AN EVALUATION ON ADOPTION FACTORS OF SPATIAL DECISION SUPPORT SYSTEMS IN PLANNING

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ABSTRACT

AN EVALUATION ON ADOPTION FACTORS OF SPATIAL DECISION SUPPORT SYSTEMS IN PLANNING

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Changes in production and consumption patterns as a result of globalization are leading to ever-increasing carbon dioxide emissions and environmental problems. As a result of this situation, climate change and global warming are getting more and more important. In addition to the environmental problems that are associated with increased carbon emissions, economic losses and human health threats are emerging. Today new models and approaches are being developed to reduce the destructive effects of such environmental problems. In this context, the low-carbon economy model is seen as today's world's new development model. Besides, developments in information technologies is leading the emergence of new methods in planning. In this context, one of the most important developments is the advancements in geographic information technologies. Planning is a future-oriented complex decision-making process including many stakeholders and uncertainties. Globalization, rapid population growth in cities, increased interdependencies and information flow between cities and regions increase this complexity. In this context, spatial decision support systems (SDSS) as integrated computer-based systems, come to the fore in achieving more effective decision-making processes by allowing the development of plans and projects that respond better to uncertainties.

The main purpose of this study is to determine the factors affecting the adoption of SDSS by planning institutions in strategic decision-making processes. In this context, 'Spatial Decision Support System Software Development for Carbon Emissions in GAP Region' Project conducted by METU-Research and Implementation Center (RICBED) was evaluated. Accordingly, the factors that may affect the adoption of the 'Carbon Emission Atlas and Expert System (KAUS)' SDSS, the main output of the project, in the metropolitan municipalities and development agencies which are among the potential users of this software in the GAP Region in the future, was examined.

Keywords: Decision-Making, Geographic Information Systems (GIS), Spatial Decision Support Systems (SDSS)

ÖZ

PLANLAMADA MEKANSAL KARAR DESTEK SİSTEMLERİNİN BENİMSENMESİNE YÖNELİK FAKTÖRLER ÜZERİNE BİR DEĞERLENDİRME

Erken, Şeyma
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Küreselleşme ile birlikte devam eden üretim ve tüketim yapısındaki değişimler sürekli artan karbon dioksit emisyonuna ve çevresel sorunlara sebep olmaktadır. Bu durumun bir sonucu olarak iklim değişikliği ve küresel ısınma gibi konular gün geçtikçe önem kazanmaktadır. Artan karbon emisyonu ile birlikte oluşan çevresel sorunların yanı sıra, ekonomik kayıplar ve hava kirliliği sonucunda insan sağlığını tehdit eden sorunlar da ortaya çıkmaktadır. Günümüzde bu tür çevresel sorunların yıkıcı etkilerini azaltmak adına yeni modeller ve yaklaşımlar gelişmektedir. Bu bağlamda düşük karbon ekonomi modeli çağımızın kalkınma modeli olarak görülmektedir. Bunun yanı sıra, bilgi teknolojilerindeki gelişmeler planlama alanında yeni yöntemlerin ortaya çıkmasına öncülük etmektedir. Bu bağlamda, en önemli gelişmelerden biri coğrafi bilgi teknolojilerinde yaşanan gelişmelerdir. Planlama çok paydaşlı ve birçok belirsizliği barındıran geleceğe yönelik karmaşık bir karar verme sürecidir. Küreselleşme, kentlerdeki hızlı nüfus artışı, kentler ve bölgeler arasındaki karşılıklı bağımlılıkların ve bilgi akışının artması bu karmaşıklığı artırmaktadır. Bu kapsamda entegre bilgisayar tabanlı sistemler olarak bilinen mekânsal karar destek sistemleri belirsizliklere daha iyi yanıt veren plan ve projelerin geliştirilmesine imkan sunarak daha etkin karar verme süreçlerine ulaşılmasında ön plana çıkmaktadır.

Bu araştırmanın temel amacı, mekânsal karar destek sistemlerinin stratejik karar verme süreçlerinde planlama kurumları tarafından benimsenmesini etkileyen faktörleri belirlemektir. Bu kapsamda, ODTÜ-Yapılı Çevre ve Tasarım Uygulama ve Araştırma Merkezi (YTM-Matpum) tarafından yürütülmüş 'GAP Bölgesi'nde Karbon Emisyonları için Mekânsal Karar Destek Sistemi Yazılımı Geliştirilmesi' Projesi değerlendirilmiştir. Bu bağlamda, projenin temel çıktısı olan Karbon Salım Atlası ve Uzman Sistemi (KAUS) yazılımının gelecekte GAP Bölgesi'nde bu yazılımı kullanabilecek potansiyel kullanıcılar arasında bulunan büyükşehir belediyeleri ve kalkınma ajanslarında benimsenmesini etkileyebilecek faktörler incelenmiştir.

Anahtar Kelimeler: Karar Verme, Coğrafi Bilgi Sistemleri, Mekânsal Karar Destek Sistemleri

To my beloved family,

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ABBREVIATIONS

DBM: Database Management System

DSS: Decision Support Systems

GAP: The Southeastern Anatolia Project

GIS: Geographic Information Systems

IDC: International Data Corporation

KAUS: Carbon Emission Atlas and Expert System

KM: Knowledge Management

MBM: Model Base Management

METU-RICBED: Middle East Technical University- Research and Implementation Center for Built Environment and Design

PSS: Planning Support Systems

SDSS: Spatial Decision Support Systems

CHAPTER 1

INTRODUCTION

1.1 Problem Definition and Context

In daily life, individuals or organizations make decisions on several things without having a perfect knowledge on external determinants and consequences of their choices. Decision is about making a choice from multiple sets of alternatives. However, these decisions are not all the same. They differ according to their type or structure. Simon (1960) classified the decisions under three basic categories according to their structure: structured, semi-structured and unstructured. Whereas strutured decisions are routine, repetitive, and well-defined, unstructured decisions are not well defined and they are unexpected and sensitive to sudden external changes.

In the literature there a wide range of definitions being made for planning. Some scholors defined planning process by approaching it as a process of decision making. Abbott's (2005) definition can be given as an example to these definitions. Abbott (2005) defined planning as "*a decision making by individuals and organizations that generally involves more complex situations, longer time frame for actions and outcomes, and more prior thought about alternative choices and their consequence*s" (p. 238). To be associated with Simon's categorization planning deals with semi-structured or unstructured decisions.

In its long history, urban and regional planning has undergone many changes in terms of both planning approaches and methodologies. Among these, one of the turning points of planning is the introduction of information and communication technologies (ICT) in planning, which has resulted in emergence of new methodologies. There has been always intention to use computerized technologies in planning, but the first important step taken was the development of *Geographical Information Systems (GIS)* in the 1960s. Since its initial introduction, GIS have been used in different application areas of planning. Several practies have indicated that GIS with its capability of data capturing, analysis and visualization is very useful for the decision-making processes in the urban and regional planning field. However, capabilities of GIS were insufficient to use this computurized technology in semi-structured or unstructured decision-making process. In this context, main emphasis was on the limitations of GIS in modelling of alternative scenarios for the future, evaluating the results of these models and continuous monitoring of the policies and actions in achieving desired goals (Klosterman 2012; Keenan, 2006).

As a response to the limitations of GIS and newly emerging needs of decision-making processes in a complex environment, *Spatial Decision Support Systems (SDSS)* have been developed as a second generation GIS in the late 1960s. But, especially rapid advencements in ICT in 1980's have raised the attention to SDSS. In the literature, many definitions of SDSS have been made. Generally, it is defined as interactive computer-based systems that are providing support for solving semi-structured problems (Suguraman and DeGroote, 2010). There are two important points of these definitions. The first one is that SDSS are capable of supporting semi-structured or unstructured decision. The second one is that they are interactive, i.e., they ease engagement of all the stakeholders participating in decision-making process.

Changes in planning paradigms and developments in the external environment have led to a redefinition of the role of information technologies in planning processes. The emergence of '*urban governance*' concept beginning with the late 1980's has resulted in a paradigm shift in planning. According to this approach, planners are not the only actors of decision-making process, on the contrary they think, act and plan with other people. Therefore, the emphasis has shifted from 'planning for people' to 'planning with people'. Today, planning process involves a variety of stakeholders such as citizens, governmental organizations, non-governmental organizations

(NGOs), who have different backgrounds, knowledge, perceptions, and iterests, which reflects multi-dimensional characteristics of planning process. Having stakeholders with conflicting interests increases uncertainty and ultimately complexity. As a result one of the main challenges of planning have become managing the participatory decision-making processes.

There are also external factors increasing complexity of decision-making process in planning practice. Today, the social, economic and pyhisal environment changes rapidly. Globalization, climate change, increasing physical, economic and social networks at local and global scale, continuous flow of information and developments in technology increases uncertainty and unpredictibility of the future, which results in a more complex environment (Abbott, 2005).

As planning deals with the future and make decisions for the future understanding of internal and external uncertainties, being ready for and response to these uncertainties in the best way has become one of the concerns of planning process. In this context, creating alternative future development scenarios, continuous tracking and monitoring of data, policies, strategies, actions and evaluation of their implications in achieving desired goals has become essential to have more efficient and effective planning processes.

As a result, the increasing complexity of the planning process have raised the question of how to manage this process in the most efficient and effective way. Correspondingly, the adoption and use of SDSS raises as an answer to this question thanks to its capability of data collection, storage, analysis, representation and modelling. Various SDSS applications have been developed since its first introduction. CommunityViz, Urban Footprint, UrbanSim and INDEX Planbuilder are among the most well-known and successful ones (Albrecth, 2018).

Following the developments in GIS and SDSS, the usability of these systems in planning practice has become one of the main questions. Accordingly, studies on the adoption and usability of these tools in local and regional planning institutions has also increased. These studies examined the adoption factors within the framework of individual, organizational, technical and data-related parameters. Some researchers focused on the supply side factors (technical) while others focused on the demand side (individual or organizational) factors. These studies have revealed that SDSS are not widely used in practice although their high potential to improve decision-making processes (Vonk, 2005). Nevertheless, studies focusing on deman-side factors and the use of SDSS in Turkish planning institutions are very limited. In this context, this research mainly focuses on the problem of **lack of adoption and use of SDSS by planning institutions, despite its high potential to improve the decision-making process.**

1.2 Aim of the Study and Research Questions

The main aim of this research is to provide a general framework for SDSS; to understand the current use of decision support tools in planning institutions and to reveal the factors that are effective in the adoption of SDSS by examining the organizational structure of these institutions and the main characteristics and components of SDSS. In this context, the Carbon Emission Atlas and Expert System (KAUS), which was developed in the context of 'Spatial Decision Support System Software Development for Carbon Emissions in GAP Region' Project conducted by METU-Research and Implementation Center for Built Environment and Design (METU-RICBED) between 2019 and 2020 was examined.

This study is carried out in line with the main research question which is ***what are the main barriers to the adoption and use of spatial decision support systems (SDSS) by planning institutions in strategic decision-making processes?***

Sub-questions of study are:

1. What are the drivers of the increasing need for decision support in spatial decision-making processes?
2. What are the main characteristics of KAUS software and how does it work?
3. What kind of data-related problems do decision makers encounter?

4. What are the organizational factors affecting the individual and organizational decision about adopting SDSS?

1.3 Methodology

In this thesis, an explorative research, aiming to investigate obstacles to the adoption of Spatial Decision Support Systems (SDSS) in metropolitan municipalities and development agencies in GAP Region was conducted. The research was conducted by integrating comprehensive literature review on SDSS, and the relevant case study of Carbon Emission Expert System and Atlas (KAUS).

First of all, a detailed literature review was made in order to define components of SDSS and the use of geo-information tools in planning institutions by examining earlier studies. In order to base the research into a solid theoretical framework, the studies on the use of geographic information systems (GIS) in planning institutions that started in the 1990s were examined with a retrospective perspective, then contemporary studies on the use of SDSS and PSS were examined in line with the changing technological conditions and the needs of the spatial planning. Thus, the factors affecting the adoption and use of SDSS have been revealed since the first attempts of the use of geo-information tools in planning.

The components of SDSS and the results of studies on the use of geo-information tools formed the basis in determining the parameters to be examined within the scope of case study and preparing the appropriate interview questions. The participants to be interviewed were determined by examining the potential future users of the KAUS software (see Figure 1.1). KAUS software was designed to be used in the GAP Regional Development Administration, but is also suitable for the use by different planning institutions. In this thesis, the usability of KAUS software, which is not available for use in metropolitan municipalities and development agencies in the GAP Region, but has the potential to be used by these institutions in the future, was examined. In this context, the participants determined as city planners and GIS specialists working in the Metropolitan Municipalities and Development Agencies in the GAP Region. In addition, an in-depth interview was conducted with the researcher involved in the project to better understand the difficulties experienced during the project development process. In-depth interviews were conducted by contacting the personnel of the relevant institutions and the researcher via telephone. The interviews made with twenty participants.

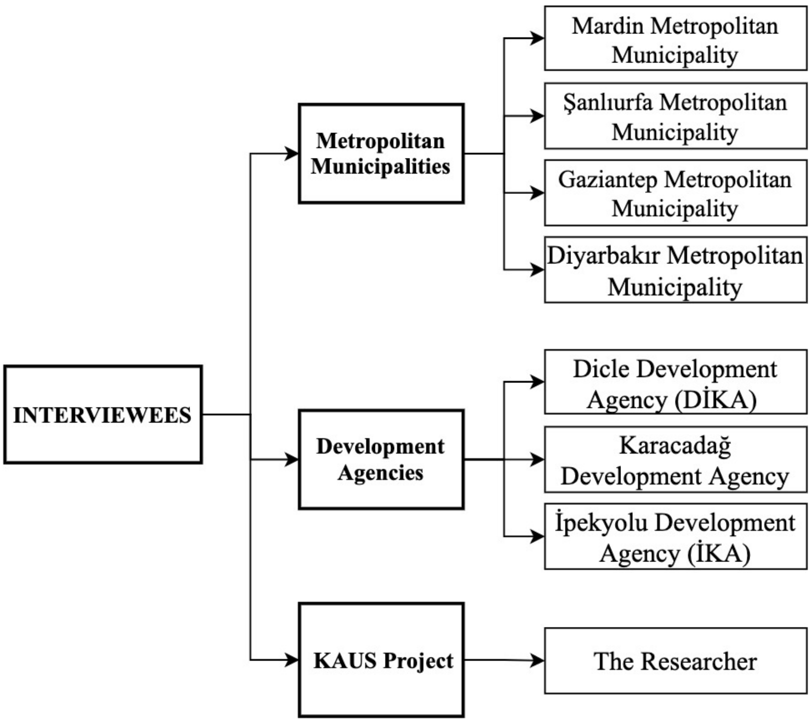

Figure 1.1 Groups of Interviewees Monitoring

After determining the factors for the adoption of SDSS by planning institutions and target users of KAUS software, the second part of the data collection was conducted through semi structured in-depth interviews with the target users. In this research, content analysis was made and descriptive quotations were used to analyze the data collected through in-depth interviews. In the content analysis, the key words mentioned by interviewees were coded to see the frequency of mentions. Applying this technique especially contributed to the analysis of data-related barriers to the adoption of SDSS.

In addition to the in-depth interviews, the relevant documents of institutions such as strategic plans of metropolitan municipalities, regional plans of development agencies, the reports of KAUS project and the KAUS software web-site were also examined in order to take a more comprehensive perspective on the institutional structure and planning content of these institutions. The data obtained from these documents were used in the research within the scope of the variables that are defined under relevant parameters to investigate obstacles to the adoption of SDSS by these institutions.

1.4 Structure of the Research

This thesis is organized under five main chapters. In the introduction, which is the first chapter, a brief background information on the research topic is given. In addition, problem statement, aim of the study, research questions and research methodology are explained.

In the second chapter, SDSS is examined with a comprehensive approach. Firstly, general definition of decision is given. Then, decision–making is discussed within the framework of stages of decision-making process and models. After that the main components, main characteristics and historical development of DSS and SDSS are given.

The third chapter focuses on the relationship between SDSS and decision-making process in urban and regional planning. Main paradigms are discussed in the context of changing role of ICT in spatial planning processes. Then, main characteristics of spatial decision-making is discussed with an emphasis on increasing uncertainty and complexity in planning environment. After that examples of SDSS applications is discussed in detail. Lastly, the factors effecting the adoption and use of GIS, SDSS and PSS in spatial planning practice and the main individual, organizational and technical obstacles to use of these tools is mentioned. In this context, a variety of studies is examined.

In the fourth chapter, the KAUS Project (Carbon Emission Atlas and Expert System) which is developed by METU-RICBED was examined as a case study. In this context, in-depth interviews conducted with the researchers who took part in the project and the personnel working in the metropolitan municipalities and development agencies in the GAP Region, which are among the main target groups of the project. In addition to that, the main characteristics and components of KAUS software is also analyzed.

In chapter five, a critical discussion of the main barriers to the adoption of SDSS is made in line with the research findings, and recommendations are made to improve the adoption of SDSS by planning institutions.

CHAPTER 2

DECISION MAKING AND SDSS

2.1 Definition of Decision Making

In everyday and professional life, human beings make several kinds of decisions by choosing from the alternatives. Decision making as being a choice was defined from different perspectives by some researchers: a choice among a set of actions, the choice of strategy to achieve the desired goal (Holsapple, 2008, p. 26).

Herbert Simon classified types of decisions into two according to their structure: programmable and non-programmable. Repetitive and routine decisions that have a wholly identified procedure to handle them are defined as programmable decisions. On the other hand, non-repetitive, complex, unstructured decisions and having a known optimal solution are non-programmable. He also added that the terms "well-structured" and "ill-structured" could be used alternately in place of "programmed" and "non-programmed." (Simon, 1977, pp. 45-46).

Based on Simon's conceptualization, decisions have been re-categorized under three groups: structured (programmable), semi-structured (non-programmable), and unstructured (non-programmable) decisions. (Sugumaran et al., 2010, p. 6) In this context, non-programmable semi-structured decisions are defined as multi-dimensional decision problems that have partially defined goals and objectives and a different set of alternative solutions (Gao et al., 2004, p. 2). In Table 2.1, characteristics of structured and unstructured decisions are conceptualized, in which semi-structured decisions can be located in between these two types of decisions.

Table 2.1 Comparison of Structured and Unstructured Decisions (Holsapple, 2008)

Structured (Programmable) decisions	**Unstructured (Non-programmable) decisions**
Routine, repetitive	Unexpected, novel, non-repetitive
Problems are recognized easily	Problems are not known in advance
Alternatives are clearly identified	Alternatives are unclear
Implications of alternatives straight forward	Implications of alternatives in determine
Criteria are well defined	Criteria are not defined
Specific knowledge needs are known	Specific knowledge needs are unknown
Reliance on tradition	Reliance on exploration, creativity, insight

As a reference to the given definition, the decision-making process in the context of urban and regional planning professions' problems and objectives can refer to spatial decision making. Since decisions made for cities, regions, or any other planning scales have a reflection on a space in the implementation phase of these decisions. Like most other decisions, decisions related to the urban and regional planning profession are not momentary and require a certain amount of time. Therefore, examining decision-making under different stages can help us better understand the process from planners' view.

2.2 Decision Making Process

Over the years, a wide range of human decision-making processes has been conceptualized. Among them, one of the most studied paradigms is Simon's conceptualization. Simon (1960) characterized the human decision-making process under the three main stages, independently from the structure of a decision, intelligence, design, and choice. Later, it was revised by the addition of the fourth phase, which is implementation (see Figure 2.1).

In the first phase, which is intelligence, the main aim of the decision-maker is to define the problem by observing the current situation and searching for the relevant information. In the design phase set of decision criteria and alternative solutions are formulated. After that, uncontrollable events which affect the decision-making process are defined and the relationship between criteria, alternatives, and uncontrollable events are set. In the choice phase, the decision-maker(s) evaluate to choose from the alternatives defined in the previous phases. (Simon, 1960) In the implementation phase, an implantation plan is developed and put into action by reviewing the analyses and recommendations, the weighting of results, and securing needed financial and non-financial resources (Philips-Wren, 2017, p. 3).

This process can be generalized under six sub-stages: the definition of the problem, determination of goals and objectives, identification of decision alternatives, evaluation of each alternative, the selection from the alternatives, and implementation (Sugumaran et al., 2011, p. 9). It should also be added that a loop system can be created in the process, enabling decision-makers to return to the previous phase to have feedback and revise what is done in this phase.

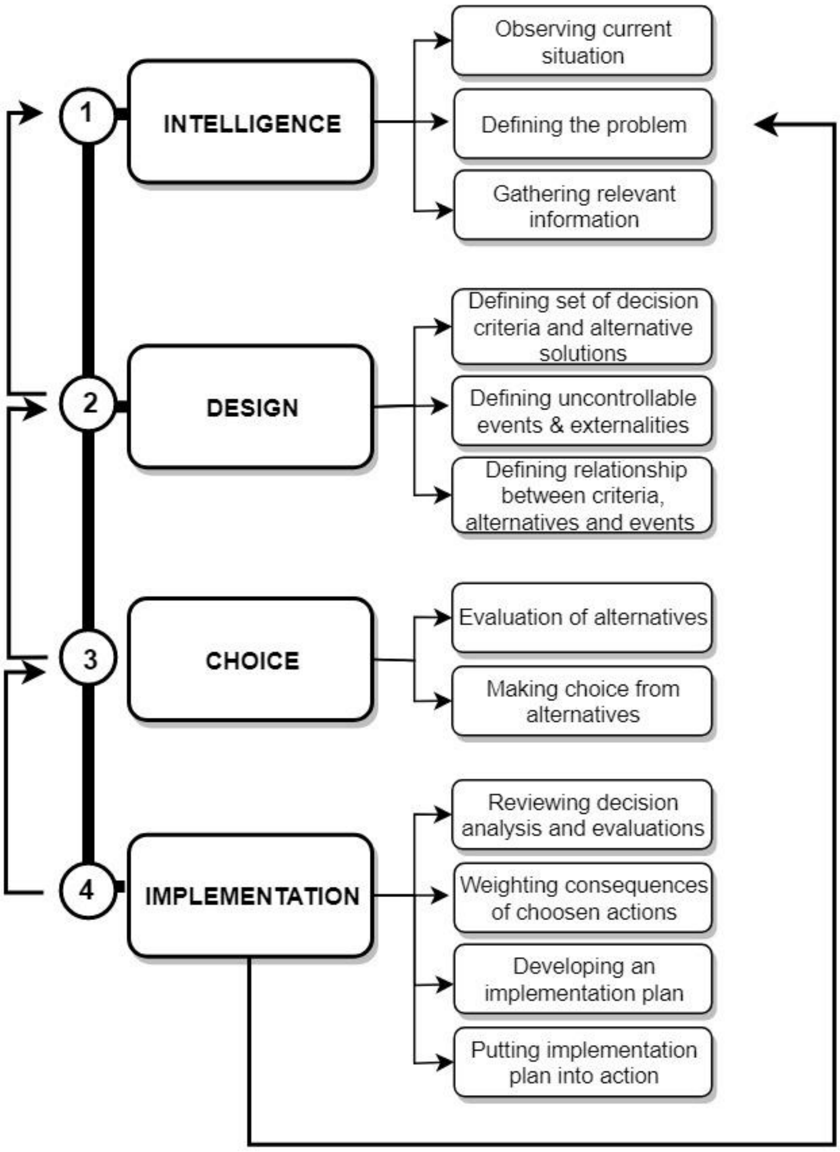

Figure 2.1 Simon's Conceptualization of Decision-Making Process (Adapted from Philips-Wren, 2017)

2.3 Models of Decision Making

Human behaviour in decision making process has been examined through different models and theories. The Rational Choice Theory developed by Adam Smith and Bounded Rationality Theory developed by Herbert Simon are among most studied theories by researchers to understand decision making process.

2.3.1 Rational Choice Theory

One of the most popular theories discussed by different professionals especially in economics is Rational Choice Theory. After its first introduction, it has started to be widely discussed in social and political sciences. This theory is developed to understand economic, social, and organizational behavior in decision making (Green, 2002, p. 2).

This theory explains human behavior in the decision-making process with the concept of rationality. It bases on the assumption of an "economic man" who is also "rational". Accordingly, while the behavior of this man's decision-making main assumptions is made. Firstly, this man has full information on all possible decision alternatives, the consequences of actions. Secondly, he has a well-organized system and sufficient skill to make comparisons among alternatives and compute each action's consequences, which will enable him to reach the best option (Simon, 1955, p. 99). In line with these assumptions, it is accepted that the problem is well-defined, that is structured, background information on problem is available and there is not a limitation of time and resources are not limited to consider all possible alternatives (Forester, 1984, pp. 23-24).

Therefore, it can be said that it is an optimization-based theory ignoring both possible internal and external factors that can affect the reliability of human decision-making, which has caused the development of a critical argument to this theory.

2.3.2 Bounded Rationality Theory

As a criticism of the rational choice paradigm, Bounded Rationality Theory was developed by Herbert A. Simon in the 1950s. His theory is an answer to questions: what is rationality? Furthermore, in what context is it bounded? According to him, rationality refers to a kind of behavior that is oriented to achieve desired objectives in current conditions and limitations (Simon, 1957, pp. 204-205).

He explained his principle of bounded rationality as;

> "The capacity of the human mind for formulating and solving complex problems is minimal compared with the size of the problems whose solution is required for objectively rational behavior in the real world or even for a reasonable approximation to such objective rationality." (Simon, 1957, p. 198)

Simon emphasized that humans experience different internal and external constraints in the decision-making process. These constraints can result from both human's cognitive limitations (internal) and the structure of the environment (external). Human-mind has some cognitive limitations and limited skills in understanding all alternatives, computing their implications and making forecasts for the future under a certain level of uncertainty or complete certainty (Simon, 1990, p. 15). In addition, there is incomplete and often unreliable information about the background of the problem, possible alternatives and consequences of actions. Time and resources are also a limitation to consider all possible alternatives, make choice among them. (Forester, 1984, p. 24; Simon, 1997, p.17).

In the context of human decision-making, Simon developed satisficing hypothesis. This hypothesis suggests that the primary goal of the decision-maker is satisficing rather than maximizing. In other words, the decision-maker tends to choose a decision alternative that is satisfactory or good enough rather than chooses the best alternative. The expected utility is maximized if the decision-maker chooses the best alternative by comparing all available alternatives. On the other hand, satisficing is realized if the decision-maker decides on an alternative that approaches or exceeds "a set of minimal acceptability criteria" (Simon, 1957, pp. 204-205).

2.4 Decision Support Systems (DSS)

There is not a single agreed-upon definition of Decision Support Systems (DSS) since several different definitions of DSS have been developed since its first introduction:

- Gorry and Scott-Morton (1971, p. 53) defined DSS as supporting computerized systems developed to solve unstructured or semi-structured problems.
- Keen (1980) emphasized that while explaining DSS, it should not be forgotten that DSS support rather than replaces the decision-maker. Also, it aims to improve the efficiency of a decision and improve its effectiveness (pp. 8-9).
- As a more general explanation, Holsapple (2008, p. 22) identified DSS as computerized technologies which increase effectiveness and innovativeness of decision-making process while processing and displaying knowledge.

From these definitions, the most important themes that SDSS address are as below:

- The first important point is related to the structural characteristics of a problem. It is emphasized that DSS are designed to solve semi-structured or unstructured problems that are complex, uncertain, and not well defined for human decision-makers to analyze and the process by using their cognitive abilities.
- The second important point is that decision support is interactive. It enables different types of users, who may have conflicting interests, to engage in the decision-making process and get in touch with other interest groups.

2.5 Spatial Decision Support Systems (SDSS)

As with decision support systems, there is not a single agreed-upon definition of SDSS. Densham (1991, p. 404) defined SDSS as "explicitly designed to support a decision research process for complex spatial problems. SDSS provides a framework for integrating database management systems with analytical models, graphical, display and tabular reporting capabilities, and the expert knowledge of decision-makers."

Wright and Buehler (1993, p. 123) defined SDSS as "*decision support systems developed for use with a domain database that has a spatial dimension, or for situations where the solution space of a problem has a spatial dimension*." Malczewski (1999, p. 281) defined SDSS as "*an interactive computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem*."

