

Achievement of Sustainable Development and the Best Strategic-Operational Management through Operations Research Techniques

Mozhgan Khodaparast Kazerooni^{*1}, Mostafa alahverdi²

¹PhD Student, Environmental Engineering (Energy Systems Engineering, Energy and Environment) & DBA Student of Management, University of Tehran, Tehran, Iran.

Corresponding Author- Email: khodaparastmozhgan@gmail.com

² Master of Marine Pollution, Kazeroon, Iran.

Abstract

Achieving the ultimate goal is central to all organizations and, consequently, holds fundamental importance in their governance. Good governance within organizations lays the foundation for achieving organizational goals ethically, effectively, and responsibly, aligning with stakeholder expectations. The implementation and execution of good governance are based on leadership, values, and a framework of mechanisms, processes, and structures appropriate to the organization's internal and external context. Through good governance, sustainable development can be achieved via "poverty reduction, job creation and sustainable prosperity, environmental protection and regeneration, and growth and development." The greedy exploitation of natural resources by humans over the past few decades has created deplorable conditions in many regions worldwide, the adverse consequences of which have affected all societies, both developed and developing. Sustainable development has been proposed by scientists and is widely monitored by governments and international institutions to address the economic, environmental, and social problems of today's world. The present study, considering decision-making as a significant management task, examines the application of scientific methods and operations research techniques, given their exceptional ability to formulate and solve organizational problems. This helps managers in their decision-making role, enabling the analysis and resolution of management problems and decisions to achieve sustainable development across all industries and activities. The aim is to create the best strategic-operational management system in various organizations, especially in the oil, gas, and petrochemical industries, to meet present needs optimally without compromising the needs of future generations and while addressing all organizational limitations, alongside industrial growth and development.

Keywords: Operations research, Management, Sustainable development.

Introduction

In 1987, the World Commission on Environment and Development (WCED), also known as the Brundtland Commission, was convened to focus on global cooperation in development issues. It was during this time that the term "sustainable development" and its official definition were first introduced. According to the Commission's definition, sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [1]. Sustainable development involves integrating economic, social, and environmental goals to maximize the well-being of current human populations without jeopardizing the capacity of future generations to meet their own needs [2, 3]. Two key concepts within this definition are the satisfaction of needs, particularly the essential and vital needs of impoverished nations, and the concept of limits to growth, which is contingent on the social scale and the level of technology governments possess to balance present and future needs.

Development should, in principle, demonstrate that the social system as a whole, in harmony with the diverse basic needs and demands of individuals and social groups within the system, transitions from an undesirable past state of life towards an improved state in both material and spiritual aspects [4]. Implementing sustainable development necessitates decision-making, intervention, and guidance from social institutions. It is important to

note that a significant challenge organizations face is making accurate and rational decisions at various stages of their operations. The importance of this is so profound that Herbert Simon, a prominent scholar in management science, considered management synonymous with decision-making. Indeed, it is sound or flawed decision-making that determines an organization's survival or demise and shapes its future in today's world. Strategic planning is not an end in itself but rather a process that identifies an organization's current position and desired future state, subsequently defining its objectives and outlining the path to achieve them. The documentation resulting from this process is termed the "strategic plan of the organization" [5].

The present study seeks to apply operations research techniques as one of the most effective management tools in this context. It is worth noting that operations research is founded on a combination of various disciplines (such as mathematics, statistics, economics, engineering, etc.), and given that management science is also an interdisciplinary field, management and operations research are closely related.

Research Background

Operations research as a field of study was developed and expanded by British scientists during World War II. The British wartime administration tasked a group of scientists specializing in tactical and strategic issues related to air and ground defense with conducting research in this area. The primary reason for undertaking such studies was the scarcity of resources and the constraints of the military budget. Consequently, it became essential to examine and determine how to utilize military resources effectively and to their fullest potential. The significant results obtained from operations research by the British team quickly motivated the United States military administration to engage in similar activities. Subsequently, comparable operations research groups began functioning in other nations, including Canada and France. Following the war, the success of these military groups garnered the attention of industrial managers. Numerous experts, including industrial and economic consultants who had collaborated with the operations research groups during the war, gradually recognized that the underlying principles of industrial and economic problems were similar to those of military problems, with only the context differing. Thus, operations research began to serve industry, economics, and governmental operations [6]. The earliest adopters of operations research methods were large institutions and corporations, such as oil companies, as initially only these entities possessed the financial capacity to employ these techniques. Later, with increased awareness of operations research problems and methodologies, smaller companies were able to leverage this field to address their challenges without incurring significant costs, leading to its widespread use today by numerous service, healthcare, governmental, and educational organizations [7].

