International Journal of Information Systems and Project Management (IJISPM)
2025, 13(3), e130304, DOI: 10.12821/ijispm130304

RESEARCH ARTICLE

# A decision support process for the selection of sustainable public ICT project investments

**Muhammed Rasit Ozdas**
Gazi University, Ankara, Türkiye,
muhammedrasit.ozdas@gazi.edu.tr

**Ozel Sebetci**
Aydin Adnan Menderes University,
Aydin, Türkiye, osebetci@adu.edu.tr

**Tamer Eren**
Kirikkale University, Kirikkale,
Türkiye, tamereren@gmail.com

**Hadi Gokcen**
Gazi University, Ankara, Türkiye,
hgokcen@gazi.edu.tr

**Abstract**

The allocation of limited public resources to public investments necessitates selecting projects with the highest social and economic value, along with the greatest likelihood of success. However, the literature lacks well-defined criteria to measure the alignment of such projects with national policies, social benefits, and institutional capabilities. This paper aims to fill this gap by presenting a process methodology and a set of criteria for evaluating and prioritizing public sector information and communication technologies (ICT) projects. A project selection process is defined with a comprehensive criteria set, and it was tested on 11 carefully selected information and communication technology projects. A process has been defined consisting of prerequisite elimination, criteria weighting, project scoring, and verification. Both AHP and TOPSIS methods were utilized. The study also attempts to measure social benefits with respect to Türkiye's national priorities, through more tangible sub-criteria. To the best of our available knowledge, the study provides the most comprehensive set of criteria for selecting ICT investment projects in the public sector. The findings reveal that projects aligned with national priorities and providing high social benefits were ranked highest. The fact that project criteria provide feedback from a broad perspective shows that information systems can also support project maturation, along with project selection.

**Keywords**

public investment projects; decision support systems; project selection; project success; multi-criteria decision-making.

Received: 29 June 2024 | Accepted: 22 November 2024

## 1. Introduction

A key responsibility of the public sector is to enhance citizens' welfare by allocating limited national resources to areas that maximize social benefits while minimizing risks. This is a challenging task that has led to numerous qualitative and quantitative studies (PSB, 2020c, p. 1). The public sector tries to fulfill its mission through different tools such as investments, taxation, regulation, auditing, and incentives. Among these, public investment stands out as a significant specialized instrument. Among public investment projects, information and communication technologies (ICT) projects offer high added value and have a multiplier effect on other sectors. Due to limited resources for public investments, institutions must select ICT projects that maximize value while minimizing budget requirements.

In national-scale projects, a wide variety of criteria exist, such as the conformity of the project with national objectives, its social benefits, the capabilities of the executing organization, and its financial feasibility. Often, a choice has to be made between conflicting criteria. Human intelligence has difficulty in considering many parameters at the same time. Therefore, systematic methodologies are needed to assist decision-makers (Druzdzel & Flynn, 2002, p. 8). In the literature review, no comprehensive and inclusive set of criteria specific to the public sector was identified. This study aims to address this gap in the literature.

A systematic, evidence-based approach to project selection is important for three reasons. It increases the objectivity of the project evaluation process, helps public institutions gain a better understanding of how their proposed projects are assessed, strengthens the overall institutionalization of the project evaluation process. Thus, subjectivity in project evaluations will be reduced, new staff will adapt more easily, and it will become possible to create detailed datasets on projects for future use.

In 2024, the Turkish Government allocated 30.6 Billion Turkish Liras (TL), equivalent to approximately 956 million USD, for ICT investments (PSB, 2023b), representing 3.1% of the 1 Trillion TL total public investment budget. Even minor improvements in the project selection process could lead to substantial benefits. Given that methodology developed for ICT sector can potentially be applied to other sectors as well, the study has a significant potential for financial impact.

In Türkiye, Presidency Office of Strategy and Budget (PSB) is responsible for overseeing the approval process of public investments. Each year, between August and September, public institutions submit the projects they plan to implement in the following year to the PSB. This study focuses on establishing criteria for prioritizing IT projects proposed to PSB in Türkiye. Among multi-criteria decision making methods (MCDM), the Analytic Hierarchy Process (AHP) method is used to form criteria weights. 11 sample projects have been chosen as sample. Experts made pairwise comparisons and scored projects according to criteria. TOPSIS method is used to rank the projects. But simply scoring categories of criteria and creating a static final ranking would not suffice for the evaluation of the social impact, organizational adequacy, etc. Hence, a decision support model (DSM) and a decision support system (DSS) is provided to experts, allowing them to dynamically activate-deactivate various criteria groups and observe changes in project rankings.

The main structure of the study is as follows. The second section provides information on public investment projects and their evaluation processes in Türkiye, which is essential for understanding the general framework in which the study is applied. The third section presents a literature review. The methodology used in the study is explained in the fourth section. The fifth section covers the application according to the methodology. The study concludes with a discussion and summary of the results.

## 2. Background

The public sector holds a significant position in a country's economy due to its substantial financial power (Rosen, 2005; Şeker, 2019, p. 19). According to the OECD, infrastructure investments that provide benefits for more than one year are classified as public investments (OECD, 2014). As part of public expenditures, investments have a longer-term impact on the national economy compared to other types of spending. Public investment is viewed as a policy tool to ensure economic growth, innovation and prosperity (OECD, 2016, p. 12). It is one of the most important tools governments use to implement economic and social policies (Çetin, 2019, pp. 6–7) and is a key factor in increasing gross national product (Masten & Grdović Gnip, 2019, p. 1179). Public sector investments differ from private sector investments in terms of considerations related to social benefits.

Public investments are executed as projects. According to the Project Management Institute (PMI), a project, in general terms, is a set of activities with a certain budget, predetermined start and end dates, and defined operations and processes in order to create a product, service or benefit (PMI, 2009). The European Commission defines a project as a set of activities aimed at achieving clearly defined objectives within a certain period and with a certain budget (European Commission, 2014).

Budgets are allocated for the implementation of projects. In situations where a limited budget must be allocated to a large number of projects, it is important to select the projects with the highest added value. Unlike the private sector, which generally focuses on a few objectives, many goals coexist in the public sector (Şeker, 2019, p. 64). These may include the quality of service provided to citizens, support for disadvantaged groups, and strategic benefits, among others.

The approach to assessing social benefits in public investment projects has evolved over time. Project analysis in public investments began to gain prominence globally during the 1960-1970 period. However, in the 1970s, development aspects beyond economic growth, such as income distribution, became important. It was also recognized during this time that improving income distribution was a challenging task (DPT, 2001, pp. 4–5). This shift marked a significant milestone in project evaluation. In this period, both social and economic dimensions began to be considered. Social benefit is multifaceted, and the target audience can be any segment of society. Therefore, the criteria's adequacy is crucial for effective project evaluation. Social benefits are also directly related to the structure and priorities of a nation.

ICT investments hold a special place within public investments. In addition to being a sector that contributes to the economy, the ICT sector also creates a leverage effect on other sectors. Since the early 2000s, organizations have regarded ICT investments as important tools for enhancing efficiency and effectiveness (Gunasekaran et al., 2001).

To date, the project selection literature has developed and diversified across a broad spectrum. One possible reason for this that the issue of project selection arises in every aspect of life. Another reason could be that different sectors and conditions require different methods. Two main areas stand out in the literature on project selection: some studies focus on pairwise comparisons of projects, while others deal with the overall portfolio management. While both areas are important, this study focuses on project comparisons, a prerequisite for effective portfolio management.

## 3. Literature review

In the 1960s, Türkiye entered what is known as the "planned period". In this period, development plans became central to the national development goals. Public investments also began to be addressed within this broader framework (PSB, 2020b). The preparation of national plans and the approval processes for public investments are both coordinated by the PSB. Basic principles and guidelines for the selection and prioritization of projects have been established by the PSB (PSB, 2020a). Principles regarding public ICT investments are also prepared and updated annually by the PSB. The principles provide information on which projects will be prioritized in the ICT sector (PSB, 2022). However, the list of priorities and conditions is not concrete enough to be converted into objective criteria that can be consistently followed by each expert at the PSB and considered by institutions preparing project proposals. Therefore, although the existing policies and principles are instructive, they currently do not provide a systematic methodology.

In addition to Türkiye, many other countries have faced challenges in evaluating public sector projects, particularly balancing financial constraints with social benefits. For example, in Trinidad and Tobago, Benjamin (1985) applied goal programming to select energy sector projects, emphasizing the importance of minimizing risks while maximizing long-term social benefits. Similarly, in the European Union, the OECD (2016) developed a framework for public infrastructure investments, which integrates sustainability and social impact considerations into project evaluations. These examples illustrate the global relevance of MCDM methods for addressing the complex nature of public investments.

Methods for prioritizing projects are divided into financial and non-financial methods (Gray & Larson, 2018). While financial analysis is also important in public sector projects, the main determinant remains social benefit. Hence, there is a need for an analysis that covers, but goes beyond, financial cost-benefit analysis. It is also important to note that many public services have no alternatives (non-rivalry) and, in most cases, beneficiaries cannot be identified (non-excludability) (McNutt, 1999). These characteristics also make a pure financial analysis inadequate.

Mathematical models are also widely used within the project selection literature. However, these methods require both complex implementation processes and robust datasets (C.-T. Chen & Cheng, 2009). Although ICT projects share many similarities with projects in other sectors, they also have their distinctive features. It has been observed that technical factors alone are not sufficient for ICT success today and that behavioral, political, and other institutional factors have become more critical for organizations (Ragowsky et al., 1996).