By synthesizing different definitions (Suguraman et al., 2010) made the definition of SDSS as;

> "integrated computer systems that support decision-makers in addressing semi-structured or unstructured spatial problems interactively and iteratively with functionality for handling spatial and non-spatial databases, analytical modeling capabilities, decision support utilities such as scenario analysis, and effective data and information presentation utilities." (p. 14).

The given definitions show that DSS and SDSS have common characteristics in terms of design and system components. It is mainly conducting spatial analysis and capturing of both spatial data in addition to non-spatial data makes SDSS different from traditional DSS. which available alternatives and actions can be followed and analyzed in reaching the desired objective.

2.6 Main Characteristics of (S)DSS

As a reference to given definitions and components of S(DSS), its common characteristics are listed below:

- Oriented to solve semi-structured or unstructured decision problems

- Aims to provide support for decision makers rather than replace them
- Oriented to improve both effectiveness and efficiency of the decision-making process
- Ability to support all phases of decision-making
- Ability to capture both spatial and non-spatial data*
- Flexible system architecture, providing opportunity to merge model base and data base in different ways.
- A flexible architecture enabling users to add new capabilities with respect to their changing needs
- Ability to provide support for 'multiple independent or interdependent' decisions
- Ability to provide support not just for individual decision making but also for groups or teams.
- Consist of integrated and interactive user interface enabling decision makers to conduct different decision-making styles
- Ability to conduct spatial data management, spatial and geographical analysis and spatial modelling (Marakas, 2003, p. 3; Ayeni, 1997, p. 3)

2.7 Historical Overview of SDSS

Since the origins of (S)DSS dates back to the period of increasing search for new spatial decision-making tools because of some limitations of Geographical Information Systems (GIS) practices, the development pattern of GIS is also given in this part.

2.7.1 Introduction of Geographic Information Systems (GIS)

There was a rise of needs for tools to optimize decision-making by using predictive models and deal with insufficiency in available data and inadequacy of traditional computation methods in urban planning beginning with the 1960s. (Ayeni, 1997, p.

4). As a response to increasing need in the planning field, advances in computer-based technology and developments in spatial sciences have provided the basis for the development of GIS (Malczewski, 2004, p. 9).

GIS is defined as a computer system capable of displaying and storing spatial or geographical data and enabling the integration of non-spatial data. As depicted in Figure 2.2, functional components of GIS are data capture and preparation, data management, data manipulation and analysis, and data presentation (Huisman and By, 2009, p.145).

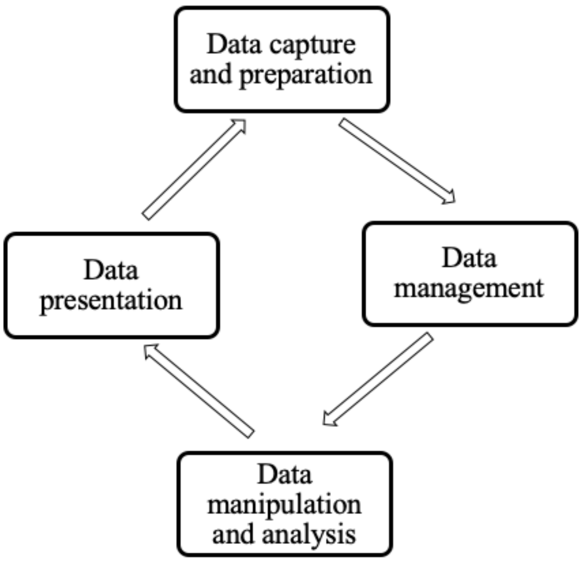

Figure 2.2 Functional Components of GIS (Adapted from Huisman & By, 2009)

In this context, the capabilities of GIS can be briefly listed as follows;

- Collection, storage and manipulation of spatial and non-spatial data
- Analysis of the data according to needs of users
- Display of the data in cartographic forms, thematic mapping
- Generation of reports (Fischer and Nijkamp, 2011, p. 3; Keenan, 2006, p. 14).

Decision-making process can be examined under three different processes which are: managerial, operational and strategic. Firstly, managerial decision-making process related with the effective and efficient gathering and use of resources in achieving specified objectives. It focuses on interaction of people. Secondly, operational decision-making process related with the effective and efficient processing of tasks which is the main focus of it. Thirdly, strategic decision-making is the process of defining objectives, policies and resources to achieve them. Strategic decision-making making process deals with the complex and non-routine problems (Gorry et al., 1971, p. 50). As depicted in Figure 2.3, different decision-making processes requires the use of different geo-information tools. GIS differs from DSS and SDSS in this context. Whereas GIS is capable of solving structured decision problems, DSS and SDSS are capable of solving semi-structured or unstructured problems for in strategic decision-making process.

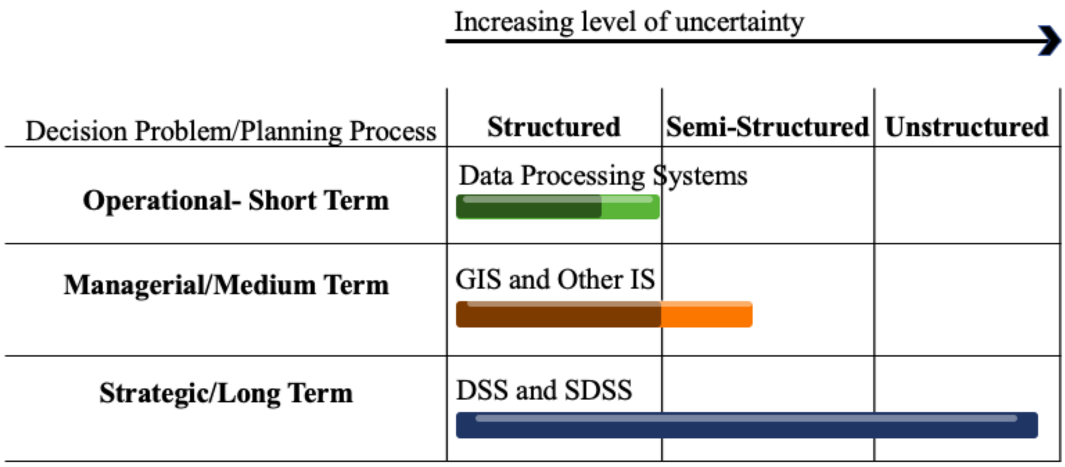

Figure 2.3 Decision-Making Process and Decision Structure Monitoring

According to their capabilities and system design GIS, DSS and SDSS show some differences. As seen in Table 2.2, they are differentiated from each other according to type of decisions and system components. Although GIS is capable of functioning generic spatial analysis, it does not include necessary modeling tools which enable users to conduct specific analysis, which can be emphasized as the main difference between GIS and (S)DSS and driving force for the initial development of DSS (Densham 1991, p. 405-406; Keenan, 2006, p.15-16; Suguraman et al., 2010, p. 67).

Klosterman (1997, p. 49), defined Planning Support Systems (PSS) as “information technologies planners use to perform their unique professional responsibilities as planners.” The main difference between SDSS and PSS is that while PSS is applicable only for planning specific issues, SDSS has a wider application area. A PSS includes components of a typical DSS, that is data, models, and visualization, Like SDSS, GIS is one of the most important components of GIS (Geertman et al., 2004, p. 292). Eventually, PSS and SDSS have many common points while taking into account the components and general purpose of these support tools.

Table 2.2 Comparison of GIS, DSS and SDSS (Keenan, 2006)

GIS	**DSS**	**SDSS**
Used for structured decisions	Used for semi-structured and unstructured decisions	Used for semi-structured and unstructured decisions
Concerned with spatial data	Can be in any problem domain	In problem domain with spatial component
General purpose tool	Specialised software	Specialised software
Sophisticated interface	Sophisticated interface	Sophisticated interface
Spatial Database	Database	Database with spatial component
General spatial data handling models	Specific decision models	Specific decision models making use of general spatial data models

2.7.2 Development of DSS and SDSS

Since GIS have deficiencies in terms of spatial analysis and modeling capabilities, they cannot provide all the required functions for urban and regional planning processes (Fischer et al., 2011. p. 53). Being complex and multi-dimensional are prominent features of spatial problems. This makes most of them semi-structured or unstructured problems (Gao et al, 2004). Although GIS have important contributions to spatial decision-making processes in terms of data gathering and storage, it has some limitations in solving semi-structured problems (Chakroun and Benie, 2014, p. 2). All these factors led to the search for new computer-based tools to be used in planning and formed the basis for the development of DSS.

Historical development of DSS and SDSS can be categorized under four main phases (see Figure 2.4.):

1. Introduction of DSS (1960-1980): Initial developments of DSS have been seen in the context of two research areas: theoretical and technical studies. In the 1950 and 60s, theoretical studies focusing on organizational decision-making were conducted in the Carnegie Institute of Technology. As a second research area, technical studies on DSS via the use of interactive computer technology conducted at the Massachusetts Institute of Technology in the mid-1960s. During the 1970s, studies on DSS became widespread. In this period both practical and technical issues on DSS has been discussed among various researcher and academicians (Shim et al., 2002, p. 111; Power, 2009, p. 124).

Beginning with the late 1960s, GIS started to be used in the field of planning field. But, the number of planning departments that installed GIS was very limited because of the high price of hardware, lack of data and software. Therefore, in that period, its use was not widespread, and it was on a personal level (Yeh, 1999, p. 877).

2. Prominence of DSS (1980-1990): At the beginning of the 1980s, discussions on DSS were carried one step further with the various studies on building and designing DSS, i.e., the scope of DSS was started to expand. Thanks to these developments, application areas of DSS expanded beyond finance, business, and management (Power, 2008, p. 126). However still, there were no significant advancements in the use of SDSS tools in the field of planning because of technical and conceptual problems (Ayeni, 1997, p. 4).

On the other hand, thanks to the further development of hardware and software technologies and improvements in data management, the use of GIS by urban and regional governments, especially in developed countries such as Australia, North America and Europe in the early 1980s (Yeh, 2008, p. 3).

3. Prominence of SDSS (1990-2000): At the beginning of this period, recognition of SDSS has started to spread and gain importance in the GIS community. However, it does not have a central place in GIS technology because of the diversity of techniques in SDSS. In the late 1990s, GIS became more accessible and the use of it became widespread in developing countries. Parallel to this, SDSS has achieved prominence in the planning field with advancements in GIS (Yeh 1999, p. 877; Keenan, 2006, p. 6). The development of SDSS has continued and applications of SDSS has increased thanks to advancements in technology. Main achievements in this period can be summarized as; development of group SDSS and single usage, integration of intelligent components, and provision of Web-based SDSS (Suguraman et al., 2010, pp. 42-43).

4. Expansion of SDSS (the 2000s): The main characteristics of this period was accelerated technological developments in data, software and hardware (Keenan and Jankowski, 2019, p. 65). The use of SDSS applications in different fields has continued to increase rapidly after the 2000s (Suguraman et al., 2010, p. 48). Nevertheless, such geo-information tools in urban and regional planning are still not still widely used and more developments are needed to be achieved for the efficient and effective decision-making process (Geertman and Stillwell, 2003, p. 25; Vonk et al. 2005, p. 909).

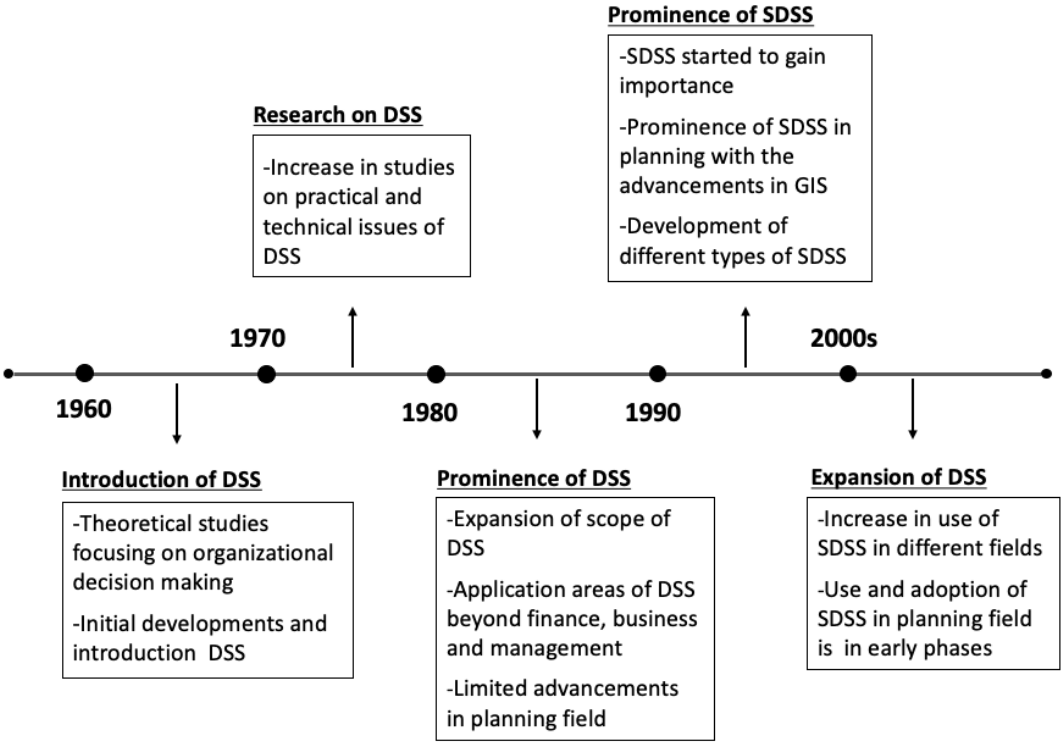

Figure 2.4 Development Phases of DSS and SDSS

2.7.3 Components of (S)DSS

In earlier works, components of (S)DSS are defined different ways by different researchers. Whereas Sprague (1980, p. 15) defined three components: database management (DBM), model base management (MBM) and dialog management, Armstrong, Densham and Rushton (1986) proposed four components: DBM, MBM, display and report generators and a user interface and Gao et al. (2004) proposed six main components as data, model, solvers, visualization, scenario, and knowledge. Based on these different descriptions, (Suguraman et al., 2010, pp. 67-68) stated that a decision support system is comprised of five major components: database management, model base management, dialogue management, knowledge management, and stakeholder (see Figure 2.5).

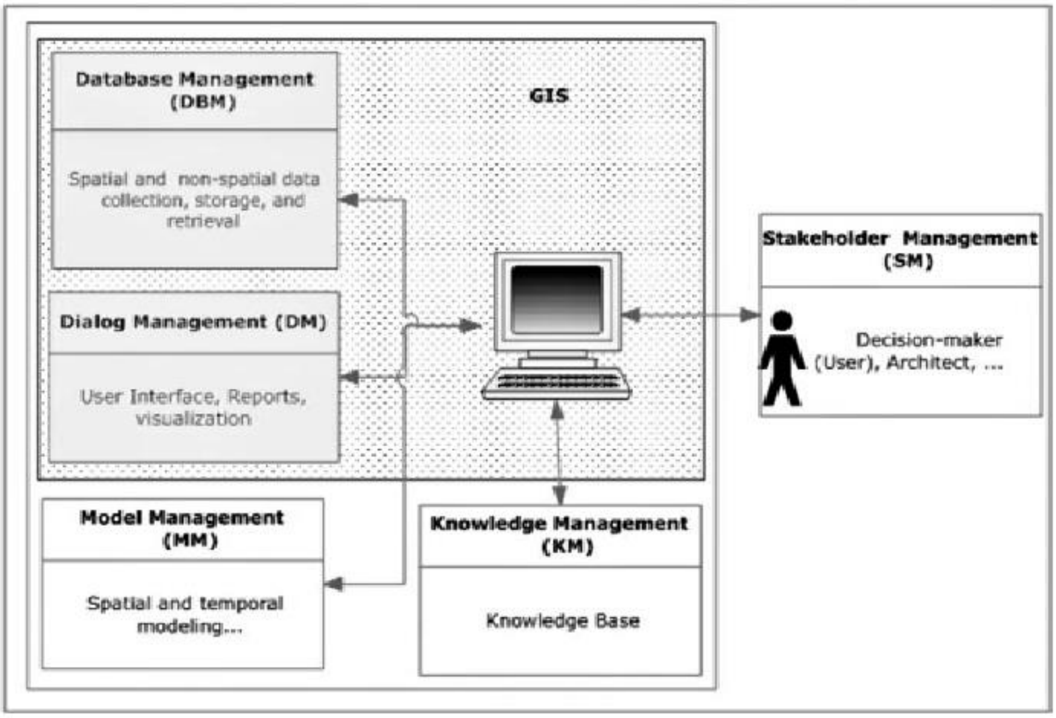

Figure 2.5 Components of S(DSS) (Suguraman and DeGroote, 2010)

2.7.3.1 Database Management (DBM)

The DBM is the core of a typical SDSS. A database is where different types of data (locational, thematic and topological) stored and manipulated (Densham, 1991, p. 408). Malczewski (1999, p. 25) defined database as *"a collection of nonredundant data in a computer organized so that it can be expanded, updated, retrieved and shared by various users."* Since data stored and processed in (S)DSS can be collected from various sources in different types, the data management subsystem is vital to relate different data types into a common subject and make them comparable (Marakas, 2003, p. 10). The source of collected data can be both internal and external (Forgionne, 2003, p. 5).

The database management system has main tasks:

- Providing a data definition language including description and attributes of related data
- Coordinating the tasks on storage, access and dissemination of information available in database. DBM is responsible from multiple functions such as making updates on stored data as transactions occur, integrating data collected from various sources and retrieving data to make queries and produce reports.
- Carrying out administrative functions related to database. In the context of data security, it is responsible from preventing unauthorized access, recovering database error, recording data usage and acquisition.
- Ensuring logical independence between the database and DSS in order to operate the system successfully. While making decision, DSS users take the information from a large pool of real-time or historical data. In this context, main task of DBM is to ensure physical organization and structuring of the data (Marakas, 2003, p. 10).

2.7.3.2 Model Base Management (MBM)

A model is created to simplify the reality to have a better understanding of an event or process. Therefore, various characteristics of an event or process can be determined by using the model base component of (S)DSS. Running an (S)DSS model is more advantageous than experiencing that event or process in real life to predict expected outcomes because it is less time-consuming and requires less effort and financial resources (Marakas, 2003, p. 13). A MBM can contain a variety of models according to decision-making problem such as statistical analysis, network analysis, mathematical models, simulations, and projections (Chakhar and Martel, 2004, p. 104-105.)

Like the database subsystem, the model base of a traditional DSS may vary in number, size, and complexity. Despite varying characteristics, the model base management system has some common tasks:

- Creating new models and algorithms rapidly
- Integrating different models via the database
- Design of analytical tools and command structure to run the model.
- Data and parameters are main inputs of the model which users enter. MBM manages this process by enabling easy entrance of these inputs and easy access to different models.
- Enabling specialization of models with respect to user's own preferences by allowing modification and easy update of the models
- Including a model library in which description on the function and application of models is provided (Sprague, 1980, p. 17; Densham 1991, p. 409; Marakas, 2003, pp. 14-15, Suguraman et al., 2010, pp. 145-147).

2.7.3.3 Dialog Management (User Interface)

It is one of the essential subsystems to construct a successful DSS by providing effective interaction between users and other components of DSS (Suguraman et al., 2010, p. 166). Flexibility and usability of a DSS is directly related with the user interface component (Sprague, 1980, p. 17). The user interface designed to be 'easy to use' (Densham, 1991, p. 410). Easier access to the system means a better interface which requires less effort and training from users while using (S)DSS. In order to fulfill its responsibilities, a user interface should include software (menu, command tools) and hardware components (monitoring, input facilities), and it should deal with requirements related to human interaction, reporting, and easy accessibility (Marakas, 2003, p. 19).

Malczewski associated the success of a user interfaces with five main parameters:

- **Accessibility**: It refers to intuitive and facilitative characteristics of user interface enabling easy applications.
- **Flexibility**: It refers to ability of recovering mistakes and unintended actions.

- **Interactivity**: It refers to efficient flow of data and information between users and the system and users themselves.
- **Ergonomic layout**: It refers to ability of constructing effective communication system between different users and the system.
- **Processing-driven functionality**: It refers to ability of clarity of completed tasks and tasks that will be carried out in the further steps (Malczewski, 1999).

The certain tasks of user interface can be summarised as:

- Supporting interaction between users and other components of (S)DSS
- Handling different dialogue styles
- Recording and analysing previous dialogs
- Generation of reports and presentation of data and outcomes in different formats such as tables, graphics, texts and so on (Sprague, 1980, p. 20; Marakas, 2003, pp. 19-20, Suguraman et al., 2010, p. 167)

2.7.3.4 Knowledge Management (KM)

Although it is not a necessary component of an (S)DSS, it can be seen in many applications of (S)DSS. KM stores all the knowledge, provides expert knowledge and guides users during the decision-making process. (Suguraman et al., 2010, p. 179) The structure of a decision is decisive in the required level of reasoning and the level of reasoning increases from structured decisions to unstructured decisions. Reasoning as a process of creating new by the combination(s) of existing data is conducted in KM (Marakas, 2003, p. 16).

Knowledge can be comprised of definitions, constraints, rules, facts, previously obtained outcomes, or any other kind of information defined by the (S)DSS designer. In KM, descriptions of objects, their relationship, uncertainties, and probabilities are also included. (Marakas, 2003, p. 16; Chakhar et al., 2004, p. 105). In other words, the KM system includes all the necessary knowledge that users have to know in order to use the system effectively (Sprague, 1980, p. 20).

The typical process in the knowledge management component is followed as below:

- Acquisition of knowledge by designers of (S)DSS
- Transformation of collected knowledge into set of rules or facts in knowledge base
- Analysis of knowledge base in interface engine

Provision of linkage between knowledge base, inference engine and users by the user interface component (Suguraman et al, 2010, p. 179).

2.7.3.5 The Stakeholder

The decision-makers are one of the essential components of the S(DSS). Most of the decision problems, especially spatial decision problems, include a wide variety of individuals and groups who may have different interests in the decision-making process. Different stakeholders of the S(DSS) have different roles in processing the system. Accordingly, Suguraman et al. (2010, p. 175) categorized the stakeholders into four different groups:

- ***Expert***: The expert has extensive knowledge about the structure of S(DSS) and is capable of processing technical tasks such software, algorithms, monitoring in order to develop necessary tools that is used in addressing decision problems.
- ***Developer***: The developer is responsible from collecting requirements defined by users, design of system architecture, development of user interface and programming.
- ***Analyst***: The analyst has the responsibility of defining models, running simulations, analysing data, generating outputs and interpretation of the results.

- ***Decision Maker/End Users***: The end users represent stakeholders to whom services are provided to create different decision scenarios and the results of interface component. (Suguraman et al, 2010, p. 175-177).

2.7.4 Decision Making Process in SDSS

The decision-making process in a typical SDSS is summarized in Figure 2.6 by synthesizing all the information gathered in this chapter. The process is examined under three main stages: determination of inputs, processing, and output generation.

In the first stage, data gathered in the database and parameters defined by the decision-maker(s) is sent to the model base via the user interface. By using these inputs, decision models and suggested solutions are created. Then, the results of these analyses and modeling are produced as an output for decision-makers. The decision-maker can make changes or additions in the inputs and start the process again by using provided output feedback. Therefore, there is a circular process fed by the circulation of feedback between the decision-maker and the system.

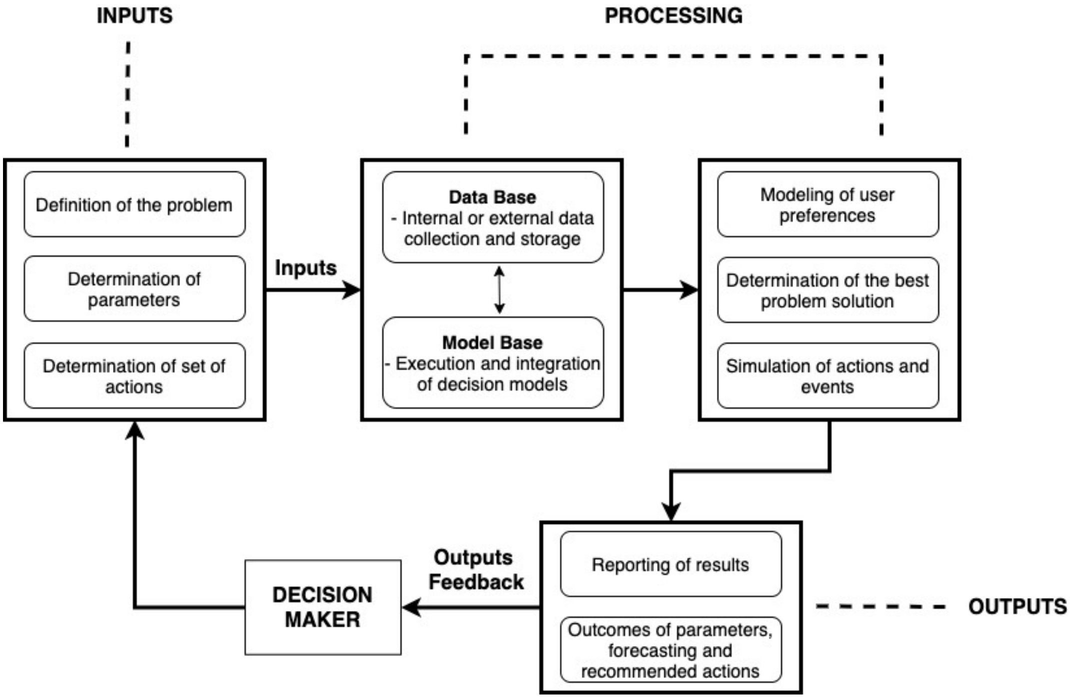

Figure 2.6 Decision Making Process in S(DSS)

CHAPTER 3

SDSS IN PLANNING PRACTICE

In this chapter of the study, main purpose is to present changing role of information technology in city and regional planning, to analyze different applications of SDSS and discuss why and how the use of SDSS has become necessary in the context of changing planning approaches and the decision-making process. In order to better understand drivers of the growing need for the use of SDSS, changing internal dynamics of the planning profession and other external dynamics (globalization, recent developments in technology, etc.) have been discussed.

3.1 Planning Paradigms and IT: Evolving Perspectives

The development of GIS and planning is interrelated with each other. The definition of planning and the changes in planning approaches from the past can be examined to understand how the role and use of information technologies (IT) in planning have evolved until today.

The relationship between planning and IT through evolving planning perspectives until today is illustrated in Figure 3.1. Klosterman (1997) conceptualized this relationship under four main stages. Accordingly, planning paradigm shifted from the assumption of planning as applied science in the 1960s to the political process-oriented approach in the 1970s. Moreover, there was an emphasis on communication in the 1980s and collective-design perspective of planning in the last decade). Correspondingly, concerns and use of IT in planning have been evolved, likewise progress of planning paradigms. The main focus of the 1960s, which was on the data-oriented information systems, has been shifted to information management systems in the 1970s, and decision support systems based on knowledge in the 1980s to intelligence-based decision support systems in the 1990s and beyond. (Klosterman, 1997, p. 45)

3.1.1 Planning as Applied Science

The 1960s were the period when the concept of “rationality” was dominant in planning profession. “Planning as applied science” approach was also shaped under the influence of this concept. The primary assumption of the applied science approach is that planning is composed of rational processes requiring the application of scientific knowledge and techniques. In this approach, rationality was defined as selecting the best policies and actions among the alternatives in order to achieve desired future (Klosterman, 1997, p. 48). In the rationality tradition, it is accepted that all necessary knowledge for the planning problem to be addressed is available in principle. Besides applied science approach, the planning process based on rationality concept was also called as “blueprint planning”, “master planning” or “end-state planning” by different professionals. (Geertman, 2006, p. 870).

With the development of computer-based information technologies in the late 1950s, their role in planning process has gained importance and quantitative techniques began to be used in decision-making processes (Nedovic-Budic, 2000, p. 81; Klosterman, 1997, p. 6). According to applied science approach, GIS is used in value-free planning processes as "data-centered information technology" that is capable of collecting and storing necessary data and producing information from these databases. The underlying assumption of the applied science model is that having more information is always better and one of main the role of planner is to provide this information, which improves the quality of the policy-making process (Klosterman, 1997, pp. 47-48).