Methods

Given that every system is a unified entity, it must possess a purpose, mission, and function. The function of a system is rooted in its need for survival and serves to answer the question of what the system aims to achieve. For instance, in the private sector, the function of a production system typically involves creating opportunities: firstly, to produce goods and services required by society; secondly, to secure a reasonable return on investment for shareholders; and thirdly, to generate employment for the populace. Therefore, realizing the system's function necessitates establishing goals and defining the objectives towards which the system's operations should be oriented. The potential for modeling and employing mathematical models and techniques in addressing scientific decision-making problems can only be fully realized through the application of operations research [8]. Various methods of operations research are outlined below [9].

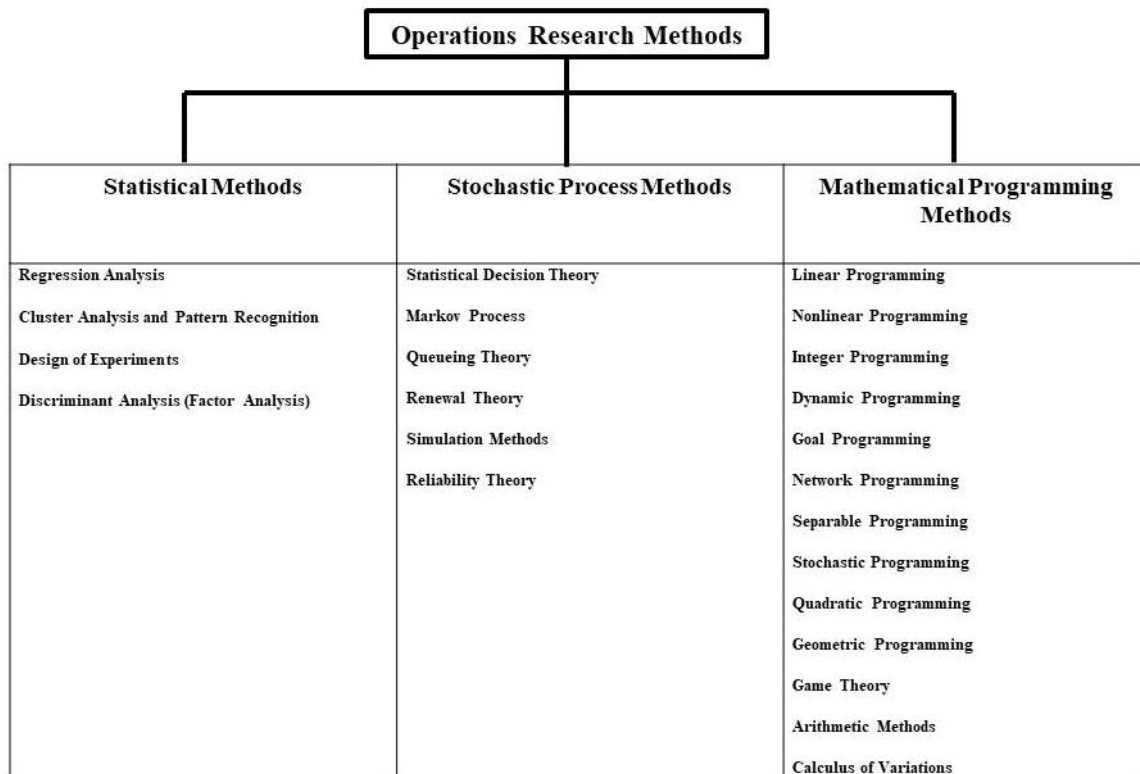


Figure 1: Operations Research Methods

The intricate and complex problems frequently encountered in operations research necessitate exceptionally extensive calculations. Often, these computations cannot be executed manually. The progress in computer technology in the contemporary era has yielded computational capabilities millions of times faster than manual approaches.