Project prioritization involves multiple criteria and factors. A ‘criterion’ refers to any principle or standard used in evaluation, while a ‘factor’ refers to any situation, condition or influence that contributes to an outcome (Lim & Mohamed, 1999). While “criteria” are emphasized in the evaluation of projects, “factors” that affect outcomes are considered in predicting the success of projects. Since there is an evaluation of the projects within the scope of the research, the selection of criteria becomes crucial.

Since project selection problems are inherently multi-criteria and conflicting criteria often co-exist, MCDM methods are extensively used in this field. In multi-criteria selection problems, a solution that ideally satisfies all criteria is usually not possible (Ishizaka & Nemery, 2013, pp. 1–2). Therefore, the focus is on solutions that closely approximate the ideal. To date, many MCDM methods have been developed and new methods continue to be introduced (Wallenius et al., 2008). While there are examples of using a single selection method, it is also common to combine multiple methods.

Souza et al. (2021) conducted a study that focused on R&D projects. In their study, they examined the frequency of use of MCDM methods that have been used since 1970. They found that the most commonly used single method is AHP and its variations, followed by ANP and real option analysis (ROA). It was also revealed that in studies where more than one method was used together, AHP and data envelopment analysis (DEA), as well as TOPSIS and DEMATEL, were often combined. In the literature, AHP and TOPSIS methods have been applied together in various scenarios for project selection. These include the utilization of fuzzy AHP and TOPSIS methods for project selection in general (Han et al., 2019), the application of fuzzy AHP and fuzzy TOPSIS methods together in the selection of construction projects (Taylan et al., 2014), general-purpose project selection (Mahmoodzadeh et al., 2007), utilizing fuzzy AHP and fuzzy TOPSIS methods for risk prioritization and selection of contractor participation in public-private partnership projects using a case study (Jokar et al., 2020), using AHP and TOPSIS for selecting eligible economy actors for call for grants (Chrit et al., 2022), and project selection for oil fields (Amiri, 2010). In these examples, AHP is generally used to determine criteria weights, while TOPSIS is used to rank alternatives. Triantaphyllou et al. (1994) note risk of inconsistency and calculation complexity in fuzzy methods, especially those utilizing large criteria sets. Although fuzzy methods are utilized to tackle uncertainty, this is not the case in public investment projects in Türkiye, because uncertainty in planning phase results in project rejection and subsequent maturation by the proposing institution. In addition to clarifying the methods used in project selection, it is also necessary to determine the set of criteria to be used. The first step of the literature review in this context is undoubtedly the identification of the criteria currently used in the selection of public ICT investment projects in Türkiye.

The hierarchical criteria structure of AHP makes issues more understandable. Inconsistency ratio aspect of the method increases trust and objectivity (Saaty, 1980). On the other hand, as in all pairwise comparison methods, utilizing methods such as AHP involve partial subjectivity (Dong et al., 2010). TOPSIS is easy and flexible to implement (Hwang & Yoon, 1981). Chen (2010) states that both methods assume independence of criteria, which is hard to achieve, especially in large criteria sets, but combining them balances such disadvantages to some extent. Similarly, Sharma et al. (2020) found that combining these two methods yielded better results instead of using only AHP, and increased trust.

According to the Investment Program Preparation Guide prepared by PSB (PSB, 2023a), public investment projects, regardless of sector, must align with key national policy documents and institutional strategic plans, include adequate social benefit analysis, be completed within a reasonable timeframe, and support private sector investments. In addition to the general criteria, PSB also defines specific criteria for the ICT sector (PSB, 2022). Some of these criteria relate to technology dependency. These include preventing contractor or technology dependency, reducing foreign dependency by using domestic capabilities, and avoiding product or platform dependency. In addition, it should centrally address the need for information system infrastructure, ensure interoperability and data sharing, effectively utilize human resources, and consider the total cost of ownership. Some of these criteria are critical for successful completion of any project. Therefore, they can also be considered prerequisites for the project evaluation process.

In addition to the criteria taken into account in the current processes in Türkiye, it is also important to consider the criteria of organizations such as the OECD, IMF, and World Bank. Including the approaches of these organizations is crucial due to joint projects and Türkiye's participation in international agreements. The OECD Development Support Committee developed a project evaluation approach in 1991, which included the criteria of relevance, effectiveness, impact, and sustainability. This categorization is still widely used by many international organizations, particularly the European Union (Çelik, 2010, pp. 51–55). While the International Monetary Fund (IMF) considers the cost-benefit ratio as the primary parameter for selecting public investment projects, it also emphasizes the efficiency of investments (IMF, 2015). Although these criteria are comprehensive, they are often very difficult to measure and quantify. Recently, the focus of international organizations in project selection has shifted towards portfolio management and, more broadly, toward the management of the entire public investment process. In this context, the World Bank's Public Investment Management Reference Guide (Kim et al., 2020) and the IMF's Public Investment Management Assessment (PIMA) framework (IMF, 2022) are two complementary references that provide a framework for the integrity of the public investment process and its integration with national policies. OECD specifically highlights data access and transparency in public policy and public investment (OECD, 2019).

Another important source for determining the criteria set is the existing body of literature. Although the existing literature is extensive, we focused on studies that are relevant from a public sector perspective. Chu et al. (1996) proposed a DSS for project portfolio selection. To prioritize projects, they used criteria such as project cost, implementation time, and probability of project success. In their study, experts scored the likelihood of success. Henriksen and Traynor (1999, p. 164) developed a set of criteria for project prioritization, including factors such as alignment with the duties and objectives of the organization, feasibility of technical requirements, the potential to achieve project goals with available resources, and the economic impact of the project if successful. Sowlati, Paradi, and Suld (2005, p. 1283) proposed a project prioritization approach for information systems projects by using a variety of criteria. These included the reduction of organizational expenditures, the reduction of man/months needed to complete tasks, social benefits that cannot be measured concretely, short project completion times, and the project's contribution to the efficiency of organizational processes. They also considered financial and personnel resources as cost factors.

In the project portfolio literature, understanding the differences between the public and private sectors is crucial. Tregear and Jenkins (2007) examined the key differences these sectors in the construction of project portfolios. They found that public projects are driven by citizen demand, public accountability, political sensitivity, alignment with the overall public ecosystem (such as other ongoing projects), supporting national or institutional standardization, and promoting cultural improvement.

Costantino et al. (2015) proposed an approach to estimate the cumulative predicted success of a project portfolio by using the critical success factors of projects through neural networks. Although project success factors alone are not sufficient for project prioritization, they can be considered complementary elements. They used criteria such as the suitability of the project mission, top management support, consultation with affected parties, personnel capabilities, and the ability to handle unexpected risks. The use of artificial neural networks is only possible when sufficient structural data from previous years is available.

Huang et al. (2008) prioritized publicly funded technology development projects in Taiwan by combining a fuzzy AHP approach with an exact decision matrix approach. The categories they used include technology competitiveness, technology compatibility, economic benefit, social benefit, the quality of the technical plan, and adequacy of resources. Project risk was also analyzed as a separate criterion group, which included technical risk, development risk, and commercial risk.

In Trinidad and Tobago, a small Caribbean country, the goal programming method was applied to select public projects in the energy sector (Benjamin, 1985). Four of the identified priorities also apply to ICT projects: minimizing the number of active projects, promoting long-term economic development, increasing employment, and reducing investment risks.

In their study on the risks of software projects, Keil et al. (1998) identified 11 risk factors. From these, four basic risk categories were identified. These are senior management and end-user support, scope and requirements (project planning), project management success and team competence, and the management of unexpected environmental risks. The first two categories are considered the most critical because they are elements that project managers cannot manage.

Kim and Chang (2013) proposed a methodology for national R&D projects, using criteria such as relevance to government objectives, clarity of project objectives, employment potential, relevance of the technical plan, technical flexibility, domestic substitution potential, and income generation potential.

Karasakal and Aker (2017) combined data envelopment analysis and AHP for R&D projects. The criteria weights were calculated using AHP and added to the model as a regional constraint. Their criteria included the technology used in the project, the appropriateness of the project design, the adequacy of resources and technical team, top management support, and employment generation potential.

Albert Hirschman, one of the founders of development economics, was the first to attempt to make project appraisal a standard practice in the field of development through his work on World Bank projects in the 1960s. Hirschman viewed the influence of politics on project acceptance as inevitable (Hirschman, 2015). Similarly, Turnpenny et al. (2009) examined the political influence on the project selection process and emphasized its importance. Chopra (2015) emphasized the role of political ownership in the implementation of India's social policies.

The selection of criteria in a DSM for project selection is critical. However, the design of the DSS remains the primary factor in enabling experts to benefit from the system. In this context, it is important to incorporate insights from the literature into the methodology. Ghasemzadeh and Archer (2000) argue that a DSS should offer users flexibility in both the choice of methodology and the sequencing of projects. Since "supporting" the user is a key feature of a DSS, a general ranking of projects, as well as specialized rankings according to different categories would support the user, making the methodology adopted in this study a good example of a DSS.

Andersen questioned project planning as an approach (Andersen, 1996) and, along with colleagues, proposed a phased planning approach (Andersen et al., 2009). The observability of immature projects in the design of a DSM allows for multiple stages of maturation rather than a single acceptance-rejection process. The methodology proposed in this study aligns with this approach. Adopting a phased process rather than a single acceptance-rejection method better supports organizations.