3.1.1.1 Planning as Politics

The emergence of the approach of "planning as politics" in the 1970s caused some questions and critics intended for the assumptions of the applied science model. It was emphasized that added that planning could not be a value-free process, but it is a value driven process (Klosterman, 1997, p. 48; Geertman, 2006, p. 872). While this approach was against the assumption of planning as a value-free process, it was defended that IT and scientific techniques used in planning are inevitably political and contributing to administrative and technical power. In this period, the main focus shifted from data to information which is the organizing, analyzing and summarizing data within a logical meaning. (Klosterman, 1997, p. 50). In addition to this it was emphasized that there is lack of available information and knowledge. Consistency and reliability of these information and knowledge was also one of the issues in this period. (Klosterman, 1987, p. 443)

Another emphasis was on the failure of the applied science model in explaining the relationship between planning and society. According to this new approach, planning is often “a highly contentious political process involving the multiple and shifting agendas of model developers, agency personnel, elected and appointed officials, advisory groups, and a myriad of community representatives.” (Klosterman, 1987, p. 443).

3.1.1.2 Planning as Communication and Collective Design

1980s was the period when the approach of planning as a socio-political process was enriched. As a result of the number of empirical studies, it was revealed that planning is not just composed of the collection and provision of the information that can contribute to the decision-making process, but it involves much more. (Klosterman, 1997, p. 49). “Communicative planning” paradigm has emerged in this period. According to this paradigm, planning has started to be defined as a process in which reasoning is made through communication between individuals instead of being an individualized process. This kind of reasoning raises the question “How to act in the world to adress our collective concerns” (Healey, 1992, p. 150). In other words, "the collective common sense" and the formalized knowledge of independent variables were to main realms of rationality in which this view is grounded. In addition to information technologies and quantitative methods that can support the policy-making process, 'untangle' activities, for example, advice-giving, story-telling, another kind of metaphor, and rhetorical devices are components of the planning process in communicating the others (Klosterman, 1997, p. 49).

Main emphasis shifted from information to knowledge and DSS has gained importance as a new type of IT in this period. (Klosterman, 1997, p. 50). According to view of planning as communication and collective design, “all forms of knowledge are socially constructed it accepts that values are not predetermined but are established in the communicative process itself.” (Foley, 1997, p.1). In addition to objective knowledge, subjective is also one of the components of the planning process. In this context, computer-based decision support systems have begun to come forward as a kind of IT tool to combine objective and subjective components of this process. (Malczewski, 2004, p. 15). Planner’s role was also redefined with respect to this approach. Accordingly, transmitting information to others is more critical than the planners' role as planning agency or technical advisor. Therefore, planners act as facilitators in this communication process (Foley, 1997, p. 1; Malczewski, 2004, p. 14). The main role of DSS is also to facilitate collective design by improving communication and interaction between actors Klosterman, 1997, p. 49.)

As a result, the view of planning as communication and collective design is the period when DSS and SDSS were on the rise as tools that supports a more open and inclusive decision-making process in planning.

1960s	1970s	1980s	1990s and beyond
Planning as applied science; -Planning is a rational process -The planner's most important role is providing more and better information -Information is a value-free and politically neutral process -The more information, the better decision-making in planning ***Focus on data-oriented information systems;*** -IT is viewed as providing the information needed for a value-free and politically neutral process of "rational" planning -Invitation period of GIS as a tool for collecting and storing required data and deriving information from databases -Limited use of GIS because of the expensive price of hardware, lack of data and software	***Planning as politics;*** -Planning deals with socio-political systems that are composed of interest groups with conflicting values and preferences -Planning cannot be value-free -Key underlying concepts become public participation, negotiation, compromise, consensus building, and conflict management ***Focus on information management systems;*** -IT is viewed as inherently political, reinforcing existing structures of influence, increasing power of administrators and technical experts, and transforming the policy-making process -Invitation period of GIS -Limited use of GIS because of the expensive price of hardware, lack of data and software	***Planning as communication;*** -The view of planning as a part of socio-political system was reinforced -Planning is not just composed of the collection and provision of the information. 'Untangle' activities such as advice-giving, story-telling, the other metaphors and rhetorical devices are components of planning ***Focus on knowledge based information systems;*** -IT and planners' technical analysis are seen as often less important than the ways in which planners transmit this information to others -Use of GIS in planning became feasible in developed countries -Computer-based SDSS gained importance in combining objective and subjective elements	***Planning as collective design;*** -The view of planning as reasoning together -Two realms of rationality: 'the collective common sense' and the collaborative attempts of groups 'deciding and acting together' and the formalized knowledge of autonomous individuals ***Focus on intelligence based information systems;*** -IT viewed as a providing the information infrastructure that facilitates social interaction and communication that attempts to achieve collective goals. -Use of GIS in planning became widespread both in developed and developing countries as a collaborative decision support system -The use of SDSS and PSS is not widespread yet

Figure 3.1 Planning Paradigms and Role of Information Technologies (Adapted from Klosterman, 1997)

3.2 Drivers of Changes in Spatial Decision-Making Process

3.2.1 Urban Governance: Multi-Actors and Conflicting Interest

One of the factors having role in changing process of spatial decision making is the concept of *urban governance.* It has been at the core of urban planning related discussions since late 1980s (McCann, 2016, p. 312).

Over time the term ‘governance’ has started to be used in order to clarify changes in the definition of government, the process of governing and the way society is governed (Rhodes, 2007, p. 1246). The management of inter-organizational linkages have become necessary in today’s ‘network society’, which led the shift from 'government' to 'governance' (Edelenbos and Dijk, 2017, p. 5). “*Governance comprises collective practices of framing and targeting problems, namely, practices in which governmental actors play a crucial role, but for the success of which societal actors are also increasingly relevant.*” (Haus and Klausen, 2010, p. 258). In the literature, there is variety of not same but similar to these similar definitions of governance. But, common acceptation that can be concluded from these definitions is that the prior interest of governance is providing necessary basis for ensuring collective action. This collective action has brought about blurring boundaries between formal institutions of state and private sector (Stoker, 1998, p. 17-18). Therefore, the government is not the only actor, but it is one of the actors of decision-making process (Obeng-Odoom, 2012, p. 206). This means that development of the concept of governance has enabled formulation of more participatory and multi-actor decision making processes.

The shift to 'governance' concept has important implications on urban and regional planning. Hendriks (2013, p. 555) defined urban governance as “*the more or less institutionalized working arrangements that shape productive and corrective capacities in dealing with urban steering issues involving multiple governmental and nongovernmental actors.”* There many factors in the emergence of urban governance concept. These can be summarized as increasing pressure on urban areas because of climate change, rapid urbanization and population growth the development of economic sectors in global scale, increasing competitiveness and collaboration between cities in global scale and the increasing complexity of relationship between people and space in the local scale. The increasing interdependencies in global and local scale necessitates the emergence of networks through which information flow is provided between actors (Edelenbos et al., 2017, p. 2-3).

The concept of urban governance and the complexity of the planning process are interrelated with each other. Today, developed and developing countries include the public, private sector, government organizations and NGO(s) as the actors of urban and regional planning process (Edelenbos et al., 2017, p. 1). In this respect, governance becomes more multi-dimensional in terms of scale, sectors and actors.

By leaving behind the idea of planners think, decide and design for people, planning methodology has redefined with the idea of both planners and people should cooperate as actors in the planning process. The main idea behind this definition is that planners should not be expected to have all kinds of knowledge and ability to conduct different stages of the planning process. The people whom planners cooperate with comprise of two groups. The first group is decision-makers evaluating and approving plans and people who target group of plans are. Therefore, this can be seen as a call for shifting to planning methods embracing multiple actors (Ayeni, 1997, p. 2). These actors have different interests, and perceptions, which makes the process more complex. Lack of knowledge of the interrelation between social, economic and technological dynamics, how actors will behave and how to monitor and analyze these interrelations also leads to an increase in uncertainty. Therefore, the more complex, uncertain and diverse planning environment necessitates adoption of new tools to have effective urban governance (Dijst and Schenkel, 2018, p. 300).

When considering increasing complexity and the need for integrating these actors into the planning process, taking advantage of the digital age has become necessary to have the effectiveness of the decision-making process in planning. User-friendly SDSS come into prominence within this context. SDSS can be conceptualized as an instrument to ensure communication of all involved actors and the flow of information to let them follow progress across different geographical boundaries on a national and international scale.

3.2.2 Big Data

In the era of 'small data', collected data was fewer in terms of quantity and less complex, which allowed the use of traditional methods to make spatial analysis and decision making (Schintler and Chen, 2019, p. 2). Small data can be defined as a dataset composed of samples, not generated continuously, having relatively fewer variables and coarse spatial scale in limited access. Therefore, these kinds of datasets can be analyzed through studies such as focus groups, interviews, case studies, questionnaire surveys, etc. These types of studies are time and place-specific, composed of limited sample size, limited scope and scale, and more expensive and time-consuming to conduct (Kitchin, 2013, pp. 4-5).

However, recent advancements in ICT led collection of more and more spatial and non-spatial data from different digital channels, i.e., the transformation of small data into big by the accumulation of continuous data. Therefore, the terminology of 'big data' was firstly introduced 20 years ago as a component of the digital age (Schintler et al., 2019).

Rabari and Storper defined big data as the data that is collected and recorded with the use of digital technologies such as social media, the internet and smart devices (2014, p. 3). Although there are many definitions of big data in the literature, most interpreted, used and adapted one is Doug Laney's conceptualization. He conceptualized characteristics of growing data with 'Vs' model. Within the context of this model, 3 'Vs' was defined which are: volume, velocity and variety. (See Figure 3.2) (Kitchin and McArdle, 2016, p. 1)

- ***Volume***: It refers to amount of data collected. Advancements in information technologies and internet have led generation and collection of data in massive volumes via multiple sources, which make data volume bigger.
- ***Velocity***: It refers to timeliness characteristics of big data, which means that gathering and transferring of data should be rapid and real-time.
- ***Variety***: It stands for different types of data sources. Data can be both in structured, semi-structured or unstructured format such as audio, text, images, webpage, video and more. So, sources of data as well as structure of data can vary (Kitchin et al., 2016, p. 1; Chen, Mao and Liu, 2014, p. 173; Philip-Chen and Zang, 2014, p. 314).

If it is necessary to emphasize common assumption of different definitions, it is assumed that big data refers to large and complex dataset requiring adapting traditional data processing methods and developing new methods for the analysis of data.

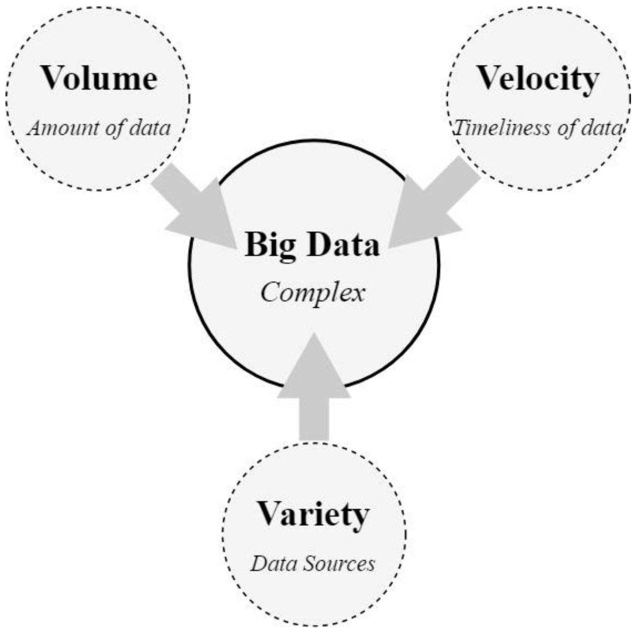

Figure 3.2 Big Data Vs Model

According to the 2018 statistics of International Data Corporation (IDC) thanks to rapid advancements in digital technologies, the total amount of data created globally is forecasted to dramatically increase in the near future, from 33 zettabytes in 2018 to 175 zettabytes in 2025 (Reinsel et al, 2018, p. 6) (see Figure 3.3).

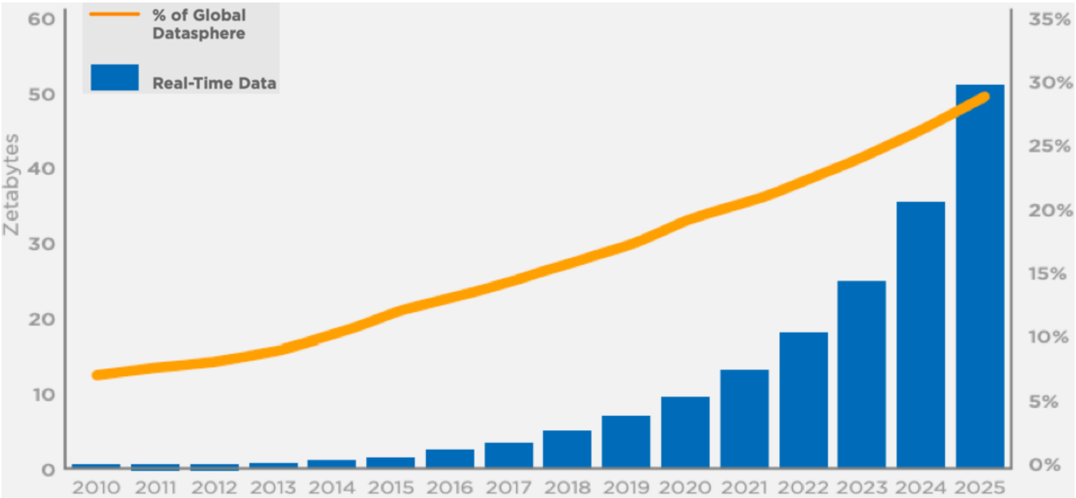

Figure 3.3 Volume of data created worldwide from 2010 to 2025 (in zettabyte) (Reinsel et al., 2018)

In addition, the annual size of real-time data in the global data sphere is expected to increase from five zettabytes in 2018 to 51 zettabytes in 2025 (Reinsel et al, 2018, p. 13) (see Figure 3.4). These statistics can be interpreted as a sign of the need for adopting new tools in data recording, analyzing, which is to say, in the decision-making process.

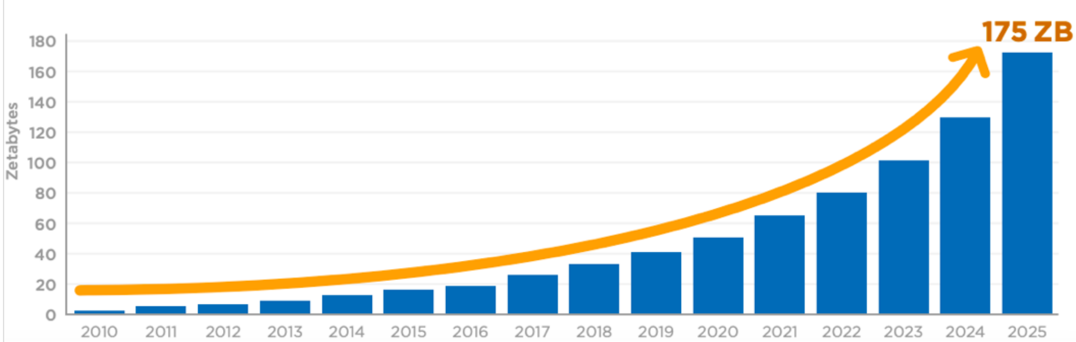

Figure 3.4 Annual size of real time data in the global data sphere from 2010 to 2025 (in zettabyte) (Reinsel et al., 2018)

Over the time, with the increasing effect of technological developments on the environment in cities and regions, the concept of big data has gradually increased its importance at urban and regional studies. Urban and regional planning requires different types of data that can be gathered from the different spatial scales for the decision-making process. Given statistics have shown that there is an ever-increasing amount of data collected globally. These data are highly concentrated in cities (Philip-Chen and Zang, 2014).

Rapid urbanization has a significant effect on the growth of data. The total population of urban areas is 55 % of the world's population, estimated to reach 68% by 2050. This increase refers to 2.5 billion people added to the urban population by 2050 (UN, 2019, p. 1). This statistic shows that one of the sources of big data, which is data on the built environment and human interactions, will continue to increase through the ever-increasing urbanization process.

We are in an age that all kinds of information that can be collected from the city are becoming a significant focus on urban and regional planning. Thanks to advanced ICT, the physical environment, human behavior, and interactions are transferred to digital platforms, which are now called as "digital skin" of the city, including different participants such as citizens, non-governmental organizations, and governmental authorities. That allows managing and governing cities and regions in new ways that were not possible within the technology of the past (Rabari et al., 2014, p. 2).

Although big data allows better understanding and monitoring of physical environment and movements at urban and regional scale, it brings about some challenges as well. The blurring boundary between the physical and digital world and growing data volume have increased the complexity of data. The capabilities of traditional tools have been limited to process such this data. As a result, analyzing, manipulating processing and transferring data have become one of the main challenges (Schintler et al., 2019, p. 2; Batty, 2017, p. 34). Therefore, it is critical to apply a more innovative set of methods and techniques to handle challenges of that much-complicated data.

3.2.3 The Need for Continuous Monitoring and Evaluation

In the last few years, spatial planning has been defined from various aspects. Nowadays, it is seen as the continuous process of decision-making on the use and development of the land in economic, social, environmental aspects. This process includes various stakeholders and linkages with other sectoral policies, which brings about conflicts. These characteristics of planning process necessitates aims for continuous follow-up and improvement under the changing circumstances. In that sense, continuous evaluation, monitoring, providing feedback, and reviewing spatial plans are essential phases of decision-making in order to ensure the effectiveness of spatial planning. (Segura and Pedregal, 2017, p. 2)

Evaluation of the spatial plans refers to the process of measuring established goals, objectives, and strategies in terms of their achievement and developing suggestions for the proper revisions of the planning policies and design principles (Segura et al., 2017, p. 3). On the other hand, monitoring of spatial planning refers to the ongoing process to provide stakeholders regular feedback through continuous information gathering to understand how much progress has been made towards achieving vision, aims, and objectives (UNDP, 2009, p. 8). (Segura et al., 2017, p. 3) emphasized that these two concepts differ in terms of purpose, aim, the time they are performed, the actors who perform them and the content (see Figure 3.5)

Aspects	Evaluation	Monitoring
Purpose	Accountability, information, improvement of the design and implementation of the plan	To ensure that what is planned and regulated is actually enforced
When it is performed	Before, during, and after implementation of the plan	During implementation of the plan
Who performs it	External or internal evaluators	Team in charge of the plan
Content of the process	Assess relevance, usefulness, effectiveness and efficiency	Measure the performance and results
Aim of the process	Assess the adequacy of the plan	Correct deviations
Notion of public action	Allows questioning the plan	Does not question the plan

Figure 3.5 Aspects of Evaluation and Monitoring (Segura and Pedragal, 2017)

Monitoring and evaluation help to improve efficiency and effectiveness of planning process by:

- Improving decision-making process
- Allowing continuous track of progress
- Determining problems in-time and proposing solutions for these problems
- Generation of knowledge and share of this knowledge with stakeholders
- Providing guidelines for the future plans and projects (UN-Habitat and UCLG, 2020, p. 4-9)

Monitoring and evaluation is not newly developed phenomena, it has been on the agenda of planning literature since late 1960s. Recently, monitoring and evaluation has been discussed and redefined through new decision-making tools with the development of technologies such as GIS (Seasons, 2008, p. 431). Technological developments in data gathering and storage process, has been contributed to tracking of data collected from different sources, and the monitoring of human movements and the physical environment. In order to have an efficient and effective planning process it is required to adopt a monitoring and evaluation process (Milne and Watling, 2019, p. 235). Considering that decision-making processes have become more complex because of increasing conflict of interest and interdependency, evaluation and monitoring as the phases of this process needs to be supported by new tools and methodologies inspired by recent advances in ICT and other digital technologies.

3.2.4 Increasing Uncertainty and the Need for Scenario Development

Uncertainty refers to the lack of knowledge about the outside environment, future intentions and value judgements. When people make decisions in their daily lives, they do not have perfect information about the consequences of their choices. Similarly, planning is faced with many uncertainties is faced in planning process. “Planning is about changing the future and therefore must try to understand what is known and unknown about the future.” (Abbott, 2005, p. 237).

Uncertainty in planning process arises from internal and external factors. Whereas internal factors affect the individuals or organizations taking part in planning process, external factors affect everyone in urban area or region (Abbott, 2009, p. 504). Climate change, technological developments, increasing global connections and interdependencies, improvements in information technologies and unexpected natural, economic, social and ecological events are causing a rapidly changing and more complex external environment where uncertainty about the future increases and making predictions for the future becomes difficult. Since the planning is in a continuous interaction with external environment, it is affected from these changes. (Abbott, 2005, p. 237; Rauws 2017, p. 32). Besides these external factors, involvement of different stakeholders with different knowledge, values and interests in planning process creates the value uncertainty. The other organizations’ and individuals’ future-oriented intentions, aims and actions, who are involved in urban environment raises organizational uncertainty (Abbott, 2009, p. 505).

Increasing uncertainties in planning process and external environment necessitates shift from traditional planning approaches to innovative ones (Stojanovic, 2014, p. 81). Preparing cities and regions for future uncertainties and challenges requires consideration of alternative future scenarios and their implications (Güell and Miguel, 2017). One of the most prominent advantages of scenario building is describing various possible or desired futures rather than just one future. The scenario method can help to understand better the effects of different factors shaping the urban environment, their interaction with each other, and identify alternative patterns and make assumptions for future development while making decisions (Stojanovic, 2014, p. 82).

Therefore, it has become essential for planners to take into account future-oriented scenarios while making decisions to see expected outcomes under changing conditions, to be prepared for the future transformations, to identify possible alternative strategies and paths for future development, and to keep up with these uncertainties and complexities in the most effective way. When looking at the components of SDSS, it can be seen that SDSS allows decision-makers to define future scenarios in terms of different topics within the defined time. This means that SDSS is one of the tools that may contribute to the decision-making process of planners under increasing complexity and uncertainty.

In conclusion, as depicted in Figure 3.6;

- the increase in interdependencies between institutions and individuals at the global and local scale, the inclusion of various stakeholders having different interests in the planning process,
- the increasing complexity of data collection and data processing as a result of the increase of data produced in cities and regions,
- increasing uncertainties and externalities

have increased the complexity of planning process. This complex nature of the planning process has brought particular needs for decision-making processes. These needs require the use of support tools that can respond to new needs and contribute to decision-making processes in planning. In this respect, the use of support tools gains importance to respond to new needs in decision-making processes in planning.

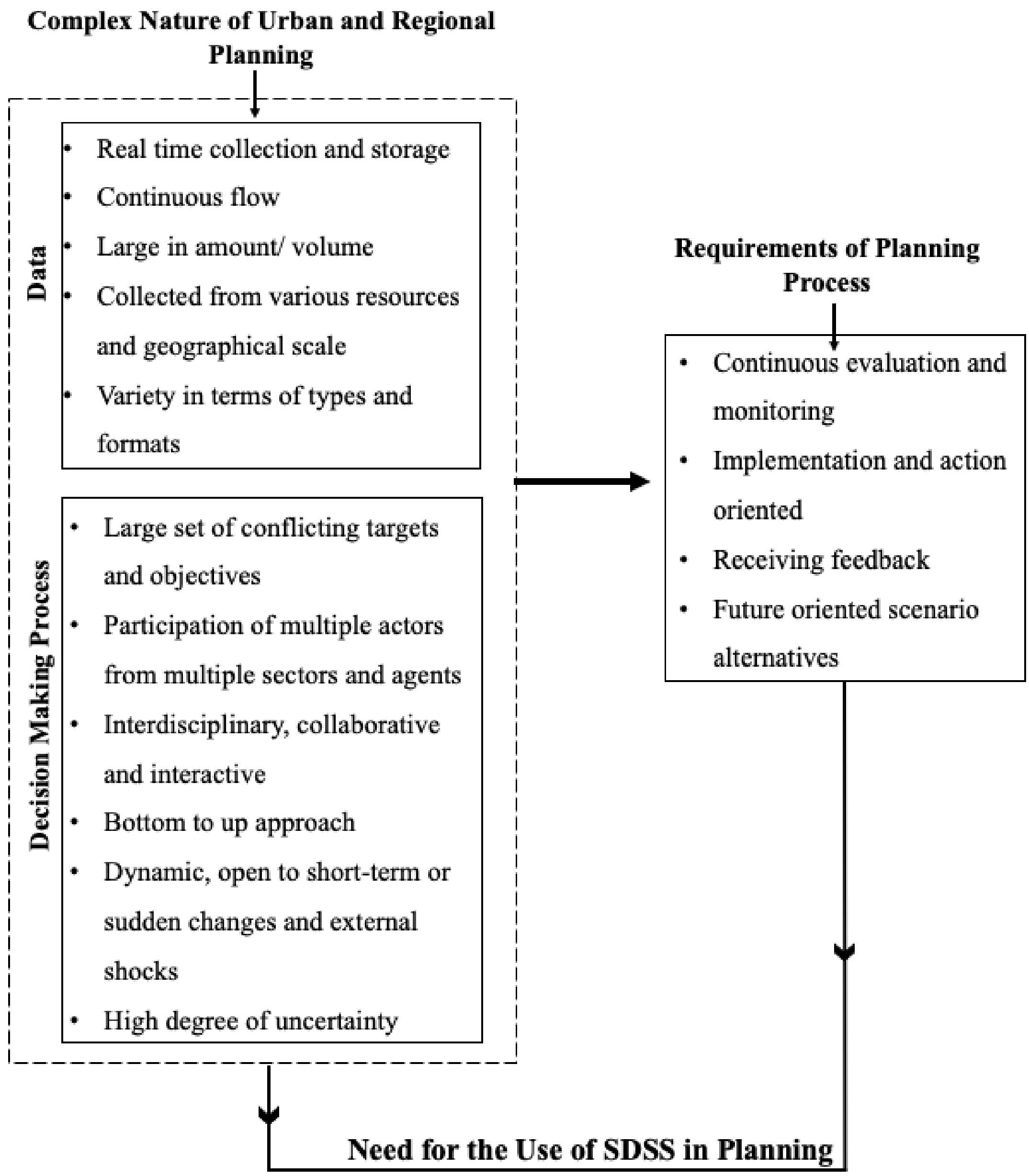

Figure 3.6 Decision-Making Process in Planning and Need for SDSS

3.3 Applications of SDSS in Planning Practice

Planning scale can range from a region to a city, a neighborhood, a parcel, or a street block in terms of scale. According to Geertman and Stillwell (2004, p. 295), DSS have primarily been developed in order to assist policy development and determination of actions in land use planning and strategic planning processes. As dynamics, relationships, and problems in urban life evolve, the subjects of urban planning also continue to expand and application areas of SDSS in the planning field vary too. Therefore, SDSS has various application areas in urban and regional planning processes with the main focus on urban design, environmental management, land development, conservation, transportation, agriculture and rural development, housing, infrastructure, etc. (see Figure 3.7). In addition, to see different domains of SDSS, this categorization is important to see the applicability of SDSS in different research areas of the planning profession (Yeh, 2008).

