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## Decision-making support system for travel planning for people with disabilities based on fuzzy set theory

**JEL Classification:** I14; I18; J18; C24

**Keywords:** *expert systems; fuzzy modeling; people with disabilities; accessibility of regional tourism; social tourism*

### Abstract

**Research background:** In recent years, there has been increasing attention to the needs of tourists with disabilities. Several international studies confirm that this target group has been marginalized in tourism due to physical, economic, social, and environmental barriers. However, the integration of intelligent decision-support systems can significantly enhance accessibility and inclusion in tourism.

**Purpose of the article:** This research aims to develop effective methods and algorithms for constructing intelligent systems and software that generate precise and high-quality travel

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plans for tourists with disabilities. The primary objective is to create a decision support system for trip planning, using the example of Visegrad Group countries (the Czech Republic, Hungary, Poland, Slovakia).

**Methods:** The decision support system is structured around two core components: the data level and the knowledge level. The data layer compiles a structured database of actual visits by disabled tourists. The knowledge layer consists of mathematical models forming a comprehensive decision-making framework. The formalization of the system employs fuzzy set theory, fuzzy logic, expert evaluation, and intelligent knowledge analysis. This research introduces: an information model for assessing the accessibility of destinations; fuzzy method of determining the degree of accessibility of destination, considering the level of limited capabilities of the participant of the tourist movement; decision-making method when travel planning on the accessibility of the region on goal needs.

**Findings & value added:** The decision-making support system was verified and tested on real data from 41 participants in the Visegrad Group countries. A distinctive feature of this research is the development of a dynamic, adaptive decision-support mechanism that evolves with real-world user data. Unlike standard accessibility evaluation approaches, this system provides personalized travel recommendations and continuously refines its ranking model based on user experiences. This ensures a long-term impact on smart tourism, sustainable travel planning, and enhanced accessibility for people with disabilities.

## Introduction

In the recent years, there has been an increasing attention paid to the requirements of the tourists with disabilities (PwD). These individuals have the same needs and desires in the field of tourism as the other people and despite the existence of the United Nations Convention on Rights of Persons with Disabilities, the concerns about the rights of this population group are increasing. Several international studies confirm that this target group has not been preferred in tourism for a long time due to the existence of physical, economic, social, environmental, and the other obstacles, which affect not only tourists, but also the local destinations (Gillovic & McIntosh, 2015; Michopoulou *et al.*, 2015; Nyanjom *et al.*, 2018). According to the World Health Organization (WHO), it affects the disability of hundreds of millions of families around the world per year and currently, approximately a 10-percent share of the global population lives with disabilities in the European Union that is approximately 80 million inhabitants with some kind of disability. According to the World Bank data, approximately a 15-percent share of the world population has at least one disability (WHO, 2017). In a relation with the processes of the demographic ageing, there is a strong prerequisite for increasing the ageing rate of this population group. Given that the percentage of people with disabilities is sig-

nificantly higher in older age groups, it is important to consider the impact of demographic aging on accessible tourism. This aspect is particularly relevant within the framework of the silver economy, where tourism for people with disabilities can play a crucial role in social inclusion and economic sustainability.

From the social perspective, increasing accessibility in tourism can significantly improve the quality of life for individuals with disabilities, enabling them to engage more fully in society. From an economic standpoint, developing accessible tourism can drive new markets, enhance destination competitiveness, and contribute to broader national economic growth. Given the aging population and the growing demand for accessible tourism, this sector represents a critical opportunity for both social progress and economic development.

Several research studies point to the fact that the tourism industry ignores the needs of inhabitants with disabilities that leads to open or moderate discrimination (McKercher *et al.*, 2003). Tourism marginalization can be discouraged by PwD from the purchase of its products (Horner & Swarbrooke, 2004; Loi *et al.*, 2017), while the reluctance also plays an important role to explore the experience of a disabled tourist (Karadimitriou *et al.*, 2021; Rubio-Escuderos *et al.*, 2024; Gillovic *et al.*, 2021). Accessible tourism requires that everyone with the same benefits independently of economic, social, as well as physical conditions (Darcy *et al.*, 2020; Agovino *et al.*, 2017) has the opportunity to have access to it.

By now, few research studies have analyzed the relationship between tourism and PwDs, and those, which exist, were primarily focused on exploring the availability of tourism, transport processes, hotel accommodation, attractions and institutional/information support (Gillovic *et al.*, 2021; Cassia *et al.*, 2020; Singh *et al.*, 2021; Awan *et al.*, 2022). With the development of informatization, the accessibility of the information, which tourists with disabilities need, has increased. Despite the expansion of the PwDs services, the problem of disability is solved without considering various forms of disability. PwDs have different types and degrees of disability, so their access and use of tourism facilities will differ significantly not only depending on the type of disability, but also in a way of provision of the services and measures for PwDs (Ferrer *et al.*, 2016; Gabruč & Medarić, 2022). A major issue is not only misinformation, but also insufficient information on the supply side, according to which potential demand is created. Hence, the correct dissemination of information on the available destina-

tions has become a key factor in increasing the possibilities and availability of tourism for PwDs. According to some research studies, PWD motivation is increasing, and it depends how available services are adapted to the particular disability. The decision-making process of the various PwDs groups is very different from the decision-making process of tourists without disabilities that is influenced by many factors. Each disability requires special attention and the various services (Moura *et al.*, 2023). This fact is considered sufficiently when defining the tourism offer that may possess a negative impact on the outcome of the decision-making process related to the dissatisfaction of the tourists with disabilities and many restrictions during the destination (Nicolaisen *et al.*, 2012; Kong & Loi, 2017).

Despite the growing interest in accessible tourism and a significant amount of research focused on the analysis of physical and informational barriers for people with disabilities (Card *et al.*, 2006; Kastenholz *et al.*, 2015), current approaches to developing decision support systems in this area have several limitations. In particular, previous research has mostly focused on the analysis of the accessibility of individual objects or regions, without taking into account the individual needs of different groups of people with disabilities (Alkahtani *et al.*, 2015; Chikuta *et al.*, 2019). In addition, existing information systems (ICS) to support tourism choices often rely on rigidly deterministic algorithms that do not adapt to the personal needs of users, which can lead to inefficient route planning and tourist dissatisfaction (Chou *et al.*, 2008; Forouzandeh *et al.*, 2021).

Unlike traditional models that focus on physical accessibility or use rigid algorithms, our approach personalizes recommendations based on disability type, severity, and travel goals. By incorporating fuzzy logic, our system adapts to the diverse needs of people with disabilities, ensuring more accurate and individualized travel planning. The proposed approach allows for dynamically adapting recommendations according to the level of tourist limitations and their personal travel goals. This contribution not only provides higher accuracy and personalization of route planning, but also forms the basis for future research aimed at expanding adaptive intelligent systems in the field of accessible tourism.

Today, information and communication systems (ICS) are widely used in the travel and tourism industry. Since the introduction of such systems, they have helped make decisions based on simple data operations. With the development of ICS, decisions are made based on the use of intelligent systems and intellectual analysis of knowledge, which help tourists plan

their trips and take such a process to a completely new level. Planning a trip involves a complex process that includes many aspects. Our research is aimed at choosing a region to be visited by participants of the tourist movement with disabilities. Such a trip-planning task is computationally expensive. Therefore, the development of effective methods and algorithms is the basis for the construction of intelligent systems and ICS software that derive real and high-quality travel plans for participants in the tourist movement.

Our research is aimed at helping people with disabilities make an informed decision when planning a trip, taking into account: the experience and knowledge of participants of the tourist movement with disabilities who have already visited the destination; type of disability or mobility restriction; a vector of goals of a potential tourist, in which the evaluation of coordinates for accessibility goals could satisfy a potential tourist, when planning a trip.

This fact was a motivation for our study, whose main purpose is to develop a decision-making support system when planning travel for people with disabilities on the example of the countries of the Visegrad Group (the Czech Republic, Hungary, Poland, Slovakia).

The major contributions of this study are summarized as follows:

- we are developing an information model of assessing the level of accessibility of destination. At the same time, we formalize the collection of information regarding the indicator of the type of disability or mobility limitation.
- we develop a fuzzy method of determining the degree of accessibility of destination, considering the level of limited capabilities of the participant of the tourist movement.
- we are developing a decision-making method when travel planning on the accessibility of the region on goal needs. This method will transition from destination availability to region availability.
- we verify and test the developed decision support system on real data in the countries of the Visegrad Group.

Consequently, the essence of the decision-making support system when planning a trip for people with disabilities is that it derives a general comprehensive assessment of the region, based on the statements of experts on the issue of accessibility at the destination, the type of disability, the goal needs of the potential tourist, according to which the ranking of accessibility takes place regions.

The conducted research has the following structure. Part 2 provides a literature review of the research issues. Part 3 describes a formal formulation of the problem and a decision support system for travel planning for people with disabilities, which consists of two components: the data layer and the knowledge layer. In part 4, the decision support system is verified and tested, and an example of evaluation on real data is given. The results of the conducted research are discussed in part 5. The obtained new results and ideas for the future development of regional tourism of people with disabilities are described in part 6.

### **Literature review**

Social tourism and tourism for PWD are a very important tourism segment (Agovino *et al.*, 2017), while this demand is constantly growing (Portales, 2015; Farkas *et al.*, 2022). Several experts declare that tourism for PwDs can bring several economic benefits and hence, it can return on investment. At the same time, it can eliminate the negative impacts of seasonality (Aln *et al.*, 2012). Many PwDs travel with an accompanying person that increases the potential space of barrier-free tourism and thus, it brings additional income (Ribeiro *et al.*, 2018; Chikuta *et al.*, 2019).

The authors, who have been investigating the development of social tourism for long time, point to the fact that the development of tourism for PwDs has strong restrictions still. Constraints on the tourism demand side represent a direct consequence of the bid restrictions (Lyu, 2017; Domínguez *et al.*, 2013). The research studies are dominated by observing the relations between PwDs and tourism from the demand side, while many restrictions and barriers which PwDs face can be socially constructed. Therefore, the correct dissemination of information on the available destinations, has become a key factor in increasing the possibilities and availability of tourism for PwDs (Zenko & Sardi, 2014; Kastenholz *et al.*, 2015).

An improvement of the offer in tourism for PwDs means the gradual removal of the environmental, information, and personnel barriers on the provider side that requires the considerable costs on the side of the tourism service providers. Few studies were aimed at examining the perception of managers for the provision of the service for PwDs and it is clear from the available outcomes that these managers perceive the difficulty of providing

the high-quality service for the given people and understanding their individual needs (Darcy & Pegg, 2011; Poria *et al.*, 2011).