## 4. Method

The literature review has shown that project selection is a well-researched field and that MCDM methods are commonly employed. Multiple methods are frequently combined in various phases of project selection. The studies indicate that project prioritization is typically based on a limited number of criteria. It is observed that there are few studies targeting a holistic analysis based on cost-benefit at the national level. This study aims to address the literature gap and the potential for selection of public sector ICT projects.

In the prioritization of projects, some criteria may influence the order of priority of a project, while others may be sufficient for the acceptance or rejection of a project by themselves. For example, a project that is not legally feasible and is unlikely to become feasible in the future will not be implemented even if all other conditions are optimally met. An example of this would be a project falling under the mandate of one public institution while another public institution wants to implement.

Social benefits play a critical role in the evaluation of public ICT projects. Social benefit is directly influenced by trends such as sustainability, resilience, changes in employment regimes, and digital transformation. However it is not possible to quantitatively measure to what extent a project aligns with these trends. Hence, in this study, we developed sub-criteria aimed at quantifying these benefits in a more tangible manner. These sub-criteria were derived from an extensive literature review and expert consultations, focusing on factors such as accessibility improvements, social inclusiveness, and the overall enhancement of public welfare. Each sub-criterion was carefully designed to capture a distinct aspect of social impact that contributes to the broader success of the project.

The selection of social impact sub-criteria was guided by both theoretical and practical considerations. Drawing on models and frameworks from prior public sector evaluations (Henriksen & Traynor, 1999; IMF, 2022; Keil et al., 1998; Kim et al., 2020; OECD, 2016, 2019), we identified key factors such as the number of beneficiaries, enhancements to national security, and employment opportunities. These sub-criteria were selected for their ability to measure tangible outcomes that directly affect citizens. Türkiye's national goals for short and long term also played a key role in the selection of such criteria. Global trends such as cybersecurity and resilience, sustainability, governance-focused public administration, digital transformation were addressed. Since these trends are relatively abstract and not quantifiable, we adopted an approach to identify causes and accelerators of such trends. For example, we preferred using access to information as a catalyst for transparency and the commitment of key stakeholders as an indicator of governance-based public administration.

PSB has the responsibility of approving public investments and executes this duty through a sectoral structure. One of the sectoral departments is the ICT department, consisting of a department head and eight experts. ICT investment projects are evaluated by these experts at PSB. For ICT projects incorporating elements from other sectors (e.g., agriculture, education), consultative support is obtained. Evaluating national projects requires a unique set of expertise, in fields including, but not limited to political, legal, economic, technical, and strategic. The required expertise is not theoretical but requires extensive on-the-job training. Because of the need for multi-disciplinary expertise, this study strongly depended on the expertise within PSB, along with a literature review.

Out of eight experts, one has a PhD, five have a master's degree, the remaining two have a bachelor's degree. Three of them have more than 20 years of experience, other three have between 10 and 20 years of experience, and the remaining two have less than 10 years of experience. They graduated from a variety of fields, including public administration, business administration, engineering, and economics. Additionally, apart from the general knowledge of project evaluation that everyone gains, each expert has specialized in a sub-field of ICT over time. Differences in specialization and fields of graduation formed a learning environment that is open to negotiation and learning from each other. On the other hand, a lack of a common methodology hinders experts from reflecting their experience across all areas of project evaluation. The need for a systematic approach has initiated this study.

After the initial literature review was conducted, a total of 43 criteria were identified, some of which were mentioned above. The remaining steps of this study were put into practice by PSB experts as group work. According to these experts, four of the criteria were deemed so critical that initiating the project without meeting them would pose a serious risk. Since scoring was not an option for these criteria, they were removed from the project prioritization criteria list and added to the pre-qualification criteria group. These preconditions are listed in Table 1. Projects that do not pass the pre-qualification stage are not taken into consideration.

The remaining 37 criteria from the pre-qualification criteria were grouped into five categories and those with similar qualities were combined. As a result of the merging, 20 criteria were identified. The list of criteria and their descriptions were reviewed by eight PSB experts and their feedback was collected. With the help of the experts, both the number of criteria and the criteria groupings were revised. During these discussions, seven additional criteria were noted and three criteria were deemed less important than the others. At the end of the study, 30 criteria were established, including six pre-qualification criteria and 24 comparison criteria (Table 1, Table 2). In the selection and grouping of the criteria, aspects such as their singular importance, their alignment with the related criteria group, and ensuring coherence were considered so that, when met, the group's objective would also be achieved. In addition to these, recently submitted project proposals were evaluated in terms of any possible need for additional criteria. Both AHP and TOPSIS methods require that criteria do not influence each other. Special effort was made to distinguish the criteria from each other to minimize their influence. Criteria explanations helped in defining the boundaries.

Table 1. Pre-qualification criteria

| Criteria | Source |
|---|---|
| Project is compliant with the responsibility of the organization and the public sector in general | (Huang et al., 2008; IMF, 2022; J.-H. Kim et al., 2020; Y. Kim & Chang, 2013; PSB, 2023a) |
| Required legal base is available and project is not in conflict with main legal framework | (PSB, 2023a) |
| Project is not a duplicate of or very similar to another existing project | (PSB, 2023a) |
| Sufficient prior analysis of the project has been carried out | (Karasakal & Aker, 2017; Keil et al., 1998; Y. Kim & Chang, 2013; PSB, 2023a) |
| Financial predictability is ensured | (IMF, 2022; J.-H. Kim et al., 2020; PSB, 2022) |
| Proper analysis and fulfilment of stakeholder requirements were fulfilled | (Keil et al., 1998; PSB, 2022) |

2025, 13(3), e130304, DOI: 10.12821/ijispm130304

Table 2. Project prioritization criteria

| Criteria | Explanation and Source |
|---|---|
| **Alignment with national and sectoral policies and political support (NPS)** | |
| Alignment with key national policies | The project serves policies and strategies on a national scale and covering all sectors, especially the National Development Plan (IMF, 2020, 2022; J.-H. Kim et al., 2020; PSB, 2023a) |
| Alignment with organizational strategic plan | The project serves the realization of the objectives and actions written in the organization's own strategic plan (Henriksen & Traynor, 1999; PSB, 2023a) |
| Alignment with a sector-specific strategy | The project serves the realization of the objectives and actions written in national strategies specific to a particular field such as cyber security, e-government, smart cities, etc. (PSB, 2023a) |
| Level of political ownership | The project is subject to political oversight, is closely followed politically, and is one of the commitments made to citizens (Deepta Chopra, 2015; Hirschman, 2015; Schneider et al., 2022; Turnpenny et al., 2009) |
| **Critical multiplier effects (CME)** | |
| Being a common infrastructure | The project outputs are reusable in many areas, the project eliminates the need for a large number of various investments, the project plays an enabling role for private sector investments in the implementation area, the project contributes to standardization in a specific area (PSB, 2022) |
| Contribution to national security | Replacing the foreign-origin solution that currently poses a risk to cyber security with a national alternative, enhancing cyber security (Expert Opinion) |
| Creation of new business and employment opportunities | The project will increase citizens' ICT literacy and create awareness and know-how in a field where employment is currently insufficient. People employed in the project are not in this scope (Benjamin, 1985; Karasakal & Aker, 2017; Y. Kim & Chang, 2013) |
| Access to information and transparency | Increased added value resulting from the integration of different data sources, the project's potential to increase the objectivity and usability of public data, enabling transparency in public service delivery. (OECD, 2019; PSB, 2022) |
| Production of domestic technologies | The project includes elements that will enable the use of domestic technologies and the development of domestic products and solutions. (Y. Kim & Chang, 2013; PSB, 2022) |
| Prevention of corruption | Eliminating the lack of control caused by the fragmentation of public information systems and preventing corruption by cross-checking data from different sources (IMF, 2022; J.-H. Kim et al., 2020; OECD, 2014, 2016) |
| **Other project benefits (OPB)** | |
| Number of beneficiaries and magnitude of benefit | Number of stakeholder organizations and/or citizens directly benefited by the project (Expert Opinion) |
| Use of domestic technologies | The project includes elements that will enable the use of domestic technologies and the development of domestic products and solutions (Y. Kim & Chang, 2013; PSB, 2022) |
| More efficient use of personnel and resources | Cost efficiency through transition to lower-cost licensing types, introduction of new cost-effective technologies, integration of services, becoming more sustainable with a reduced workforce (Karasakal & Aker, 2017; Y. Kim & Chang, 2013; PSB, 2022) |