The advancement of computers has facilitated the development of software designed for solving complex operations research problems. While only a limited number of software packages were available in 1984, it is noteworthy that the current number of effective operations research software exceeds 100. The accelerating growth of operations research software has enabled operations research techniques to become more aligned with practical application than theoretical considerations, and their scope has broadened to encompass commercial and industrial organizations. The most prominent practical and professional software include LINDO, GAMS, and LINGO; however, it is crucial to recognize that the utilization of these software alone does not ensure the attainment of sound management decisions. Consequently, to gain a deeper understanding of the implementation of these mathematical techniques in management, the fundamental concepts and essential elements required for applying this methodology will be discussed in the subsequent sections.

1. Definition of Operations Research

Operations research encompasses multiple definitions, often varying based on its diverse users. This field has been defined by various individuals according to its application within organizations, with the most prominent definitions being as follows:

1. Operations research is a collection of scientific and technical methods employed to identify problems within a system and to pursue optimal solutions to these problems.
2. Operations research involves the application of scientific methods to examine and analyze intricate activities and operations within large organizations.

Perhaps the most significant definition of operations research can be articulated as follows: “The application of the scientific method to analyze and resolve management problems and decisions” [6].

2. Characteristics of Operations Research

The most significant characteristics of operations research encompass the following:

1. The primary emphasis of operations research lies in managerial decision-making.
2. The operations research approach employs a scientific methodology.
3. In operations research, problems and decisions are analyzed from a systemic viewpoint.
4. The field of operations research integrates several independent disciplines. In other words, operations research represents interdisciplinary knowledge.
5. Mathematical models are utilized in operations research.
6. Computers are employed extensively in operations research.

3. The Operations Research Approach to Problem Solving

A primary characteristic of operations research and its techniques is the emphasis on a systematic and logical methodology for problem-solving. It is due to this characteristic that these techniques are presented within the framework of the "scientific method." This approach, as illustrated in Figure 2, encompasses the following steps:

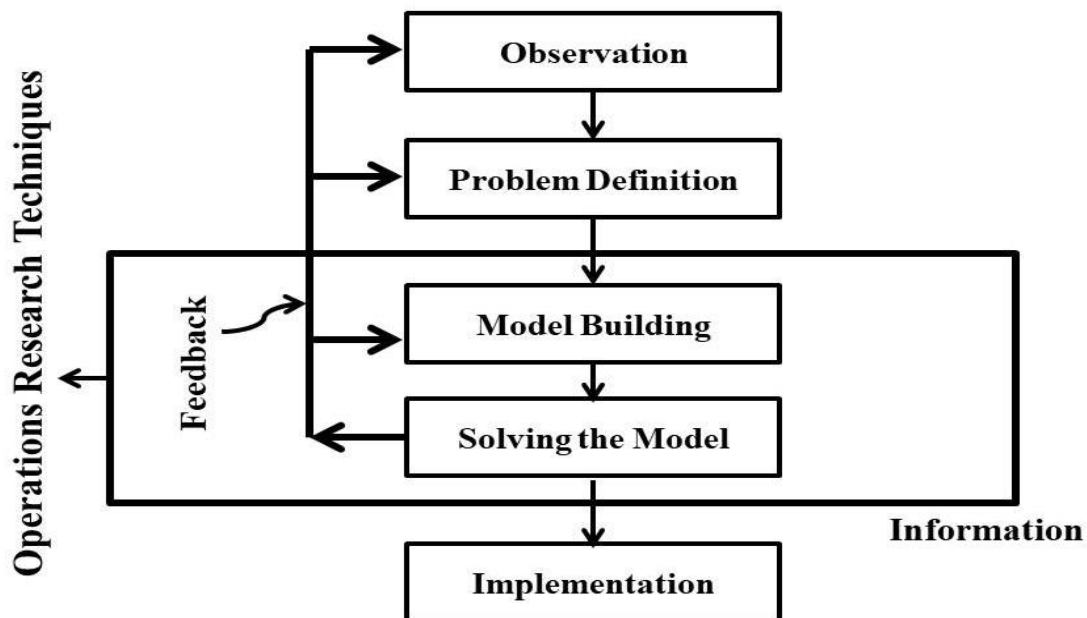


Figure 2: Problem-Solving Process in Operations Research

We will now examine the implementation and analysis of each of the aforementioned five steps:

3.1. Observation

The initial step in the operations research process is to define the problem existing within the system or organization. Every system or organization is continually subject to issues and challenges that impede its ability to achieve its objectives. The manager should either personally or through experts "observe" the organizational factors and their interactive relationships to conduct an organizational "diagnosis" and define the problem. Numerous organizations attempt to engage external consultants in addition to internal diagnostic teams. External consultants can assist in identifying and defining many problems that are considered intrinsic to operations by

individuals within the organization. The collective efforts of managers and consulting groups within the organization are directed towards identifying the problem based on observations of the operational processes within the organization and its environment.