Several authors examine the PwDs satisfaction with tourism and these results point to the fact that PwDs achieves the higher levels of the life satisfaction than people without disability. Tutuncu (2017) examined the satisfaction of PWD with existing infrastructure, tourist products and services, and the potential for improving barrier-free tourism in the selected destination. Their outcomes demonstrate that transport, accommodation, entertainment, and infrastructure do not provide PWD with a complete barrier-free approach that can significantly affect the PwDs decision-making processes in the future. Similarly, the other studies declare these negative findings (Nicolaisen *et al.*, 2012; Farkas *et al.*, 2022; Zenko & Sardi, 2014). According to Tutuncu (2017), the most disadvantaged group in the hotels were people with the physical disabilities and wheelchair users. The insufficient and inaccessible areas possess a negative impact on the PWD satisfaction related to the given stay and thus, they can significantly affect their loyalty to the destination or to the accommodation facility.

#### *Determinants of the barrier-free tourism development*

The numerous empirical studies declare the positive impact of tourism on well-being and life quality. These effects are felt by PwDs particularly (Pearce, 2011; Lehto *et al.*, 2018). Improving the availability of tourism for these people can lead to the support of the social capital construction (Mithen *et al.*, 2015). Tourism is an important sector for the economic growth of the countries and social tourism has become increasingly desirable.

Many authors criticise the lack of the available and inclusive leisure services and the resulting low level of the PwDs participation in them (Stumbo *et al.*, 2011; Kastenholz *et al.*, 2015).

The importance of tourist experience for the PwDs decision-making processes is reported by several authors (Rubio-Escuderos *et al.*, 2024; Gillovic *et al.*, 2021; Chikuta *et al.*, 2019). The studies confirm that PWD browse through many stages until they become active tourists, while tourism can be considered a comprehensive process for them from planning, coordinating, road management, self-management, and so on (Schrijver *et al.*, 2022). The PwDs decision-making process is influenced by several factors, such as, for instance, the limited range of negotiations, the need for an

assistant like carer, knowledge of the target language, availability of state aid (Karadimitriou *et al.*, 2021; Rubio-Escuderos *et al.*, 2024; Ferrer *et al.*, 2016).

Many research studies examine the special PWD barriers in tourism through an application of the various differentiation aspects. Kastenholz *et al.* (2015) examine the physical, internal, cultural, and social barriers that confront the benefits for PWD. Some authors have focused on the specific types of the affections of tourists and thus, drawing an attention to the different needs as well as the experience of tourism. Such experience for tourists with mental disabilities Gillovic *et al.* (2021), neurological disorders (McIntosh, 2020), or with visual impairment (Qiao *et al.*, 2022) extend and develop inclusive understanding of tourism experience for PwDs.

Some authors declare that disability creates other tourism barriers for PwDs and for some PwDs groups physical accessibility represents only a part of the barrier related to tourism for them (Kastenholz *et al.*, 2015; Card *et al.*, 2006). This points to the fact that the health limitations also relate to each other and the work restrictions that are also related to the financial limitations on the tourism use. The gender differences can also represent a significant determinant in the deciding process about participation in the tourism activities (Xie *et al.*, 2008; Sweet & Kanaroglou, 2016). Nevertheless, as stated by Alkahtani *et al.* (2015), the gender differences are associated with the different interests, the activities related to leisure time, the occupations, and so forth.

#### *Fuzzy approaches application in decision-making processes in tourism*

In the last decade, fuzzy methods have been increasingly used to develop optimal decision-making systems and mechanisms. These methods have also placed pressure on data collection processes and the quality of databases. In tourism, we see a strong engagement of these methods to increase the availability and competitiveness of tourism, safety, attractiveness of destinations, and so on (Tsaur & Wang, 2007; de Paula *et al.*, 2021; Andria *et al.*, 2020). Gradually, their role is also inclining in the benchmarking processes (Ruiz-Meza *et al.*, 2022; Ulkhaq *et al.*, 2019; Chou *et al.*, 2008).

The multicriterial methods are considered by many authors to be an important tool for the decision-making processes that are based the on-tourist satisfaction ratings. Yu *et al.* (2018) draw an attention to the importance of the online reviews on the tourist website for the decision-

making of tourists. According to the authors, the online reviews represent an important research problem. Law (2007) proposed the fuzzy decisions model for the website evaluation. The authors pay an attention to the subjective consumer perception of the quality of the website and hence, they propose the process of an evaluation of the relative performance of the website and increasing the competitiveness of the destinations.

Fuzzy techniques are recommended as a suitable tool for tourists in choosing a destination (Popovic *et al.*, 2019). They are also useful in selecting optimal accommodation, where price, distance from the center, safety, location, and reservation conditions are important criteria. Mahdi and Esztergár-Kiss (2021) applied the combining fuzzy-AHP and GIS methods to select the optimal accommodation facility and confirm that improving the accommodation conditions can increase the attractiveness of the destination as well as its competitiveness. Forouzandeh *et al.* (2021) propose a new approach related to the tourism recommendations that is based on the combination of the Artificial Bee Colony (ABC) algorithm and the fuzzy model TOPSIS. The outcomes of the study confirmed the high accuracy of the proposed method for the tourist decision-making processes.

The multicriterial methods are also employed by the authors to reveal the factors affecting the development of tourism through an exploration of the potential for the new forms of tourism, while the geographical and environmental aspects appear in the forefront (Yang & Kong, 2022; Ivanov, 2021; Puška *et al.*, 2022). Nilashi *et al.* (2019) applied the fuzzy approaches to the medical tourism decision-making processes. They applied the multicriteria decision-making techniques, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Fuzzy Order of Preference by Similarity to Ideal Solution (Fuzzy TOPSIS). The outcomes show the most important factors for the medical tourism adoption human and technological factors. Liao *et al.* (2022) confirmed that the analytical hierarchical process (AHP) and the TOPSIS methods are the most widely applied MCDM methods to evaluate tourism, selection of hotels, evaluation of the attractiveness of destinations through an evaluation of the bibliometric analysis and the methodologies. Similarly, Ziyadin *et al.* (2019) applied the fuzzy techniques to create a model of sustainable tourism and strategic management through an application of the fuzzy algebra mathematical apparatus. The model considers the environmental and social indicators. Andria *et al.* (2021) employed the FMCDM method for the tourism sustainability evaluation processes. The authors compared the results of FMCDM with im-

proved DEA, while DEA showed the better characteristics than a comparator for evaluating the inefficient units. Dinçer and Yüksel (2019) consider the evaluation of the investment strategies to be important for sustainable tourism. For this purpose, the Hybrid of Decision-Making Approach Based on Type-2 Fuzzy Sets interval, and fuzzy approaches consider the approaches to the decision-making processes in the field of tourism offer.

Based on the overview, research on tourism for PwDs is fragmented. However, there are strong multidisciplinary connections between the studies. Exploring fuzzy-based multi-criteria models (Hašková *et al.*, 2023) in decision-making under uncertainty can offer valuable insights, especially when integrating sustainability aspects, as seen in various applications like investment selection and resource management. Several dimensions of barrier-free tourism take place, while binds to the particular diagnosis's groups and systemic solutions of barrier-free tourism are absent. The critical points and potential areas for improvement are identified in the studies, but particular suggested solutions and tools, which would help PwDs in the difficult decision-making processes, are missing. It has a negative impact on the PwDs satisfaction related to tourism and their loyalty as well as on the further development of barrier-free tourism in the international perspective and economic development of the countries.

## Methods

### *Formal formulation of the evaluation problem*

The decision-making support system for travel planning for PwDs is a model for processing both data and knowledge. Therefore, the following management subjects are defined: experts — participants of the tourist movement with disabilities (respondents of the research questionnaire) who visited the destination and expressed their opinions regarding its accessibility; potential tourists — people with disabilities planning a trip based on the assessment of the level of accessibility of the region and acting as a person who makes further decisions; the system analyst is the person responsible for setting up all evaluation processes of the expert model.

Let the level of accessibility in the selected regions  $R = \{R_1; R_2; \dots; R_n\}$ , be evaluated when planning a trip for PwDs. We have  $E = \{e_1; e_2; \dots; e_c\}$  — a set of participants of the tourist movement with disabilities who visited

the destination and based on their experience gave feedback about the accessibility at the destination. Such reviews are provided according to groups of evaluation criteria  $G_1; G_2; \dots; G_l$ , for the purpose of forming a database. P is a potential tourist with disabilities, for whom the level of accessibility of the region will be derived according to his goal needs, to make a travel decision.

Let the system-theoretical-multiple model of the task of assessing the level of accessibility of the region when travel planning be presented as follows:

$$M(R, E, P, m_{TD}, K_{LA}, M_{SA}, M_{DA})|Y(f). \quad (1)$$

Here we have:  $m_{TD}$  – the type of disability or restriction of mobility;  $K_{LA}$  – information model of assessing the level of accessibility of destination;  $M_{SA}$  – a fuzzy method of determining the degree of accessibility of destination, taking into account the level of limited capabilities of the participant of the tourist movement;  $M_{DA}$  – a decision-making method when travel planning on the accessibility of the region on goal needs.

As a result, the initial estimate  $Y(f) = \{AR; R^*\}$ , is obtained, which consists of:  $AR$  – the ranking series of accessibility of regions, which takes into account the limitations of the potential tourist and his goal needs;  $R^*$  is an alternative solution for a potential tourist when planning a trip. The initial estimate  $Y(f)$  contains the content of the validity of decision-making at the level of regional tourism when planning a trip for PwDs.

Fuzzy logic is used in the study because of its ability to handle the uncertainty and complexity of data such as tourist reviews, accessibility criteria, and individual limitations of PwDs. It allows the modeling of multi-criteria problems where parameters may be incomplete or conflicting, providing adapted and personalized decision-making. This is important for PwDs travel planning, as each person with a disability evaluates accessibility differently, depending on physical limitations and needs.

For a visual interpretation of the decision-making support system, when travel planning for PwDs, a structural diagram is given, Fig. 1.

Fig. 1. shows the structural diagram of the decision-making support system, which is divided into two components: the data level and the knowledge level. In the program implementation of the developed system, these levels will be backend and frontend, respectively. At the data level, we have a set of experts  $e_1, e_2, \dots, e_c$ , information about their type of disabil-

ity or mobility limitation  $m_{TD}$  and the regions they visit  $R_1, R_2, \dots, R_n$ . After that, feedback from experts  $e_1, e_2, \dots, e_\zeta$  is collected according to the developed information model for assessing the level of accessibility of the destination  $K_{LA}$ . All information is stored in the database. At the knowledge level, we have a potential tourist  $P$ , who is planning a future trip and aims to choose the best region for this. The potential tourist provides information about their type of disability or mobility restriction  $m_{TD}$ , and also expresses their own target needs in the future trip. The fuzzy method  $M_{SA}$ , based on information from the database, determines the degree of accessibility of the destination, considering the level of disabilities of the participants in the tourist movement.  $M_{SA}$  is also used to calculate the assessment of the level of disabilities of the potential tourist. The set of initial data at this stage is presented to the knowledge base. Next, the information is processed by the decision support method for planning a trip regarding the accessibility of the region according to the target needs  $M_{DA}$ . The output is the initial assessment  $Y(f) = \{AR; R^*\}$ :  $AR$  is a ranking series of accessibility of regions, which considers the limitations of the potential tourist and his target needs;  $R^*$  is an alternative solution for the potential tourist when planning a trip. Based on the initial data, the potential tourist makes a decision on the choice of a region for the future trip. If the resulting alternative solution does not satisfy the potential tourist, then the travel planning decisions are revised by changing the target needs.