| Criteria | Explanation and Source |
|---|---|
| Increasing public revenues and preventing waste | Short-term financial recovery of the initial investment cost, collection of taxes that are currently uncollected, creation or better delivery of a value-added public service that is subject to a fee (Benjamin, 1985; Henriksen & Traynor, 1999; IMF, 2022; J.-H. Kim et al., 2020; Y. Kim & Chang, 2013) |
| Reduced technology or contractor dependency | Reducing technology dependency by using standard equipment, using widespread technologies, increasing interoperability; reducing contractor dependency by ensuring preserving institutional know-how, changing infrastructure to open systems (PSB, 2022) |
| **Financial adequacy and sustainability (FAS)** | |
| Ease of implementation and maintenance | The project can be realized in a short time and the small-scale budget is sufficient to cover both initial investment cost and maintenance expenses (Benjamin, 1985; Henriksen & Traynor, 1999; PSB, 2023a) |
| Project cost | Total ownership cost of the project, including, but not limited to energy costs, workforce costs, recurring cost. (Henriksen & Traynor, 1999; Karasakal & Aker, 2017; PSB, 2022) |
| Cost to stakeholders | Direct cost to stakeholders, such as any licensing or equipment to be able to participate in the project, or integration work to be carried out (PSB, 2022) |
| Direct cost to citizens | The cost to citizens when they need to pay for the service, or purchase any equipment to use the service (PSB, 2022) |
| **Competence of the executing organization (CEO)** | |
| Commitment of top management and key stakeholders | Positioning the project as a top priority for the top management of the organization, making necessary interventions at points where the project may be blocked (Costantino et al., 2015; Karasakal & Aker, 2017; Keil et al., 1998) |
| Appropriateness of technology choice | The selected technical architecture is sustainable, has the flexibility to allow for easy expansion when necessary, and has a technical design that ensures a low level of contractor dependency (Henriksen & Traynor, 1999; IMF, 2020; Y. Kim & Chang, 2013) |
| Competence of the technical team | Both the technical competence and project management skills of the team responsible for executing the project are sufficient to successfully implement and maintain it effectively (Costantino et al., 2015; Karasakal & Aker, 2017; Keil et al., 1998) |
| Past project experience | The organization is able to achieve a certain level of success in each project by institutionalizing project management processes, has qualified technical and project management teams (Keil et al., 1998) |
| Manageability of project risks | Risk factors such as uncertainty from R&D activities, risk from changes in technology, risks from changes in needs can be reduced to manageable levels (Benjamin, 1985; Chu et al., 1996; Costantino et al., 2015; IMF, 2020; Keil et al., 1998) |

### *4.1. AHP*

AHP method was first proposed as a framework by Saaty in 1977 (Saaty, 1977) and systematized in 1980 (Saaty, 1980). In AHP, the criteria are first organized in a hierarchical structure. Then, the criteria in each level of the hierarchy are subjected to pairwise comparison among themselves. Since AHP values subjective information, i.e. comparisons are largely based on personal experience. As a result of the comparisons, a superiority matrix is formed, which contains the relative superiority of the criteria (Yadav & Jayswal, 2013, pp. 775–776).

Miller found that the human brain can process an average of seven components of short-term memory, which can vary by ±2 depending on the individual (Miller, 1956). Therefore, the number of criteria to be included in the pairwise comparison should not exceed these thresholds. Another important consideration in the use of the method is that a criterion with a large number of sub-criteria has a higher weight than one with a smaller number of sub-criteria (Stillwell et al., 1987; Weber et al., 1988). To avoid this situation, the number of criteria in the criteria group at any level should not be fewer than four. These considerations were taken into account when determining the criteria.

Since the AHP method was used to determine the criteria weights within the scope of the study, the relevant part of the AHP method for determining the criteria weights was analyzed. In addition to this, a consistency index calculation was also made. The following formulas were used to calculate the consistency ratio. In the first formula, $\lambda_{max}$ is the maximum value in the matrix and n represents the number of elements in the matrix (Eq. 1).

$$Consistency\ Index = \frac{\lambda_{max} - n}{n-1} \quad (1)$$

The consistency index is divided by the random index series (Eq. 2), a constant coefficient that varies based on the number of elements, to calculate the consistency ratio.

$$Consistency\ Ratio = \frac{Consistency\ Index}{Random\ Index\ Series\ [n]} \quad (2)$$

If the consistency ratio resulting from the calculation is less than 0.1, it is concluded that the matrix, and therefore the judgments of the decision makers, are consistent.

### *4.2. TOPSIS*

TOPSIS (Technique For Order Preference By Similarity To An Ideal Solution) is an MCDM method. It was created by Hwang and Yoon (1981) and further developed by Chen and Hwang (1992). In the TOPSIS method, the convergence rate of alternative options to the ideal state is calculated. The solution that is closest to the positive ideal solution point and farthest from the negative ideal solution point is considered to be the most ideal solution (Demireli, 2010, p. 104). First, a matrix is created from the alternatives and the criteria against which these alternatives will be compared. The criteria weights obtained from the AHP method are used to determine the summation effect of each criterion. In the second stage, the matrix is subjected to a normalization process. During normalization, each criterion is divided by the square root of the sum of the squares of all criteria. For negative criteria, the result is subtracted from 1.

$$Z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} (y_{ij})^2}} \qquad i = 1....n;\ j = 1....k \quad (3)$$

$$Z_{ij\ (negative)} = 1 - \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} (y_{ij})^2}} \qquad i = 1....n;\ j = 1....k \quad (4)$$

In the third stage, the elements of the decision matrix normalized in the second stage are weighted. Weighting was performed by multiplying the elements with the criteria weights previously determined by AHP (Eq. 5).

$$X_{ij} = w_i \cdot Z_{ij} \qquad i = 1 \dots . n; j = 1 \dots . k \quad (5)$$

In the next step, $m^*$ and $m^-$ ideal sequences are created by determining the maximum and minimum values in each column of the normalized matrix. Then, the distance to the most ideal point is calculated by the following formula (Eq. 6).

$$S_i^* = \sqrt{\sum_{j=1}^{k}\left(X_{ij} - X_j^*\right)} \qquad i = 1 \ldots .n \tag{6}$$

Similarly, the distance to the most negative state is calculated using the following formula (Eq. 7).

$$S_i^- = \sqrt{\sum_{j=1}^{k}\left(X_{ij} - X_j^-\right)} \qquad i = 1 \ldots .n \tag{7}$$

### *4.3. Application steps of methods*

The methods used in the research complement each other. The criteria weights determined by AHP were used in TOPSIS to rank projects. Application steps of both methods are shown in Fig.1. The first two steps shown in the figure belong to the AHP method. In these steps, criteria are established and their weights are determined. The remaining steps belong to the TOPSIS method, where project scores were determined using the decision matrices and the final project ranking was obtained.

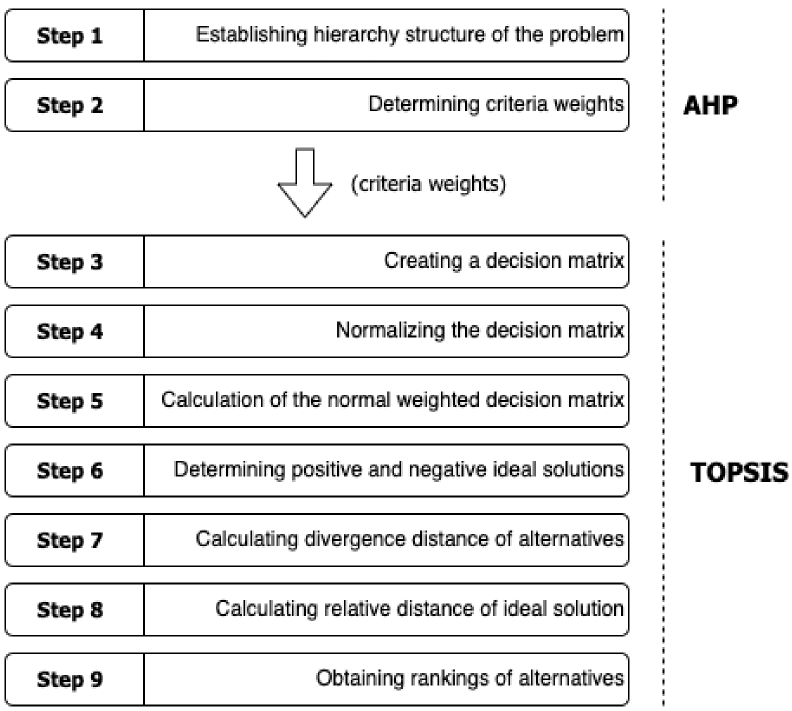


Fig. 1. Application steps for AHP and TOPSIS

## 5. Results

A process has been defined for weighting the criteria shown in Table 2 and validating them with sample projects. In the previous sections, the problem was defined, and the criteria were identified. The steps of weighting the criteria, selecting the sample projects, scoring the projects and verifying the system scores were conducted using DSS interfaces. Fig.2 shows all the steps of the methodology implementation, including problem definition and criteria setting. The process diagram detailing how the steps will be implemented is shown in Fig.3.

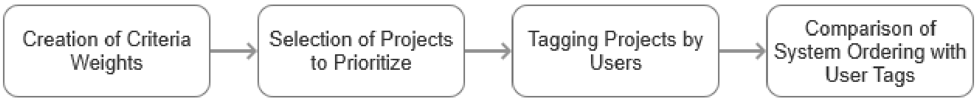


Fig. 2. Application Steps of Recommended Methodology

Since DSS interfaces were extensively used, testing these interfaces was also an important step. For testing, a sample problem was first solved in Excel, then it was checked whether the same results could be obtained from the DSS.