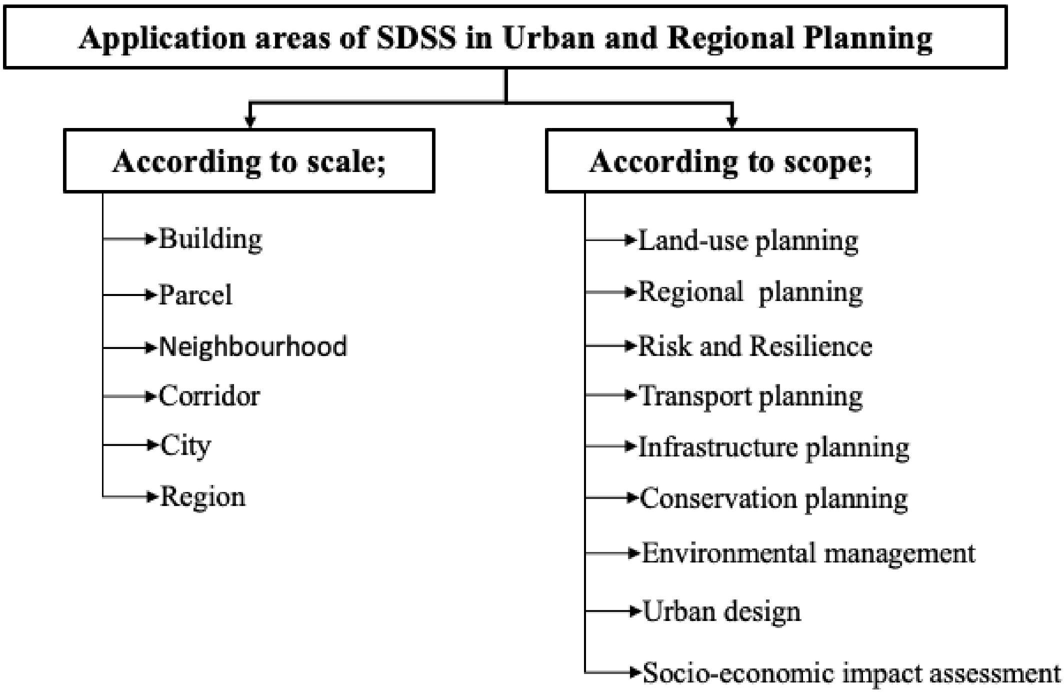

Figure 3.7 Application areas of SDSS in Planning

As mentioned before, SDSS is a kind of planning tool which can ease decision making process and improves effectiveness of this process. In order to benefit advantages of SDSS, different applications have been developed to refer different problems in different scales. Urban Footprint, CommunityViz, UrbanSim and INDEX Planbuilder are SDSS applications which are most known and successful transition of the academic researches into the real life. a national and international scale (Albrectht, 2018).

3.3.1 UrbanSim

The micro-simulation software, UrbanSim, is initially designed in the mid-1990s with the main aim of supporting integration of land use, transportation and environmental planning It has been continuously updating in order to improve performance of the software (Waddell and Liu, 2008, pp. 2-3; Waddell, 2011, p. 216). It is an example of planning support systems that have successfully transitioned from academic to commercial. (Albrecht, 2018, p. 229)

It enables users to make current situation analysis, generate alternative scenarios and compare them, use models to evaluate outcomes of these scenarios in achieving aims and objectives (see Figure 3.8). It is able to provide support for formulation of a variety of planning policies by enabling users to make accessibility, location choice, housing, employment and environmental analysis on county, city, metropolitan or regional scale (Waddell, 2002, pp. 303-304).

UrbanSim can be used by different stakeholders taking part in planning process such as planning organizations, citizens, planners, advocacy groups and public institutions. One of the main aims of his open-source software is to encourage collaboration. (Waddell et al., 2008, pp. 4-5).

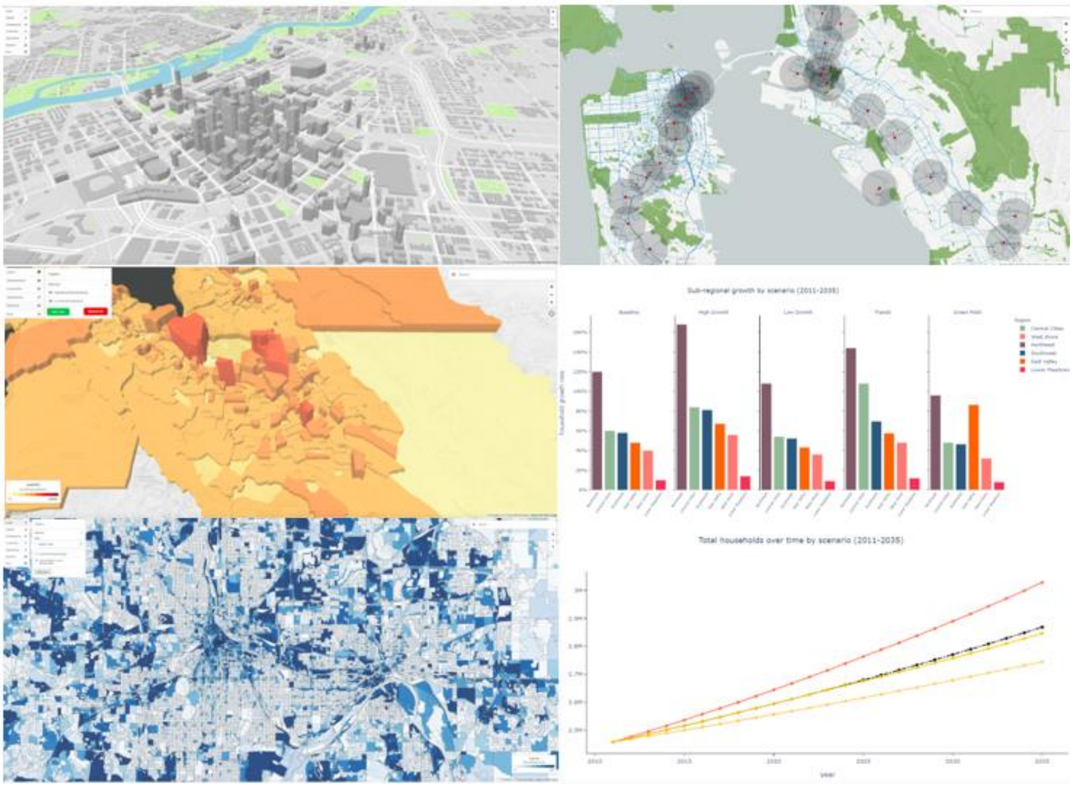

Figure 3.8 UrbanSim Software

Source: https://cloud.urbansim.com/docs/general/documentation/layers.html

https://cloud.urbansim.com/docs/general/documentation/chart_dashboard.html#chart-dashboard-section

3.3.2 Urban Footprint

Urban Footprint is a cloud-based urban intelligence software to support innovative and sustainable planning solutions. It provides support for planners in four steps of decision making by reducing the time spent for collecting necessary data, quick evaluation of existing conditions, modeling future scenarios, analyzing outcomes of future scenarios in states, cities, and regions (UrbanFootPrint, 2012, p. 3-4).

Its' dataset includes a variety of attributes such as land use, transportation, environment, socio-demographic characteristics, education, public health, infrastructure, and more. Thanks to its extensive datasets, Urban Footprint enables users to develop scenarios and make analyses to develop planning policies on emissions, public health, energy and water use, and transit accessibility. (See Figure 3.9). Users can view results of the scenarios in real-time (UrbanFootPrint, 2012, pp. 5-13).

Similar to UrbanSim, Urban Footprint is designed for use by urban and regional planners, private planning firms, public agencies, analysts, designers and non-profit organizations. (UrbanFootPrint, 2012, p. 18).

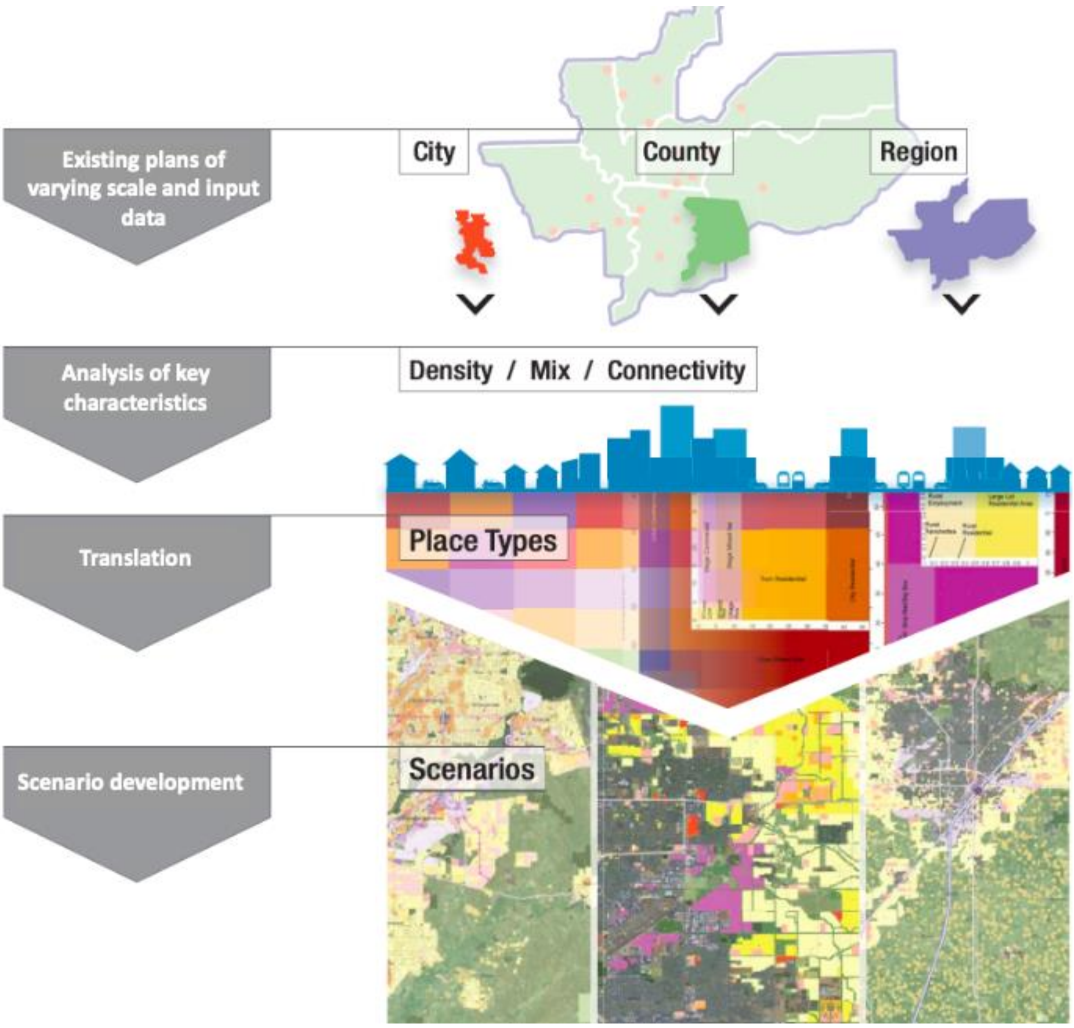

Figure 3.9 Urban Footprint Software (Urban Footprint, 2012, p. 14)

3.3.3 CommunityViz

CommunityViz is a GIS-based decision support software, initially introduced by The Orton Family Foundation to be used in community planning (Kwartler and Bernard, 2001, p. 285).

Sophisticated tools of CommunityViz enable users to gather and analyze large datasets, understand current situation, create different development or growth scenarios and understand impacts of these scenarios and future trends by using a variety of input (see Figure 3.10). This software allows visualization of results in different formats such as charts, maps graphs and 3D modelling, which contributes to ease understanding of information, making more effective plans (Walker and Daniels, 2011).

Planning organizations, landowners, NGOs, communities, designers, public officers and citizens are among main target groups of CommunitiyViz. It mainly gives importance to inclusion of public in decision making to ensure transparency of planning process (Kwartler et al., 2001, p. 286; Walker et al., 2011).

CommunityViz software has an extensive application area to be used in decision-making processes such as city and regional planning, transport planning, land use, resources and environmental protection (Li and Jiao, 2013, p. 11). It can be used in different scales from neighborhood to regional (Walker et al., 2011).

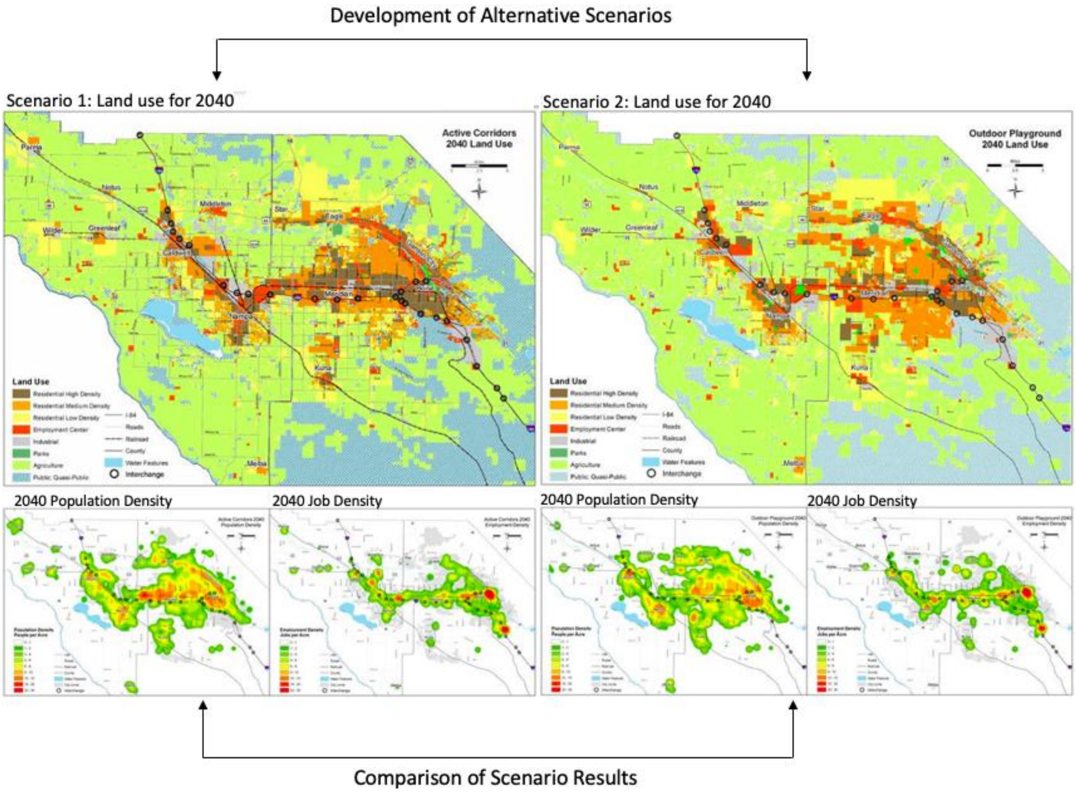

Figure 3.10 CommunityViz Software (Placeways LLC et al. 2012, p. 18-19)

3.3.4 INDEX PlanBuilder

INDEX is an interactive GIS desktop based and open source cloud-based planning support software to mainly assist decision making in urban and regional planning. It was initially introduced in 1994 by Criterion Planners. INDEX enables users to measure existing conditions, create alternative scenarios, visualize results in charts, tables or maps, evaluate performance of these scenarios and monitor planning process (see Figure 3.11). INDEX is also capable of evaluating consistency of planning goals and policies and changes can be recorded periodically, which provides support for the implementation phase of planning (See Figure). (Condon et al., 2009, p. 20; Criterion Planners, 2007, p. 1) One of the most important advantage of INDEX is that it supports all stages of decision-making in planning (Li et al., 2013, p. 11)

Like the other support tools, its database is composed of different geographical scale from building level to regions. It has quite a lot of indicators that are used as a basis for scenario creation and analysis in terms of demographics, land use, housing, employment, transportation, energy use and climate mitigation. It enables engagement of a variety of participants such as planning agencies in local and regional scale, educational institutions, tool developers and public. (Condon et al., 2009, p. 21; Li et al., 2013, p. 10).

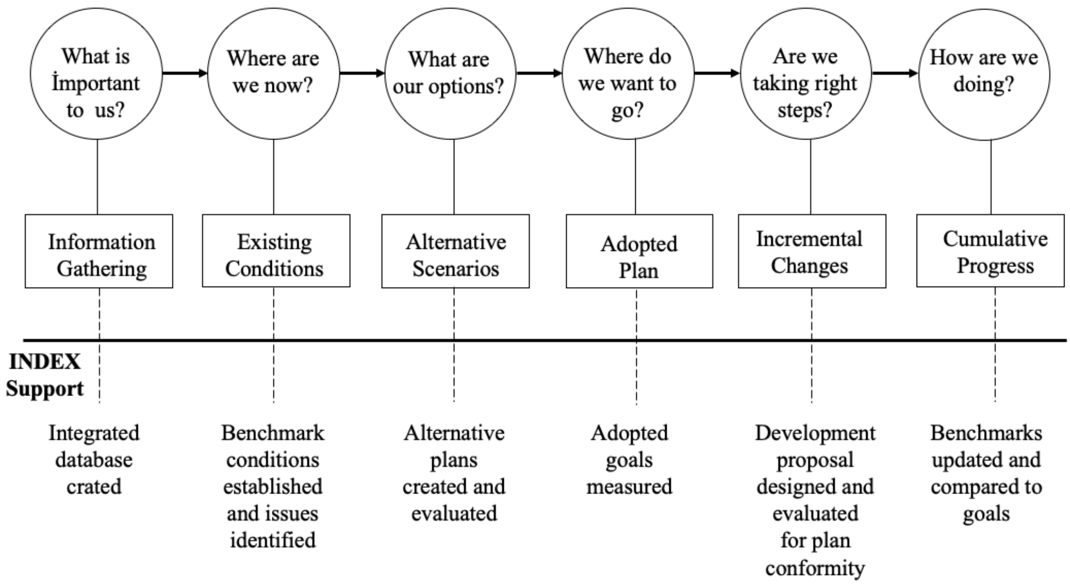

Figure 3.11 INDEX PlanBuilder Software (Criterion Planners, 2007, p. 2)

Based on the mentioned features of these four SDSS, a detailed comparison was made in terms of application areas, stakeholders, scales, policy supports and data types (see Figure 3.12).

Tool	Scope/Application Area	Scale	Stakeholders	Policy Support	Data	Software
CommunityViz	Environmental management, Regional Transportation Planning, Comprehensive Planning, Site selection Public Participation and Engagement	From neighborhood to regional	Municipalities, Metropolitan Planning Organizations (MPOs), NGOs, universities, federal agencies, consulting firms and citizens	Data gathering Current situation analysis Scenario creation Impact assesment Collaboration	Historical dand up-to date data (updates on a weekly basis)	Extension of ArcGIS Desktop
UrbanSim	Land use planning, motorized and non-motorized accessibility, urban design, housing affordability, environmental planning	From parcel to regional	real estate professionals, planners, Metropolitan Planning Organizations (MPOs), NGOs and students	Data gathering Current situation analysis Scenario creation Simulation and Projection Impact assesment Evaluation and	Historical and up-to date data (updates on every quarter)	Cloud based
Urban Footprint	Land use planning, Transport planning, Emissions, Energy Use, Conservation, Risk and Resilience, Public Health, Housing	From building to regional	planners, public agencies, environmental analysts, academic institutions, real estate developers and NGOs	Data gathering Current situation analysis Scenario creation Projection Impact assesment Evaluation and monitoring	Historical and up-to date data (periodical updates)	Cloud based
INDEX	Land use planning, Transport planning, Environmental management, Housing, Employment	From parcel to regional	municipal and regional planning agencies, data providers, GIS specialists, project managers and public	Data gathering Current situation analysis Scenario creation Evaluation and monitoring Implementation	Historical and up-to date data (periodical updates)	Extension of ArcMap GIS Desktop and Web based

Figure 3.12 Comparison of SDSS Applications Adapted from Condon et al., 2009

3.4 Approaches for the Evaluation of Planning Support Tools

Despite all the apparent benefits and advantages of SDSS and PSS, it has been seen that the use of these support tools in planning practice has not become widespread yet. Klosterman (1998, p. 35) complained that ''*instruments for planning support are no better developed now than they were ten years ago*'', and he was equally pessimistic about the adoption of new instruments and computer applications in planning practice in the near future. Brail emphasized the situation by saying that "*the question remains, however, about how such systems [PSS] will enter the planning and public policy arena*" (Batty, 2004, p. 329).

In addition to the fact that these geo-information support tools are not widely used, it is seen that the use of such tools cannot go beyond data storage and mapping. That is, the potentials of these tools are not fully utilized (Timmermans, 1997). As the low level of adoption has become a recurring problem in recent decades, and there is an increasing need for such support systems resulting from the problems of planning becoming more complex, multi-dimensional and versatile, the tools that are currently in use and are in the process of being released have been evaluated many times in terms of their adoption and use. As a result of these studies, it has been observed that there are various bottlenecks limiting the active and widespread use of PSS and SDSS. Whereas some of these bottlenecks are peculiar to such support tools, some of them are related to ICT in general (Geertman, 2013, p.50).

When looking at the different definitions of SDSS, it is seen that some researchers define SDSS as a subset of GIS that enables the storage, processing, and analysis of spatial data. In contrast, others define it not as a subset of GIS, but a 'superset' consisting of GIS and other techniques (Keenan, 2003, p. 33). In addition, definitions of PSS emphasize that a PSS consists of components of a typical DSS and GIS. SDSS and PSS do not consist of only GIS, but their main component is GIS (Klosterman, 1997, p. 51). Thus, GIS, SDSS, and PSS have many common traits and cannot be evaluated separately, although they have some distinctive features.

Since one of the main components of SDSS and PSS is GIS and the factors affecting the adoption of these support tools planning field are both related to the structure of these support tools and factors affecting adoption of ICT in general, the studies conducted for the adaption of GIS in the planning field are also included in this research.

3.4.1 Diffusion of Innovation Theory

Rogers (1983, p. 5) defined diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system". The main purpose of this theory is to explain the transition of technological innovation from the invention process to the widespread use or (not use) (Dillon and Morris, 1996, p. 9). Diffusion has been used as an umbrella term comprising the awareness-raising, adoption, implementation, and routinization processes of geo-information technologies in several studies (Campbell and Masser, 1995, pp. 5-6)

Rogers (1983) also developed a model which is called the innovation-decision process in order to explain innovation diffusion (see Figure 3.13). He also suggested an innovation acceptance model, which defines a process consisting of five main stages:

- In knowledge, which is the first step of the process, an individual or organization becomes aware of the innovation and gains an understanding of its functioning.
- In the persuasion stage, the decision-maker exhibits a positive or negative attitude toward the innovation. In the decision stage, the decision-maker decides whether to adopt or reject the innovation.
- In the implementation stage, the decision-maker starts to use the innovation.
- In the confirmation stage, an individual or organization makes the final decision whether to keep on using the innovation with respect to experiences. According to this model, indicators affecting the adoption of an innovation

are "perceived characteristics of the innovation, characteristics of decision-making units, the nature of communication channels and other prior conditions" (Rogers, 1983, p. 165)

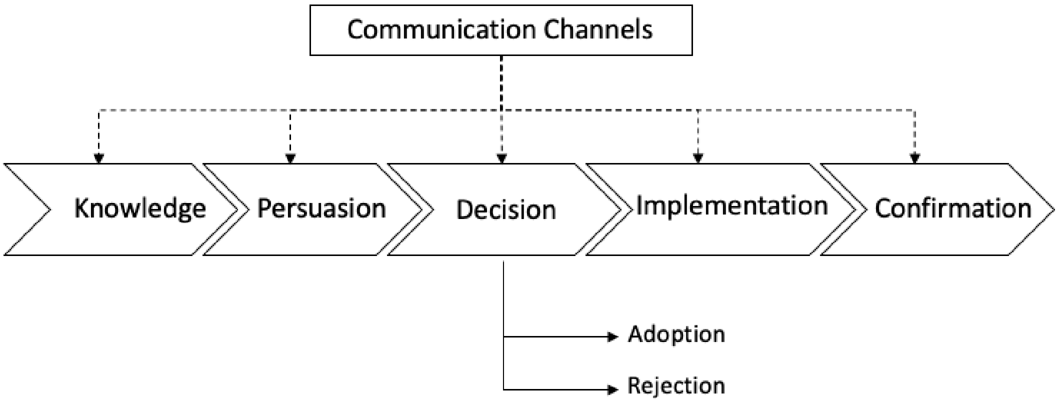

Figure 3.13 Innovation Decision Process (Adapted from Rogers, 1983)

3.4.2 Adoption of GIS in Planning Practice

Several empirical studies searching for determinants of adoption and use of GIS in the planning field have been conducted beginning with the early 1990s. (see Table 3.1). Most of these studies were based on the Diffusion of Innovation Theory developed by Rogers. (Nedovic-Budic and Godschalk, 1996, Brown, 1996; Campbell et al., 1995, Croswell, 1991; Klosterman, 1995; Onsrud and Pinto, 1993; Ventura, 1995)

Organizations, organizational units, organizational sub-units, and individuals are among adopters of geo-information tools in planning (Nedovic-Budic et al., 1996, p. 555). Parallel with these, human factors and organizational factors as decision-making units, technological/technical factors, and institutional factors have been identified as determinants of adoption of GIS in planning institutions both on a local and regional scale (Ventura, 1995, p. 462). It is also seen that the researchers differed while grouping the variables in their studies. For instance, while some researchers emphasize the importance of individual adoption and consider human factors as a separate category, others have considered individual characteristics within the scope of organizational factors. In addition, some researchers defined the external factors affecting the organizational adoption as institutional, while others defined them as managerial or political.

3.4.2.1 Organizational Factors

Most of the decisions related to innovation acceptance are made by organizations which are among the adopters of innovation (Rogers, 1983, p. 22). That's why they have been the units of analysis in technology acceptance studies. In general, organizational factors are related to the understanding and perception of the technology by the members of an organization and the way the organization adopts the innovation (Ventura, 1995, p. 463). Several studies have shown that organizational factors are one of the most important determinants of the adoption of an innovation (Nedovic-Budic et al., 1996, p. 554; Klosterman, 1995, p. 7). Although variables under organizational factors may change, they are generally accepted as size and demographic factors, organizational structure, resource availability, availability of skilled and trained personnel, management attitudes, and networking.

3.4.2.2 Human Factors

The adoption of an innovation in an organization requires adopting that innovation by individuals as a member of the organization. Therefore, human factors are one of the determinants of the adoption of innovation by organizations. Human factors are related to individuals' attitudes, perceptions, experiences, and other characteristics as end-users. Some researchers accepted it as an independent factor from the organizational factors in the adoption process, whereas some included them under the organizational factors. It includes variables such as perceived relative advantage, the perceived complexity of the innovation, values, and beliefs, and exposure to the innovation (Nedovic-Budic et al, 1996, p. 555).

3.4.2.3 Technical/Technological Factors

Technical/technological factors are both related to characteristics of the components of geo-information tools, system design, and technical capacity. In general, data availability, data quality, data networking, software complexity, and software compatibility are accepted as the variables of technical/technological factors (Ventura, 1995, p. 463). Some researchers identified data-related factors as a separate parameter, rather than identifying them under technical factors (Campbell et al. 1992; Yeh, 1999). It can be said that the common point of the researchers is that it is necessary to have some data and software standards in order to acquire and use the software properly.