A two-component decision support system for travel planning for PwDs is presented.

**The first component of the decision-making support system when planning a trip is the data level.** To develop an adequate decision-making support system for planning and choosing a region for visiting by PwDs, it is necessary to have real data. Such data should be based on the experiences of PwDs visiting destinations. Therefore, the first component of the developed system is the collection of feedback based on the proposed information model and the formation of a database for obtaining knowledge. In the first part, data is collected separately for participants in the tourist movement. For this, the information model  $K_{LA}$ , is presented, based on which further evaluations will take place.

*K<sub>LA</sub> — information model of assessing the level of accessibility of destination*

Let there be a set  $G_1; G_2; \dots; G_l$  of groups of criteria for evaluating the destination with respect to accessibility. Each such group consists of a set of evaluation criteria  $K_g = \{K_{gi}; i = \overline{1, \theta_g}\}$ ,  $g = \overline{1, l}$  accessibility of the destination. Experts express their opinion on the issue of accessibility at the destination according to each evaluation criterion. To formalize experts' statements, a set of linguistic variables  $\Lambda = \{\lambda_1; \lambda_2; \lambda_3; \lambda_4; \lambda_5\}$ , is proposed, which expresses the following meaning:  $\lambda_1$  – “Strongly disagree”;  $\lambda_2$  – “Disagree”;  $\lambda_3$  – “Neither agree nor disagree”;  $\lambda_4$  – “Agree”;  $\lambda_5$  – “Strongly Agree”.

The set of criteria contains the impressions of the participants of the tourist movement regarding accessibility at the destination. Next, groups of evaluation criteria included in the information model are proposed.

$G_1$  – parking at the place of residence.

$K_{11}$  – the availability of parking spaces for persons with disabilities (PwDs) was adequate.

$K_{12}$  – the allocation of parking spaces for PwDs met the required standards.

$K_{13}$  – the proximity of the disabled parking space to the entrance was optimal (closest to the entrance).

$K_{14}$  – the parking space markings were clear and easily distinguishable (e.g., signage).

$K_{15}$  – the dimensions of the parking space for PwDs met the required specifications (adequate width).

$K_{16}$  – the aisle width in the parking areas met the required standards.

$G_2$  – entrance to the accommodation facility.

$K_{21}$  – the entrance to the accommodation can be considered barrier-free.

$K_{22}$  – the gradient of the ramp meets the required specifications.

$K_{23}$  – the width of the ramp was fine.

$K_{24}$  – the construction and location of the ramp were satisfactory.

$K_{25}$  – the construction of the lifting platform was satisfactory.

$K_{26}$  – the location of the lifting platform was suitable.

$K_{27}$  – there were no curbs or other minor architectural barriers at the entrance.

$K_{28}$  – the width of the entrance door to the accommodation facility is satisfactory.

$K_{29}$  – the entrance door did not contain elements that make it difficult to enter the hotel (fittings, high handles, etc.).

$G_3$  – hall and reception.

$K_{31}$  – the entrance can be considered barrier-free.

- $K_{32}$  – lanes for the visually impaired were clearly marked.
- $K_{33}$  – the audio induction loop was accessible to the hearing impaired and those using a hearing aid or other assistive device.
- $K_{34}$  – limited-service areas (e.g., reception desk) were available to serve customers with disabilities.
- $G_4$  – elevators in the accommodation facility.
- $K_{41}$  – the width of the elevator door is satisfactory.
- $K_{42}$  – the width of the lifting device was satisfactory.
- $K_{43}$  – use of the elevator was constant (both inside and outside).
- $K_{44}$  – the floor surface of the elevator was suitable for the needs of people with disabilities.
- $G_5$  – hotel room.
- $K_{51}$  – an adjustable bed was available that suited my needs.
- $K_{52}$  – the height of the bed is satisfactory.
- $K_{53}$  – the space under the bed was satisfactory.
- $K_{54}$  – the bed had a firm mattress that suited my needs.
- $K_{55}$  – the bathroom had a wide clean space.
- $K_{56}$  – the height of the tables is satisfactory.
- $K_{57}$  – the convenience of moving around the room (carpet, floor, etc.).
- $K_{58}$  – a handheld showerhead was available, meeting the individual's needs.
- $K_{59}$  – the mirror is placed at a convenient distance for the disabled.
- $K_{510}$  – the height of the toilet seat is satisfactory.
- $K_{511}$  – access to the cabinet beneath the sink was unobstructed.
- $K_{512}$  – there was a vast space in the room.
- $K_{513}$  – control of mechanical parts of accessories (water faucet, light, air conditioner) was convenient.
- $K_{514}$  – all the controls were visible from the bed.
- $K_{515}$  – a bar fridge was available for medication which suited my needs.
- $G_6$  – mobility and security.
- $K_{61}$  – the grab bars in the bathroom were accessible and suited my needs.
- $K_{62}$  – the railing was the entire length of the bathroom.
- $K_{63}$  – the shower had a bench or other alternative arrangement.
- $K_{64}$  – there were seats available in the elevator that suited my needs.
- $K_{65}$  – the non-slip floor was functional in the bathroom.
- $K_{66}$  – there was an emergency button in the bathroom, the location of which suited me.
- $K_{67}$  – the room was located not far from the elevator.

- $K_{68}$  – the door opened without problems (e.g. handles).  
 $G_7$  – equipment – comfort/rest/additional mobility of the accommodation object.  
 $K_{71}$  – access to the gym was seamless.  
 $K_{72}$  – access to the hotel pool was no problem.  
 $K_{73}$  – access to other recreation areas (wellness, sauna) in the hotel was without problems.  
 $K_{74}$  – access to the hotel bar/cafe was no problem.  
 $G_8$  – services and security.  
 $K_{81}$  – room service was available.  
 $K_{82}$  – assistance services available (e.g. assistance with luggage).  
 $K_{83}$  – orientation was clearly marked.  
 $K_{84}$  – the evacuation plan was clear.  
 $G_9$  – restaurant and business services in the tourist center.  
 $K_{91}$  – the interior of catering establishments is adapted to the needs of people with disabilities.  
 $K_{92}$  – there were enough aisles between the tables.  
 $K_{93}$  – the height of the table and the legroom under it are satisfactory.  
 $K_{94}$  – the counters were adapted to PwD.  
 $K_{95}$  – public catering establishments were clean.  
 $K_{96}$  – access to shops has been adjusted for people with disabilities.  
 $K_{97}$  – the aisles between the racks in the stores were wide enough for my needs.  
 $G_{10}$  – parking at the destination/near the tourist attraction.  
 $K_{10\ 1}$  – the allocation of disabled parking spaces was satisfactory.  
 $K_{10\ 2}$  – the distance of the disabled parking space to the entrance was appropriate (closest to the entrance).  
 $K_{10\ 3}$  – the marking of parking spaces was clear and easily identifiable (e.g. a board).  
 $K_{10\ 4}$  – the size of the parking space for the disabled is satisfactory (wide enough).  
 $K_{10\ 5}$  – the width of the aisles in the parking lots was satisfactory.  
 $G_{11}$  – physical accessibility of tourist destination attractions.  
 $K_{11\ 1}$  – attractions at the destination were available.  
 $K_{11\ 2}$  – sidewalks and roads at the destination were barrier-free.  
 $K_{11\ 3}$  – availability of information signs for people with disabilities.  
 $K_{11\ 4}$  – transport (e.g. public transport) has been adapted for people with disabilities.

$K_{115}$  – there were toilets adapted for the needs of people with disabilities.

$G_{12}$  – the attitude of residents.

$K_{121}$  – residents and other visitors were attentive.

$K_{122}$  – residents and other visitors were willing to help.

$K_{123}$  – I had no feeling of inferiority, from other visitors.

For adequate evaluation, it is necessary to have databases and knowledge bases built on the real data of experts, while considering the level of their limited capabilities. Therefore, for each participant of tourist movement  $E$  information is obtained regarding the indicator of the type of disability or mobility limitation –  $m_{TD}$ . The indicator  $m_{TD}(m_{1TD}; m_{2TD})$  includes two variables:  $m_{1TD}$  – type of disability or mobility restriction;  $m_{2TD}$  – the percentage recognized by the expert regarding his disability.

The type of disability or mobility limitation is qualitative information that is summarized in a certain way. Therefore, the expert is asked to choose a set of values that belongs to his constraint. Such a linguistic evaluation  $m_{1TD}$  can have a set of the following values:

$m_{11}$  – physical limitations only in a wheelchair.

$m_{12}$  – a disabled person in a wheelchair with the ability to walk short distances with the help of crutches.

$m_{13}$  – disabled with crutches.

$m_{14}$  – a disabled person with the use of a cane.

$m_{15}$  – neurodegenerative disability in a wheelchair.

$m_{16}$  – neurodegenerative disability with crutches.

$m_{17}$  – neurodegenerative disability without compensatory aids.

$m_{18}$  – chronic diseases with the use of a wheelchair.

$m_{19}$  – chronic disease with the use of crutches.

$m_{110}$  – chronic illness without compensatory aid.

$m_{111}$  – sightless.

$m_{112}$  – deaf.

Another variable  $m_{2TD} \in [0; 100]$  represents a quantitative value in the form of a percentage, determined by the expert in relation to his disability.

Without reducing the generality, the group of criteria is open. The model is presented in a general form, so it has no restrictions on the number of groups or criteria.

Thus, the main function of the information model is to collect feedback from experts. A set of such reviews is stored in a database, based on which knowledge is subsequently obtained to assess the level of accessibility of the region.

**The second component of the decision-making support system when planning a trip is the level of knowledge.** After collecting feedback from other participants in the tourist movement and forming a database, the data is processed. Here, a potential tourist with disabilities decides to visit the region using: a knowledge base; a fuzzy method of determining the degree of accessibility of destination, taking into account the level of limited capabilities of the participant of the tourist movement —  $M_{SA}$ ; a decision-making method when travel planning on the accessibility of the region on goal needs —  $M_{DA}$ .