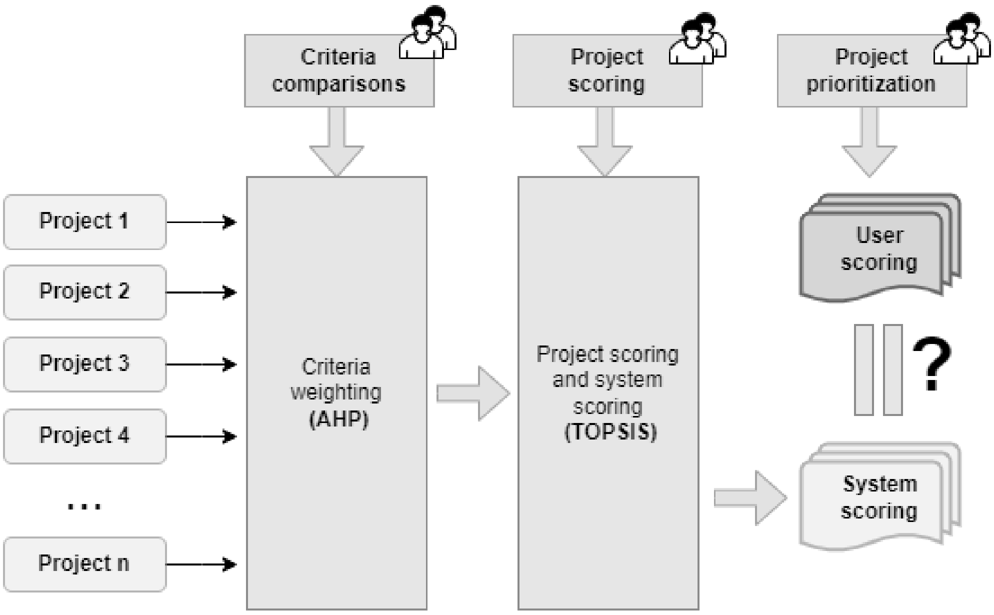


Fig. 3. Stages Carried Out in the Methodology

### *5.1. Creation of criteria weights*

DSS used in this study has the capability of accepting criteria as a hierarchical group and offering pairwise comparison scoring. The experts initially reviewed the criteria individually. In determining the weights of the criteria in Table 2, the expert group decided on the criteria weights during a group discussion session. The group work helped reduce potential subjectivities to an acceptable level. DSS performed the final calculation using the AHP method. Since each expert has distinctive expertise in specific areas of ICT, experts shared their views on the criteria involved, which helped create a learning environment. Organizational culture based on mutual negotiation helped avoid certain experts' opinions carrying more weight than they should. Experts were previously exchanging ideas on projects, this time, exchanging ideas on project selection criteria were also added value. AHP consistency ratios, calculated dynamically by the DSS, are given in Table 3. The criteria weights obtained are presented in Table 4. Both local and global weights are given. Some criteria are negative and are indicated with a "(-)" sign in Table 4.

Table 3. AHP consistency ratios

| | Main | NPS | CME | OPB | NEX | FAS | CEO |
|---|---|---|---|---|---|---|---|
| **Ratio** | 0.012 | 0.014 | 0.021 | 0.070 | 0.009 | 0.062 | 0.006 |

Table 4. Calculated Criteria Weights

| **Criteria** | **Local Weights (%)** | **Weights (%)** |
|---|---|---|
| **NPS. Alignment with national policies and political support** | | **20.5** |
| Alignment with key national policies | 52.1 | 10.7 |
| Alignment with organizational strategic plan | 5.3 | 1.1 |
| Alignment with a sector-specific strategy | 12.7 | 2.6 |
| Level of political ownership | 29.9 | 6.1 |
| **CME. Critical multiplier effects** | | **35.5** |
| Being a common infrastructure | 30.0 | 10.7 |
| Contribution to national security | 20.0 | 7.1 |
| Creation of new business and employment opportunities | 5.0 | 1.8 |
| Access to information and transparency | 6.2 | 2.1 |
| Production of domestic technologies | 19.4 | 6.9 |
| Prevention of corruption | 19.4 | 6.9 |
| **OPB. Other project benefits** | | **10.0** |
| Number of beneficiaries and magnitude of benefit | 13.0 | 1.3 |
| Use of domestic technologies | 20.6 | 2.0 |
| More efficient use of personnel and resources | 9.6 | 1.0 |
| Increasing public revenues and preventing waste | 24.3 | 2.4 |
| Reduced technology or contractor dependency | 32.5 | 3.2 |
| **FAS. Financial adequacy and sustainability** | | **5.3** |
| Ease of implementation and maintenance | 16.1 | 0.9 |
| **(-)** Project cost | 13.7 | 0.7 |
| **(-)** Cost to stakeholders | 35.1 | 1.9 |

| Criteria | Local Weights (%) | Weights (%) |
|---|---|---|
| **(-)** Direct cost to citizens | 35.1 | 1.9 |
| **CEO. Competence of the executing organization** | | **28.7** |
| Commitment of top management and key stakeholders | 14.8 | 4.2 |
| Appropriateness of technology choice | 14.8 | 4.2 |
| Competence of the technical team | 38.2 | 10.9 |
| Past project experience | 16.1 | 4.7 |
| Manageability of project risks | 16.1 | 4.7 |

### *5.2. Selection of projects to prioritize*

Every year, PSB publishes Public Information and Communication Technologies Investments Report. The report presents the complete list of ICT projects approved for inclusion in the Government Investment Program for the relevant year. 335 ICT projects were included in the 2023 Public ICT Investments Report. The total investment volume of these projects was approximately 21.2 billion TL. More than half of the total budget was allocated to maintenance-related expenses (PSB, 2023b).

A subset of these projects must be selected for the study, requiring a clear rationale for sample selection. Some projects included in the investment program have a specific characteristic that are well-known to PSB experts. For example, a project is obviously meant to increase national security. Another project is of critical importance for the development of national information infrastructure. The criteria set can be more effectively tested with projects whose features are clearly observed. The DSS must be capable of identifying the relevant features for each project. Therefore, projects that stand out in certain aspects were selected for the accuracy test of the system. Among the selected projects, 11 projects with distinctive characteristics and best known by experts were used as a sample within the scope of the research (Table 5). Full names of the projects were not written for confidentiality reasons, and the project budgets were slightly changed.

A different method was employed in the calculation of project cost factors. This method is more appropriate than the Likert scale, as it allows for the estimation of project costs in numerical terms. We used the cost factors listed in Table 5, i.e. project budget, maintenance cost and direct costs to stakeholders. Direct cost to stakeholders refers to the amount that each stakeholder needs to pay for the project to be fully implemented. For instance, while a data center project for an institution does not require stakeholder costs, a nation-wide open source software project requires each stakeholder to convert its software base to open source to ensure full implementation. The maintenance cost was calculated for a period of five years, which is common in IT related estimations. The total cost was calculated using the formula: “Cost x (maintenance cost x 5) + cost to stakeholders”. Normalization of this cost was then performed, where the project with the highest cost was assigned a value of 1, producing the project cost factor.

Projects 10 and 11 were eliminated during the pre-selection phase. Project 10 was eliminated due to a change in legislation, which took duty away from the institution responsible for the project. Project 11 was eliminated because it lacked a legal basis. For effective use, hints were used to guide users across screens.

Table 5. Project List for Testing the Methodology

| No | Project | Budget | Maintenance Cost | Stakeholders' Direct Cost | Total Cost | Coef. |
|---|---|---|---|---|---|---|
| 1 | A core infrastructure for national security | 6 | 0 | 5 | 11 | 0.0122 |
| 2 | A data collection and standardization project | 300 | 0 | 0 | 300 | 0.3333 |
| 3 | A central records management system | 50 | 5 | 10 | 85 | 0.0944 |
| 4 | A core infrastructure for geographical datasets | 36 | 6 | 20 | 86 | 0.0956 |
| 5 | A nation-wide open source software project | 51 | 10 | 30 | 131 | 0.1456 |
| 6 | An integrated platform for security software solutions | 17 | 0 | 0 | 17 | 0.0189 |
| 7 | A disaster recovery system of an institution | 3 | 1 | 0 | 8 | 0.0089 |
| 8 | An institutional open source software transformation | 2 | 0 | 0 | 2 | 0.0022 |
| 9 | A data center of an institution | 80 | 8 | 0 | 120 | 0.1333 |
| 10 | A project for traffic data standardization | 135 | 0 | 0 | 135 | 0.1500 |
| 11 | National central data center | 600 | 60 | 0 | 900 | 1.0000 |

### *5.3. Tagging projects by users*

Experts scored the projects using the DSS interfaces as a group. Group work was also preferred in this stage because detailed information about the projects was not available to each expert, and the exchange of ideas among experts would allow for more objective scoring. For each project, a score was given based on the criteria determined in the previous stage. A 5-level Likert scale (very low, low, normal, high, very high) was used in scoring alternatives. However, as there were cases where some projects had no impact on certain criteria, the option "No impact" was added to the options. An example to this situation is that projects that have no revenue-generating aspect should not be scored on criteria about revenue generation.

On the scoring screens, the imprint and summary information of the projects are also presented. The scores entered by the users into the system, based on the agreed results of the group work, were converted into project rankings using the TOPSIS method. The DSS interfaces were used for scoring and methodical calculations.

### *5.4. Comparison of system ordering with user tags*

A ranking was obtained with the TOPSIS method by means of criteria weights and project scores calculated in the previous phase. The DSS screen was designed to allow dynamically enabling/disabling one or more criteria groups. When a criteria group was deactivated, the weights of the remaining groups were proportionally increased on-the-fly so that their totals add up to 100%. Ajax technology was specifically used for this interface to display results on the screen in real time. Thus, it was possible to determine in which criteria groups the projects stood out. Differences between group's ranking and system ranking were analyzed. Each criteria group was designed to reflect a different aspect of the projects. This approach aligned with the goal of viewing the projects through different and meaningful lenses. Whether the system rankings captured specific project strengths was tested. Table 6 shows scores for each criteria category. Scores were weighted according to group weights, and then normalized. The final total score for each project was calculated (Table 6).