3.4.2.4 Institutional/Political/Managerial Factors

They are external political and economic factors that affect the adoption of innovation by an organization. The adoption of a new technical tool such as GIS will have an impact on how information is produced and distributed and so do the power relations between organizations. Parallel with this, it is emphasized that adopting such tools is not solely a technical process (Klosterman, 1995, p. 9) On the contrary, it is a process in which managerial and political factors have considerable impacts. Therefore, economic, social, and political accountability of them is important (Harris and Weiner, 1998, p. 68) Intergovernmental relations, political choices and perceptions, and financial support are among variables of these factors (Ventura, 1995, pp. 465-466)

Table 3.1 Review on Adoption and Use of GIS in Planning Institutions

Study	Variables	Main Findings
Brown, 1996	**Organizational Factors** -Organizational coordination and conflicts -Apathy and fear of change -Planning and management support -Staff availability -Goal agreement -Training/Understanding of technology -Leadership -Resource Availability **Technological Factors** -Data structure and source materials -Software complexity -Data communications and networking -Data Software Standards/ Integration	-Conflicts between stakeholders is the main issue for adoption of GIS -Lack of funding is the one of the most important obstacle to adoption of GIS -There is lack of coordination between different departments of the organization
Campbell and Masser ,1992	**Data Related Factors** -Data integration/Standardization -Data availability -Cost of data capture **Technical Factors** -Availability of hardware -Software compatibility -Software complexity **Organizational Factors** -Technical experience -Availability of skilled staff -Awareness of user needs -Management attitude -Financial structure	-Cost of data capture the most severe data-related issue -Lack of reliable hardware and software compatibility are most important technical obstacles to adoption GIS -Difficulty in establishing financial viability as an organizational obstacle to the adoption of GIS -Lack of technical experience is another obstacle to adoption of GIS
Ventura, 1995	**Organizational Factors** -Organizational structure -Fear of change -Staff availability -Attitude of individuals -Training **Technological Factors** -Data quality -Data suitability -Data access -Hardware capacity **Institutional Factors** -Intergovernmental relations -Financial support -Political leader's perceptions	-Lack of skilled staff in GIS programming -Lack of available data -Lack of accurate data -Lack of attention and funding for initial and ongoing training -Lack of management support for equipment and hardware

Table 3.1 (Continued)

Nedovic-Budic and Godschalk, 1996	**Human Factors** -Perceived relative advantage -Compatibility with values and beliefs -Computer experience -Perceived complexity of GIS -Exposure to GIS technology -Computer/GIS related anxiety -Attitude toward work-related change -Communication behavior (networking) **Organizational Factors** -Size and demographic profile -Availability of resources -Organizational structure -Changeability -Accessibility of technology -Availability of external support -Communication with other agencies -Internal social relations **Management Factors** -Support (training, funding for hardware and software)	-Perceived relative advantage of GIS is the most essential variable for the adoption by individuals -Computer experience is another major factor influencing adoption of GIS by individuals -Active networking is associated with the higher use of GIS -Organizational conflicts and instability is one of the most important obstacle to adoption - External funding and political support are important external determinants of adoption -User training and support contributes to increase use of GIS
YEH, 1999	**Data-Related Factors** -Data availability -Data Quality -Data Acquisition -Availability of data processing equipment **Organizational Factors** -Management strategy -Organizational and environmental stability -Communication and networking -Availability of skilled personnel -Availability of expertise -Training **State-of-the-art of Planning** -Skills of planners and planning systems -Awareness of innovation	-Lack of available data (socio economic and spatial) -Unavailability of up-to-date data is most important constraint for the adoption of GIS -Difficulty in integrating different types of data -Lack of planners' awareness of benefits and potentials of GIS -Limited skills of planners as an obstacle to adoption of GIS -Lack of training because of inadequate expertise and funding
Mennecke and West, 2001	**Technological Factors** -Source data -Data collection -Data management -Data integration **Managerial &Organizational Factors** -Organizational resource -System implementation & policies -Management support -Organizational politics	-Difficulty in collecting social, economic and political data -Lack of trained personnel -Lack of accurate and timely data -Conflicts between agencies over geo-information technologies causes issues related to data sharing and coordination

3.4.3 Adoption of DSS and PSS in Planning

Following the earlier studies on the adoption of GIS in urban and regional planning, studies on the adoption and use of SDSS and PSS have gained importance. Most of the evaluation studies of PSS have been conducted, with an emphasis on the supply side, which is the system requirements, technical issues, and software architecture, of support. In contrast, a limited number of studies have been undertaken, emphasizing the demand side of it (the users and characteristics of the planning process itself). (Vonk et al., 2005, p. 909; Vonk and Geertman, 2008, p. 156) While former researchers approached the topic as a quantitative problem, the latter researchers approached it as a qualitative problem. In this context, the research questions them differentiate from each other. Authors focusing on the demand-side of planning support tools, shape their research questions with the main aim of understanding the relevance of these tools with planning practices, such as:

- Are the tools useful, or usable for planning practitioners?
- Do they have effective supportive characteristics for planning decisions and policy determination?
- Do the actors of planning profession understand how to use these tools?

As well as understanding the technical capabilities of the SDSS, finding answers to these type of questions is also important to understand the adoption of decision support tools to planning practices in consideration with specific characteristics of this profession, to put into practice them in a useful way (Deal and Pallathucheril, 2009, p. 29).

In addition to these two different approaches, some researchers have developed a new approach for the evaluation of SDSS by combining demand-side and supply-side studies. One of the most prominent of these studies has been Vonk's (2005) study.

In order to find out the factors blocking adoption and widespread use of PSS, Vonk (2005) adapted the conceptual framework developed for organizational innovation adoption by Frambach and Schillewaert (2002) with reference to Roger's theory of DOI. While adopting this framework, he also took into account earlier studies on GIS adoption and Rogers' 'Theory of Diffusion of Innovations'. According to this framework, organizational, individual, social, technical, and external factors are the main components of the PSS adoption process (see Figure 3.14). These factors are;

- Persuasion influences (support, marketing, awareness, product improvement and implementation support)
- Perceived innovation characteristics (data-related factors and characteristics of innovation)
- Social influences (social organization of users)
- Adopter characteristics (characteristics of organization and individuals)
- External conditions (Frambach et al., 2002, p. 165; Vonk, 2005, p. 55)

Although Vonk's (2005) study shows some differences from earlier studies on GIS adaption in terms of classification of the factors affecting PSS adoption, it is also seen that there are many common points in terms of factors and related variables used in these studies.

1. **The Instrument Approach:** This approach explains the problem of usage of decision support tools in planning with the main emphasis on instruments determining the instrumental quality of decision support tools. Accordingly, the main focus is on the usefulness and user-friendliness aspect of the tool. The main assumption is that if the instrumental quality of the support tool is poor, then this will prevent users from using the tool. The instrumental quality of these tools is defined as "consisting of the judgment of how well the instruments are capable of carrying out the tasks that they were made for and how well they fit the capabilities and demands of intended users" (Vonk, 2006, p. 21; Geertman and Stillwell, 2009, pp. 5-6)
2. **The User Approach**: The second approach is mainly based on characteristics of users and other external social and institutional factors to understand the level of acceptance and usage of the planning support tools.

These user-related factors are determinants of acceptance of these tools. It is mainly assumed that "non-acceptance" prevents users from using them. In this approach, the user is taken as a dependent variable. The related characteristics of users, instruments, organizations, social environment, external environment, and other facilitating conditions are the main influencers of the acceptance process (Vonk et al., 2005; Geertman et al. Stillwell, 2009, p.6)

3. **The Transfer Approach**: This approach explains the problem with the main focus on the aspects of transfer that determines diffusion of decision support tools in planning. The main assumption is that if there is hindered diffusion, then users may be discouraged from using the tool. The process of transfer of innovation into practice is examined in relation to the 'adoption of this innovation by individuals, groups, or organizations. It is defined as an evolutionary process in which acceptance takes place in relation to the varying aggregation of these individuals, groups, and organizations (Vonk, 2006, pp. 22-23; Vonk et al, 2007, p. 746).

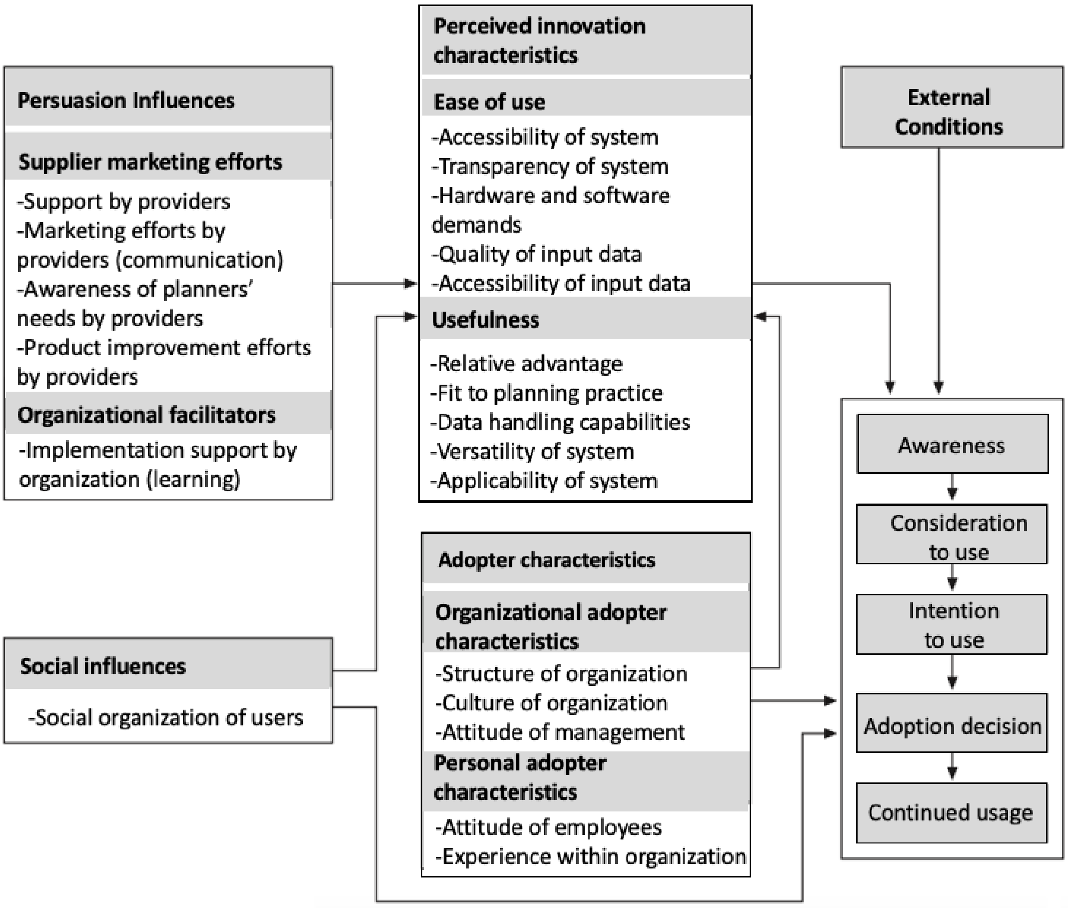

Figure 3.14 Framework for Use and Adoption of PSS (Vonk, 2006)

Geertman (2006) also developed a comprehensive conceptual framework in order to show the relationship between contextual factors and use of planning support tools (see Figure 3.15).

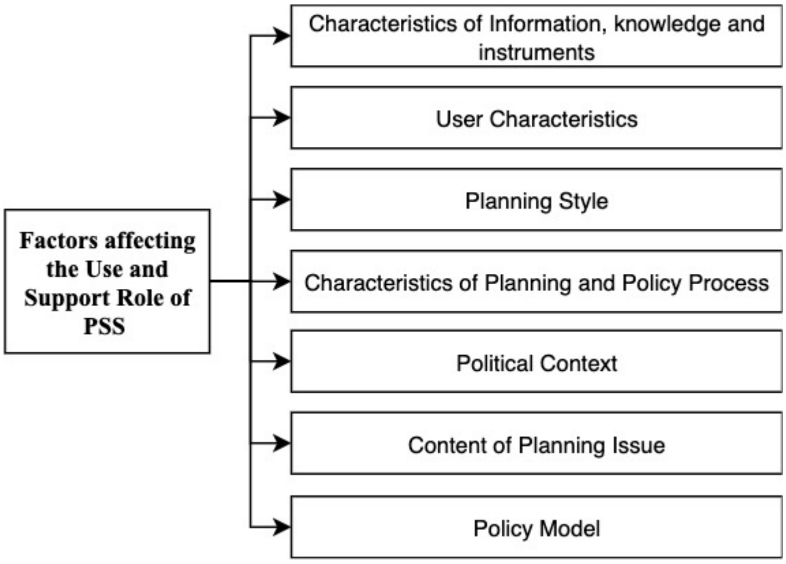

Figure 3.15 Determinants of Support Role of PSS (Adapted from Geertman, 2006)

- Characteristics of information, knowledge, and instruments are one of the determinants of PSS use. In this context, availability, accessibility, and accuracy issues related to data required are important factors. In addition to these, functionality characteristics such as user-friendliness, transparency and flexibility are effective in the level of adoption.
- The appropriateness of the support tools and the content of the planning issue is an important factor for the acceptance of these tools. Since the planning problems are semi-structured or ill-structured, formal and informal knowledge is needed in the decision-making process. The structure of these tools should be appropriate to handle this different information and knowledge and make necessary modeling and analysis.
- The characteristics of the users, that is, the differences in the profession and working areas of the planners, differentiate the demands and requirements expected from PSS. In addition to this, users' attitudes, qualifications, skills, and experience are also important factors for the adoption.
- Characteristics of the planning process are another factor affecting the use of support tools. Specific characteristics of each planning process such as time

period of the plans, stakeholders participated in-process and publicity are determinants of the adoption level of PSS.

- The political context is an important determinant of the way the support tools are implemented in the planning process. Whereas some authorities support the use of PSS and other information technologies in order to increase interaction, cooperation, and participation in the planning process, others support the use of these technologies to achieve a more efficient and effective planning process in which planning issues are better understood and represented.
- Planning style and policy model are among the factors affecting the use of support tools in planning. Planning style "is the time-bound normative opinions as to the way in which planning job should be performed." (Geertman, 2006, p. 869). Planning style may change in line with the difficulties and needs brought about by the planning style that is applied in a certain period. Planning styles and policy models are effective in the way the support tools are implemented in the planning process. For instance, the use of planning support tools as an instrument to improve communication between different stakeholder or as an instrument to solve urban design issues.

Based on the conceptualizations of Vonk (2005) and Geertman (2006), various studies have been carried out on the use of SDSS and PSS in local and regional scale. the variables used in these studies were determined based on these studies (see Table 3.2). Then, the problems regarding the use of these systems were identified, which will be discussed in the following pages.

Table 3.2 Review on Adoption and Use of SDSS & PSS

Study	Variables	Main Findings
Hamerlinck, 2011	**Adoption Factors** -Persuasive influences -Social influences -Adopter characteristics -Perceived innovation characteristics	-Hardware and software costs is the most prominent barrier to the use of PSS -Lack of staff and time is other key barrier to the use of PSS -Lack of technical support and training is another barrier to use of PSS
Russo, Lanzilotti, Costabile & Petit, 2018	**System-related factors** -Fit to tasks & user -Cost -Software compatibility -Learnability -Efficiency -Transparency & reliability -Visualization capabilities **Non-system-related factors** -Awareness -Skills and experience -Social organization -Law and regulations -Data availability -Management supports	-Planners' awareness of the software tools and their benefits is one of the most prominent non-system-related challenge to the adoption -Planners' skill and experience to use these tools is another most prominent challenge to the adoption -Tools' fit to tasks and users is the key system-related challenge to the adoption -Cost of these tools is another important challenge to the adoption by planning organizations
Goodspeed & Hackel, 2019	**Adoption Factors** -Perceived benefits -User characteristics -Technical details -Development process -Jurisdiction characteristics and motivations -Planning style	-User training is important for the successful adoption of PSS -Issues related to accuracy of data is an obstacle to effective use of PSS -Lack of jurisdictions' awareness and interest is one of the most important barrier to the use of PSS

Table 3.2 (Continued)

Schindler, Dionisio & Kingham, 2020	**<u>Data-related & Technological Factors</u>** -Availability of data -Quality of data -Complexity of the tool **<u>Procedural Factors</u>** -Appropriateness for local context -Resource availability -Political expectations and implementation in regulatory framework -External factors (such as changes in environment) -Socio-technical interactions and communication	-Lack of stakeholders' awareness of the available tools and their benefits is most important challenge to adoption -Although tools can be transferred from one context to another, appropriateness for local context is an important challenge -Availability of fit-for-purpose data and access to these data is one of the key challenges

3.4.4 Barriers to Adoption of GIS, SDSS and PSS in Planning

Beginning with the early 1990s, several studies have revealed barriers to the adoption and widespread of different support tools such as GIS, SDSS, and PSS at local and regional scales in the planning field. Among these barriers most mentioned are data-related issues, lack of experienced staff, lack of support for training, lack of awareness of the potential of support tools, and lack of internal and inter-organizational cooperation and coordination in the planning field. design

3.4.4.1 Data-related Factors

DBM is the essential component of GIS, SDSS, and PSS. For this component to work effectively during the decision-making process, data standards should be established (Innes and Simpson, 1993, p. 232). These data standards concern both the availability and quality of data as well as data gathering methods (Klosterman, 1995, p. 4). Several studies that started in the early 1990s have revealed that data-related issues such as data availability, accuracy, accessibility, quality, timeliness, and data gathering methods are one of the important barriers to the adoption and use of GIS. These issues can be listed as;

- Unavailability of up-to-date and accurate data
- Lack of accessibility to complete social and economic data at local and regional scale
- Lack of reliability and consistency of data because of limited resources, personnel skills and expertise
- Restriction of access to financial and commercial data in order to prevent speculation and data security issues.
- Data sharing, communications and networking issues (Klosterman, 1995, p. 4-5; YEH, 1999, pp. 885-886, Göçmen and Ventura, 2010, p. 177).

Considering the studies carried out in the following periods, although it is emphasized that the digital availability of spatial data and access to these data increased thanks to technological developments, it cannot be said that the problems related to data have been completely overcome for both users and system designers

With the increase in the size and volume of data produced at both regional and urban scale, the data format, sources of the data, databases, and stakeholders involved in data networking have diversified, which has resulted in increased complexity and uncertainty of spatial data. The comparison, integration, suitability, scale compatibility, and accessibility of fit-for-purpose data are still seen as one of the barriers to the adoption and use of spatial decision support tools (Schindler et al, 2020, p. 9).

3.4.4.2 Staff Availability and Experience

The use of decision support tools requires experienced and trained users who are expected to collect the data, process the data, use specific tools, run models and make necessary analysis in the decision-making process (Klosterman, 1995, pp. 9-10; Ventura, 1995, p. 464; Brits et al. 2013, p. 84, Suguraman et al., 2010, p. 455). In other words, it is necessary to have a certain level of knowledge and experience about the software in order to integrate these tools in the decision-making process and take the full advantage of them (Suguraman et al., 2010, p. 455; Göçmen et al., 2010, p. 173). That is why the experience and qualification of staff are used as a variable in innovation adoption studies.

There is a positive relationship between training, experience, and technology acceptance. Accordingly, increased skill and experience have a positive effect on the adoption and use of GIS in the planning field (Nedovic-Budic et al., 1996, p. 564). On the other hand, earlier studies indicated that planners are not given initial and ongoing training and there is a lack of funding and expertise for training activates, which is one of the most important challenges to the adoption of GIS and SDSS (Nedovic-Budic et al, 1996, pp. 560-561, Ventura, 1995, p. 464, Yeh, 1999, p. 886) Similar results have been emphasized in more recent studies. For instance, Vonk (2006, p. 51) found that lack of experience within the planning organization is the most significant indicator blocking widespread usage of planning support tools. In web-based research conducted by Göçmen et al. (2010, p. 176), in which planners working in local and regional agencies in Wisconsin included as respondents, lack of training is identified as the most important obstacle to the use of GIS in planning by more than half of the respondents.

3.4.4.3 Awareness

The adaption and acceptance of innovation within an organization primarily depend on the awareness of the existence of the innovation. Being aware of innovation, i.e. awareness-knowledge, is the first step in launching the innovation acceptance process (Rogers, 1983, pp. 164-165). With reference to this, awareness is included as a variable in the adoption process of GIS, SDSS, and PSS in various studies. Recent studies have shown that planners and managers are unaware of the availability, value, potentials, and benefits of these tools. Accordingly, lack of awareness of these tools is one of the main bottlenecks to the use and adoption. (Schlinder et al, 2020, p. 8 Vonk et al, 2005, p. 916).

3.4.4.4 Communication Channels and Networking

Communication is the process of exchanging information between individuals, groups, or organizations to have a mutual understanding (Rogers, 1983, p. 17) A communication network refers to the interconnectedness of individuals through mutual information sharing. It is analyzed in order to understand the communication structure and behavior of individuals or organizations (Rogers, 1983, pp. 294-295) Since planning is a complex process involving a variety of stakeholders who have different interests, the interaction between these stakeholders and inclusion of all participants in the decision-making process is necessary for the effective use decision support tools which necessitates a dependency between these stakeholders (Schindler et al., 2020, p. 9; Suguraman et al., pp. 453-454). Both internal and inter-organizational networking is crucial to ensure the exchange of data, to increase willingness to use these tools and awareness about existence and potentials (Nedovic-Budic et al., 1996, p. 554). This means that networking is directly or indirectly related to some of the other determinants of innovation adoption.

Earlier studies have shown that interpersonal and inter-organizational coordination and cooperation, i.e. communication behavior, are one of the most important factors influencing diffusion of geo-information support tools in planning practice (Brown, 1996, p. 196; Nedovic-Budic et al., 1996, p. 563; Ventura, 1995, p. 465). In a study carried out by Vonk et al. (2007, p. 752), it was concluded that there is a communication gap and miscommunication between GIS specialists, planners, and managers, which poses an obstacle to the use and development of effective PSS. Similar to this result, Schindler et al. (2020, p. 9) stressed that lack of collaboration between system developers, planners, and researchers is still a current issue that hampers the widespread use of special decision support tools in planning.

As a result, there is no doubt that the development of ICT has contributed to the development of various data collection techniques and support tools for data storage and processing in urban and regional decision-making processes. Despite all these developments, recent studies have revealed that the obstacles to using and adopting GIS, SDSS, and PSS in the planning field, which were emphasized in earlier studies, have not been eliminated and a new set of obstacles have emerged.

CHAPTER 4

EVALUATING THE FACTORS AFFECTING THE ADOPTION OF SDSS IN GAP REGION: CASE OF KAUS PROJECT

The main aim of this chapter is to present the general framework of the KAUS Project and to discuss the obstacles to the adoption of the KAUS by metropolitan municipalities and development agencies in the GAP Region in the context of research questions. This discussion was made through the analysis of the in-depth interviews with the personnel of these institutions and the researcher involved in the KAUS Project.

4.1 Project: Spatial Decision Support System Software Development for Carbon Emissions in GAP Region

The rapid growth of population, rapid urbanization, the increase in industrial activities, the use of fossil fuels, and the rapid consumption of resources cause several environmental problems and trigger global warming. As a result, global warming has become one of the most important and urgent problems on a global scale. It has also become one of the main issues in urban and regional planning. In this context, new models for spatial and economic growth have begun to be developed.

In order to overcome the effects of climate change, adaptation and mitigation policies are developed on a local, regional and national scale. In this context, the concept of carbon neutrality and carbon-neutral economy has been developed, which means achieving zero net carbon dioxide emissions through the transition from a linear economy to a circular carbon-neutral economy (Apa et.al, 2019). Adoption of a carbon-neutral economy can support the increase of competitiveness of the region by contributing to the creation of new employment areas, business models, development of skills, and increase of the knowledge intensity of companies (OECD, 2015, p.14). Therefore, it offers several advantages to support regional development as well as reducing emissions, protecting the environment, and developing carbon reduction technologies.

Adoption of a governance model which requires the involvement of main stakeholders such as public institutions, private sectors, and citizens is necessary to achieve goals and strategies (Apa, 2019, p. 14). Production, consumption, and flow of information among these actors are highly important for the efficiency and effectiveness of the process. The problems related to economic, social, and environmental sustainability are not structured, on the contrary, they are unstructured, complex, and multidimensional. Such a complex decision-making process requires the use of a support tool in achieving goals and objectives. SDSS can be used as an instrument to provide a knowledge base, integrate and flow information among stakeholders through an interactive user interface. The project of 'Spatial Decision Support System Software Development for Carbon Emissions in GAP Region' has been developed within the framework of this main idea by METU-Research and Implementation Center for Built Environment and Design (METU-RICBED).

4.1.1 Aim of the Project

This project, in which I took part as a researcher, was carried out between 2019 and 2020 by METU-RICBED in partnership with the GAP Regional Development Administration of the Ministry of Environment and Urbanization. The project team consists of 23 people from different professions. The main aim of the project was to develop a software that enables the calculation of carbon emissions originating from the transportation, industry, agriculture, construction and waste sectors in the GAP Region, the creation of future carbon emission forecast models, and the evaluation, management and monitoring of the projects developed in these sectors during the transition to a carbon neutral economy. In the first phase of the project, the algorithm of the software was designed, and in the second phase the cloud-based software was developed. This interactive software, which is the main output of this project, is called "Carbon Emission Atlas and Expert System (KAUS)". After the project was completed in 2020, the KAUS software was made available to the GAP Development Administration.

KAUS software is capable of supporting the establishment of necessary cyclical connections, which is coordinated by the GAP Regional Development Administration, for development, management, prioritization, monitoring, and evaluation of the projects and analysis of external effects of different projects on each other in the process of transition to a carbon-neutral economy in the region. Therefore, this software is a very important tool in terms of reducing the time planners and those working in different areas of expertise in carbon emission reduction spend on collecting historical or up-to-date data on the region, conducting analysis and developing strategies, and strengthening the data capacity in the region.

Although this software was designed to be used by the GAP Regional Development Administration, the flexible system architecture of the KAUS indicates that this software can be used by different planning institutions in the future. The metropolitan municipalities and development agencies in the GAP Region are among these potential users. In this thesis, the main purpose is to determine the factors that may affect the future adoption and use of KAUS software which is not yet in use in these institutions, and to evaluate this software in the context of these factors.

4.1.1.1 Stakeholders of the Project

The project team was determined by considering the technical expertise required for the development of SDSS software and the areas of expertise, knowledge, and skills needed to create a development model bases on carbon neutrality. Based on this, a project manager, urban and regional planners, engineers from different expertise, an economist and data scientist, and software specialists were included in different phases of the project. Considering the benefits of the KAUS, it was aimed to actively involve development agencies, municipalities, organized industrial zone administrations, and universities as end users, as well as the GAP Regional Development Administration, which is the project stakeholder.

4.1.1.2 Components of the KAUS

The KAUS software is composed of three main components: a DBM, a MBM and the user interface.

4.1.1.3 The Database Management System (DBM)

Since the transition to a carbon neutral economy in GAP Region is a multi-sectoral project it requires the use of a wide variety of data sources and types. In this context, the dataset is categorized under two main headings with respect to functions;

- **Consumption Data:** Consumption data are used to analyze the current situation of the region in terms of carbon dioxide consumption in the specified variables and to forecast change of this consumption after 2020 at the scale of region, province and district. Consumption data is composed of electricity, natural gas and oil consumption at province scale (see Table 4.1).

Table 4.1 Consumption Dataset (Adapted from METU-RICBED, 2020)

Data	**Sector/Type of Consumption**	**Data Source**
Electricity Consumption	Illumination, Housing, Industry, Agricultural Irrigation, Firm	Energy Atlas, EPDK
Natural Gas Consumption	Conversion, Energy, Transportation, Industry, Service, Housing and Other	Energy Atlas, EPDK
Oil Consumption	Gasoline, Diesel, Fuel-Oil, Aviation Fuels	Energy Atlas, EPDK

- **Emission Factors Data:** It is composed of data which is used to convert electricity, natural gas and oil consumption data to carbon emissions.
- **Demographic Data:** It includes the data of demographic indicators defined for the relevant actions under main sectors in order to estimate the impact of these actions on carbon emissions.
- **Spatial Data:** It covers data of spatial indicators defined for the relevant actions under main sectors. This dataset is also used as an input in measuring the impact of these actions on carbon emissions**.**
- **Climate and Environment Data:** It covers data of climatic and environmental indicators assigned to the specified actions under main sectors to measure the impact of these actions on carbon emissions (see Table 4.2).

Table 4.2 Spatial Dataset (Adapted from METU-RICBED, 2020)

Type of Data	**Data**	**Data Source**
Demography	Population	TÜİK
Demography	Household Size	TÜİK
Demography	Population Density	TÜİK
Demography	Gross Domestic Product (GDP)	TÜİK
Demography	Population by Education Status	TÜİK
Demography	In-Migration and Out-Migration	TÜİK
Demography	Employment Rate	TÜİK
Demography	Number of Qualified Employee in Industry	TOBB
Transportation	Airport Passenger Capacity	DHMI
Transportation	Number of Motor Vehicle	TÜİK
Transportation	Number of Heavy Vehicle	TÜİK
Transportation	Number of Cars Per Person	TÜİK
Spatial	Land Use	Municipality
Spatial	Thresholds (Slope, Fault Lines, Flood Zones)	Municipality
Spatial	Type of Buildings (Public, Commercial, Housing)	TÜİK
Spatial	Number of Buildings	TÜİK
Spatial	Building Stores Height	TÜİK
Spatial	Housing Property	TÜİK
Spatial	Agricultural Land Size	TÜİK
Climate	Annual Average Temperature	MGM
Climate	Maximum Daily Wind	MGM

Table 4.2 (Continued)

Climate	Annual Average Temperature Precipitation	MGM
Climate	Annual Average Hours of Sunshine	MGM
Environment	Air Quality	TÜİK
Environment	Order of Priority in Water Pollution	CSB
Environment	Sources of Soil Pollution	CSB

4.1.1.4 The Model Base Management System (MBM):

MBM of KAUS is composed of three different models;

- KAUS Simulation Model: This mode is capable of three main calculations by using numeric data. Firstly, it calculates the rate of change in carbon emission as a result of the implementation of the actions. Secondly, it calculates the maximum number to be reached in terms of households, the number of employees, and the number of households engaged in agricultural activities in line with the target emission reduction. Thirdly, it calculates the costs as a result of the implementation of projects covered by the actions.
- Forecast Model: The forecast model is based on “R” software that is used for statistical calculations. This model enables users to calculate the change of carbon dioxide emissions between 2020 and 2025 for each action in terms of monthly electricity, oil, and natural gas consumption variables at province and district scale.
- Individual Carbon Footprint Calculation Model: This model calculates the carbon footprints of individuals by using fuel consumption data in housing, data on choice and use of transportation modes, and information on habits in daily life.