*$M_{SA}$  – a fuzzy method of determining the degree of accessibility of destination, considering the level of limited capabilities of the participant of the tourist movement*

Let the participants of the tourist movement with disabilities (experts) visit the destination and express their attitude on the issue of accessibility according to the proposed groups of criteria. Since the presented research is focused on regional tourism, the travel decision-making support system will recommend the general region to visit. Regional ratings will reflect objective reality, as they are derived from many reviews regarding the accessibility of the destination. Then the generalized content of group opinion is obtained within the region. And as you know, group opinion is close to the truth. In this regard, there is no need to collect information about a specific object at the destination. The level of accessibility of multiple destinations determines the general impression of the accessibility of the region. Furthermore, without loss of generality, the fuzzy method is rearranged for some experts  $e$  in the visited region  $R$ . The set of input linguistic variables has the following form, Table 1.

In the first step, to compare the data, it is necessary to assess the level of the expert's limited capabilities. In the second step, the expert's reasoning needs to be generalized and standardized across groups of evaluation criteria.

In the first step, the following approach is used to assess the level of the expert's limited capabilities.

It is proposed to use intellectual analysis of knowledge, based on membership functions, to reveal uncertainty and subsequently compare data regarding the type of disability or mobility limitation. For this purpose, a Z-like membership function is considered, which can be applied to problems of

uncertainties of the "low level" type. For example, a quadratic Z-spline would look like this:

$$\mu_{1TD} = \begin{cases} 1, & \omega < 1; \\ 1 - \frac{(\omega-1)^2}{18}, & 1 \leq \omega \leq 4; \\ \frac{(7-\omega)^2}{18}, & 4 < \omega < 7, \\ 0, & \omega \geq 7. \end{cases} \quad (2)$$

where  $\omega$  is the number of elements from the set  $m_{1TD} = \{m_{11}; m_{12}; \dots; m_{112}\}$  for the considered expert  $e$ . The membership function has the following meaning: the greater its value, the lower the level of the expert's limited capabilities.

Further, for another variable of the indicator  $m_{2TD}$ , which is the percentage recognized by the expert regarding his disability, it is similarly suggested to use a quadratic Z-spline:

$$\mu_{2TD} = \begin{cases} 1, & m_{2TD} \leq 10\%; \\ 1 - \frac{(m_{2TD}-10)^2}{1800}, & 10\% < m_{2TD} \leq 40\%; \\ \frac{(70-m_{2TD})^2}{1800}, & 40\% < m_{2TD} < 70\%, \\ 0, & m_{2TD} \geq 70\%. \end{cases} \quad (3)$$

The value of the membership function  $\mu_{2TD}$  characterizes the level of disability of a participant in the tourist movement. The logic is as follows: the larger the value of  $\mu_{2TD}$ , the lower the level of the expert's limited capabilities.

The parameters of the membership functions constructed above were adjusted based on the experience of the authors of the article and real data from V4 countries. Thus, normalized data are obtained for the indicator of the type of disability or mobility limitation:  $m_{TD} = (\mu_{1TD}; \mu_{2TD})$ .

Next, to derive one normalized estimate of the level of limited capabilities of the expert  $\overline{m}_{TD}$ , it is proposed to use the approach of intellectual analysis of knowledge based on multidimensional membership functions. Values  $(\mu_{1TD}; \mu_{2TD})$  are characterized by the uncertainty of the "average value" type. In two-dimensional space, cone-shaped or pyramidal membership functions are used to reveal such uncertainty. Without reducing generality, we consider a conical membership function with base (1; 1) and scaling by coordinates(2; 2):

$$\overline{m}_{TD} = \begin{cases} 1 - \lambda, & \text{if } \lambda < 1, \\ 0, & \text{otherwise.} \end{cases}, \quad \lambda = \frac{1}{2} \cdot \sqrt{(\mu_{1TD} - 1)^2 + (\mu_{2TD} - 1)^2}. \quad (4)$$

Thus, the participant of the tourist movement  $e$  receives a normalized assessment of the level of limited opportunities in the visited region –  $\overline{m}_{TD}(e, R) \in [0; 1]$ . This indicator has the following meaning: the greater the value, the lower the level of various violations, restrictions on activity, and obstacles to the active activity of a participant in the tourist movement.

Consider the second step of the fuzzy method.

Let each linguistic variable be assigned some quantitative estimate  $\alpha$ . The level of assessment  $\alpha$  increases if the indicator has good feedback from experts at the destination. In connection with the further normalization of the data, it is proposed to express the quantitative assessment through the following characteristic function:

$$\alpha = \begin{cases} \alpha_1 = 1 & \text{if } \lambda_1 - \text{"Strongly disagree"}, \\ \alpha_2 = 2 & \text{if } \lambda_2 - \text{"Disagree"}, \\ \alpha_3 = 3 & \text{if } \lambda_3 - \text{"Neither agree nor disagree"}, \\ \alpha_4 = 4 & \text{if } \lambda_4 - \text{"Agree"}, \\ \alpha_5 = 5 & \text{if } \lambda_5 - \text{"Strongly agree"}. \end{cases} \quad (5)$$

To obtain a normalized and compared value, within a group of criteria, an averaged value is used:

$$\sigma_g = \frac{1}{5\theta_g} \sum_{i=1}^{\theta_g} \alpha_{gi}, \quad g = \overline{1, l}. \quad (6)$$

where  $\sigma_g \in [0; 1]$ ,  $\theta_g$  is the number of criteria in the corresponding group  $g$ . The resulting value has the following meaning: when  $\sigma_g$  approaches unity, then the expert is satisfied and has a good impression of the set of accessibility criteria at the destination.  $\sigma_g$  is the normalized score of the group of accessibility criteria at the destination.

Next, the normalized evaluations are aggregated for all groups of accessibility criteria at the destination according to the following formula:

$$\bar{\sigma} = \frac{1}{l} \sum_{g=1}^l \sigma_g. \quad (7)$$

Of course, a convolutional approach can also be used here, using the importance of groups of criteria. The authors of the article consider the assessment of such importance in future studies as one of the tasks.

At the output of this method, an assessment and the degree of accessibility of the destination are derived, considering the level of limited capabilities of the participant of the tourist movement. To adequately interpret such a dependence, the following function is constructed:

$$\Xi_{SA} = \begin{cases} 0, & \bar{\sigma} < 0; \\ (\bar{\sigma})^{\overline{mTD}}, & 0 \leq \bar{\sigma} \leq 1; \\ 1, & \bar{\sigma} > 1. \end{cases} \quad (8)$$

This score  $\Xi_{SA}$  is calculated by the corresponding expert  $e$  in the visited region  $R$ , so we denote it  $\Xi_{SA}(e; R)$ . The construction of such a function is driven by the following logic: an expert with a low level of disability, after visiting a destination, has a bad impression of accessibility, then the output score  $\Xi_{SA}$  tends to 0. Conversely, the output score  $\Xi_{SA}$  tends to be 1 if an expert, with a strong level of limited capacity, receives a good impression of accessibility at the destination. Therefore, this function can adequately interpret the situation regarding comfort at the destination of PwDs.

Next, the degree of accessibility of the destination is determined in the form of a linguistic assessment regarding the level of comfort in the destination (region  $R$ ) for PwDs ( $e$ ), respectively by type of disability and its percentage. For this, the obtained value  $\Xi_{SA} \in [0; 1]$  is mapped to one variable of the term-sets  $LC = \{lc_1, lc_2, \dots, lc_5\}$  putting the following content:

- $\Xi_{SA} \in (0,8; 1]$  –  $lc_1$  = “High level of comfort at the destination for a PwD ( $m_{1TD}$ ) and its percentage ( $m_{2TD}$ )”.
- $\Xi_{SA} \in (0,6; 0,8]$  –  $lc_2$  = “Level of comfort at the destination for a PwD ( $m_{1TD}$ ) and its percentage ( $m_{2TD}$ ) above average”.
- $\Xi_{SA} \in (0,4; 0,6]$  –  $lc_3$  = “Average level of comfort at the destination for a PwD ( $m_{1TD}$ ) and its percentage ( $m_{2TD}$ )”.
- $\Xi_{SA} \in (0,2; 0,4]$  –  $lc_4$  = “Low level of comfort at the destination for a PwD ( $m_{1TD}$ ) and its percentage ( $m_{2TD}$ )”.
- $\Xi_{SA} \in [0; 0,2]$  –  $lc_5$  = “Very low level of comfort at the destination for a PwD ( $m_{1TD}$ ) and its percentage ( $m_{2TD}$ )”.

Since the fuzzy method was introduced for some experts  $e$  in the visited region  $R$ , the evaluation procedure is repeated for all participants of the tourist traffic from the database.

Thus, based on the fuzzy method of determining the degree of accessibility of the destination considering the level of limited opportunities of the participant of the tourist movement, for each expert  $e$  in the visited region, an assessment, and the degree of accessibility of the destination is obtained, considering the level of limited opportunities of the participant of the tourist movement. Such initial data are presented in the form of Table 2 and form part of the knowledge base of the researched problem.

It is clear that Table 2 forms a sparse matrix, as the experts do not visit all the regions, but each expert has visited at least one. Therefore, the matrix will have at least one value per row for some region.

In addition, if we have more than one expert in a certain region in the database, then within the criteria groups there is an aggregated impression of the experts regarding the availability of the region.

$$\Omega_g = \frac{\sum_{k=1}^{\zeta} \sigma_g(e_k, R_j)}{NV}, k = \overline{1, \zeta}, g = \overline{1, l}. \quad (9)$$

where  $NV$  is the number of experts who visited the corresponding region  $R_j$ ,  $j = \overline{1, n}$ . The resulting value has the following meaning: when  $\Omega_g$  approaches unity, then on average the experts are satisfied and have good impressions about the set of accessibility criteria within the region.

*M<sub>DA</sub>* – a decision-making method when travel planning on the accessibility of the region on goal needs

For the decision-making support method, when planning a trip according to target needs, the normalized scores  $\Omega_g$ ,  $g = \overline{1, l}$  of groups of accessibility criteria at the destination are considered. Such assessments form another part of the knowledge base of the researched problem.

A feature of the decision-making support method when planning a trip is that potential tourists  $P$  have their own goals regarding groups of accessibility criteria. Also, the potential tourist expresses information for the indicator of the type of disability or mobility limitation  $m_{TD}(P)$ , namely: the type of disability or mobility limitation ( $m_{1TD}(P)$ ) and the percentage recognized by the expert regarding his disability ( $m_{2TD}(P)$ ). Next, to reveal the uncertainty and compare the data, the values of the membership functions are calculated using formulas (2) and (3). After that, according to formula (4), one normalized assessment of the level of limited opportunities for a potential tourist is derived  $\overline{m_{TD}}(P)$ .