We followed a different method for calculating project cost factors. Since we have some numbers to estimate project costs, numerical values were deemed more appropriate than a likert scale. We used cost factors listed in Table 5, namely project budget, maintenance cost and stakeholders' direct costs. Maintenance cost was calculated for a duration of five years, which is common in ICT-related estimations. Project with the greatest total cost had a cost factor of 1.000, and other projects were scored accordingly.

Table 6. TOPSIS results by category and Total

| Project | Total | | NPS | | CME | | OPB | | FAS | | CEO | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scr. | # | Scr. | # | Scr. | # | Scr. | # | Scr. | # | Scr. | # |
| **P1.** A core infrastructure for national security | 50.6 | 3 | 85.1 | 3 | 47.6 | 4 | 39.6 | 4 | 99.6 | 1 | 55.6 | 6 |
| **P2.** A data collection and standardization project | 46.7 | 5 | 44.1 | 7 | 47.4 | 5 | 27.2 | 7 | 0.0 | 9 | 62.7 | 4 |
| **P3.** A central records management system | 49.3 | 4 | 85.1 | 3 | 49.8 | 3 | 20.0 | 8 | 36.9 | 4 | 33.4 | 9 |
| **P4.** A core infrastructure for geographical datasets | 40.6 | 6 | 100 | 1 | 35.6 | 6 | 32.6 | 6 | 59.7 | 3 | 36.8 | 8 |
| **P5.** A nation-wide open source software project | 58.4 | 2 | 95.5 | 2 | 55.1 | 2 | 59.7 | 3 | 78.6 | 2 | 58.0 | 5 |
| **P6.** An integrated platform for security software solutions | 63.8 | 1 | 71.7 | 5 | 62.7 | 1 | 69.0 | 2 | 25.4 | 7 | 88.0 | 1 |
| **P7.** A disaster recovery system of an institution | 14.9 | 9 | 2.2 | 8 | 8.9 | 9 | 12.8 | 9 | 27.1 | 6 | 42.6 | 7 |
| **P8.** An institutional open source software transformation | 34.0 | 7 | 53.0 | 6 | 17.1 | 7 | 71.9 | 1 | 28.8 | 5 | 87.6 | 2 |
| **P9.** A data center of an institution | 25.2 | 8 | 2.2 | 8 | 16.9 | 8 | 37.4 | 5 | 20.6 | 8 | 67.4 | 3 |

As can be seen in Table 6, in addition to a cumulative scoring and ranking, scoring and ranking for each criteria category are also presented. This approach provides more detailed clues about project strengths and risks. It was chosen because the evaluation process is a living process. The needs of public institutions are ongoing, and it is assumed that the proposed projects are relevant to these needs. Therefore, the rejection of projects should not be considered a definitive rejection, but rather as giving institutions time to rework their projects. With the proposed set of criteria, the shortcomings in both the institutional capacities of the institutions and their projects can be seen more objectively. However, it is still recommended that the set of criteria be refined before it is presented to the applicant public institutions.

## 6. Findings, discussion and recommendations

Table 6 presents important findings on different aspects of the projects. Discussing these findings provides insights into how closely the criteria used in the study and the scoring process align with real-life situations. A project that the criterion set ranks high in a certain category should also be ranked high in the same category by the experts, and a project receiving a low score in a category should similarly be considered inadequate in the same category by the experts.

Projects 6 and 1 aims to enhance national cybersecurity infrastructure. Project 6 does this by creating a framework for private sector, while project 1 aims to build a government-wide secure communication medium. Risks are low for these projects, since institutions responsible for cybersecurity have high technical capabilities. Top management support is also higher for these projects. The high ranking of projects related to national security aligns with the opinions of PSB experts in this field.

Projects 3 and 4 were ranked roughly lower. They are relatively costly, and both have some disadvantages; Project 3 offers a clear benefit, but not as critical as other projects having national scope. However, its low risks make it a good alternative. Although project 4 provides greater benefits, it also involves greater risks in terms of critical stakeholder support and technical competence.

It is noteworthy to examine project 5; although it ranked 5th in organizational competence, it ranked 2nd in the overall ranking. The objectives of this project, which aims to introduce open source software to all public institutions, are clear and important. Open source software has a direct impact on both human resources capacity and national security by preventing dependence on foreign software. Therefore, it also raises the ranking for national substitution. Hence, the high risk associated with organizational competence could not lower the ranking of this project. However, the main conclusion to be drawn here is not the ranking information itself. The methodology proposed in the study provides insight into which aspects of the projects need to be improved. For this project, further steps should be taken to improve organizational competence.

Public policy documents are assumed to emphasize the most value-added public investment projects. However, this may not always be the case. It is interesting to observe the differences in ranking between national policies and critical multiplier effects of public investment projects. Alignment with national policies and critical multiplier effects are ranked almost equally across all projects, except for projects 4 and 6. Project 4 scored highest in the alignment with national policies category and lowest in the critical multiplier effect. The project has a high level of political ownership. It has clear benefits on a national scale, but scored low compared to other critical projects on the list. The opposite is true for project 6. Although the critical multiplier effect of the project is very high, it lags in terms of alignment with national policies and political ownership. This characteristic of the proposed methodology is noteworthy as it creates a feedback loop from public investment projects to national policy cycle.

Projects 7, 8, and 9 are not national, but organization-wide projects. It is understandable that such projects score lower than those of national scale, due to their narrower benefit scope. The methodology used should be able to distinguish national scale projects from organization-wide projects in rankings. The highest-scoring organization-wide project has a score of 34.0, while the lowest scoring national scale project is 40.6. The score differences are more pronounced in the critical multiplier effect category. The blurring of the differences in the overall category is due to the fact that the scoring takes into account a wide range of factors. The proposed methodology is not designed as a simple ranking system. The user can focus on each set of criteria and evaluate projects from different perspectives.

Scores (especially those in the institutional capability group) should not be considered final. With insights and feedback on the main risk factors, organizations can improve their projects for better scoring. Thus, our methodology not only provides hints about project rankings, but also helps organizations identify the critical aspects of their projects and the areas that urgently need improvement. An obvious example in our project sample is project 5. Although it aims to address a national need, the lack of organizational competence prevents it from doing so. Once this issue is recognized and quantitatively documented, the institution will be easily guided and motivated to mitigate this risk factor.

Overall, the expert group was satisfied with the criteria, criteria weights and the resulting project rankings. Although both criteria and their weights are subject to change, it was beneficial for experts to observe the projects through different lenses. The project selection process, driven by concrete data and enhanced feedback, met the experts' expectations for the DSS design. The criteria set could be further developed and customized for specific types of projects. For instance, there may be differences between software projects and information system infrastructure projects. While maintaining common criteria, specialized criteria can be applied for different types of projects. The current version of the methodology provides a solid foundation for further improvements.

Similar frameworks have been successfully adapted to different sectors such as transportation (Henriksen & Traynor, 1999) and healthcare (de Souza et al., 2021), demonstrating that the proposed decision support system can meet the needs of various public project environments in other countries as well. This study aligns well with previous studies due to its extensive literature review for criteria. It also improves upon previous work by offering two key advantages. One advantage is that literature review revealed a lack of comprehensive set of hierarchical criteria. This study should be viewed as a first step toward addressing this important gap. Another significant benefit is that the criteria, process, and complementary DSS interface help project evaluation become a living process. This approach has not received significant attention in the literature.

In terms of using DSS, Ghasemzadeh and Archer's (2000) emphasis on the flexibility of methodology choice and sequencing of projects was partly covered by this study. Flexibility of project sequencing with respect to different criteria combinations was found useful by PSB experts. In terms of the flexibility of methodology, including other methods for criteria weighting, scoring, and ranking, and allowing users to choose the methodology is recommended as a development in the DSS. The proposal of Andersen et al. (2009) on a phased planning approach for projects is considered to be fully achieved by this methodology.

Caution should be exercised with the cumulative scores resulting from the weightings and project scores, as both the weighting of criteria and the scoring of projects are inherently subjective. The aim is not to fully eliminate subjectivity, but to provide a method that minimizes it as much as possible. Therefore, it would be more appropriate to consider projects with particularly close scores as having equivalent scores. Conversely, obvious score differences should indeed be considered indicating a meaningful difference.

While we believe we have reduced it to an acceptable level, a certain degree of subjectivity still exists within the criteria groups. Especially in the field of project selection, addressing subjectivity is not easy. Nevertheless, two types of measures were taken. On the one hand, experts were made aware of the remaining subjectivity. On the other hand, coloring was used in DSS interface to display three main categories (green, yellow and red). This approach helped projects to be viewed as a part of broader group, instead of a single ranking order.

Another limitation of the study was the size of the expert group. Since the necessary competencies were only available within the PSB, the study could not be extended to a broader group of experts. Hence, there are certainly areas within the criteria that are open to improvement. It is also important to note that measuring social benefits is directly related to the structure and priorities of the relevant country. The criteria were specifically designed for use by the Turkish Government. In Particular, criteria regarding social benefit naturally reflect Türkiye's political priorities. Needless to say, it is possible to revise the criteria to align with the priorities of other countries.

Eleven projects selected for the sample were few in number, but they clearly stood out in certain aspects. After the methodology is implemented, it is recommended to revise the criteria set and weightings, as new projects are evaluated. The study was conducted specifically for public ICT investment projects, but the methodology has a significant potential for all investment projects. With minor criteria revisions, the methodology can also be adapted for cross-sector comparisons.