3.2. Problem Definition

Once a problem within the organization is identified, it must be defined with precision and clarity. An inaccurate and ambiguous definition can lead to oversimplification and an unsuitable solution. Therefore, "specifying" the problem and the extent to which it can impact the performance of organizational units are crucial for its definition. Given that the presence of a problem will hinder the effective attainment of organizational goals, it is necessary to define the method for achieving these goals and objectives. Focusing on the goal ensures that attention is directed towards the true nature of the problem.

3.3. Model Building

In operations research, a model serves as a concise and abstract representation of a problem in the real-world and organizational context. While a model can be depicted as a figure or diagram, it frequently comprises a set of mathematical relationships. These mathematical relationships within an operations research model consist of numbers and symbols. An equation is generally recognized as a "functional relationship" or simply a "relationship." These equations involve dependent and independent variables, with their coefficients termed "parameters." However, the objective function does not fully encapsulate the problem's complexity, and organizational constraints necessitate the definition of additional relationships beyond the objective function. The manager must verify that the constructed model accurately reflects the actual behavior of the system or organization.

3.4. Solving the Model

A problem formulated as an operations research model must be solved using appropriate operations research techniques. Each technique is designed to solve a specific type of model; thus, the model type and the solution technique constitute distinct aspects of operations research. It is important to note that the value of a decision variable does not represent the manager's final decision but rather provides "information" to aid in making that decision. Therefore, this information represents data processed by the solved model.

3.5. Implementing Results

The problem-solving techniques in operations research furnish information that assists managers in making more informed decisions. However, managers should not apply the results derived from model solutions without careful managerial consideration and reflection. In reaching the final decision, managers should integrate the information obtained from the model with their own expertise and the insights of consultants. If a manager disregards the information yielded by solving the model using operations research techniques, they effectively negate all the steps undertaken in the scientific operations research process. A scientific study holds limited value until its implementation. The true worth of the scientific study process lies in its impact on the performance of the system under investigation.

3.6. Repeatability of the Operations Research Process

Completing the five stages of the operations research process does not inherently signify the completion of the process. Revisions may be necessary at any point during model construction, solution, and implementation. For instance, in numerous instances, a new facet of the problem may emerge during model development, or a need to alter the model structure or problem definition may arise during the model solving or implementation phase. Consequently, the requirement for "feedback" becomes essential at each stage. Furthermore, new information acquired from the environment and the organization's future trajectory can significantly influence the problem's structure and the model. Therefore, as time progresses and the problem's scope becomes clearer, the operations research process is reiterated. The notion that "there is only one model and one solution for a problem and nothing else" is thus refuted, and the model must be continually revised and reconstructed. Revision at each stage of the operations research process is achieved through the incorporation of "feedback" within the system

or process. Based on Figure 2, it can be observed that the collection of model construction and solution techniques is termed operations research techniques. The outcome of these techniques is information, which serves as the basis for final managerial decision-making.

4. Scope of Operations Research

The complexity and volatility of the organizational environment have complicated managerial decision-making. Managers contend with numerous constraints, including limitations in resources, energy, human capital, materials, and finances, when striving to achieve specific objectives. The primary goal for most managers and organizations is to attain greater profitability, or in other words, to maximize profits. Additionally, some organizations aim to minimize their expenditures and waste. Research indicates that the degree to which operations research models are utilized varies based on the mathematical sophistication of the model and the quantity of data it employs. Given the computational nature of this field, operations research is closely linked to computer science, and operations research analysts typically employ proprietary software or code developed internally or by colleagues. Commercial operations research software is commonly referred to as problem-solving tools and can be integrated into existing software and custom-written code. Operations research analysts frequently encounter novel problems and must ascertain which methodologies best align with the system architecture, improvement targets, and temporal and computational limitations. Consequently, the role of human expertise in operations research is paramount. Similar to other analytical tools, operations research techniques alone are insufficient to resolve problems.

Operations research problems center on maximization (e.g., profit, production line speed, increased output) or minimization (e.g., reduced cost, less waste, and risk mitigation) under one or more constraints. Operations research involves the pursuit of the optimal solution to intricate problems modeled in mathematical terms to enhance or optimize system performance [10].