Next, concerning the normalized estimate of the level of limited opportunities of a potential tourist, relative estimates of proximity to all estimates of the level of limited opportunities of participants in the tourist movement, which are in the database  $\overline{m}_{TD}(e, R)$ , are determined. For this, values are calculated according to the following formula for all estimates  $\overline{m}_{TD}(e_k, R_j)$ ,  $k = \overline{1, \zeta}$ ,  $j = \overline{1, n}$ :

$$\varphi = 1 - \frac{|\overline{m}_{TD}(P) - \overline{m}_{TD}(e_k, R_j)|}{\max\{\overline{m}_{TD}(P) - \min(\overline{m}_{TD}(e_k, R_j)); \max(\overline{m}_{TD}(e_k, R_j)) - \overline{m}_{TD}(P)\}} \quad (10)$$

The values of  $\varphi(e_k, R_j) \in [0; 1]$  characterize the relative estimates of the proximity of experts in the visited region to the assessment of the level of limited opportunities of a potential tourist. If  $\varphi(e_k, R_j) = 1$ , then the restriction of the potential tourist coincides with the participant of the tourist movement  $e_k$  in the region  $R_j$ . And vice versa, if  $\varphi(e_k, R_j) = 0$  there is an absolute mismatch between the expert's restriction  $e_k$  and the potential tourist.

Let the system analyst establish a certain level  $\omega \in [0; 1]$  of compliance with the limitation of the potential tourist  $\varphi(e_k, R_j) \in [0; 1]$ . After that, only those regions for which the value  $\varphi(e_k, R_j) > \omega$  are selected for consideration as potential regions:  $R = \{R_j | \varphi(e_k, R_j) > \omega, j = \overline{1, n}\}$ .

Let the following goals be proposed in terms of groups of criteria:  $C_1, C_2, \dots, C_l$ . For example, for the developed information model for assessing the level of accessibility of the destination  $K_{LA}$  the given goals are as follows:  $C_1$  – the goal of convenient parking at the place of residence;  $C_2$  – the goal of accessibility standards for the entrance to the accommodation facility;  $C_3$  – the goal of matching the hallway and reception;  $C_4$  – the purpose of the standards of accessibility of elevators in the accommodation facility;  $C_5$  – the goal of hotel room comfort;  $C_6$  – the goal of mobility and security;  $C_7$  – equipment goal – comfort/rest/additional mobility of the accommodation facility;  $C_8$  – service and security goal;  $C_9$  – the goal regarding restaurant and business services in the tourist center;  $C_{10}$  – the goal of convenient parking at the destination/near the tourist attraction;  $C_{11}$  – the goal regarding the physical accessibility of the attractions of the tourist destination;  $C_{12}$  – the goal regarding the appropriate level of attitude of residents.

Next comes the task of assessing the level of accessibility of the region, when planning a trip consisting of  $l$  goals. Then vectors  $C_1(P) =$



**THEN**  $U = (u_1, u_2, \dots, u_l)$  **ELSE...**

Thus, the potential tourist  $P$  sets a linguistic desire to the vector of goals, which is translated into the vector of the initial quantitative and normalized assessment  $(u_1, u_2, \dots, u_l)$ , that is  $(u_1, u_2, \dots, u_l) = (t_1, t_2, \dots, t_l)$ .

For the developed information model, the fuzzy knowledge base for assessing the accessibility level of the region is as follows.

**IF** we have goals:

$C_1$  – is the goal of convenient parking at the place of residence ( $a_{11}$  is a minimal need then  $u_1 = 0.2$ ;  $a_{12}$  is a minor need then  $u_1 = 0.4$ ;  $a_{13}$  is an existing need then  $u_1 = 0.6$ ;  $a_{14}$  is a significant need then  $u_1 = 0.8$ ;  $a_{15}$  is a priority need then  $u_1 = 1$ )

**AND**  $C_2$  – the purpose of standards of accessibility of the entrance to the accommodation facility ( $a_{21}$  is a minimal need then  $u_2 = 0.2$ ;  $a_{22}$  is a minor need then  $u_2 = 0.4$ ;  $a_{23}$  is an existing need then  $u_2 = 0.6$ ;  $a_{24}$  is a significant need then  $u_2 = 0.8$ ;  $a_{25}$  is a priority need then  $u_2 = 1$ )

**AND**  $C_{12}$  – the goal regarding the appropriate level of attitude of residents ( $a_{121}$  is a minimal need then  $u_{12} = 0.2$ ;  $a_{122}$  is a minor need then  $u_{12} = 0.4$ ;  $a_{123}$  is an existing need then  $u_{12} = 0.6$ ;  $a_{124}$  is a significant need then  $u_{12} = 0.8$ ;  $a_{125}$  is a priority need then  $u_{12} = 1$ )

**THEN** the logical statement is formulated as follows.

If a potential tourist needs convenient parking at accommodation  $A_1$ , the need for appropriate standards of access to accommodation facility  $A_2$ , ..., the appropriate level of attitude of the residents  $A_{12}$  then  $U = (u_1, u_2, \dots, u_{12})$ .

If necessary, the system analyst can change the quantitative levels or rules in the goals. And the knowledge base itself, similarly to groups of criteria, is open, so the number of goals can be changed relative to the information model if necessary.

Next, for all regions, there are values  $Z_j = (z_{1j}, z_{2j}, \dots, z_{lj}), j = \overline{1, n}$ , which represent relative estimates of the proximity of the evaluated regions to the



$$Z_{4j}^* = \sqrt{\sum_{g=1}^l w_g \cdot (z_{gj})^2} - \text{optimistic convolution.} \quad (18)$$

After that, based on the obtained  $Z_j^*$  values, a ranking series of the accessibility of the regions is built:

$$AR = (AR_1, AR_2, \dots, AR_n). \quad (19)$$

A decision-making support system enables a potential tourist to choose a region for travel, considering accessibility goals and type of disability:

$$R^* = \max_j Z_j^*, \quad j = \overline{1, n}. \quad (20)$$

From a mathematical point of view, the best alternative solution for choosing a region in terms of accessibility, when planning a trip, will be the closest to the “Vector of the goals of a potential tourist”. The larger the value of  $Z_j^*$ , the more accessible the region is to the goals of the potential tourist who plans their trip and decides to visit the region while considering the level of the potential tourist's limited capabilities.

The innovation of the decision-making support system when planning a trip for PwDs is that, based on the statements of experts on the issue of accessibility at the destination, the type of disability, and the goal needs of the potential tourist, it derives a general comprehensive assessment of the region, according to which the ranking of accessibility takes place regions.

## Results

The decision-making support system for travel planning for PwDs has been verified and tested on real data in the countries of the Visegrad Group (the Czech Republic, Hungary, Poland, and Slovakia) which included a total of 19 regions (Data from the evaluation of 41 participants 2024).

The Visegrad Group countries were selected for the study because of their geographical and cultural similarities, which allows for a comparison of tourism systems and accessibility for people with disabilities in a single context. These countries have a significant development of tourism, which makes them interesting for studying the impact of inclusive tourism on the economy. Although these countries have made some steps towards ensur-

ing accessibility for people with disabilities, there are different levels of development of policies and infrastructure, which allows for a comparative analysis. In addition, they are members of the EU, which ensures common European accessibility standards, and at the same time, there is significant potential for improving accessible tourism in the countries.

The authors are conducting a comprehensive study on the development of intelligent decision-making support systems for regional tourism in the V4 countries. The presented research is a constituent part of it. A research questionnaire with 132 questions was developed for a comprehensive study. The data collection procedure itself took place in the period from March to December 2021 and was made possible thanks to the cooperation of several organizations. As a result, for the period from 2017 to 2021, data was collected from 2,343 respondents of tourism participants in the V4 countries. Out of 2,343 respondents, there were 41 participants of the tourist movement with disabilities. To display the results and the possibility of reproducing the decision-making support system by other researchers, an example of evaluation on 41 participants of the tourist movement with disabilities is given.

*The first component of the decision-making support system when planning a trip is the data level.*

Based on the available 41 participants of the tourist movement with disabilities, using the information model for assessing the level of accessibility of the destination, a database was formed. An excerpt of the database is shown in Table 3, and the entire database is available at (Data from the evaluation of 41 participants 2024).

*The second component of the decision-making support system when planning a trip is the level of knowledge.*

Calculations are first carried out using the developed fuzzy method of determining the degree of accessibility of the destination —  $M_{SA}$ . In the first step, to compare data, it is necessary to assess the level of limited capabilities of experts. For this, the membership functions  $\mu_{1TD}$  and  $\mu_{2TD}$  are calculated, respectively, according to formulas (2) and (3). Next, a cone-shaped membership function according to formula (4) is used to derive one normalized estimate of the level of limited capabilities of experts  $\overline{m}_{TD}$ .

In the second step of the fuzzy method, some quantitative estimate  $\alpha$ , is assigned to each linguistic variable, according to the formula (5). Further, to obtain a normalized and compared value, formula (6) is used to obtain  $\sigma_g$ ,  $g = \overline{1,12}$  averaged value within the criteria group.

After that, aggregation of  $\bar{\sigma}$  normalized estimates for all groups of accessibility criteria at the destination is carried out according to formula (7). At the output of this method, according to formula (8), the  $\Xi_{SA}$  score and the degree of *LC* accessibility of the destination are derived, considering the level of limited capabilities of the tourist traffic participant.

All results of calculations by 41 experts are given in (Data from the evaluation of 41 participants 2024), and fragments of calculations by previous experts are illustrated in Table 4.

As can be seen from the table, expert  $e_{25}$  in the West Pomeranian Voivodeship (PL) region received the best impression of accessibility at the destination.

Next,  $M_{DA}$  is considered – a method of supporting decision-making, when planning a trip regarding the accessibility of the region according to the goal needs.

Let us have some potential tourist  $P$ . First, let him express information about:  $m_{1TD}(P)$  type of disability or mobility restriction – “Disabled in a wheelchair, Neurodegenerative disability, Sightless”;  $m_{2TD}(P)$  percentage recognized by an expert regarding his disability – 45%.

After that, the values of the membership functions are similarly calculated according to formulas (2) and (3):  $\mu_{1TD}(P) = 0.778$ ;  $\mu_{2TD}(P) = 0.347$ . According to formula (4), one normalized assessment of the level of limited opportunities for a potential tourist is derived  $\overline{m_{TD}}(P) = 0.655$ .

Next, concerning the estimate  $\overline{m_{TD}}(P)$  the relative estimates of proximity to all estimates of the level of limited opportunities of 41 participants of the tourist movement are determined according to formula (10). Let the system analyst set the level of limitation of a potential tourist at  $\omega = 0.6$ . The calculation results are shown in Fig. 2.