One of the key challenges in public ICT investments is ensuring that the benefits of these projects extend well beyond the initial implementation phase. The proposed criteria can be adapted to evaluate the long-term sustainability and social impacts of ICT projects. By incorporating metrics that assess the continued relevance, effectiveness, and efficiency of these projects, decision-makers can ensure that investments provide ongoing value. This long-term impact assessment can include factors such as the scalability of the project, its adaptability to technological advancements, and the persistence of social and economic benefits over time.

While the proposed framework was designed for public ICT projects in Türkiye, its underlying principles can be adapted for use in other sectors and/or countries. The MCDM approach and the criteria used in the AHP and TOPSIS methods can be customized to fit different economic, social, and political contexts. For example, sectors such as healthcare, infrastructure, or education, which also require strategic prioritization of public investments, may benefit from the adaptability of this framework. Furthermore, by adjusting criteria weights to account for different national policies or sector-specific challenges, the framework could serve as a valuable tool for project selection in various environments and for making cross-sector effectiveness comparisons.

DSS was used to support experts in the PSB. A more effective approach may be to make it available for use by the project-owning organizations. In this way, the goal of improving projects according to national objectives will be more easily achieved. After four or five years of application, enough data sets will be obtained. This will create the potential to utilize numerical analysis, data mining, and artificial intelligence methods.

## 7. Conclusion

Public investments play a fundamental role in public policies. Therefore, the effectiveness of public investments is of critical importance for channeling public policies toward more appropriate areas. It is a well-known fact that public resources are limited. National social welfare strongly depends on how these limited resources are utilized.

In this study, a methodology was developed for evaluation and continuous improvement of public ICT projects, using the AHP and TOPSIS methods. It was observed that the methodology provides adequate objectivity and effectiveness in selecting, prioritizing, and improving projects. The criteria set developed within the scope of the study was shown to be aligned with expert opinions.

The basic philosophy of a DSS is that information systems support the decision-making processes. Hence, the main approach in this study was to help decision makers gain detailed insights into various aspects of projects. A dynamic interface supports experts from this perspective.

Projects involving national security, development of domestic technologies and those addressing a national need are given more prominence and recognition by the methodology. In cases where these projects have significant risks, methodology also gives crucial feedback, enabling the responsible institution to further refine the project to mitigate risks.

The criteria set provides a systematic approach to measure social benefit. However, accurately identifying the criteria for measuring social benefit, assigning the correct weights to them and objectively scoring projects according to these criteria can reduce the margin of error. The methodology proposed in the study was tested on 11 projects. In the future, testing it on a larger sample may enhance both the criteria set and the scoring mechanics.

In conclusion, this research contributes to both the academic and practical realms by providing a robust framework for the evaluation of public ICT projects. Its broader implications include improved resource allocation, more transparent decision-making, and enhanced project success rates in various sectors. By fostering a systematic approach to project evaluation, the framework offers governments and organizations a pathway to maximize the social and economic value of their investments, ultimately leading to more impactful and sustainable public projects.

## Acknowledgments

The authors did not receive support from any organization for the submitted work.

## References

Amiri, M. P. (2010). Project selection for oil-fields development by using the AHP and fuzzy TOPSIS methods. *Expert Systems with Applications*, *37*(9), 6218–6224. https://doi.org/10.1016/j.eswa.2010.02.103

Andersen, E. S. (1996). Warning: Activity planning is hazardous to your project's health! *International Journal of Project Management*, *14*(2), 89–94. https://doi.org/10.1016/0263-7863(95)00056-9

Andersen, E. S., Grude, K. V., & Haug, T. (2009). *Goal directed project management: Effective techniques and strategies*. Kogan Page Publishers.

Benjamin, C. O. (1985). A Linear Goal-Programming Model for Public-Sector Project Selection. *Journal of the Operational Research Society*, 36(1), 13–23. https://doi.org/10.1057/jors.1985.3

Çelik, Ş G. (2010). *Monitoring and Evaluation of Public Investments: Recommendations for Turkey* [Master's Thesis, In Turkish]. Department of Finance, Institute of Social Sciences, Hacettepe University.

Çetin, V. R. (2019). *Evaluation of the Economic Impact of Public Transport Infrastructure Investment Expenditures and Alternative Financing Methods: A Computable General Equilibrium Analysis for Turkey* [Doctoral Dissertation, In Turkish]. Department of Finance, Institute of Social Sciences, Ankara University.

Chen, C.-T., & Cheng, H.-L. (2009). A comprehensive model for selecting information system project under fuzzy environment. *International Journal of Project Management*, *27*(4), 389–399. https://doi.org/10.1016/j.ijproman.2008.04.001

Chen, S.-J., & Hwang, C.-L. (1992). *Fuzzy Multiple Attribute Decision Making: Methods and Applications*. Springer Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-46768-4

Chen, T. (2010). Integration of AHP and TOPSIS in Decision Making for Collaborative Systems. *Expert Systems with Applications*, *37*(12), 8082–8088. https://doi.org/10.1016/j.eswa.2010.05.017

Chrit, S., Azmani, A., & Azmani, M. (2022). Combining AHP and Topsis to Select Eligible Social and Solidarity Economy Actors for a Call for Grants. *International Journal of Advanced Computer Science and Applications*. https://doi.org/10.14569/IJACSA.2022.0131148

Chu, P.-Y. V., Hsu, Y.-L., & Fehling, M. (1996). A decision support system for project portfolio selection. *Computers in Industry*, *32*(2), 141–149. https://doi.org/10.1016/S0166-3615(96)00067-X

Costantino, F., Di Gravio, G., & Nonino, F. (2015). Project selection in project portfolio management: An artificial neural network model based on critical success factors. *International Journal of Project Management*, *33*(8), 1744–1754. https://doi.org/10.1016/j.ijproman.2015.07.003

de Souza, D. G., dos Santos, E. A., Soma, N. Y., & da Silva, C. E. (2021). MCDM-Based R&D Project Selection: A Systematic Literature Review. *Sustainability*, *13*(21), 1-34. https://doi.org/10.3390/su132111626

Deepta Chopra. (2015). *Political commitment in India's social policy implementation: Shaping the performance of MGNREGA* (Working Paper No. 50; ESID Working Papers). Effective States and Inclusive Development (ESID).

Demireli, E. (2010). TOPSIS Multi-Criteria Decision-Making System: An Application on Public Banks in Turkey [In Turkish]. *Journal of Entrepreneurship and Development*, 5(1), 101–112.

Dong, Y., Liu, Y., Zhang, G., & Yao, T. (2010). Research on the analytic hierarchy process in decision making for selecting. *Management Science Letters*, *2*(5), 849–858. https://doi.org/10.5267/j.msl.2010.0067

State Planning Organization (DPT). (2001). *Eighth Five-Year Development Plan, Specialization Commission Report on Social Services and Assistance* [Specialization Commission Report, in Turkish]. State Planning Organization.

Druzdzel, M. J., & Flynn, R. R. (2002). Decision Support Systems. In A. Kent (Ed.), *Encyclopedia of Library and Information Science* (Second Edition, p. 10). Marcel Dekker.

European Commission. (2014). *Guide to Cost-Benefit Analysis of Investment Projects: Economic Appraisal Tool for Cohesion Policy 2014-2020*. European Commission, Directorate-General for Regional and Urban Policy.

Ghasemzadeh, F., & Archer, N. P. (2000). Project portfolio selection through decision support. *Decision Support Systems*, *29*(1), 73–88. https://doi.org/10.1016/S0167-9236(00)00065-8

Gray, C. F., & Larson, E. W. (2018). *Project management: The managerial process* (Seventh edition). McGraw-Hill Education.

Gunasekaran, A., Love, P. E. D., Rahimi, F., & Miele, R. (2001). A model for investment justification in information technology projects. *International Journal of Information Management*, *21*(5), 349–364. https://doi.org/10.1016/S0268-4012(01)00024-X

Han, B., Zhang, X.-X., & Yi, Y. (2019). Multi-criteria project selection using fuzzy preference relations based AHP and TOPSIS. *2019 Chinese Control and Decision Conference (CCDC)*, 3809–3816. https://doi.org/10.1109/CCDC.2019.8833175

Henriksen, A., & Traynor, A. (1999). A practical R&D project-selection scoring tool. *IEEE Transactions On Engineering Management*, *46*, 158–170. https://doi.org/10.1109/17.759144

Hirschman, A. O. (2015). *Development Projects Observed*. Brookings Institution Press.

Huang, C.-C., Chu, P.-Y., & Chiang, Y.-H. (2008). A fuzzy AHP application in government-sponsored R&D project selection. *A Special Issue Dedicated to the 2008 Beijing Olympic Games*, *36*(6), 1038–1052. https://doi.org/10.1016/j.omega.2006.05.003

Hwang, C.-L., & Yoon, K. (1981). *Multiple Attribute Decision Making: Methods and Applications A State-of-the-Art Survey*. Springer Berlin Heidelberg.

IMF. (2015). *Making Public Investment More Efficient* [Staff Report]. International Monetary Fund.

IMF. (2020). *Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment*. International Monetary Fund.

IMF. (2022). *PIMA Handbook: Public Investment Management Assessment*. International Monetary Fund.

Ishizaka, A., & Nemery, P. (2013). *Multi-criteria decision analysis: Methods and software*. Wiley.