In essence, operations research can be defined as the art of optimization, that is, the skill of determining the minimum or maximum of objective functions, to the extent that it can be considered the art of formulating objective functions. From an organizational perspective, operations research assists management in achieving its objectives through the application of the scientific process and in pursuit of sustainable development [11]. Occasionally, to address multifaceted problems involving multiple stages and temporal dependencies, these problems are broken down into smaller, sequential sub-problems. At times, several objectives must be optimized concurrently, necessitating a balance between these diverse objectives. Therefore, the accurate identification and application of operations research methods are essential for achieving optimal management practices in the pursuit of sustainable development.

Results and Discussion

Development is a dynamic, comprehensive, and multidimensional phenomenon that has preoccupied numerous planners, statesmen, policymakers, researchers, and experts, with the aim of improving living conditions, enhancing human capabilities, expanding opportunities, and benefiting humanity [12]. Unbalanced industrial development has exposed the world to various problems, threats, and challenges, including poverty and hunger, increasing inequality within and between nations, marginalization, youth unemployment, health crises, escalating violence and terrorism, the exploitation of natural resources, and widespread environmental degradation. These existing challenges underscore the fact that without due consideration for sustainable development, nations cannot maintain a healthy and optimal existence [13].

Undeniably, in the current century, we are confronted with problems of considerable complexity, and the disparity between the intricacy of these issues and human capacity appears to be widening. Consequently, addressing these problems necessitates appropriate knowledge, theories, methodologies, and tools. To this end, academic endeavors and collaborations across the natural, social, human, and engineering sciences are increasingly vital [14]. Daily, new national, regional, and international regulations are enacted; new opportunities, needs, crimes, and demands emerge; and new technologies are unveiled. Evaluating and examining such intricate systems is undoubtedly challenging. Furthermore, the unpredictable nature of the future and pervasive uncertainty in the environment necessitate that decision-makers possess a framework and

methodology for making informed decisions, a capacity inherent in the field of operations research [15]. Operations research presents a suitable approach applicable not only to technical domains but also to social sciences [14]. Traditional models often lack the capacity to effectively address multiple criteria in optimization problems, a significant factor contributing to their inefficiency in resolving sustainable development challenges.

For any problem confronting humanity, the managerial perspective encompasses the past, present, and future, as well as both long-term and short-term considerations, involving numerous interrelated decision variables. The future remains unpredictable, its assessment is fraught with chaos and potential catastrophe, its structures are discrete and variable, its innovations are unforeseen, and new agents can emerge at any time [16]. Analogous to how physics models phenomena in the natural world, operations research models human systems. Operations research is poised to play a crucial role in this domain in the future, as human systems, particularly social and economic systems, are becoming increasingly intricate [15]. It is important to note that effective management and planning for sustainable development necessitate the integrated application of the three dimensions—environment, society, and economy—within the framework of operations research.

Findings

Considering the variations among countries in their development status, political systems, available resources, and demographic attributes, the strategic goal mapping of an organization in one nation will differ from that of a comparable organization in another. Consequently, devising a framework illustrating the interrelationships between goals is essential for development policymaking at both national and organizational levels. A significant challenge for experts lies in developing methodologies capable of simultaneously addressing the complexities, uncertainties, diverse values, and political ramifications inherent in such contexts. Thus, multi-criteria decision-making within operations research can function as a mechanism for integrating disparate scientific perspectives within a public choice framework—a valuable tool that incorporates ethical considerations and the concern of a civilized society for the welfare of future generations into its modeling processes.

Suggestions

With the advancement of technology and the readily available and rapid access to information via computers and information transmission networks, the utilization of information in decision-making has assumed new significance. A discipline that has proven instrumental in this domain is operations research, a field that employs a range of models and techniques to support managerial decision-making.

It is proposed that operations research be leveraged to design a systematized framework, facilitated by information technology, for informed decision-making aimed at achieving sustainable development and the optimal allocation of resources across various systems and organizations. This framework would serve to provide logical underpinnings for decision-making by seeking to comprehend and structure complex conditions, and by utilizing this understanding to forecast system behavior and enhance system performance.

Consequently, it is recommended that this body of knowledge be applied to analyze intricate conditions and to make judicious and optimal decisions that foster organizational excellence and growth in accordance with the principles of sustainable development.

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