Then the regions are selected for the next calculation  $R = \{R_j | \varphi(e_k, R_j) > 0.6, j = \overline{1, n}\}$ . As a result, 12 experts from 8 regions are obtained:  $R_1$  =Nitra region (SK) – expert  $e_3$ ;  $R_2$  =Zilina region (SK) – experts  $e_4, e_{16}$ ;  $R_3$  =Banská Bystrica Region (SK) – experts  $e_5, e_{24}$ ;  $R_4$  =Prešov region (SK) – experts  $e_{12}, e_{19}$ ;  $R_5$  =Trnava Region (SK) – experts  $e_{22}, e_{23}$ ;  $R_6$  =West Pomeranian Voivodeship (PL) – expert  $e_{26}$ ;  $R_7$  = Hajdú-Bihar County (HU) – expert  $e_{32}$ ;  $R_8$  = Liberec region (CZ) – expert  $e_{34}$ .

As we can see, in some regions there is more than one expert in the database, then within the criteria groups there is an aggregated impression of experts regarding the accessibility of the region according to formula (9), Table 5.

Let the potential tourist express his own goal needs for the planned trip. Such an expression is given as a "vector of the goals of a potential tourist" according to the goals  $C_1, C_2, \dots, C_{12}$ :  $U = (A_1, A_2, \dots, A_{12})$ , where  $A_1 = a_4$ ;  $A_2 = a_3$ ;  $A_3 = a_3$ ;  $A_4 = a_5$ ;  $A_5 = a_5$ ;  $A_6 = a_4$ ;  $A_7 = a_1$ ;  $A_8 = a_2$ ;  $A_9 = a_3$ ;  $A_{10} = a_2$ ;  $A_{11} = a_2$ ;  $A_{12} = a_3$ .

Then, using a fuzzy knowledge base on the assessment of the level of accessibility of the region is obtained  $(u_1, u_2, \dots, u_{12}) = (0.8; 0.6; 0.6; 1; 1; 0.8; 0.2; 0.4; 0.6; 0.4; 0.4; 0.6)$ .

Moreover  $(u_1, u_2, \dots, u_{12}) = (t_1, t_2, \dots, t_{12})$ .

Next, for all regions, there are values according to formula (13), which represent relative estimates of the proximity of the evaluated regions to the vector of goals of a potential tourist for each goal  $C_1, C_2, \dots, C_{12}$ . The result is recorded in the form of Table 6.

Let the potential tourist set the weighting coefficients for each goal from the interval  $[1,10]$ :  $v_1=8$ ;  $v_2=6$ ;  $v_3=6$ ;  $v_4=8$ ;  $v_5=10$ ;  $v_6=7$ ;  $v_7=6$ ;  $v_8=6$ ;  $v_9=8$ ;  $v_{10}=6$ ;  $v_{11}=7$ ;  $v_{12}=9$ .

Normalized weighting factors are calculated according to the formula (14):  $w_1=0.09$ ;  $w_2=0.07$ ;  $w_3=0.07$ ;  $w_4=0.09$ ;  $w_5=0.11$ ;  $w_6=0.08$ ;  $w_7=0.07$ ;  $w_8=0.07$ ;  $w_9=0.09$ ;  $w_{10}=0.07$ ;  $w_{11}=0.08$ ;  $w_{12}=0.1$ .

At the next stage, evaluations are aggregated using convolutions. Let the potential tourist choose the average convolution according to formula (17):

$Z_{31}^* = 0.36$ ;  $Z_{32}^* = 0.57$ ;  $Z_{33}^* = 0.5$ ;  $Z_{34}^* = 0.71$ ;  $Z_{35}^* = 0.66$ ;  $Z_{36}^* = 0.32$ ;  $Z_{37}^* = 0.73$ ;  $Z_{38}^* = 0.49$ .

After that, based on the obtained  $Z_3^*$  values, a ranking series of the accessibility of the regions is built:  $AR = (R_7; R_4; R_5; R_2; R_3; R_8; R_1; R_6)$ .

The results of the study show that the decision support system for travel planning for people with disabilities was successfully tested on real data from 19 regions of the Visegrad Group countries. The analysis assessed the level of accessibility for people with disabilities in these regions and considered the individual needs of potential tourists. The results showed that the best choice for a potential tourist was the region  $R_7$ , which best meets his needs and level of limitations. This approach allows for effective comparison of different regions and choosing the best option for tourists with disabilities.

## **Discussion**

In the work, a decision-making support system was developed when travel planning for PwDs, which, based on the feedback of participants of the tourist movement with disabilities, takes into account their level of comfort at the destination, is based on the goal needs of a potential tourist and derives a ranking of regions to visit based on the similarity of the limited opportunities of a potential tourist to the participants of the tourist movement. Designed for this: information model of assessing the level of accessibility of destination; a fuzzy method of determining the degree of accessibility of destination, taking into account the level of limited capabilities of the participant of the tourist movement; a decision-making method when travel planning on the accessibility of the region on goal needs; verified the developed decision-making support system based on real data in the regions of the V4 countries; an example of evaluation based on the data of 41 participants of the tourist movement with disabilities for regions from the V4 countries is illustrated.

The decision-making support system is based on two components: data level and knowledge level. The level of data forms a database of actual visits to the destination by participants of the tourist movement with disabilities, further regional tourism is evaluated based on their experience. The level of knowledge consists of mathematical models that collectively represent a decision-making support system when planning a trip for PwDs. For the formalization of the system, the mathematical apparatus of the theory of fuzzy sets and fuzzy logic, expert evaluation, and intellectual analysis of knowledge is used. The choice of such a mathematical tool makes it possible to increase the degree of reasonableness of decision-making regarding travel planning.

The value of the decision-making support system when planning a trip for PwDs is that: on the one hand, the system is based on real feedback from the participants of the tourist movement, who expressed their impressions about accessibility at the destination, and on the other hand, it considers the goal needs and information regarding mobility restrictions of the potential tourist. At the output, a ranking number of regions is obtained in terms of their availability relative to the goal needs of a potential tourist. Another important aspect of this study is that all settings of the decision-making support system are tested and verified on real data. This will make it possible to develop real and high-quality travel plans for participants of

the tourist movement with disabilities. On the other hand, this decision-making support system can be useful for business and public authorities to understand the need for the quality of integrated tourism services for PwDs.

It is proved above that the developed decision-making support system has important practical value. Note that the formal description of the system is presented in the format of data and knowledge levels. This is done to easily implement it in software tools for quick practical use. In the program implementation of the system, the levels of data and knowledge will be Backend and Frontend, respectively. This presentation of the system is aimed at attracting a wider audience.

Existing approaches to travel planning for PwDs (Agovino *et al.*, 2017; Darcy *et al.*, 2020) primarily focus on static accessibility information, such as databases of barrier-free locations or generalized accessibility ratings of destinations. Previous works (Kastenholz *et al.*, 2015; Card *et al.*, 2006) have proposed rule-based and statistical methods for evaluating accessibility, yet they often lack adaptability to the specific needs of an individual traveler. Moreover, traditional accessibility assessment models do not consider the dynamic nature of accessibility, relying mostly on expert-driven or infrastructure-based evaluations without integrating real user feedback.

Compared to these approaches, our proposed decision-making support system introduces a more personalized and data-driven methodology. Unlike prior models, which provide generic accessibility ratings, our system incorporates real-time feedback from PwDs who have visited specific locations, allowing for a more context-aware and user-centric assessment. By leveraging fuzzy logic and expert evaluations, our system effectively addresses the inherent uncertainty in accessibility perception, which previous deterministic models fail to capture.

Another key advantage of our model is its ability to generate personalized travel recommendations. While earlier research has focused on accessibility as a binary measure (accessible/non-accessible), our approach ranks destinations based on their suitability for an individual traveler, considering both their specific mobility limitations and travel goals. This level of granularity enhances the decision-making process and improves travel planning accuracy for PwDs.

Additionally, our model is tested on real-world data from the V4 countries, providing empirical validation that is often missing in other studies. The integration of data and knowledge levels in our system allows for

seamless adaptation to different regions, which is a significant improvement over existing models that require manual adjustments for each location.

By offering an adaptable, user-feedback-driven, and goal-oriented approach, our decision-making support system not only surpasses the existing methodologies, but also contributes to the development of inclusive tourism policies. The ability to personalize travel recommendations based on real user experiences makes our system a superior alternative to traditional accessibility evaluation frameworks.

The advantages of the decision-making support system stem from the fact that: the system is easily adapted to any region, groups of accessibility criteria are easily configured, and the goal needs of PwDs are easily configured; the information model is presented in a general form, so it does not have any restrictions on the number of groups or criteria; a set of linguistic assessments of the type of disability or mobility limitation can be easily modified, which does not affect further calculations; the level of limited capabilities of the potential tourist and his goal needs for visiting the destination are taken into account; the system outputs a ranking of the accessibility of regions, which takes into account the limitations of the potential tourist and his goal needs; the system displays an alternative solution for a potential tourist when planning a trip; the decision-making support system uses the theory of fuzzy sets and fuzzy logic, which reveals the uncertainty of input expert evaluations; all parameters of the decision-making support system were adjusted on real data.

Enhancing the coherence of the proposed decision-making support system with global inclusive tourism policies strengthens its practical impact. By aligning the system's methodology with international accessibility frameworks, such as the UNWTO Guidelines on Inclusive Tourism, our approach can serve as a valuable tool for policymakers and stakeholders in the tourism sector. Furthermore, integrating the model into existing regional and national tourism strategies will foster more data-driven and user-centered decision-making, ultimately improving travel experiences for PwDs.

A limitation of our study was the use of different types of characteristic functions and membership functions of one and many variables. This also includes setting their parameters. The adequacy of the decision-making support system depends on the level of data, that is, on the amount of feedback from experts with disabilities. Therefore, it is necessary to make

a wider sample of the research questionnaire, while expanding the geography of the research in other countries. However, these limitations do not affect the obtained results and innovative approaches. The reliability of the obtained results is ensured by the justified use of the mathematical apparatus. The rationality of alternative solutions when planning a trip for participants of the tourist movement with disabilities contributes to the development of inclusive regional tourism and proves the advantages of the developed model.

Addressing the identified limitations through future research will further enhance the system's applicability. Expanding the geographic scope and increasing the dataset of user feedback will refine the ranking model, ensuring greater accuracy in assessing accessibility. Moreover, incorporating real-time data updates and AI-driven predictive analytics can improve the system's adaptability to dynamic accessibility conditions. These advancements will not only strengthen the decision-making framework, but also contribute to the ongoing development of inclusive tourism policies on a global scale.

## **Conclusions**

The main goal of the research is to develop a decision-making support system when planning a trip for PwDs, based on the example of the countries of the Visegrad Group. At the same time, the following scientific results were obtained.

Firstly, developed information model for assessing the level of accessibility of destination, which consists of 74 criteria, which are divided into 12 groups and contain impressions of participants of the tourist movement regarding accessibility at the destination. It formalizes the collection of information regarding the indicator of the type of disability or mobility limitation. The model is presented in a general form, so it has no restrictions on the number of groups or criteria. This model represents the level of feedback data.