Jokar, E., Nejad, A., & Lork, A. (2020). Risk prioritization and selection of contractor participating in Public-Private Partnership (PPP) infrastructure project using Hybrid Fuzzy AHP and Fuzzy TOPSIS (Case Study: Saveh-Salafchegan Freeway Project). *Journal of Construction Engineering, Management & Innovation*, *3*(1), 1–16.

Karasakal, E., & Aker, P. (2017). A multicriteria sorting approach based on data envelopment analysis for R&D project selection problem. *Omega*, *73*(C), 79–92. https://doi.org/10.1016/j.omega.2016.12.006

Keil, M., Cule, P. E., Lyytinen, K., & Schmidt, R. C. (1998). A Framework for Identifying Software Project Risks. *Commun. ACM*, *41*(11), 76–83. https://doi.org/10.1145/287831.287843

Kim, J.-H., Fallov, J. A., & Groom, S. (2020). *Public Investment Management Reference Guide*. World Bank Group. https://doi.org/10.1596/978-1-4648-1529-4

Kim, Y., & Chang, H. (2013). A Study on Project Selection Framework for Future ICT Technologies. In *Wireless Personel Communications*. 73(4), 1591–1600. https://doi.org/10.1007/s11277-013-1268-8

Lim, C. S., & Mohamed, M. Z. (1999). Criteria of project success: An exploratory re-examination. *International Journal of Project Management*, *17*(4), 243–248. https://doi.org/10.1016/S0263-7863(98)00040-4

Mahmoodzadeh, S., Shahrabi, J., Pariazar, M., & Zaeri, M.S. (2007). Project selection by using fuzzy AHP and TOPSIS technique. *World Academy of Science, Engineering and Technology*, 1.

Masten, I., & GrdovićGnip, A. (2019). Macroeconomic effects of public investment in South-East Europe. *Journal of Policy Modeling*, 41(6), 1179-1194. https://doi.org/10.1016/j.jpolmod.2019.05.005

McNutt, P. (1999). Public goods and club goods. *Encyclopedia of Law and Economics*, 927–951.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81–97.

OECD. (2014). *Recommendation of the Council on Effective Public Investment Across Levels of Government*. Organization for Economic Co-operation and Development (OECD). https://www.oecd.org/regional/regional-policy/Principles-Public-Investment.pdf

OECD. (2016). *Integrity Framework for Public Investment* (OECD Public Governance Reviews). Organization for Economic Co-operation and Development (OECD).

OECD. (2019). *Using Digital Technologies to Improve the Design and Enforcement of Public Policies* (OECD Digital Economy Papers). Organization for Economic Co-operation and Development (OECD).

Project Management Institute (PMI). (2009). *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* [in Turkish]. Project Management Institution of Turkey (PMI TR).

Ragowsky, A., Ahituv, N., & Neumann, S. (1996). Identifying the value and importance of an information system application. *Information & Management*, *31*(2), 89–102. https://doi.org/10.1016/S0378-7206(96)01072-5

Rosen, H. S. (2005). *Public Finance* (7th ed.). McGraw-Hill.

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, *15*(3), 234–281. https://doi.org/10.1016/0022-2496(77)90033-5

Saaty, T. L. (1980). *The Analytic Hierarchy Process* (1.). McGraw-Hill.

Presidency of Strategy and Budget (PSB). (2020a). *2021-2023 Investment Program Preparation Guide* [Guide, in Turkish]. Presidency of Strategy and Budget.

Presidency of Strategy and Budget (PSB). (2020b). *Development Plans* [Government Agency Website, in Turkish]. Presidency of Strategy and Budget. http://www.sbb.gov.tr/kalkinma-planlari/

Presidency of Strategy and Budget (PSB). (2020c). *Commercial and Financial Analysis of Public Investment Projects* [Guide, in Turkish]. Presidency of the Republic of Turkey, Strategy and Budget Office, Directorate General of Sectors and Public Investments.

Presidency of Strategy and Budget (PSB). (2022). *Public Information and Communication Technology Investment Principles* [in Turkish]. Presidency of Strategy and Budget.

Presidency of Strategy and Budget (PSB). (2023a). *2024-2026 Investment Program Preparation Guide* [in Turkish]. Presidency of Strategy and Budget.

Presidency of Strategy and Budget (PSB). (2023b). *Public Information and Communication Technology Investments Report (2023)* [in Turkish]. Presidency of the Republic of Turkey, Strategy and Budget Office, Directorate General of Sectors and Public Investments.

Schneider, L., Wech, D., & Wrede, M. (2022). Political alignment and project funding. *International Tax and Public Finance*, *29*(6), 1561–1589. https://doi.org/10.1007/s10797-022-09758-6

Şeker, M. (2019). *Public Finance* [in Turkish]. Istanbul University, Faculty of Open and Distance Education.

Sharma, D., Sridhar, S., & Claudio, D. (2020). Comparison of AHP-TOPSIS and AHP-AHP methods in multi-criteria decision-making problems. *International Journal of Industrial and Systems Engineering*, *34*(2), 203–223. https://doi.org/10.1504/IJISE.2020.105291

Sowlati, T., Paradi, J., & Suld, C. (2005). Information systems project prioritization using data envelopment analysis. *Mathematical and Computer Modelling*, *41*, 1279–1298. https://doi.org/10.1016/j.mcm.2004.08.010

Stillwell, W. G., von Winterfeldt, D., & John, R. S. (1987). Comparing Hierarchical and Nonhierarchical Weighting Methods for Eliciting Multiattribute Value Models. *Management Science*, *33*(4), 442–450. https://doi.org/10.1287/mnsc.33.4.442

Taylan, O., Bafail, A. O., Abdulaal, R. M. S., & Kabli, M. R. (2014). Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies. *Applied Soft Computing*, *17*, 105–116. https://doi.org/10.1016/j.asoc.2014.01.003

Tregear, R., & Jenkins, T. (2007). Government Process Management: A review of key differences between the public and private sectors and their influence on the achievement of public sector process management. *BPTrends, October 2007*.

Triantaphyllou, E., Lootsma, F., Pardalos, P., & Mann, S. (1994). On the Evaluation and Application of Different Scales For Quantifying Pairwise Comparisons in Fuzzy Sets. *Journal of Multi-Criteria Decision Analysis*, *3*, 133–155. https://doi.org/10.1002/MCDA.4020030302

Turnpenny, J., Radaelli, C. M., Jordan, A., & Jacob, K. (2009). The Policy and Politics of Policy Appraisal: Emerging Trends and New Directions. *Journal of European Public Policy*, *16*(4), 640–653. https://doi.org/10.1080/13501760902872783

Wallenius, J., Dyer, J. S., Fishburn, P. C., Steuer, R. E., Zionts, S., & Deb, K. (2008). Multiple Criteria Decision Making, Multiattribute Utility Theory: Recent Accomplishments and What Lies Ahead. *Management Science*, *54*(7), 1336–1349. https://doi.org/10.1287/mnsc.1070.0838

Weber, M., Eisenführ, F., & von Winterfeldt, D. (1988). The Effects of Splitting Attributes on Weights in Multiattribute Utility Measurement. *Management Science*, *34*(4), 431–445. https://doi.org/10.1287/mnsc.34.4.431

Yadav, A., & Jayswal, S. C. (2013). Using Geometric Mean Method of Analytical Hierarchy Process for Decision Making in Functional Layout. *International Journal of Engineering Research and Technology*, *2(10)*, 775-779.

2025, 13(3), e130304, DOI: 10.12821/ijispm130304

## Biographical notes

**Muhammed Raşit Özdaş** – After graduating from Izmir Institute of Technology, Department of Computer Engineering (Türkiye), M. Raşit Özdaş completed his last year of Bachelor's degree in Germany. After working at national research institute of Türkiye for a short time, he has been working at the Presidency of Strategy and Budget for more than 15 years. He completed his master's degree in Secure Information Systems Management at George Mason University (U.S.), then completed his master's degree at Gazi University (Türkiye) and continues his doctorate education at the same university.
ORCID: 0000-0003-3925-1205

**Özel Sebetci (Asst.Prof.)** – He is a faculty member at Aydın Adnan Menderes University (Türkiye), serving in the Department of Computer Technologies at Aydın Vocational School. He began his academic journey by completing his undergraduate, master's, and doctorate studies at Gazi University (Türkiye). In addition to his academic work, Dr. Sebetci is the owner of Budunai Informatics and Technology Ltd., which operates in the Aydın Adnan Menderes University Technopark. His expertise includes information systems, management information systems, artificial intelligence, machine learning, software development, and web programming.
ORCID: 0000-0002-2996-0270

**Tamer Eren (Prof.)** – He worked as a research assistant at Kırıkkale University (Türkiye) and Gazi University (Türkiye) between 1997-2009. He has worked as Assistant Professor in 2009, Associate Professor in 2013, and Professor since 2019 at Kırıkkale University. His field of study is scheduling, multi-criteria decision making, ergonomics, and operations research.
ORCID: 0000-0001-5282-3138

**Hadi Gökçen (Prof.)** – He is graduated from Industrial Engineering Department in Gazi University (Türkiye). In the years of 1989 and 1994, he received M.Sc. and Ph.D. degrees in Industrial Engineering from Gazi University. Dr. Gökçen received the title of Associate Professor from manufacturing and service systems in 1998 and title of Professor in 2004. His research interests include optimization theory and methods, production planning and control, assembly line balancing, decision support systems and logistics management. Dr. Gökçen has over a hundred national and international publications and has an H-index of 22.
ORCID: 0000-0002-5163-0008