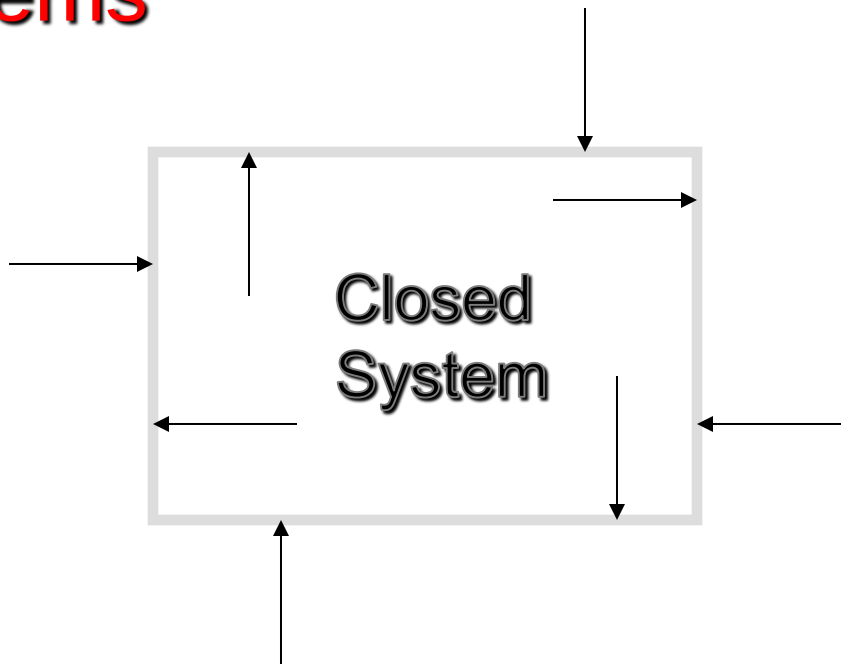


System Approach



Systems

Open System



Characteristics of OR Study

- Earlier on, four essential features of operations research were listed. Two important ones are discussed here.
- They are:
  a) The Interdisciplinary Approach, and
  b) Systems View or Orientation,

Characteristics of O/R Study

a) A major characteristic of OR studies is **interdisciplinary approach.**

- That is, OR uses mixed teams of members of different discipline backgrounds.
- In other words, studies are conducted by mixed teams from diverse disciplines, such as economics, psychology, mathematics, sociology, history, engineering and other physical sciences.
  - This might confirm the old age which states that two heads are better than one.

Characteristics of OR Study…

- The mixed teams approach has made operations research an outstanding new way of solving problems.
- OR employs teams of experts so that all aspects of a problem may be taken into account.
  - An OR team working in the same plant might include representatives of several physical sciences, mathematics, and engineering, an economist, occasionally a sociologist, and psychologist.

Characteristics of OR Study…

b) The **systems view** as used in OR pays attention to:

- the interrelatedness of the components of the system, and
- the interaction of the system with its environment.

- This is because, a system is a set of interacting variables, but each system is part of a larger system.
- For example,
  - A single department is a system in which the variables include the procedures, the equipment, the organization structure, and the people.

Characteristics of OR Study

- A change in procedures might make it necessary:
  - to get a new equipment or
  - to change the organization structure in some way, and
  - it might very well affect the attitude of the people in the department or
  - make it necessary for them to learn new skills.
- Similarly, any change in any one of the variables is likely to affect the others, at least in a minor way.
- But a department is part of a larger system, that is of the company as a whole; and any change in it is likely to affect at least some of the variables in other departments.
- And, of course, the company itself is a part of the economy system.
  - Hence a change in the company might affect other companies in the entire economy system of the nation.

Operations Research-Application Areas

- Economics
- Operations Management
- Finance
- Marketing
- Information Systems and Decision Support Systems

Economics

Economists use linear and nonlinear programming, the theory of variational inequalities, optimal control theory, dynamic programming, game theory, probability choice models, utility theory, regression and factor analysis and other techniques to study:

- Equilibrium,
- Optimal investment,
- Competition,
- Consumer behavior, and
- A host of other phenomena.