Secondly, a developed fuzzy method of determining the degree of accessibility of the destination, considers the level of limited capabilities of the participant of the tourist movement. The input data are linguistic variables regarding the impression of the participants of the tourism movement regarding accessibility in the destination. The method uses the principles of

fuzzy sets. As a result, the method for each expert in the visited region derives a quantitative normalized assessment and the degree of accessibility of the destination, considering the level of limited capabilities of the participant of the tourist movement.

Thirdly, a decision-making method for travel planning on the accessibility of the region on goal needs was developed. The method goes from destination accessibility to region accessibility. The method considers the type of disability of a potential tourist. The concept of the "Vector of the goals of a potential tourist" is introduced to consider his goal needs regarding the accessibility of the region in terms of groups of criteria. The method is based on the principles of fuzzy logic and intellectual analysis of knowledge. The built knowledge base is open, so the number of goals, the number of levels, and the rules in the goals can be changed if necessary. At the output, alternative options of regions in terms of accessibility are obtained that are closest to the goals of the potential tourist who plans their trip and decides to visit the region, while considering the level of limited capabilities of the potential tourist.

Fourthly, the decision-making support system has been verified and tested on real data in the Visegrad Group countries. An example of an assessment of 41 participants of the tourist movement with disabilities is illustrated.

Further research will be aimed at developing software applications focused on the needs of tourists with disabilities, which will ensure convenient travel planning for this category of people. The implementation of software solutions based on the proposed decision-making support system will significantly enhance the practical value of this research by providing real-time accessibility assessments and personalized travel recommendations for tourists with disabilities. In particular, a web-based analytical system for business and government agencies will be developed that will use methods of obtaining and presenting knowledge to support the development of regional tourism in the context of inclusion.

The next stage will be the research and implementation of innovative technologies, in particular artificial intelligence, to adapt tourist routes and services to the individual needs of people with various types of disabilities. It is additionally planned to study the potential of adaptive technologies to create personalized tourist experiences, which will ensure a high level of accessibility and comfort.

Overall, this research opens up new directions for sustainable and innovative development of regions in the field of tourism, improving the quality of life of people with disabilities and ensuring an inclusive approach to planning tourist routes and services.

## References

- Agovino, M., Casaccia, M., Garofalo, A., & Marchesano, K. (2017). Tourism and disability in Italy. Limits and opportunities. *Tourism Management Perspectives*, 23, 58–67. <https://doi.org/10.1016/j.tmp.2017.05.001>.
- AlKahtani, S. J. H., Xia, J. C., Veenendaaland, B., Caulfield, C., & Hughes, M. (2015). Building a conceptual framework for determining individual differences of accessibility to tourist attractions. *Tourism Management Perspectives*, 16, 28–42. <https://doi.org/10.1016/j.tmp.2015.05.002>.
- Aln, E., Domnguez, T., & Los, N. (2012). New opportunities for the tourism market: Senior tourism and accessible tourism. *InTech*, 1, 139–166. <http://doi.org/10.5772/38092>.
- Andria, J., di Tollo, G., & Pesenti, R. (2020). A heuristic fuzzy algorithm for assessing and managing tourism sustainability. *Soft Computing*, 24, 4027–4040. <https://doi.org/10.1007/s00500-019-04170-5>.
- Andria, J., di Tollo, G., & Pesenti, R. (2021). Fuzzy multi-criteria decision-making: An entropy-based approach to assess tourism sustainability. *Tourism Economics*, 27(1), 168–186. <https://doi.org/10.1177/1354816619885207>.
- Awan, M. I., Shamim, A., Saleem, M. S., & Gill, S. S. (2022). Service inclusion for tourists with disabilities: Scale development and validation. *Journal of Services Marketing, Journal of Services Marketing*, 36(7), 977–990. <https://doi.org/10.1108/jsm-09-2021-0364>.
- Card, J. A., Cole, S. T., & Humphrey, A. H. (2006). A comparison of the accessibility and attitudinal barriers model: Travel providers and travelers with physical disabilities. *Asia Pacific Journal of Tourism Research*, 11(2), 161–175. <https://doi.org/10.1080/10941660600727566>.
- Cassia, F., Castellani, P., Rossato, C., & Baccarani, C. (2020). Finding a way towards high-quality, accessible tourism: The role of digital ecosystems. *TQM Journal*, 33(1), 205–221. <https://doi.org/10.1108/tqm-03-2020-0062>.
- Chikuta, O., du Plessis, E., & Saayman, M. (2019). Accessibility expectations of tourists with disabilities in national parks. *Tourism Planning & Development*, 16(1), 75–92. <https://doi.org/10.1080/21568316.2018.1447509>.
- Chou, T. Y., Hsu, C. L., & Chen, M. C. (2008). A fuzzy multi-criteria decision model for international tourist hotels location selection. *International Journal of Hospitality Management*, 27(2), 293–301. <https://doi.org/10.1016/j.ijhm.2007.07.029>.

- Darcy, S., & Pegg, S. (2011). Towards strategic intent: Perceptions of disability service provision amongst hotel accommodation managers. *International Journal of Hospitality Management*, 30(2), 468–476. <https://doi.org/10.1016/j.ijhm.2010.09.009>.
- Darcy, S., Mc Kercher, B., & Schweinsberg, S. (2020). From tourism and disability to accessible tourism: A perspective article. *Tourism Review*, 75(1), 140–144. <https://doi.org/10.1108/tr-07-2019-0323>.
- Data from the evaluation of 41 participants of the tourist traffic with disabilities. Retrieved from [https://docs.google.com/spreadsheets/d/1HliTn-GwQDQIFLFTAUBbhM3cPg9W3G-a/edit?usp=share\\_link&ouid=111497346858387909549&rtf\\_of=true&sd=true](https://docs.google.com/spreadsheets/d/1HliTn-GwQDQIFLFTAUBbhM3cPg9W3G-a/edit?usp=share_link&ouid=111497346858387909549&rtf_of=true&sd=true) (22.12.2024).
- de Paula, L. B., Gil-Lafuente, A. M., & Alvares, D. F. (2021). A contribution of fuzzy logic to sustainable tourism through a case analysis in Brazil. *Journal of Intelligent & Fuzzy Systems*, 40(2), 1851–1864. <https://doi.org/10.3233/jifs-189191>.
- Dinçer, H., & Yüksel, S. (2019). Selecting investment strategies for European tourism industry using the hybrid decision making approach based on interval type-2 fuzzy sets. *Journal of Intelligent & Fuzzy Systems*, 37(1), 1343–1356. <https://doi.org/10.3233/jifs-182773>.
- Domínguez, T., Fraiz, J. A., & Alén, E. (2013). Economic profitability of accessible tourism for the tourism sector in Spain. *Tourism Economics*, 19(6), 1385–1399. <https://doi.org/10.5367/te.2013.0246>.
- Farkas, J., Raffay, Z., & Petykó, C. (2022). A new approach to accessibility, disability and sustainability in tourism—multidisciplinary and philosophical dimensions. *Geojournal of Tourism and Geosites*, 40(1), 319–326. <https://doi.org/10.30892/gtg.40138-834>.
- Ferrer, J. G., Sanz, M. F., Ferrandis, E. D., McCabe, S., & García, J. S. (2016). Social tourism and healthy ageing. *International Journal of Tourism Research*, 18(4), 297–307. <https://doi.org/10.1002/jtr.2048>.
- Forouzandeh, S., Berahmand, K., Nasiri, E., & Rostami, M. (2021). A hotel recommender system for tourists using the Artificial Bee Colony Algorithm and Fuzzy TOPSIS Model: A case study of tripadvisor. *International Journal of Information Technology & Decision Making*, 20(01), 399–429. <https://doi.org/10.1142/s0219622020500522>.
- Gabruć, J., & Medarić, Z. (2022). How to deal with tourism constraints for seniors? Evidence from social tourism programmes. *Journal of Tourism and Cultural Change*, 20(5), 633–651. <https://doi.org/10.1080/14766825.2021.1987446>.
- Gillovic, B., & McIntosh, A. (2015). Stakeholder perspectives of the future of accessible tourism in New Zealand. *Journal of Tourism Futures*, 1(3), 223–239. <https://doi.org/10.1108/jtf-04-2015-0013>.
- Gillovic, B., McIntosh, A., Cockburn-Wootten, C., & Darcy, S. (2021). Experiences of tourists with intellectual disabilities: A phenomenological approach. *Journal of Hospitality and Tourism Management*, 48, 155–162. <https://doi.org/10.1016/j.jhtm.2021.06.003>.

- Hašková, S., Vochozka, M., & Kučera, J. (2023). A fuzzy evaluation model of manufacturing machinery in terms of sustainable business. *Entrepreneurship and Sustainability Issues*, 10(4), 71–88. [https://doi.org/10.9770/jesi.2023.10.4\(5\)](https://doi.org/10.9770/jesi.2023.10.4(5)).
- Horner, S., & Swarbrooke, J. (2004). Tourism and travellers with disabilities. *International Cases in Tourism Management*, 2004, 324–337. <https://doi.org/10.1016/B978-0-7506-5514-9.50040-4>.
- Imanov, G. (2021). Fuzzy estimation of national green economy index and investments distribution. *Fuzzy Models in Economics*, 402, 55–71. [https://doi.org/10.1007/978-3-030-61282-5\\_4](https://doi.org/10.1007/978-3-030-61282-5_4).
- Karadimitriou, C., Kyriakaki, A., & Michopoulou, E. (2021). Accessible tourism as a transformational force for tourism and hospitality. *Emerging Transformations in Tourism and Hospitality*, 1, 142–153. <https://doi.org/10.4324/9781003105930-11>.
- Kastenholz, E., Eusébio, C., & Figueiredo, E. (2015). Contributions of tourism to social inclusion of persons with disability. *Disability & Society*, 30(8), 1259–1281. <https://doi.org/10.1080/09687599.2015.1075868>.
- Kong, W. H., & Loi, K. I. (2017). The barriers to holiday-taking for visually impaired tourists and their families. *Journal of Hospitality and Tourism Management*, 32, 99–107. <https://doi.org/10.1016/j.jhtm.2017.06.001>.
- Law, R. (2007). A fuzzy multiple criteria decision-making model for evaluating travel websites. *Asia Pacific Journal of Tourism Research*, 12(2), 147–159. <https://doi.org/10.1080/10941660701243372>.
- Lehto, X., Luo, W., Miao, L., & Ghiselli, R. F. (2018). Shared tourism experience of individuals with disabilities and their caregivers. *Journal of destination marketing & management*, 8, 185–193. <https://doi.org/10.1016/j.jdmm.2017.04.001>.
- Liao, H., Yang, S., Kazimieras Zavadskas, E., & Škare, M. (2022). An overview of fuzzy multi-criteria decision-making methods in hospitality and tourism industries: Bibliometrics, methodologies, applications and future directions. *Economic Research-Ekonomska Istraživanja*, 36(3), 1–42. <https://doi.org/10.1080/1331677x.2022.2150871>.
- Loi, K. I., Macau, S. A. R., & Kong, W. H. (2017). People with disabilities (pwd) in the tourism industry. Retrieved from <https://wp.nyu.edu/cts2015/wp-content/uploads/sites/657/2015/06/Loi-and-Kong.pdf>.
- Lyu, S. O. (2017). Which accessible travel products are people with disabilities willing to pay more? A choice experiment. *Tourism Management*, 59, 404–412. <https://doi.org/10.1016/j.tourman.2016.09.002>.
- Mahdi, A., & Esztergár-Kiss, D. (2021). Modelling the accommodation preferences of tourists by combining fuzzy-AHP and GIS Methods. *Journal of Advanced Transportation*, 9913513. <https://doi.org/10.1155/2021/9913513>.
- McIntosh, A. J. (2020). The hidden side of travel: Epilepsy and tourism. *Annals of Tourism Research*, 81, 102856. <https://doi.org/10.1016/j.annals.2019.102856>.
- McKercher, B., Packer, T., Yau, M. K., & Lam, P. (2003). Travel agents as facilitators or inhibitors of travel: Perceptions of people with disabilities. *Tourism Management*, 24(4), 465–474. [https://doi.org/10.1016/s0261-5177\(02\)00107-3](https://doi.org/10.1016/s0261-5177(02)00107-3).