4.1.1.5 The User Interface

KAUS software allows three types of user entry as data entry personnel, project manager/officer, and viewer. The screens these users view and the commands they use vary. It has a graphical user interface that includes a menu, a variety of menu items, and tools. As seen in the Figure 4.1, KAUS' menu consists of the main page, data, project, atlas, graphic, reports, and detailed information about the software.

Figure 4.1 Home Page of the KAUS Software
Source: http://kaus.gap.gov.tr/

1. Data Tool: The data tool consists of two tabs, data entry, and data display (see Figure 4.2). The users can view the electricity, natural gas, and oil consumption data currently registered in the system at provincial and district-scale on the screen of the data display. By using the data entry tab, users that are authorized to enter data can manually update these data or uploaded data in .csv format monthly. The uploaded data is stored in the system's database and can be viewed by other users.

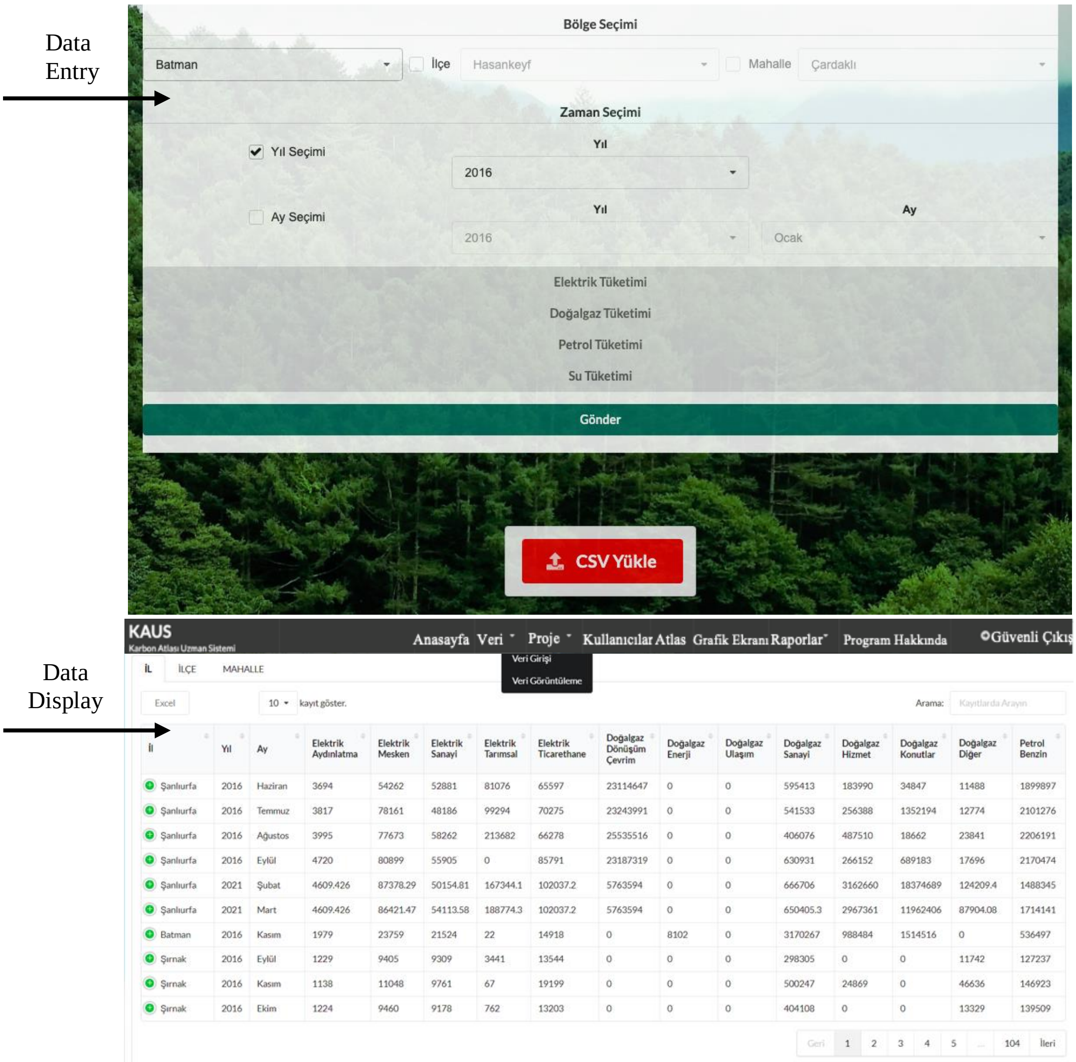

Figure 4.2 The Data Tool of KAUS Software

Source: http://kaus.gap.gov.tr/dataentry.html, http://kaus.gap.gov.tr/dataview.html

2. The Project Tool: The project tool consists of project entry, project display, and project evaluation tabs (see Figure 4.3). The project manager or officer defines the project in the system by entering the province, district, sector, implementation strategy, and action information appropriate to these strategies from the project entry tab. During the project, the project manager is expected to update the data covering the parameters defined for the project actions every 6 months. Thanks to this screen, ongoing projects can be monitored step by step, evaluations can be made during the development of the projects, and the final effects of the projects on carbon emissions can be viewed after the project is completed.

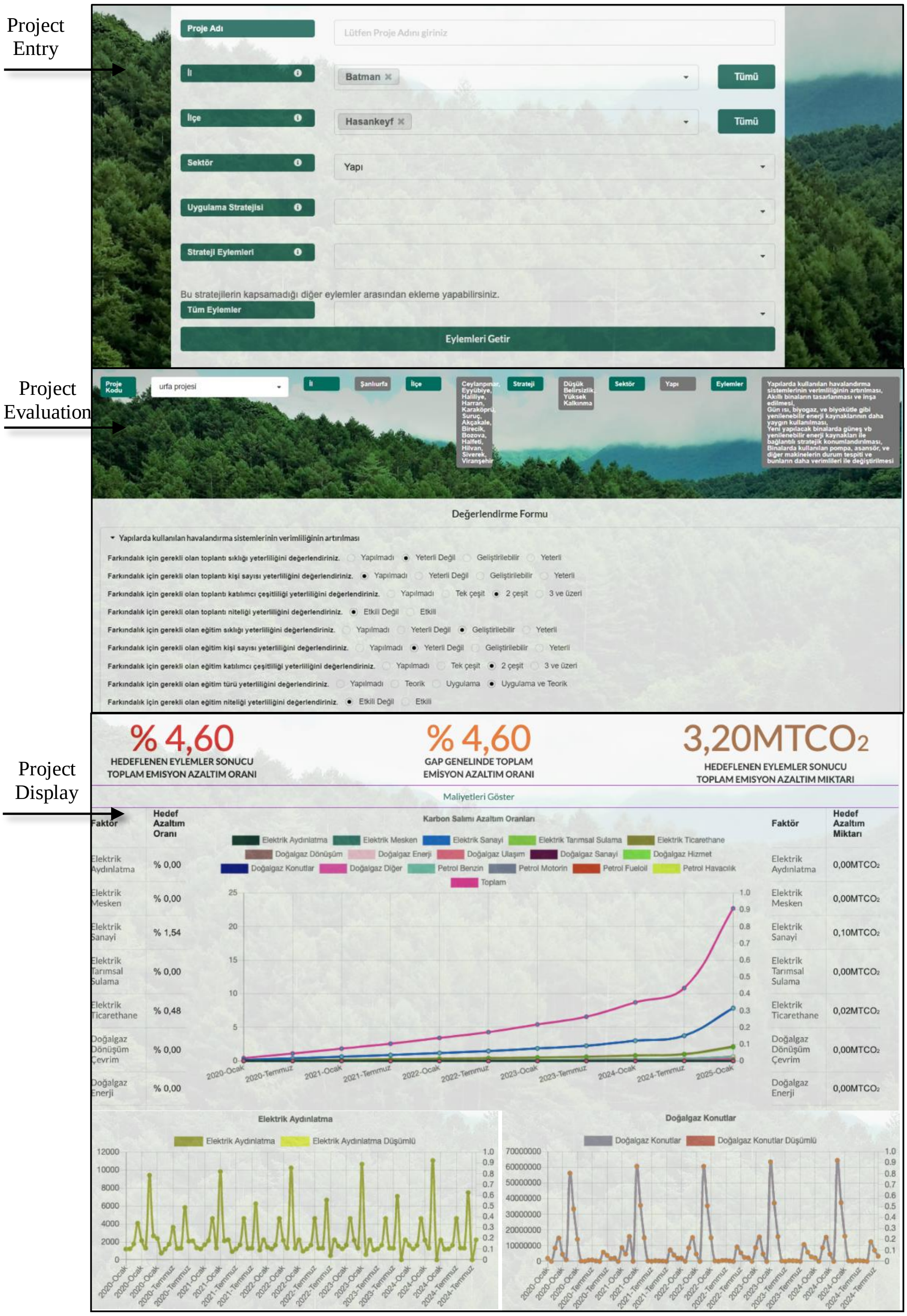

Figure 4.3 The Project Tool of KAUS Software

Source: http://kaus.gap.gov.tr/projectview.html

3. Atlas Screen: The Atlas Screen is the screen where the current and estimated carbon emissions and the reduction in carbon emissions caused by the projects are displayed on a map consisting of provincial, district, and neighborhood boundaries on a monthly or annual basis in terms of defined consumptions (see Figure 4.4). The reduction in carbon emissions caused by the projects can be monitored on the Atlas screen both during the development period of the projects and after the projects are completed.

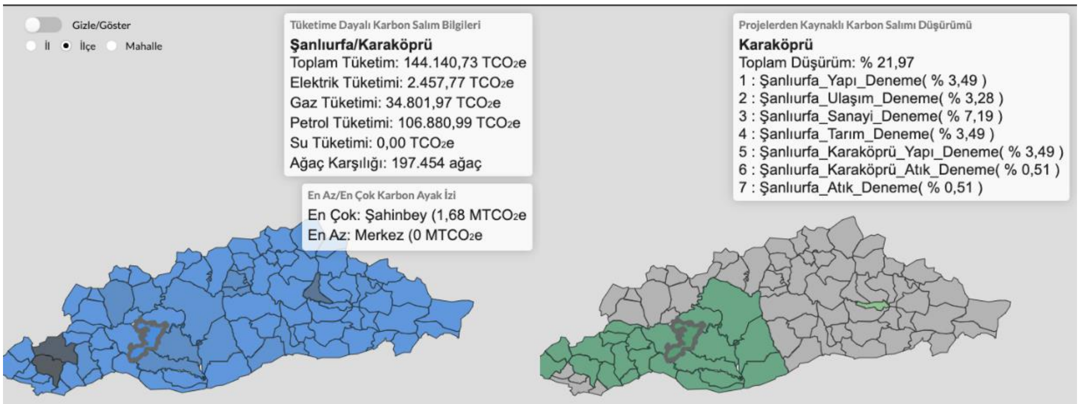

Figure 4.4 The Atlas Screen
Source: http://kaus.gap.gov.tr/atlas.html

4. Graphic Screen: It is the screen where the current and estimated carbon emissions can be viewed and downloaded on a monthly or yearly basis in terms of defined consumption types, on a provincial and district scale (see Figure 4.5). This screen can be used by data entry personnel, project manager, and viewer. (METU-RICBED, 2020)

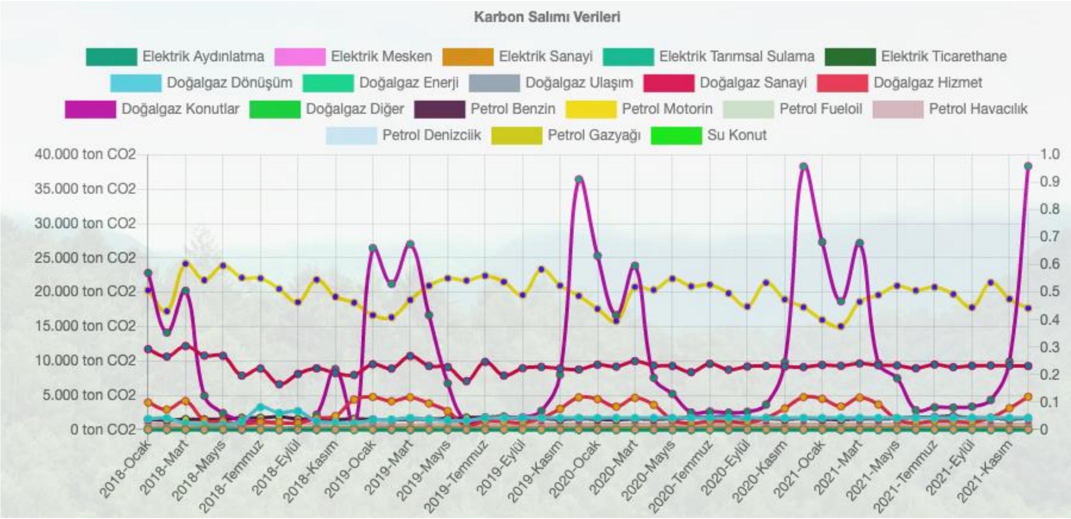

Figure 4.5 The Graphic Screen of the KAUS Software
Source: http://kaus.gap.gov.tr/home.html

5. Reports Tool: Reports tool consists of a user guide in which attributes of data are explained, and the KAUS project final report, in which general information about the software is given and the contributions of software is explained (METU-RICBED, 2020)

Based on all this information, the menu of the KAUS software, the tools in the menu bar, how these tools work and the user types are summarized in the Figure 4.6.

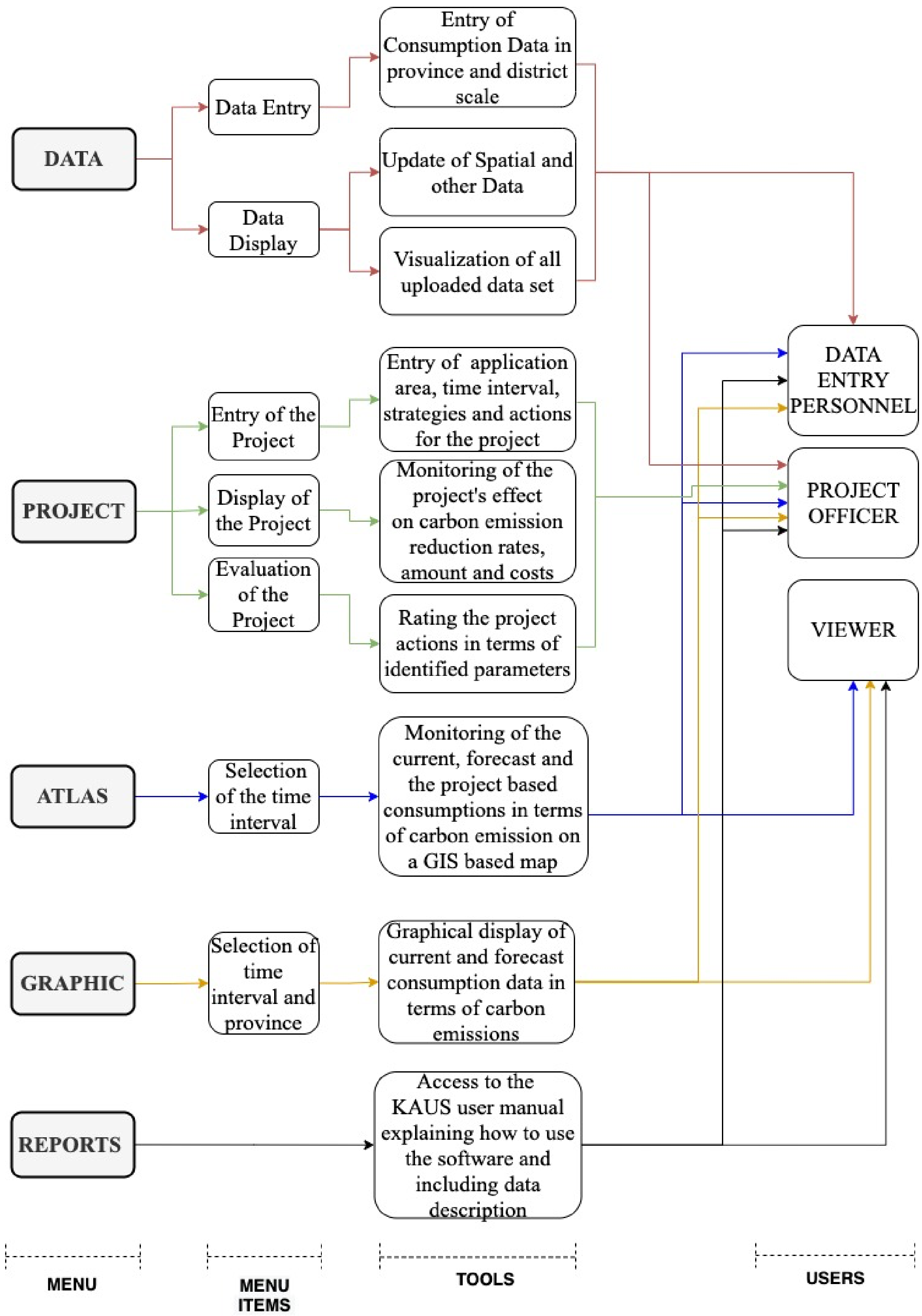

Figure 4.6 The User Interface of KAUS (Adapted from METU-RICBED, 2020)

The decision-making process in KAUS software is depicted in Figure 4.7.

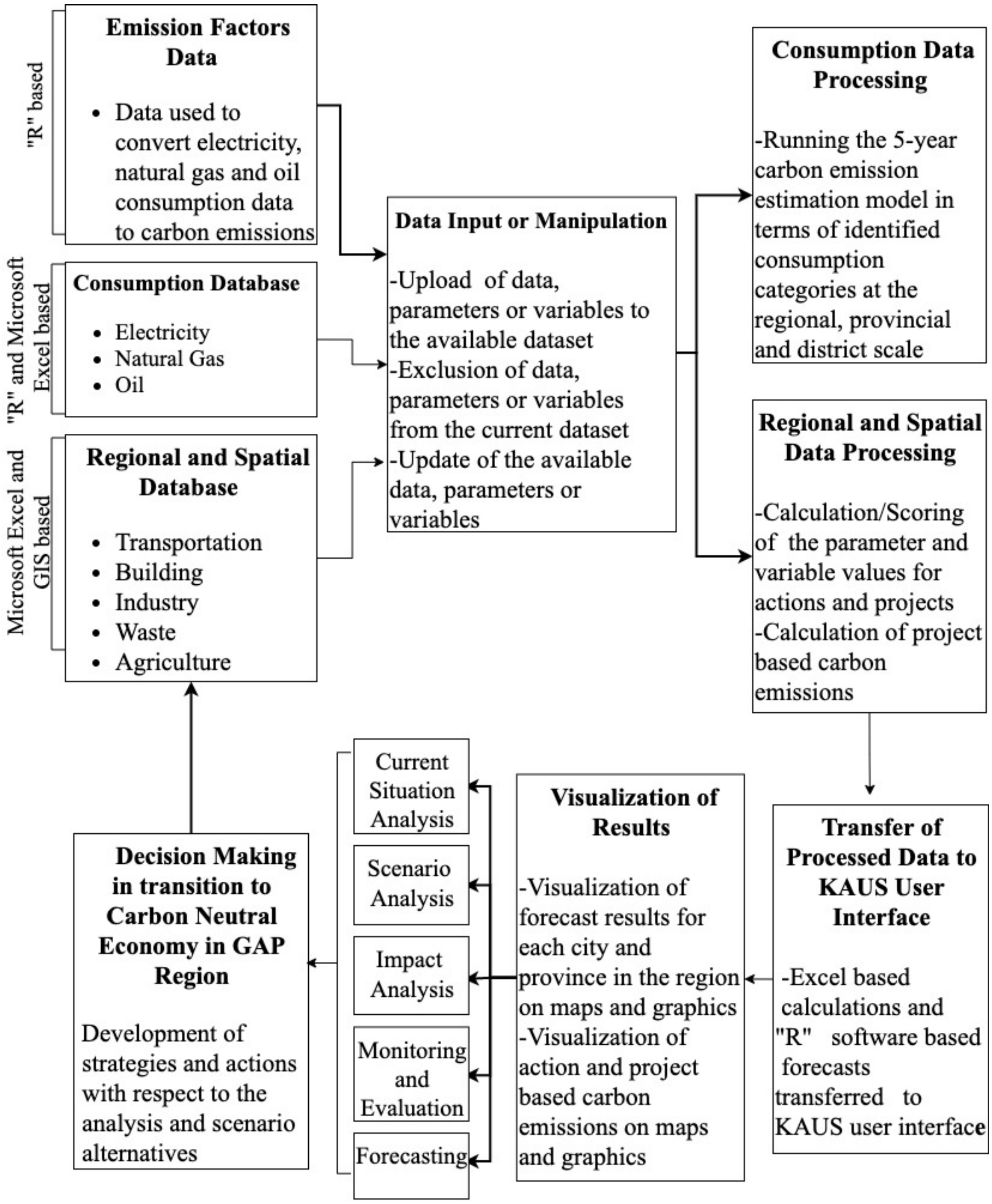

Figure 4.7 Decision-Making Process in KAUS

4.2 The Parameters and Variables Used in the Research

Based on the detailed literature review on the main characteristics and components of (S)DSS (discussed in Chapter 2) and the previous studies on adoption and use of GIS, DSS, SDSS and PSS (discussed in Chapter 3) in planning institutions, three main parameters are determined to evaluate the adoption of KAUS Software in metropolitan municipalities and development agencies in the GAP Region. These parameters are categorized as;

-*data-related factors,*
-*organizational factors,*
-*technical factors,*

Under these parameters, various variables are listed such as data availability and quality for data-related factors; awareness, technical experience and attitude for organizational factors and hardware availability, data visualization, scenario modelling for technical factor. These variables determined the scope of the parameters and were used as a guide while preparing interview questions. (see Table 4.3).

Table 4.3 Description of Parameters and Variables

Parameter	**Variable**	**Description**
Data-related Factors	Data Quality	The extent to which utility of non-spatial and spatial data fit for the intended purposes
	Data Accessibility	The extent to which non-spatial and spatial data required in decision-making process is easy to obtain
	Data Availability	The extent to which non-spatial and spatial data required in decision-making process is available
Organizational Factors	Awareness	The extent to which target users are aware of the contributions and advantages of SDSS

Table 4.3. (Continued)

	Technical Support (Training)	The extent to which training that provide users with the necessary skills to be able to use SDSS are available and adequate
	Communication and networking between institutions	The extent to which communication channels exists and networking is strong to use SDSS in an integrated way
	Attitude	The extent to which target user groups and managers approach to the use of SDSS positively
	Availability of skilled and experienced staff	The extent to which the number of skilled and experienced staff in using GIS and other GIS-based systems are enough
Technical Factors	Resource Availability	The extent to which software and hardware needed to use SDSS is available and adequate
	Fit to Planning Task	The extent to which capabilities of KAUS software is fit for the intended purposes and tasks in decision-making process
	Data Visualization and Analysis	The extent to which capabilities of KAUS software enables users to display spatial data and make necessary spatial analysis
	Scenario Modelling	The extent to which scenario modelling capabilities of KAUS software is enough to perform necessary tasks in decision-making process

4.3 Research Findings

The research findings were categorized according to the parameters and variables mentioned above.

4.3.1 The Use of GIS in Current Situation

Before going into details of the factors affecting the adoption of SDSS in GAP Region, some questions were asked to the interviewees, and also the strategic plan documents of the institutions were examined in order to understand the current situation regarding the use of GIS and GIS-based computer systems in decision-making processes.

In line with the answers of the interviewees, it was determined that although there were attempts to use GIS in the past in all three development agencies, its use was very limited. A city planner from İpekyolu Development Agency (I8) stated that:

> "In the past, the investment support office had an intention to use GIS, so ArcGIS license was obtained but it has not been used actively in the planning unit and other units until now. We are planning to use it in the future."

Another city planner from Dicle Development Agency (I6) said that:

> "We used ArcGIS only to visualize the data while preparing our latest regional plan, other than that, this software was not used throughout the organization. We are not an institution that uses this program extensively."

Therefore, GIS is not actively used continuously in all stages of the decision-making process in development agencies in the region.

It has been observed that GIS infrastructure has been established in metropolitan municipalities and the infrastructure development studies continue (I1, I14, I17). A city planner from the Gaziantep Metropolitan Municipality (I18) emphasized that:

> "We established the GIS infrastructure in our municipality and started to use it in some of our units. It is already included in the legal regulations that these programs must be used in municipalities. We continue to work on expanding the use of this program."

Another city planner from the Mardin Metropolitan Municipality (I2) said that:

> "We use the Net CAD and AutoCAD software. GIS infrastructure has not been fully established in our municipality yet."

One of the reasons for the differentiation in metropolitan municipalities and development agencies is legal arrangements. According to Metropolitan

Municipality Law No: 5216 dated 2004, “establishing geographic and city information systems” are among duties, authorities and responsibilities of the metropolitan municipalities. However, development agencies are not defined such a duty and responsibility in the legal statue.

It is understood from the explanations of the interviewees that GIS started to be established in municipalities especially in the last 1-2 years (I17, I19, I3). However, there is still a tendency to use drawing programs such as CAD systems in these institutions. The fact that GIS is used in some departments of the institution and not in the others shows that this software is not used in an integrated manner throughout the metropolitan municipalities.

Although the metropolitan municipalities have a similar profile in terms of the integrated use of GIS-based systems, it is observed that there are some differences in terms of the progress made in the use of these systems. In this context, it has been determined that Gaziantep Metropolitan Municipality has made more progress compared to other municipalities in terms of the development of GIS infrastructure and use of it.

4.3.2 Data-Related Factors

DBM is one of the most important components of a SDSS. The characteristics of the data which is the input of the DBM is a determinant for the adoption and effective use of SDSS. In this context, data-related factors for the adoption and use of SDSS was examined within the scope of the data quality, data availability and data accessibility variables.

4.3.2.1 Data Quality

One of the variables that affect users' decision-making processes is data quality. Problems in data quality cause decision-making processes to be carried out using incorrect or incomplete data. In today's uncertain environment, rapid changes are experienced in the world and the effects of these changes can be observed on a global, regional or local scale. This leads to an increase in the dynamism of the data used in decision-making processes. Consequently, it has become very important to constantly update the data in certain periods to increase the efficiency of the decision-making processes.

Employees of both metropolitan municipalities and development agencies in GAP Region stated that they have difficulty in finding up-to-date data in some areas during the decision-making process (I1, I6, I9, I14, I17, I12). A GIS specialist from the Gaziantep Metropolitan Municipality (I4) expressed this problem by saying that:

> “We have difficulties in finding up-to-date data from time to time. However, I cannot say that we have this problem in all data, the currency of the data varies depending on the data type.”

In addition to the currency of data, difficulty in finding standardized data is another problem experienced in terms of data quality (I11, I17). A city planner from Şanlıurfa Metropolitan Municipality (I15) made the following explanation for this problem:

> “We obtain data from a wide range of stakeholders in the planning processes. The data we collect may differ in terms of format. This poses some challenges in terms of data integration.”

The collection of data used in decision-making processes from a wide variety of sources causes the diversity of data types and formats. In addition, due to the differentiation in the technical infrastructure of the institutions, the software they use vary. This indicates that data shared by different institutions can be processed in different software. All these factors raise issues with data integration.