Operations Management

People in ***operations management*** use statistical sampling and estimation theory, linear and integer programming, network programming, dynamic programming and optimal control theory, queuing theory, simulation, artificial intelligence techniques, and combinatorial optimization methods to solve problems in:

- Quality control,
- Allocation of resources,
- Logistics, project scheduling,
- Labor and machine scheduling,
- Job shop scheduling and assembly line balancing, and
- Facility layout and location.

Finance

- People in finance use linear, nonlinear and integer programming, optimal control theory and dynamic programming, regression and time series to determine :
  - Optimal resource allocation,
  - Multi-period investments,
  - Capital budgeting, and investment,
  - Loan portfolio design, and
  - To try to forecast market behavior.

Marketing

- People in marketing use regression and factor analysis, time series, game theory, Markov decision theory, location theory, mathematical programming, probability choice models and utility theory to:
  - Study consumer preferences,
  - Determine optimal location in product space,
  - Allocate advertising resources,
  - Design distribution systems,
  - Forecast market behavior, and
  - Study competitive strategy.

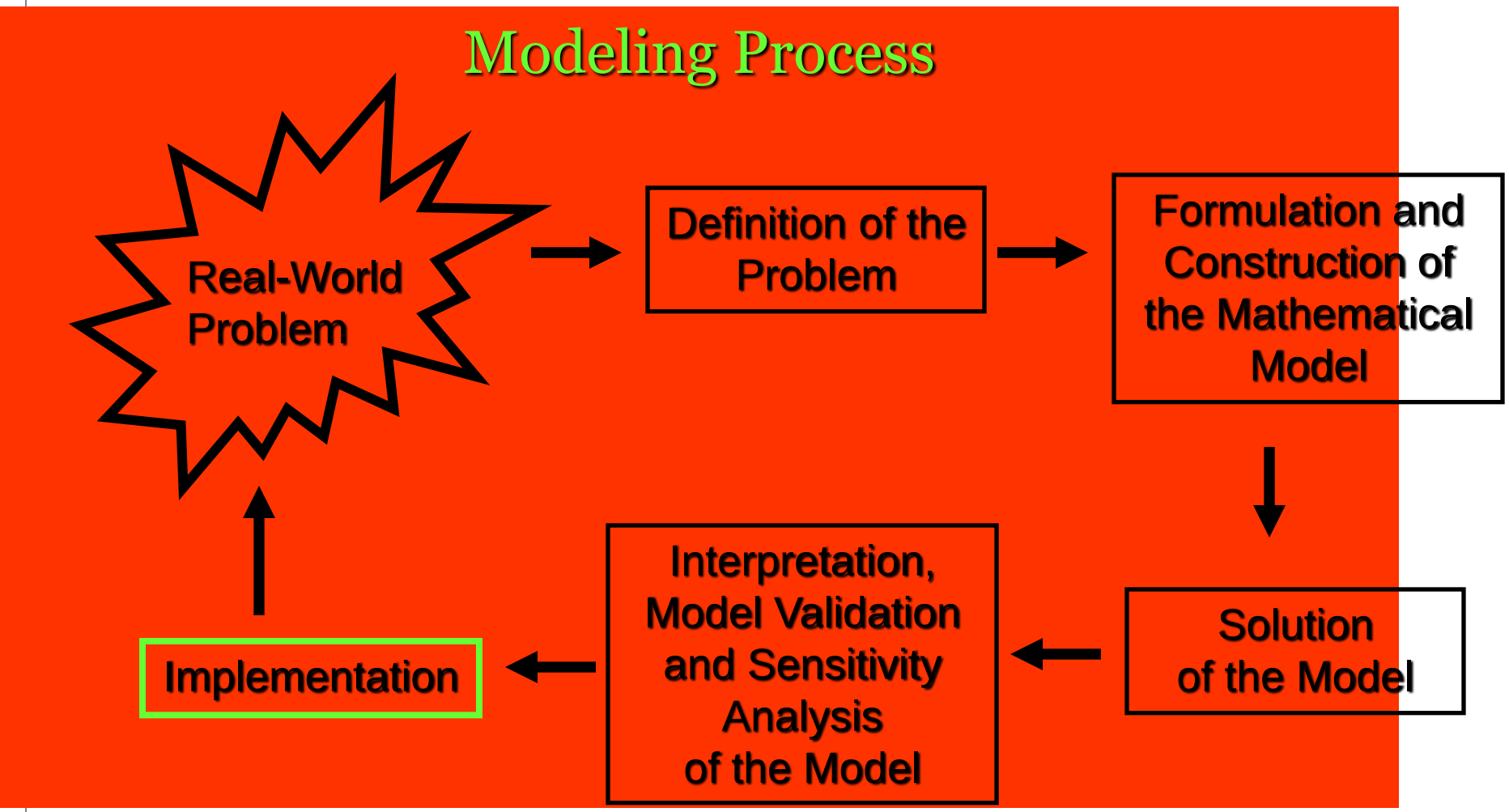
Information System & DSS

- People in ***information systems*** and ***decision support systems*** use artificial intelligence techniques, propositional and quantified logic, probabilistic logic, data structures and other computer science techniques, mathematical programming, and statistical decision theory to:
  - Design expert and other knowledge-based systems,
  - Develop efficient inference and retrieval methods, and
  - Evaluate the economic and organizational effects of information systems.

OPERATIONS RESEARCH AND MATHEMATICAL MODELING

- The distinguishing features of operations research are its uses of the applications of mathematics to real-life situations.
  - This is the process of ***mathematical modeling***.
- By this we mean the process of translating a real problem from initial context into a mathematical description, which is the mathematical model.
- That is, Operations Research links mathematics with social sciences.
- *This mathematical problem is then solved, and the resulting mathematical solution must be translated back into original context.*

Modeling Process



Models and Modeling in Operations Research

- Both simple and complex systems can easily be studied by concentrating on some portion or key features instead of concentrating on every detail of it.

- This approximation or abstraction, maintaining only the essential elements of the system, which may be constructed in various forms by establishing relationships among specified variables and parameters of the system, is called a model.

- In general, models attempt to describe the essence of a situation or activity by abstracting from reality so that the decision- maker can study the relationship among relevant variables in isolation.

- Models do not, and cannot, represent every aspect of reality because of the innumerable and changing characteristics of the real life problems to be represented. Instead, they are limited approximation of reality.

- For example, to study the flow of materials through a factory, a scaled diagram on paper showing the factory floor, position of equipment, tools, and workers can be constructed.

- It would not be necessary to give such details as the color of machines, the height of the workers, or the temperature of the building.
- *For a model to be effective, it must be representative of those aspects of reality that are being investigated and have a major impact on the decision situation.*
- **Mention some of the limitations of models?**

A model is constructed to analyze and understand the given system for the purpose of improving its performance. The reliability of the solution obtained from a model depends on the validity of the model in representing the system under study. A model, allows the opportunity to examine the behavioral changes of a system without disturbing the on-going operations.

Note: The key to model building lies in abstracting only the relevant variables that affect the criteria of the measures of performance of the given system and expressing the relationship in a suitable form. But oversimplification of problem can lead to a poor decision. Model enrichment is accomplished through the process of changing constants in to variables, adding variables, relaxing linear and other assumptions, and including randomness.

Classification of OR Model

- Model can be in the form of a graph or chart, but most frequently an OR model consist of a set of mathematical relationships. These mathematical relationships are made up of numbers and symbols.

- There are many ways to classify models:

Classification based on structure

a) Physical (Iconic) Models:

These models provide a physical appearance of the real object under study either reduced in size or scaled up. Physical models are useful only in design problems because they are easy to observe, build, and describe. It is also called static model.