4.3.2.2 Data Availability

With the developments in technology, data collection tools and methods are diversified and more data can be collected in a shorter time. Thanks to this, problems in terms of data availability have been partially resolved. However, it is obvious that technological developments have not produced a complete solution to this problem.

The fact that the decision-making processes in spatial planning are multi-sectoral and multi-scale often necessitate collection of a wide range of data. In this context, data availability is among the problems encountered in decision-making process of metropolitan municipalities and development agencies in the GAP Region (I1, I15).

A city planner from the İpekyolu Development Agency (I9) emphasized this problem by saying that:

> "I think data access is an important problem not only for this region, but also other planning institution in Turkey. We need the data stored in TURKSTAT to analyze the current situation, but we cannot obtain some data in the required detail or scale."

Another city planner from the Şanlıurfa Metropolitan Municipality (I11) emphasized that:

> "We generally find the necessary data to perform our tasks, but sometimes we have difficulty in finding available data."

In order to better understand the problems experienced with the data during the KAUS software development process, the researcher involved in the KAUS project was also interviewed. The researcher (I20) stated that:

> "We were able to find the necessary energy consumption data for carbon emission aggregation only at the district scale, but these data were not available at the district scale. In addition, we could not find consumption data such as natural gas and electricity in the number of subscribers. Since we could not find the consumption data at the district scale, we created the district data ourselves according to certain parameters."

Based on the statements of both the employees of the institutions in the GAP Region and the researcher, it has been determined that the lack of data is one of the prominent problems, especially for decision problems in which different scales are examined together and detailed data is required.

4.3.2.3 Data Accessibility

Although it is observed that the increase in data availability has a positive effect on data accessibility, it still seems to be one of the prominent problems of planning institutions in the GAP Region. A city planner from Dicle Development Agency (I6) stated that:

> "Although the accessibility to data varies according to the type of it, I still think that the most important reason why GIS cannot be used effectively is the problems related to the data. While we used to experience problems with data availability more frequently in the past, today data sharing is one of the prominent problems. Sometimes the institutions we request data from is reluctant to share data."

Another city planner from Gaziantep Metropolitan Municipality (I5) said that:

> "I cannot say we do not have problems with data access. While we have difficulties in sharing data from time to time, we experience this problem more often with private sectors. There is not a common database where we can share data with other institutions."

Similarly, another city planner from İpekyolu Development Agency (I9) emphasized that:

> "From time to time, we encounter various problems in obtaining data even from institutions that are our stakeholders such as municipalities."

The interviews revealed that one of the reasons for the lack of data accessibility is the weak communication channels and lack of cooperation between institutions. Although it is not valid in all data gathering processes, it has been observed that institutions are unwilling to mutually share data from time to time. This causes decision-making processes to be carried out with incomplete datasets. Also, it has been observed that the deficiencies in the legal arrangements, the differences in the legislation of the institutions and the fact that the data flow processes between the institutions are not coordinated by a central authority are important factors in the problems experienced in data sharing.

Another problem mentioned by the interviewees is the data privacy issues (I4, I9). The researcher stated that this problem was also experienced in the KAUS Project with the following words:

> "One of the problems we experienced with access to data due to privacy issues. For example, although consumption data is kept on a subscriber basis, we could not reach this data."

In addition to the data privacy, another problem encountered in data access is that the data sharing process takes a long time (I3, I7, I10). An environmental engineer from Gaziantep Metropolitan Municipality (I10) emphasized this problem by saying that:

> "We request data from other institutions via telephone or official correspondence. We rarely have problems with data availability. In cases where data is available, we encounter the problem that the data sharing process takes a long time."

The answers given to the interview questions have shown that information technologies are not used effectively in the data collection processes throughout the GAP Region. The traditional methods of data supply processes cause the decision-making processes to be prolonged. As mentioned before, planning processes require the use of a wide variety of data sets from various sources. The lack of a common database where stakeholders can upload and update necessary data also makes it difficult to access data and causes this process to take more time.

Considering all the variables related to data, it was determined that the problems related to data availability, quality and accessibility are effective factors in the lack of adoption of SDSS in metropolitan municipalities and development agencies in the GAP Region. As seen in Table 4.4, problems related to data quality hold the highest ratio of 56,6%, which is followed by data accessibility (30,2%). While the most mentioned problem in terms of data quality is the difficulty of finding up-to-date data (19,2%), it has been observed that the prominent problem in accessing data is unwillingness of stakeholders to share data (16,9%). Although the problems related to data availability (13,2%) are less mentioned than data quality and accessibility, it is seen that difficulty in finding detailed data is the prominent problem in terms of data availability.

Table 4.4 Frequency of Mentions of the Contents Related to Data

Parameters	Contents	Frequency of Mentions	Ratio
Data Quality	Incorrect data	6	56,6%
	Lack of up-to-date data	10	
	Lack of digitalized data	4	
	Difficulty in data standardization	5	
	Difficulty in data integration	5	
Data Accessibility	Time wasting in accessing data	4	30,2%
	Data privacy	3	
	Unwillingness to share data	9	
Data Availability	Difficulty in finding detailed data	5	13,2%
	Deficiencies in the data archive	2	
Total		53	100%

4.3.3 Organizational Factors

Organizational factors are examined within the scope of technical support (training), awareness, staff availability, communication and networking between institutions and availability of skilled staff.

Before going into a detailed analysis of these variables, it will be useful to examine the organization chart of the metropolitan municipalities in order to provide a general framework. Considering the organizational charts of Mardin, Gaziantep, Şanlıurfa and Diyarbakır Metropolitan Municipalities, it is seen that although there are minor differences in the branch offices related to information and communication technologies, these municipalities have a similar structure. It is seen that separate units for city information systems or geographical information systems have been established in each of the four metropolitan municipalities (see Figure 4.8.). In addition to these, there is a separate unit for smart cities, R&D and innovation in Gaziantep Metropolitan Municipality. Unlike metropolitan municipalities, there is no separate unit under the name of information and communication technologies in development agencies.

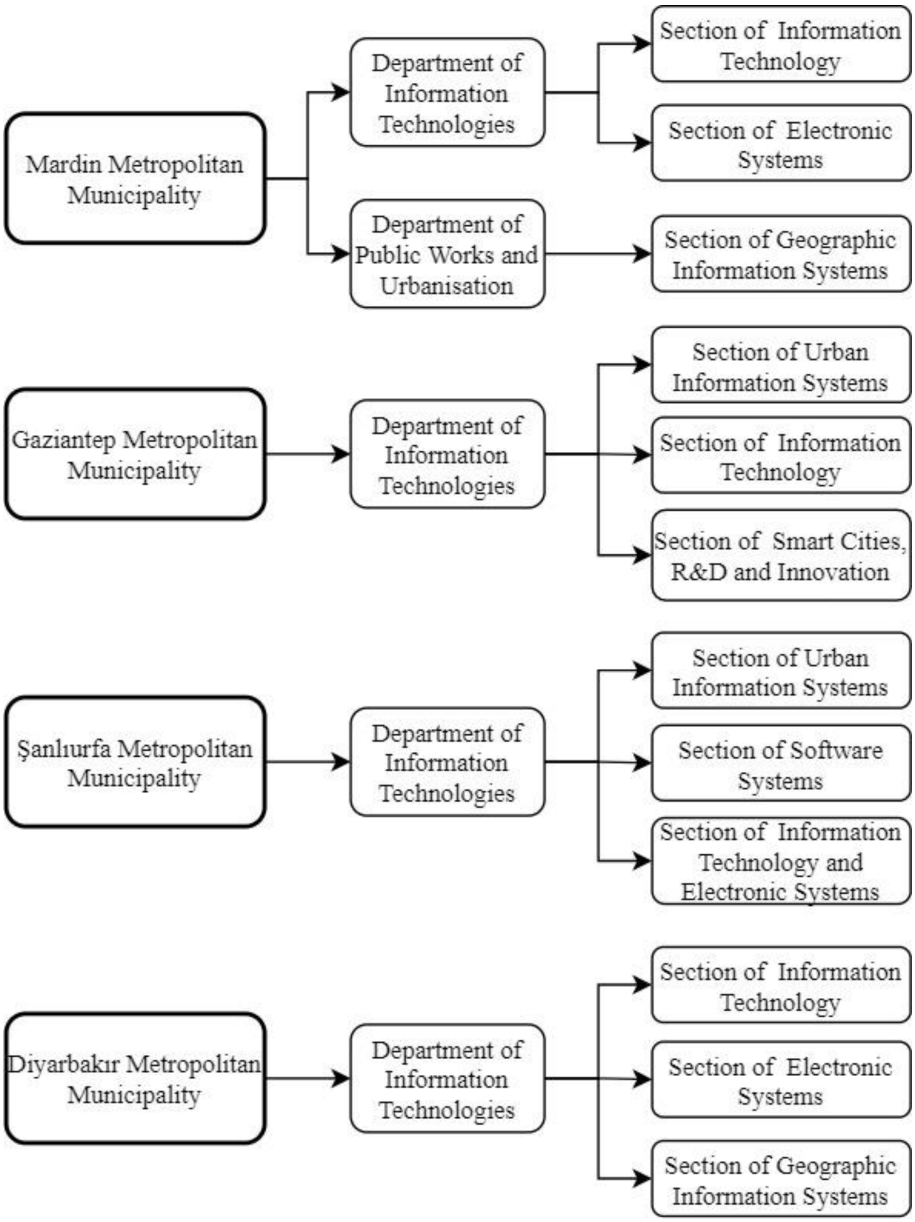

Figure 4.8 The Organizational Structure of the Metropolitan Municipalities in the Context of Information Technologies

The fact that these branch offices have already been established can be seen as an advantage to facilitate the adoption and use of SDSS in these municipalities in case they take an active role in the development of the GIS infrastructure throughout the institution and contribute to increasing the susceptibility to such technologies.

4.3.3.1 Staff Availability

The majority of the interviewees emphasized that there is a lack of trained and experienced personnel in GIS and other computerized technologies in their institutions (I2, I4, I8, I9, I15). It is seen as an important obstacle to the adoption and use of SDSS in different phases of planning process. A GIS specialist from the Gaziantep Metropolitan Municipality (I4) stated that:

> "One of the problems we face in adopting GIS based computerized technologies is related to the experience of the staff. Considering the whole region, we have difficulties in finding personnel (both cartographer and city planners) trained and experienced in GIS. For this reason, we carry on works in order to train our own personnel in this field."

Another city planner explained the situation in Diyarbakır Metropolitan Municipality (I17) by saying that:

> "The number of qualified personnel who can use GIS in Diyarbakır and the region is not enough. In our institution, the section of Geographic Information Systems was established two years ago. Since it was established recently and we are in a pandemic process, there has not been an important progress in terms of staff experience. Especially in the last 1-2 years, meetings have been carried out by the General Directorate of Geographical Information Systems to solve such problems. However, we still have a shortage of trained and experienced personnel."

The lack of skilled and experienced personnel is due to the fact that GIS-based support tools are not actively used in planning processes and there is lack of awareness of their values and potential contributions. Therefore, it is seen that the availability of experienced personnel is not perceived as a priority need by the management side. The city planner from Dicle Development Agency (I6) explained this problem by emphasizing that:

> "We have not actively used GIS software in regional planning processes in our institution. There were staff specialized in GIS, but they are not currently working here due to the frequent circulation of personnel. There may be some institutions that keep the personnel structure strong in terms of use of this software, but we do not have such a priority right now."

Another city planner explained the current situation in İpekyolu Development Agency by saying that (I9):

> "Since the profession of people working in development agencies are mostly business and economics, our personnel who know how to use GIS-based programs are very insufficient. Currently, there is only one planner who has experience on GIS in our development agency."

Another city planner from Gaziantep Metropolitan Municipality (I19) stated that:

> "I think the most prominent problem is the lack of personnel experienced in GIS. In our institution we have personnel who can use such systems, but rather than conducting this process with 4-5 people, all personnel involved in the planning processes should know how to use these systems so that they can be used more effectively."

In line with the interviews, it has been determined that there is no significant differentiation in terms of the 'availability of skilled staff' across the institutions in the GAP Region. Therefore, lack of experienced personnel in GIS stands out one of the most important obstacles to the adoption of SDSS throughout the region.

4.3.3.2 Awareness

Awareness is the first step in the process of adopting an innovation. In order for an innovation to be adopted, it is necessary for the potential adopters to have a certain level of awareness of that innovation. Accordingly, target users must have sufficient knowledge of SDSS in order to adopt these systems. In-depth interviews revealed that the personnel who have received training in GIS and know how to use these technologies have self-consciousness of the potentials of them. However, due to the lack of knowledge on SDSS, the potentials of support tools are defined through the GIS by planners who emphasized that these systems are needed and that their use will facilitate planning process. A GIS specialist from the Gaziantep Metropolitan Municipality (I4) stated that:

> "Especially until 2 years ago, the importance of GIS was not understood enough. However, we have been focusing more on this issue in our unit for the last 1-2 years and we are trying to make progress. It provides us convenience especially in terms of performing various analyzes, gather necessary data and manipulate these data."

Although the contributions of support systems in terms of data collection, storage, integration and visualization are known, it has been observed that the other capabilities and potential contributions to the decision-making process especially in strategic planning under the uncertain conditions is not fully known. It is obvious that the problem of keeping up with technological developments is one of the reasons for the lack of knowledge about SDSS. A city planner from Diyarbakır Metropolitan Municipality (I17) stated that:

> "I think that if such GIS- based support systems are used, integration between institutions will increase and work flow will be easier. The use of such systems is important especially for the integration and flow of different data sets in a more efficient and faster way. However, I do not think that planners and managers are aware of the benefits of such systems in our institution and in the region."

Another city planner from Mardin Metropolitan Municipality (I1) said that:

> "Although a separate branch office for GIS has been established in our institution, these systems are not used actively. I know how to use it and I think it will be useful to adopt such systems for more efficient work flow. But, I think that lack of awareness and level of knowledge on these systems is an important obstacle to the adoption and use of them. For this reason, such systems do not attract enough attention and therefore infrastructure cannot be established."

Considering the general structure of metropolitan municipalities and development agencies and the current use of information systems in these institutions, it is seen that there is not an environment in which common awareness on SDSS is dominated. In other words, it has been observed that there is lack of recognition about the potentials of SDSS to the planning processes due to the lack of information about SDSS at both individual and institutional level.

4.3.3.3 Training

The interviews revealed that there are differences and similarities in terms of training support for GIS in metropolitan municipalities in the GAP Region. While it was stated that such trainings were given in Gaziantep, Diyarbakır and Şanlıurfa Metropolitan Municipalities in the past, training activities were not carried out in Mardin Metropolitan Municipality since the GIS infrastructure not yet fully established (I2, I17, I18). A city planner from Diyarbakır Metropolitan Municipality (I16) emphasized the importance of trainings by saying that:

> "I think it is important to provide regular trainings on the use of such systems as they are constantly updating themselves depending on technological developments. In the past, such trainings were given in our institution, but I think frequency of these trainings should be increased to motivate personnel to use such systems"

Since GIS-based support tools are not actively used in the planning processes in development agencies, it has been observed that the employees are not given training on the use of these programs. Among the interviewees, there are city planners who have received training on GIS with their own efforts, as well as those who have participated in the trainings given within their institution (I8, I17, I18). It has been observed that all the interviewees have a positive approach to participate in such training programs and to educate themselves to be able to use computer-based support systems. A city planner from the Şanlıurfa Metropolitan Municipality (I3) stated that:

> "In order to use information technologies in the most efficient way, I think that each personnel should be educated about these systems and this training process should be continuous."

Another emphasis was made by the city planner from İpekyolu Development Agency (I8):

> "I had the opportunity to learn how to use GIS software by participating in trainings of a private company. GIS is a very specific field, which requires technical knowledge. The software of such programs is also constantly updated. For this reason, I think it is very important to train planners in this

> field. However, since computer-based support tools such as GIS are not actively used while preparing regional plans, the personnel are not given trainings for such systems."

Based on the interviews, two basic inferences have been made. The first one is that the demand for the education support is not fully met. This is the case in all metropolitan municipalities in the region. The second is that such a need and demand does not occur due to the limited use and awareness of GIS-based support tools, especially in development agencies and some branch offices of metropolitan municipalities. The fact that trainings are not carried out in a continuous and interactive way causes the trainings to not be fully efficient and the technology to be followed behind. In addition, this causes the participation rate to be limited, which results in lack of trained personnel.

Since SDSS are systems that constantly update themselves and need to be followed closely, the lack of educational support creates a challenge for the adoption of such systems. As a result, it has been observed that there is a need to increase training activities in an integrated and continuous manner in these institutions.

4.3.3.4 Networking between institutions

In transition from the concept of government to governance, the most important transformation in the field of planning is that planning has become a multi-actor process. As a result, private sector, NGOs, and different public institutions has become stakeholders of the decision-making process, which makes the process more complex. Inclusion of various stakeholders from the different sectors necessitates establishment of communication channels and cooperation. While making decisions in different areas in the field of planning, there is need to obtain data from many different sources and institutions, which can be explained by coordination and communication between different stakeholders.

Considering the statements of the interviewees, it was understood that there is no communication problem within the metropolitan municipalities and development agencies in GAP Region. However, there is lack of cooperation between these institutions (I13, I7, I16, I3, I12). Both the employees of development agency and metropolitan municipality in the region stated that lack of collaboration between public institutions stands out as an important problem in planning process. This problem emphasized by the city planner from Dicle Development Agency (I6):

> “It is not difficult to communicate with other institutions, but institutions are not coordinating with each other. One of the tasks of development agencies is to increase cooperation between the public, civil society and the private sector. When we develop a project, we can bring relevant stakeholders together. However, we cannot follow the planning process of other institutions. The legal structure may be a reason for this. There are different laws or regulations for different planning scales. Everyone works according to their own directives.”

From this point of view, one of the reasons for the lack of cooperation between planning institutions is that a holistic planning approach has not been adopted.

In fact, it is possible to see the problem of cooperation even within the institutions. This shows that an integrated planning approach has not been fully adopted yet. The lack of an integrated planning approach poses an obstacle to the development of decision support tools which requires continuous interaction. Considering the situation especially in metropolitan municipalities in the region, it is seen that whereas some planning departments use GIS-based support tools, some departments do not use such tools. This situation indicates that planning support tools are not used in a holistic manner in decision-making processes. The city planner from Mardin Metropolitan Municipality (I1) stated that:

> “I do not think integration between public institutions is sufficient. Since there is no collaboration, organizations using GIS and similar systems switch to these programs according to their own strategies. The fact that the institutions are independent from each other causes such information systems not to be given the necessary importance and not to be perceived as a need.”

A city planner from Karacadağ Development Agency (I8) emphasized the problem networking by saying that:

> “I think that the lack of cooperation and coordination between institutions prevents the integrated use of support systems such as GIS. If such systems

> are developed by creating a common database, I think it will facilitate coordination. Unfortunately, there is no such a cooperative environment at the moment. On the contrary there is competition between some institutions. I do not think there will be such environment in the near future."

Another problem is that the environment that can carry out the process simultaneously between different occupational groups (mapping engineers, architects, technicians and city planners) at different stages of decision-making processes has not been fully established. Although there is no problem between these groups in terms of communication, city planners are not actively involved in the use of applications such as urban information systems and GIS. A GIS specialist from the Gaziantep Metropolitan Municipality (I4) stated that:

> "City planners do not take an active role in the use of GIS. As GIS experts, we do the data entry and data update to the urban information system established within our municipality."

Although there is a tendency to use support tools in different units of planning institutions, especially in recent years, it is observed that there are still deficiencies. The fact that planning institutions do not cooperate with each other and do not have active communication channels makes it difficult to transfer the advantages and benefits of the planning support tools to other institutions by people who have used such systems and have experience with them.

In conclusion, the interviews showed that the lack of cooperation and communication between institutions is one of the prominent barriers to the adoption of decision support systems across the GAP Region.

4.3.3.5 Attitude

The acceptance and continued use of SDSS is directly influenced by attitude of towards these systems. In this context, attitude of target users and managers are very important. During the interviews, while the target users had a positive attitude towards the use of GIS-based support systems, they also mentioned the lack of management support (I1, I2, I5, I8, I12, I17). A city planner from Diyarbakır Metropolitan Municipality (I17) said that:

> "I used to work in the GIS branch office in this institution. In that process, I personally wanted to do something to use this system, but I couldn't get much support. I think that the administrative support should be increased in this regard."

Another city planner from the Gaziantep Metropolitan Municipality (I5) emphasized that:

> "In order for such systems to be used efficiently throughout the organization, they should also be supported by the management. The fact that this issue was not brought to the agenda on the management side in the municipality may be due to the intensity of the works and lack of knowledge on such systems. However, in the last two years management support has been increased for the establishment of such systems in our municipality."

Some interviewees stated that the lack of support on this issue derives from the lack of financial resources (I1, I2). A city planner from the Mardin Metropolitan Municipality (I1) explained this situation by saying that:

> "We have been requesting the establishment of a GIS system in our department since 2015, but this infrastructure has tried to be established nowadays. I think one of the reasons for this may be the shortage of funds. Also, since the benefits of these systems are not known, they do not attract enough attention from the management side and does not attract much attention and support is insufficient."

Considering the answers given to the interview questions, it is possible to say that the problems experienced in the support provided by the management are caused by the lack of knowledge and awareness about such systems rather than an individual negative attitude towards SDSS. It can be said that the lack of sufficient information about the contributions of such systems in the decision-making process causes support for such programs to be out of the agenda. It is clear that following the technology behind is also effective in this regard.

In conclusion, although certain problems in the management support are mentioned during the interviews, the attempt to improve GIS infrastructure in these institutions, especially in recent years, is an indication that managers and employees approach the use of such systems positively.

4.3.4 Technical/System-Related Factors

System-related factors are composed of resource availability, spatial data visualization and analysis, fit to planning task and scenario development capabilities of KAUS software.

4.3.4.1 Resource Availability

The variables related to the availability of the resources are composed of software and hardware. In this context, the interviewees were asked about their own experiences, the strategic plans of the metropolitan municipalities and the activity reports of development agencies were examined.

According to 2020-2024 strategic plan of Mardin, Gaziantep, Şanlıurfa and Diyarbakır Metropolitan Municipalities, the number of hardware (desktop computers and laptops) is sufficient and the staff can get access to the internet securely. Similarly, interviewees stated that they do not have problems in terms of hardware infrastructure in their institutions (I1, I14, I16, I18).

Since KAUS is a GIS-based software, one of the requirements for its adoption and use is the availability of GIS software. In line with the 2020-2024 strategic plan reports of the metropolitan municipalities and the explanations of the staff in the IT department, it was observed that the GIS software is currently acquired by Mardin, Gaziantep, Şanlıurfa and Diyarbakır Metropolitan Municipalities (I3, I4, I13, I17). Other software installed in these institutions are Net CAD and AutoCAD (see table 4.5).

Table 4.5 The Software Used in Metropolitan Municipalities

	Net CAD	AutoCAD	GIS	Mobile Applications	Urban Information Systems
Diyarbakır	✓	✓	✓	X	✓
Gaziantep	✓	✓	✓	✓	✓
Mardin	✓	✓	✓	X	X
Şanlıurfa	✓	✓	✓	X	✓

As a result, it can be said that the resource availability (hardware and software) is not an obstacle to the adoption and use of the KAUS software in these municipalities.

Similarly, the activity reports of Dicle, İpekyolu and Karacadağ Development Agencies for 2019 were examined. As stated in these reports, the necessary software and hardware needs are met in all development agencies. The interviewees also did not mention any shortcomings in hardware and software and stated that they do not see the resource availability as an obstacle to the use of GIS and GIS-based SDSS (I6, I7, I8).

4.3.4.2 Spatial Data Visualization and Analysis

The data set used in calculating carbon emissions in the KAUS is entered, updated and stored in excel format. Atlas, which shows the current and targeted carbon emissions spatially, consists of province and district borders layers (see Figure 4.9.).

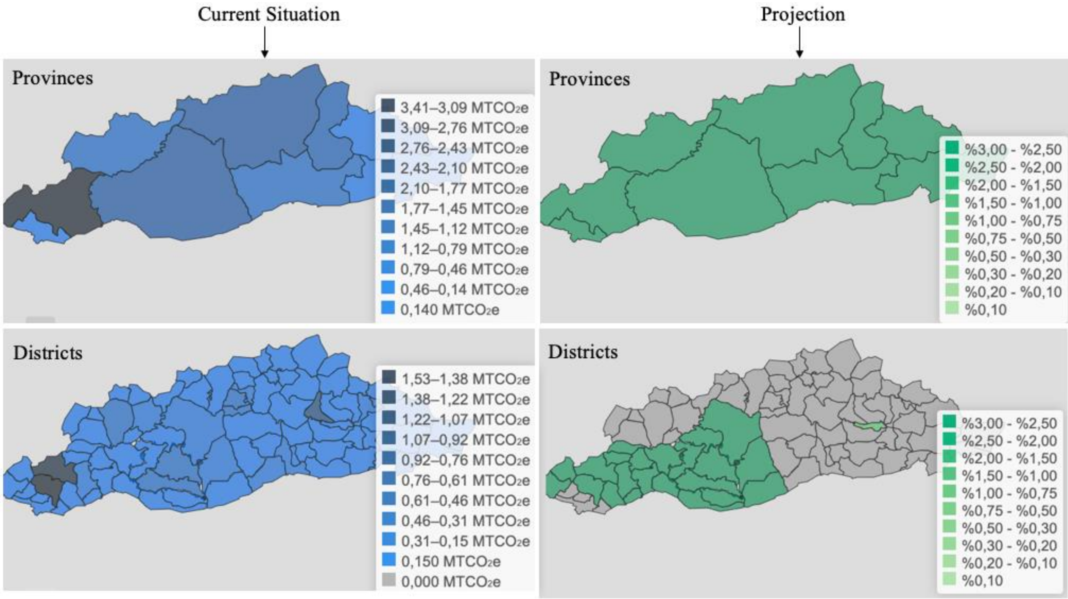

Figure 4.9 Display of the Results on the Atlas Screen
Source: http://kaus.gap.gov.tr/atlas.html

In fact, the carbon emission values shown on the Atlas are calculated as a result of analyzing the data defined under many spatial layers such as transportation, housing, industry, agriculture and waste by using an econometric model. However, it is seen that these data layers, which are stored and processed in the background of the KAUS software, cannot be displayed spatially on the Atlas and, accordingly, spatial analysis cannot be performed.

These layers can be integrated into the system later, but this process requires expertise in GIS-based SDSS programs. In addition, it is required to update these layers continuously once they are integrated to the system. Considering the insufficient number of personnel specialized in GIS in metropolitan municipalities and development agencies in the GAP Region, as mentioned before, these deficiencies in the institutional infrastructure need to be eliminated first in order to carry out this process. For this reason, the lack of spatial data visualization and the spatial analysis in decision-making processes originating from KAUS software creates an obstacle in terms of the adoption and integrated use of this software throughout the metropolitan municipalities and development agencies in the region.

4.3.4.3 Scenario Development

Today, the increase in both external and internal uncertainties and rapid changes in economic, physical and social dynamics necessitate the creation of alternative development scenarios for the future in decision-making processes and the analysis of the effects of these scenarios in spatial planning. The ability of SDSS to meet this need is one of the important features that distinguish these systems from GIS and similar technologies. Within the scope of this study, the scenario planning capability of the KAUS was examined in line with the information obtained from both the KAUS software website and the related reports of the KAUS Project.

KAUS software offers various scenario options such as disasters, the start of smart card application, natural gas infrastructure provision and widespread use, epidemics and changes in oil prices to the user type of the ‘project manager’ when calculating the carbon emissions. If the project manager chooses any of the scenario options, the carbon emission rate is calculated by considering the impact of those scenarios (see Figure 4.10).