E.g. the structure of atom , model of an airplane, photograph of a machine, layout drawing of a factory and glob. Since these models can not be manipulated and are not very useful for prediction, problems such as portfolio analysis selection, media selection, production scheduling, etc cannot be analyzed by physical models.

b) Analogue Models:

These are abstract models mostly showing inter and intra relationships between two or more parameters. For instance; histogram, frequency table, cause-effect diagram, flow charts, Gantt charts, price-demand graph, world map, organizational chart and others.

b) **Symbolic models:**

These models use symbols (letters, numbers) and functions to represent variables and their relationships to describe the properties of the system. It can be classified as verbal and mathematical models. E.g. Max.Z= 300x+2500y

Advantage of Models

Models in general are used as an aid for analyzing complex problems. In addition to this, a model can also serve as:

i) A model provides economy in representation of the realities of the system. That is, models help decision makers to visualize a system so that he/she can understand the system's structure or operation in a better any. For example, it easier to represent a factory lay out on paper than to construct it. It is cheaper to try out modifications of such systems by rearrangement on paper.

ii) The problem can be viewed in its entirety, with all the components being considered simultaneously.

iii) Models serve as aids to transmit ideas and visualization among people in the organization. For example, process chart can help the management to communicate about better work methods to workers.

iv) A model allows us to analyze and experiment in a complex situation to a degree that would be impossible in the actual system and its environment. For example, the experimental firing of satellite may be costly and require years of preparation.

v) Models simplify the investigation considerably and provide a powerful and flexible for predicting the future state of the process or system.

Identification & Definition of the Problem

➢From the viewpoint of operations research, this indicates three major aspects. They are:

a) An exact description of the goal or the objective of the study

b) Variables/decision alternatives of the system

c) A recognition of the limitations, restrictions, and requirements of the system

The Methodology of OR

- When OR is used to solve a problem of an organization, the following step /procedures would be followed:

Step-1 Formulate the Problem

- OR analyst first defines the organization's problem.
- Defining the problem includes specifying the organization's objectives and the parts of the organization (or system) that must be studied before the problem can be solved.

Step-2 Observe the System

- Next, the analyst collects data to estimate the values of parameters that affect the organization's problem.
- These estimates are used to develop (in the next step) and evaluate (in further step) a mathematical model of the organization's problem.

Step-3 Formulate a Mathematical Model of the Problem

- The analyst, then, develops a mathematical model (in other words an idealized representation) of the problem.

Step-4 Verify the Model and Use the Model for Prediction

- The analyst now tries to determine if the mathematical model developed is an accurate representation of reality.
- To determine how well the model fits the reality, one determines how valid the model is for the current situation.

Step-5 Select a Suitable Alternative

- Given a model and a set of alternatives, the analyst chooses the alternative (if there is one) that best meets the organization's objectives.
- Sometimes the set of alternatives is subject to certain restrictions and constraints.
- In many situations, the best alternative may be impossible or too costly to determine.

Step-6 Present the Results and Conclusions of the Study

- In this step, the analyst presents the model and the recommendations from to the decision making individual or group.
- In some situations, one might present several alternatives and let the organization choose/the decision maker(s) choose the one that best meets her/his/their needs.
- After presenting the results of the OR study to the decision maker(s), the analyst may find that s/he does not (or they do not) approve of the recommendations.
  - This may result from incorrect definition of the problem on hand or from failure to involve decision maker(s) from the start of the project.

Step-7 Implement and Evaluate Recommendation

- If the decision maker(s) has accepted the study, the analyst aids in implementing the recommendations.
- The system must be constantly monitored (and updated dynamically as the environment changes) to ensure that the recommendations are enabling decision maker(s) to meet her/his/their objectives.

Benefits of OR Model

- ✓ Provides a frame of reference for considering problem confronting
- ✓ Cost and time point of view
- ✓ Advantage of the manipulative facility of mathematics
- ✓ To predict based upon past or present information
- ✓ Difficult to cheat conclusion with mathematical model

Benefits may not be always achieved:

- ✓ Inaccurate, incomplete or biased data
- ✓ Wrong choice of model
- ✓ Inaccurate or incomplete specification of variable
- ✓ Poor interpretation and/or implementation of results

Otherwise the power of mathematical modeling (in O/R) to ensure efficient utilization of finance, time, labor and materials is well noticeable in any organization.

END OF CHAPTER ONE