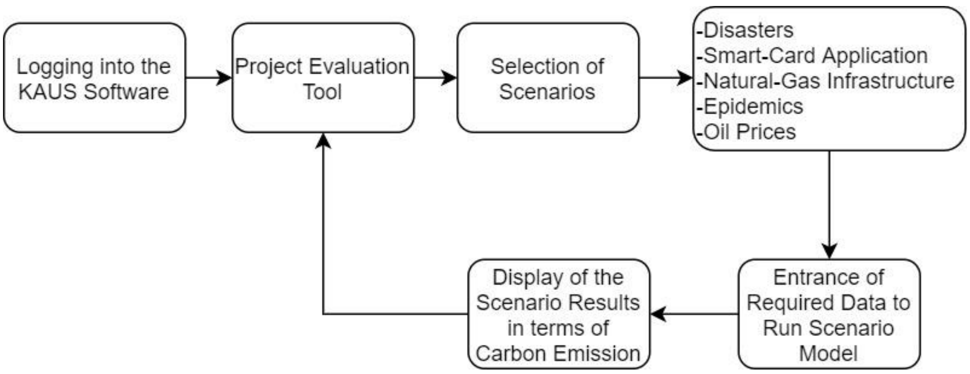

Figure 4.10 Scenario Modeling Process in KAUS Software

Although the system offers support for the creation of future scenarios to users, it has some limitations. First of all, the program does not allow for the comparative analysis of carbon emissions to be made on a single screen for cases where scenarios are included in the project or not. Similarly, the impact of different scenarios on carbon emissions cannot be analyzed comparatively. Therefore, the support provided by the KAUS software is insufficient in the detailed analysis of the effects of the scenarios, which is at least as important as the scenario creation phase in order to be ready for uncertainties and to develop the best responses to them. Moreover, the fact that users have to constantly return to the beginning of the project evaluation process to see the results of different scenarios might require more effort and time. This means an extra workload for the users.

Secondly, there is no scenario modeling tool in the menu of the software. This means that scenario models cannot be created independently of the project evaluation tool. The lack of a scenario modelling tool that works integrated with the carbon emission calculation model, which includes tools such as selecting scenarios, adding new scenarios, editing scenarios or updating the data required for the creation of the scenarios, makes the it difficult to perform these tasks and increase complexity of the software in scenario development and evaluation process. This indicates that scenario modeling capability constitutes one of the difficulties in using the KAUS software.

The other system-related shortcomings of the KAUS software is the visualization of scenario results. While a typical decision support system is expected to allow the result of a model to be displayed in different formats, the results of the scenario models are only displayed as a ratio in the KAUS software. Therefore, it is not capable of displaying results on maps or graphics.

As a result, the support provided by the KAUS software in terms of scenario work flow has certain deficiencies in the stages of creating new scenarios, displaying and analyzing scenario results, which might adversely affect the adoption and use of it by target users

4.3.4.4 Fit to Planning Task

Planning processes vary according to the subject, scale and the steps followed in the decision-making processes. One of the important factors for the adoption of SDSS is the extent to which it supports the user's needs, the decision problem, and the planning tasks. In this context, the problem handled by the user and the system architecture of the SDSS should be compatible with each other. Within the scope of ‘Fit to planning task’ variable, the KAUS software and decision-making processes of institutions were examined from two different perspectives. In this context, compatibility of KUAS software and decision-making process of institutions in terms of planning content and planning style were analyzed. The fact that KAUS software has a flexible system architecture allows the adopters to use this software in different decision-making processes as well as in decision-making processes related to carbon emissions. However, in deciding on the use of SDSS in the first place, it is very important to what extent the software's data set, analysis tools, modeling capabilities and scenario development tools support the problem identified by the intended users in the decision-making processes.

Since the KAUS software has an algorithm that calculates carbon emissions in the transportation, industry, housing, agriculture and waste sectors, it was first examined whether the institutions involved in the study have strategies for reducing carbon emissions in their future planning processes. When both the strategy plans of the metropolitan municipalities and the regional plans are examined, it is seen that sustainable development, environmental protection, use of renewable energy resources and raising awareness on these issues are among the future goals and strategies of the institutions (see Figure 4.11). In addition to the related documents, interviewees also emphasized that they make decisions on environmental planning issues in their institutions (I11, 112). An environmental engineer from Gaziantep Metropolitan Municipality (I10) stated that:

> “We are working on environmental protection, renewable energy sources and carbon emissions in our unit. However, we do not yet use a GIS-based program in decision-making processes. We manually process the electricity and natural gas consumption data into the excel program using the invoice information. This, in turn, prolongs the decision-making processes. If such a system is used, I think it will be very convenient in terms of analyzing changes in carbon emissions and effects of use of renewable energy, tracking necessary data and integrating different data-sets.”

This indicates that the algorithm of KAUS software and the problems identified by the metropolitan municipalities and development agencies in the decision-making processes are compatible in terms of planning content. In addition to this, the institutions aim to carry out this process with a participatory and collaborative approach. Similarly, the interviewees emphasized the increasing need for collaboration between institutions (I5, I7, I8). A city planner from Dicle Development Agency (I6) stated that:

> "As development agencies, it is one of our duties to bring together different stakeholders. In this context, I think that the use of such systems would be beneficial in terms of ensuring a faster and continuous flow of information between the stakeholders involved in the planning processes."

In this respect, the interactive system architecture of KAUS allows both citizens and stakeholders from public and private sectors to be included in the process indicates that the planning style and the KAUS software are compatible in this respect.

As a result, the compatibility of KAUS software with the planning institutions in terms of both planning issues and type indicates that this variable does not constitute an obstacle in terms of adoption of KAUS.

Institution	Basis	Aims and Strategies
Diyarbakır Metropolitan Municipality	2020-2024 Strategic Plan of Diyarbakır Metropolitan Municipality	Increasing the use of renewable energy sources and reducing the effects of climate change Preventing environmental pollution Increasing the level of awareness Dissemination of zero waste projects Development of environmentally friendly smart transportation systems applications
Gaziantep Metropolitan Municipality	2020-2024 Strategic Plan of Gaziantep Metropolitan Municipality	Minimizing the negative effects of waste on the environment and society Raising awareness on environment and sustainability Carrying out studies on the use of renewable energy sources and increasing energy efficiency
Mardin Metropolitan Municipality	2020-2024 Strategic Plan of Mardin Metropolitan Municipality	Increasing the awareness of citizens about healthy and environmentally sensitive life Carrying out studies on alternative energy production and applications Developing activities for sustainable solid waste management
Şanlıurfa Metropolitan Municipality	2020-2024 Strategic Plan of Şanlıurfa Metropolitan Municipality	Making more integrated and effective planning for the zero waste Dissemination of activities oriented to increase environmental awareness. Increasing the amount of recycling of wastes
İpekyolu Development Agency	2013-2024 Regional Plan (TRC1 Region)	Improving Quality of Life and Ensuring Sustainable Rural Development: -Reducing environmental pollution and increasing the use of renewable energy sources -Strengthening waste management -Ensuring sustainable urbanization -Carrying out awareness raising activities on renewable energy and energy efficiency
Karacadağ Development Agency	2013-2024 Regional Plan (TRC2 Region)	Sustainable Development and Green Growth: -Use of renewable energy resources and environmentally friendly technologies -Controlling industrial and agricultural pollutants and protecting the threatened biodiversity by increasing environmental awareness -Ensuring effective management and sustainable use of land and water resources -Ensuring sustainable solid waste management
Dicle Development Agency	2013-2024 Regional Plan (TRC3 Region)	Sustainable Environment and Spatial Settlement: -Conservation and development of natural areas and ecological resources -Ensuring efficient wastewater management -Ensuring clean and continuous energy supply -Dissemination of energy efficiency practices

Figure 4.11 Content of the Environmental Planning Issues

CHAPTER 5

CONCLUSION

This research aimed to investigate the main obstacles to the adoption and use of (SDSS) in decision-making process by metropolitan municipalities and development agencies in the GAP Region within the scope of the case of the KAUS Project. In line with the purpose of the research, the general framework of SDSS was drawn, the internal and external changes in spatial decision-making processes were identified, and previous studies on the use of geo-information tools such as GIS, SDSS and PSS were examined. Based on these, the conceptual framework of the research was formed. Accordingly, the KAUS Project was examined in detail and in-depth interviews with the personnel of metropolitan municipalities and development agencies in the GAP Region was analyzed.

The following part of this chapter critically discusses the findings of the research and offers suggestions for improving adoption and use of SDSS.

5.1 Discussion of the Findings

Since the 1950s, changes in the planning approaches have led to the redefinition of the role of information technologies in this field. Today, planning is defined as a process in which many stakeholders interact with each other, rather than being a process carried out only by professionals. One way to manage this participatory process is the use of SDSS in decision-making. SDSS contributes to the establishment of communication channels and cooperation by making the decision-making process more open to the contributions of different stakeholders who has different concerns, interests and requirements (Ayeni, 1997, p. 3; Geertman et al., 2009, p. 9). From this point of view, it can be said that the use of SDSS enables identifying participants, sharing information and providing the basis for the establishment of consensus between stakeholders.

The interdisciplinary and multi-actor structure of the urban and regional planning, the development in information technologies, the increase in interdependencies on a global and local scale causes increasing uncertainties. The fact that the spatial planning is inherently open to short-term rapid changes and external shocks increases the importance of being prepared for such uncertainties and giving the best response to them (Abbott, 2005, p. 237). In this context, it necessitates the transition to more innovative methods that will allow the preparation of future scenarios and the evaluation of their impacts in decision-making processes. Considering the components and flexible system architecture of SDSS, it provides the opportunity to redefine problems, update parameters and build scenarios with respect to changing conditions. In this context, it can be said that SDSS reduces the vulnerability of the planning process to external shocks by providing an opportunity to consider uncertainties, foresee their effects and take measures against them.

Another factor increasing the need for the use of SDSS is the rise of big data. With the recent advancements in ICT, data collection methods and channels have diversified, which have led to increase in volume and amount of data (Schintler et al., 2019). This indicates that the data is getting more complex. Due to increasing complexity, the data management has become one of the challenges in the planning process of cities and regions, which are the most important sources of big data. In this context, SDSS as an innovative tool led decision-makers to collect, store, integrate and analyze data in a data-base system.

Spatial planning problems are generally semi-structured or ill-structured problems that do not have a single solution and requires consideration of a set of alternatives. In his theory of Bounded Rationality, Herbert Simon stated that human mind has cognitive deficiencies, limited skills and limited time to list all relevant alternatives and calculate their impacts. (Forester, 1984, p. 24; Simon, 1997, p.17). The limitations of human mind have increased the need for the use of SDSS (Suguraman et al., 2010, p. 11). SDSS improves the efficiency of decision-making process by enabling different planning tasks to be executed and completed faster (Brömmelstroet, 2013, p. 302). In this context, it can be said that SDSS contributes to the elimination of errors and deficiencies arising from human cognitive limitations by enabling creation of models, future-oriented scenarios, visualization and comparison of their impacts rapidly. Moreover, SDSS enables the information to be used more effectively and efficiently, contributing to the resulting plan or decision being 'better informed' (Klosterman, 2009, p. 2; Pelzer et al, 2014, p. 18). In this respect, the fact that SDSS provides easier access to data, enables interpretation of data, is open to active participation of stakeholders, and allows data to be processed with various modeling techniques contributes to making decisions and developing plans by using the information in a better way.

Despite these benefits of SDSS, their practical use in both operational and strategic decision-making processes in urban and regional planning is quite limited. (Vonk et al., 2005, p. 909). Many studies have been conducted to understand why SDSS has not been widely adopted and used, and these studies have shown that there are some individual, organizational and technical factors in the lack of adoption of these systems (Vonk et al., 2005; Russo et al, 2018; Schindler et al, 2020). In this study, the barriers to the adoption of KAUS software, which functions as a carbon emission calculator, in the GAP Region were examined in terms of data-related, organizational and technical factors.

The core component of a traditional SDSS is the data base management. Incompleteness or incorrectness of inputs of this component prevent the SDSS from working with full performance. The fact that the KAUS software is multi-dimensional and multi-actor due to the variety of sectors it includes requires the collection of a wide variety of data from different sources. Although the diversification of data collection tools with technological developments is seen as an advantage in terms of data availability and accessibility, on the other hand, the diversity of data formats and sources, increases data uncertainty for SDSS. It has been determined that such problems are also encountered in the metropolitan municipalities and development agencies in the GAP region. Interviewees stated that they have difficulties in integrating data from different sources, finding up-to-date data and data sharing between institutions. At this point, the lack of a common database where the data is stored, organized, digitized and processed is seen as one of the most important deficiencies in terms of data access and data transfer between institutions.

Limitations in data quality and quantity indicates that the decision-making process is maintained with incomplete and imperfect information in these institutions. This means that the decision-making processes are not fully data-driven. For this reason, decision makers are more inclined to make intuitive decisions in planning processes due to the lack of data especially in semi-structured or unstructured decision problems that do not have a single or correct answer under uncertain and constantly changing conditions. In other words, decision making is not a fully rational process, but it is bounded-rational.

The problems that planning deals with, especially environmental planning problems, have a complex structure as they are usually multi-parameter, dynamic and vulnerable to external changes. Decision-making processes for these complex problems require continuous updating of primary data, strategies, parameters and future scenarios under rapidly changing conditions. In order to carry out such operations and meet the requirements of the SDSS the actors involved in the decision-making processes, from the data analyst and the expert to the end user, must be experienced and skilled at a certain level. One of the most common problems mentioned in the interviews is the difficulty in finding trained and experienced personnel in GIS and GIS-based systems in the GAP Region. In metropolitan municipalities, data entrance, processing, integration and modelling in GIS or Urban Information Systems is mostly carried out by surveying engineers or technicians who are GIS specialists working in department of information technologies. The number of personnel who know how to use GIS among those working in the other planning departments are quite limited. From this point of view, the insufficient number of qualified personnel who can use the SDSS, make the necessary improvements in the system architecture and updates in the model base, data base and user-interface components constitute an obstacle for the adoption and effective use of the KAUS software in the region.

Another prominent obstacle to the adoption of SDSS by these institutions is the lack of awareness. As a result of the interviews, it is seen that there is a lack of knowledge about the benefits that such systems provide to users in planning tasks at different stages of decision-making process, and even the existence of such systems in the GAP Region. The fact that interviewees describe the benefits of such systems over GIS software indicates that there is a certain level of individual awareness about the GIS, but the knowledge on the concept of SDSS is quite lacking by individuals and managers. The lack of awareness also triggers other obstacles related to institutional factors such as lack of training support and skilled staff.

In order for SDSS to be an integral part of organizations involved in spatial decision-making processes, there is a need to provide educational support at various levels. Under uncertainty conditions, it is necessary to regularly train the personnel both to make the necessary updates of the SDSS system, to learn the GIS that work integrated with SDSS and to follow the software updates. In the GAP Region, there is a huge gap in terms availability of trained personnel because the attempts to use GIS throughout the region is quite recent and the awareness on benefits of SDSS is lacking. From this point of view, the problem that stands out in terms of educational support is not an unmet demand, but the lack of sufficient demand because such training is not perceived as a priority need.

When the strategic plans of the metropolitan municipalities and the regional plans of the development agencies are examined, it is seen that there are strategies on reducing environmental pollution, using clean energy sources and increasing environmental awareness in the GAP Region. In this context, the KAUS software as a carbon emission calculator matches the problems identified by policy makers, content of planning. It can be said that this will provide an important advantage for

KAUS in terms of attracting attention by early adopters in the first place. If the KAUS system is adopted and used, it has potential to improve existing policy practices and provide support by enabling continuous monitoring and evaluation of the actions and projects aimed at achieving these strategies, and encourage the continuous learning process.

Multi-dimensional structure of planning processes requires the inclusion of stakeholders from different interest groups in the decision-making processes. While participatory structure of planning requires the use of a SDSS, it also brings difficulties in its implementation. This problem is also encountered in the GAP Region. Interviews have shown that the networking and cooperation between the stakeholders in the planning processes are not very strong. The reason for this is that the planning approach does not encourage a collaborative environment, rather than the region-specific features. Therefore, decision-making processes are shaped according to different sectors, scales and functional roles in general. In order for the KAUS system to operate with full performance, the integration of all stakeholders from each defined sector is necessary both in the data collection phase and in model-base processing where the inter-sectoral relations are examined. This necessitates a more complex relationship than the relationships these institutions currently face. Considering the lack of such a cooperative and communicative environment in the institutions, it is thought that this situation will constitute an obstacle in terms of adoption of the software.

In addition to data-related and institutional factors, technical factors are also influential in the adoption of SDSS. In this context, the vulnerabilities of the KAUS software is considered. One of the shortcomings of the KAUS software in terms of the policy and planning support is the transfer of the data processed in the background of the software to the Atlas screen. One of the important points emphasized by the interviewees is the advantages of GIS-based systems in visualizing data and performing spatial analysis. These features of GIS encourage decision makers to use it. However, in the KAUS software, the data entered in the transportation, housing, agriculture, waste and industry sectors are displayed only through excel, revealing the incapability of KAUS in supporting data spatialization and spatial data analysis tasks in decision making process. This situation, which requires spatial analyzes to be done in a separate GIS-based software and transferred to KAUS, may be perceived negatively by the targeted users as it will create additional workloads.

The increasing uncertainties and rapid changes in social, economic and physical environment necessitates the adoption of scenario-based planning to be prepared for the uncertainties. The most important feature that distinguishes SDSS from GIS is that it improves decision-making processes by providing users with the opportunity to make alternative development scenarios under such conditions. One of the vulnerabilities of the KAUS software stands out at this point. The absence of a scenario creation tool in the menu and the inability to compare the impacts of the scenarios with each other on a single screen show that there is lack of support in this respect. This may create a disadvantage for the software to attract attention and be adopted in the first place.

Interviews conducted with the employees of the institutions in the GAP Region has shown that GIS systems have recently begun to be used in these institutions. This shows that technological developments are followed relatively behind. It has been concluded that there is a tendency to make intuitive decisions instead of a data-driven scenario-based planning approach that considers the uncertainties about the future in decision-making processes, due to the problems experienced in data quality and availability and the lack of integration of information technologies in planning processes. The KAUS software, on the other hand, is a more complex system that requires monitoring and evaluation throughout the decision-making process with the creation of feedback loops. At this point, the complex system architecture of KAUS software constitute an obstacle for the adoption of these systems.

To sum up, this study, similar to previous studies, revealed that there are data-related, institutional and technical barriers to the adoption and use of SDSS in the GAP Region. However, the recent attempts to improve GIS infrastructure and the positive attitude of target users towards the use of SDSS are considered facilitator factors in terms of adoption of such systems in the region.

5.2 Recommendations for Improving the Adoption of KAUS Software

In order for the KAUS system to be adopted by the metropolitan municipalities and development agencies in the GAP region, the problems related to the institutional infrastructure identified through the in-depth interviews should be eliminated and the support role of the KAUS software for different planning tasks should be improved. In this context, suggestions developed for institutional, technical and data related obstacles are as follows:

- ***Awareness Raising****:* The first step to be taken for the adoption of SDSS in these institutions is to increase the awareness of both the personnel working in different departments and the managers about what the concept of SDSS is, its applications and the benefits of SDSS to the users in the decision-making processes. In this context, especially in metropolitan municipalities, personnel working in GIS, Urban Information Systems and Smart Cities R&D and Innovation departments and experienced in GIS-based software can take an active role and increase awareness by informing other personnel about SDSS through active and appropriate communication channels. They can transfer the information they have acquired to other employees in the institution by undertaking tasks such as following the relevant activities of other institutions, following SDSS practices from the world, visiting PSS-related websites regularly, and attending practical national and international conferences.
- ***Improving Intra-institutional and Inter-Institutional Networking****:* Establishing a communication environment where institutions with a more advanced infrastructure in GIS can share their experiences, applications, projects and the benefits they derive from applications through various communication channels such as digital platforms, user group meetings, and

workshops is important for the adoption of decision support systems. In addition, it is important to maintain an active exchange of information within the organization, especially with planners and GIS experts. In addition, improving open communication channels between KAUS software developers and decision makers are important both for software developers to demonstrate the benefits, capabilities and support for policy implementations, and for understanding further needs of decision makers.

- ***Increasing Support for Training Activities****:* The results of the interviews showed that the staff generally had a positive attitude towards participating in training programs. From this point of view, it is very important to organize interactive training programs that involve all stakeholders in the decision-making process for the use of GIS and SDSS. Repeating these trainings periodically and giving certificates to the participants at the end of the trainings can be a good strategy in terms of encouraging participation. It is clear that such trainings will contribute to increasing the capacity of qualified personnel in SDSS throughout the region.
- ***Improving Instrumental Quality of KAUS Software****:* Scenario planning techniques are very important in terms of foreseeing the consequences of uncertain situations by creating multiple futures, being prepared for uncertainties, and encouraging strategic thinking. The support role of SDSS is highly crucial to better informed decision-making under uncertain conditions. In this context, the support provided by the KAUS software should be improved. A scenario tool can be added to the menu, where the results of different scenarios for carbon emissions can be viewed on single screen rather than displaying them on different screens. In this way, users will have the opportunity to compare the results of alternative scenarios and evaluate their impacts on carbon emissions more easily. In addition, data visualization capability can be increased by creating separate layers on the Atlas screen for the spatial data processed in in the background of the

program for the building, agriculture, industry, transportation and waste sectors.

In order for the KAUS carbon emission algorithm to work with full performance, data must be collected from a large number of stakeholders from different sectors. This indicates the complex structure of the system. In order to be able to manage data-related processes in a more integrated manner on a platform with so many stakeholders, it is essential to establish a control mechanism. In this context, a new user type should be defined as a 'data inspector' who monitors data flow processes detects missing or incorrect data, and data updates.

5.3 Limitations of the Study and Implications for Further Research

In this research, obstacles to the adoption of SDSS by planning institutions was analyzed in terms of data-related, organizational and technical factors. These factors were investigated in the GAP Region within the scope of the case of KAUS. However, due to the precautions and restrictions taken within the scope of the Covid-19 global pandemic, relatively small sample of interviews were conducted that is why generalization of findings were quite limited. Another limitation of this study is that all the system-related variables that may affect the adoption of the KAUS software in terms of its usability were not included in this study since KAUS is not in use yet.

In order to further develop this research, the use of KAUS software in planning institutions can be initiated and after a certain period of use, the system-related adoption factors of KAUS can be examined in more detail through the data obtained from the experiences of the users. In this further study, usability variables such as ease of use, learnability, complexity and transparency can be included in the system-related factors affecting the adoption of SDSS by users. This might allow for a more detailed investigation of the characteristics of the KAUS software from the perspective of user experience and developing better understanding of the impacts of system-related factors on the adoption of SDSS by planning institutions.

Since the KAUS software is designed as a flexible software, it offers the opportunity to be used in other regions, provinces and districts outside the GAP Region by making relevant updates and changes in the data and parameters defined in the system. In this context, in order to further develop this research a cross-case study can be conducted by comparing the planning institutions in the GAP Region and another region with different characteristics. In this research, the variables affecting the adoption of SDSS in planning institutions can be examined with comparative analyzes by focusing on the data-related, institutional and technical factors. It might contribute to a better understanding of the similarities and differences in the variables affecting the adoption of SDSS depending on the differentiation in the institutional and technical infrastructure.

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APPENDICES

A. Interview Questions

Questions About the Institutional Factors Affecting the Use of Spatial Decision Support Systems (SDSS)

1. Which computer-based programs do you use in spatial planning processes in your department? (Autocad, Netcad, ArcGIS etc.)

2. Have you ever used Geographic Information Systems (GIS) based spatial decision support systems (SDSS) in spatial planning process before? How would you evaluate your level of knowledge about these systems?

3. Do you currently use any SDSS in your department? If so, at what stages of planning process do you use it? (Current situation analysis, scenario creation, monitoring and evaluation etc.)

4. Do you think that such systems need to be used in your department?

5. Do you think that there is sufficient number of qualified and experienced staff about SDSS? What is your assessment for this?

6. Does your institution provide training for these systems? Have you ever attended or would like to attend such a training? How would you evaluate the importance of such training in using these systems in planning processes?

7. How would you evaluate the level of awareness regarding the advantages of using SDSS in all planning processes in your institution and the approach to using these systems?

8. How would you evaluate the communication and cooperation in spatial planning processes with other departments within your institution and with other planning institutions (other municipalities and development agencies in the region)?

9. In your opinion, are SDSS used in the field of planning adequately and effectively? If not, what are the reasons for this and what can be done to use it more effectively?

Questions About the Technical Factors Affecting the Use of Spatial Decision Support Systems (SDSS)

1. Are there any problems in terms of technical equipment (software, hardware) for the use of spatial decision support systems in your institution?

2. What are the most common problems you encounter in data collection, analysis and processing? How would you evaluate these problems in terms of the use of SDSS?

B. Mülakat Soruları

Mekânsal Karar Destek Sistemlerinin Kullanımını Etkileyen Kurumsal Faktörlere Yönelik Sorular

1. Biriminizde planlama süreçlerinde hangi bilgisayar tabanlı programları kullanıyorsunuz? (Autocad, Netcad, ArcGIS vs.)

2. Daha önce planlama çalışmalarınızda Coğrafi Bilgi Sistemleri (CBS) tabanlı mekânsal karar destek sistemlerini kullandınız mı? Bu sistemlerle ilgili bilginiz ne düzeydedir?

3. Biriminizde mevcut durumda aktif olarak mekânsal karar destek sistemi kullanıyor musunuz? Eğer kullanıyorsanız planlamanın hangi aşamalarında kullanıyorsunuz?

4. Biriminizde bu tür sistemlerin kullanımına ihtiyaç olduğunu düşünüyor musunuz?

5. Biriminizde mekânsal karar destek sistemleri hakkında yeterli sayıda bilgi sahibi ve deneyimli personelin olduğunu düşünüyor musunuz?

6. Kurumunuzda bu sistemleri kullanmaya yönelik eğitimler verildi mi/veriliyor mu? Siz daha önce böyle bir eğitime katıldınız mı veya katılmak ister misiniz? Planlama süreçlerinde bu sistemlerin kullanılmasında bu tür eğitimlerin önemini değerlendirir misiniz?

7. Kurumunuzda mekânsal karar destek sistemlerinin, planlamanın tüm süreçlerinde kullanılmasının sağlayacağı avantajlara yönelik farkındalık düzeyini ve bu sistemlerin kullanılmasına yönelik yaklaşımı değerlendirir misiniz?

8. Kurumunuz içerisindeki diğer birimlerle ve diğer planlama kurumları (bölgedeki diğer belediyeler ve kalkınma ajansları) ile mekânsal planlama süreçlerindeki iletişim ve iş birliğini nasıl değerlendirirsiniz?

9. Size göre mekânsal karar destek sistemleri planlama alanında yeterli ve etkin bir şekilde kullanılıyor mu? Kullanılmıyor ise bunun nedenleri sizce nelerdir ve daha etkin kullanılması için neler yapılabilir?

Mekânsal Karar Destek Sistemlerinin Kullanımını Etkileyen Teknik Faktörlere Yönelik Sorular

1. Kurumunuzda mekânsal karar destek sistemlerinin kullanımına yönelik teknik ekipman (yazılım, donanım) açısından sorun yaşanıyor mu?

2. Veri toplama, analiz ve işleme süreçlerinde en sık karşılaştığınız sorunlar nelerdir? Bu sorunları mekânsal karar destek sistemlerinin kullanılması açısından nasıl değerlendirirsiniz?

C. Informant List

Informant Number	Occupation	Institution
I1	City Planner	Mardin Metropolitan Municipality
I2	City Planner	Mardin Metropolitan Municipality
I3	City Planner	Mardin Metropolitan Municipality
I4	GIS Specialist	Gaziantep Metropolitan Municipality
I5	City Planner	Gaziantep Metropolitan Municipality
I6	City Planner	Dicle Development Agency (DİKA)
I7	City Planner	Karacadağ Development Agency
I8	City Planner	İpekyolu Development Agency
I9	City Planner	İpekyolu Development Agency
I10	Environmental Engineer	Gaziantep Metropolitan Municipality
I11	City Planner	Şanlıurfa Metropolitan Municipality
I12	City Planner	Diyarbakır Metropolitan Municipality
I13	GIS Specialist	Şanlıurfa Metropolitan Municipality
I14	City Planner	Şanlıurfa Metropolitan Municipality
I15	City Planner	Şanlıurfa Metropolitan Municipality
I16	City Planner	Diyarbakır Metropolitan Municipality
I17	City Planner	Diyarbakır Metropolitan Municipality
ı18	City Planner	Gaziantep Metropolitan Municipality
I19	City Planner	Gaziantep Metropolitan Municipality
I20	The Researcher	The KAUS Project