- Michopoulou, E., Darcy, S., Ambrose, I., & Buhalis, D. (2015). Accessible tourism futures: The world we dream to live in and the opportunities we hope to have. *Journal of Tourism Futures*, 1(3), 179–188. <https://doi.org/10.1108/jtf-08-2015-0043>.
- Mithen, J., Aitken, Z., Ziersch, A., & Kavanagh, A. M. (2015). Inequalities in social capital and health between people with and without disabilities. *Social Science & Medicine*, 126, 26–35. <https://doi.org/10.1016/j.socscimed.2014.12.009>.
- Moura, A., Eusébio, C., & Devile, E. (2023). The ‘why’ and ‘what for’ of participation in tourism activities: Travel motivations of people with disabilities. *Current Issues in Tourism*, 26(6), 941–957. <https://doi.org/10.1080/13683500.2022.2044292>.
- Nicolaisen, J., Blichfeldt, B. S., & Sonnenschein, F. (2012). Medical and social models of disability: A tourism providers' perspective. *World Leisure Journal*, 54(3), 201–214. <https://doi.org/10.1080/04419057.2012.702451>.
- Nilashi, M., Samad, S., Manaf, A. A., Ahmadi, H., Rashid, T. A., Munshi, A., Al-mukadi, W., Ibrahim, O., & Ahmed, O. H. (2019). Factors influencing medical tourism adoption in Malaysia: A DEMATEL-Fuzzy TOPSIS approach. *Computers & Industrial Engineering*, 137, 106005. <https://doi.org/10.1016/j.cie.2019.106005>.
- Nyanjom, J., Boxall, K., & Slaven, J. (2018). Towards inclusive tourism? Stakeholder collaboration in the development of accessible tourism. *Tourism Geographies*, 20(4), 675–697. <https://doi.org/10.1080/14616688.2018.1477828>.
- Pearce, P. L. (2012). Relationships and the tourism experience: Challenges for quality-of-life assessments. In M. Uysal, R. Perdue & M. Sirgy (Eds). *Handbook of tourism and quality-of-life research. International handbooks of quality-of-life*. Dordrecht: Springer. [https://doi.org/10.1007/978-94-007-2288-0\\_2](https://doi.org/10.1007/978-94-007-2288-0_2).
- Popovic, G., Stanujkic, D., Brzakovic, M., & Karabasevic, D. (2019). A multiple-criteria decision-making model for the selection of a hotel location. *Land Use Policy*, 84, 49–58. <https://doi.org/10.1016/j.landusepol.2019.03.001>.
- Poria, Y., Reichel, A., & Brandt, Y. (2011). Dimensions of hotel experience of people with disabilities: An exploratory study. *International Journal of Contemporary Hospitality Management*, 23(5), 571–591. <https://doi.org/10.1108/09596111111143340>.
- Portales, R. C. (2015). Removing “invisible” barriers: Opening paths towards the future of accessible tourism. *Journal of Tourism Futures*, 1(3), 269–284. <https://doi.org/10.1108/jtf-04-2015-0018>.
- Puška, A., Nedeljković, M., Jeločnik, M., Subić, J., Nancu, D., & Jean-Vasile, A. (2022). An assessment of improving the sustainable agro-touristic offer in an emerging country using the integrative approach based on fuzzy logic. *Frontiers in Environmental Science*, 10, 894811. <https://doi.org/10.3389/fenvs.2022.894811>.
- Qiao, G., Cao, Y., & Zhang, J. (2022). Accessible tourism—understanding blind and vision-impaired tourists' behaviour towards inclusion. *Tourism Review*, 78(2), 531–560. <https://doi.org/10.1108/TR-03-2022-0129>.

- Ribeiro, F. R., Silva, A., Barbosa, F., Silva, A. P., & Metrólho, J. C. (2018). Mobile applications for accessible tourism: Overview, challenges and a proposed platform. *Information Technology & Tourism*, 19, 29–59. <https://doi.org/10.1007/s40558-018-0110-2>.
- Rubio-Escuderos, L., García-Andreu, H., Michopoulou, E., & Buhalis, D. (2024). Perspectives on experiences of tourists with disabilities: Implications for their daily lives and for the tourist industry. *Tourism Recreation Research*, 49(1), 48–62. <https://doi.org/10.1080/02508281.2021.1981071>.
- Ruiz-Meza, J., Brito, J., Montoya-Torres, J. R., & Castro-Vergara, A. (2022). Green fuzzy tourist trip design problem. *Advances in Operations Research*, 6828385. <https://doi.org/10.1155/2022/6828385>.
- Schrijver, J., Lenferink, A., Brusse-Keizer, M., Zwerink, M., van der Valk, P. D., van der Palen, J., & Effing, T. W. (2022). Self-management for people with chronic obstructive pulmonary disease. *Cochrane Database of Systematic Reviews*, 1, CD002990. <https://doi.org/10.1002/14651858.CD002990.pub4>.
- Singh, R., Sibi, P. S., Yost, E., & Mann, D. S. (2021). Tourism and disability: A bibliometric review. *Tourism Recreation Research*, 48(5), 749–765. <https://doi.org/10.1080/02508281.2021.1959768>.
- Stumbo, N. J., Wang, Y., & Pegg, S. (2011). Issues of access: What matters to people with disabilities as they seek leisure experiences. *World Leisure Journal*, 53(2), 91–103. <https://doi.org/10.1080/04419057.2011.580549>.
- Sweet, M., & Kanaroglou, P. (2016). Gender differences: The role of travel and time use in subjective well-being. *Transportation Research Part F: Traffic Psychology and Behaviour*, 40, 23–34. <https://doi.org/10.1016/j.trf.2016.03.006>.
- Tsaur, S. H., & Wang, C. H. (2007). The evaluation of sustainable tourism development by analytic hierarchy process and fuzzy set theory: An empirical study on the Green Island in Taiwan. *Asia Pacific Journal of Tourism Research*, 12(2), 127–145. <https://doi.org/10.1080/10941660701243356>.
- Tutuncu, O. (2017). Investigating the accessibility factors affecting hotel satisfaction of people with physical disabilities. *International Journal of Hospitality Management*, 65, 29–36. <https://doi.org/10.1016/j.ijhm.2017.06.002>.
- Ulkhag, M. M., Siamiaty, A. D., Handoko, A., Madjid, S. A., Nu, D. S. (2019). The fuzzy analytic hierarchy process for prioritizing the sustainable tourism attitude scale. *IOP Conference Series: Earth and Environmental Science*, 219(1), 012012. <https://doi.org/10.1088/1755-1315/219/1/012012>.
- World Health Organization. (2017) Model Disability Survey (MDS). Retrieved from <https://www.who.int/publications/i/item/9789241512862>.
- Xie, H., Costa, C. A., & Morais, D. B. (2008). Gender differences in rural tourists' motivation and activity participation. *Journal of Hospitality & Leisure Marketing*, 16(4), 368–384. <https://doi.org/10.1080/10507050801951452>.
- Yang, S., & Kong, X. (2022). Evaluation of rural tourism resources based on AHP-fuzzy mathematical comprehensive model. *Mathematical Problems in Engineering*, 7196163. <https://doi.org/10.1155/2022/7196163>.

- Yu, S. M., Wang, J., Wang, J. Q., & Li, L. (2018). A multi-criteria decision-making model for hotel selection with linguistic distribution assessments. *Applied Soft Computing*, 67, 741–755. <https://doi.org/10.1016/j.asoc.2017.08.009>.
- Zenko, Z., & Sardi, V. (2014). Systemic thinking for socially responsible innovations in social tourism for people with disabilities. *Kybernetes*, 43(3/4), 652–666. <https://doi.org/10.1108/k-09-2013-0211>.
- Ziyadin, S., Borodin, A., Streltsova, E., Suieubayeva, S., & Pshembayeva, D. (2019). Fuzzy logic approach in the modeling of sustainable tourism development management. *Polish Journal of Management Studies*, 19(1), 492–504. <https://doi.org/10.17512/pjms.2019.19.1.37>.

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### **Compliance with ethical standards**

This article does not contain any studies with human participants or animals performed by the authors. Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required.

### **Data availability statement**

All data generated or analyzed are included in the published article. The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation. The raw anonymized data can be provided by emailing the primary author.

### **Author contributions**

All listed authors have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the source analysis.

### **Conflict of interest statement**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Annex

**Table 1.** Input data of a visit by an expert  $e$

Region	Expert data		Opinion of an expert		
	Type of disability	Percentage of disability	Criterion group	Criterion	Linguistic assessment
$R$	$m_{1TD}$	$m_{2TD}$	$G_1$	$K_{11}$	$\Lambda_{11}$
				...	...
				$K_{1m_1}$	$\Lambda_{1m_1}$
			$G_2$	$K_{21}$	$\Lambda_{21}$
				...	...
				$K_{2m_2}$	$\Lambda_{2m_2}$
			...	...	...
			$G_l$	$K_{l1}$	$\Lambda_{l1}$
				...	...
				$K_{lm_l}$	$\Lambda_{lm_l}$

**Table 2.** Data on the degree of accessibility of the destination

Region	$e_1$	$e_2$	...	$e_m$
$R_1$	$\Xi_{SA11}$	$\Xi_{SA12}$	...	$\Xi_{SA1m}$
$R_2$	$\Xi_{SA21}$	$\Xi_{SA22}$	...	$\Xi_{SA2m}$
...	...	...	...	...
$R_n$	$\Xi_{SA n1}$	$\Xi_{SA n2}$	...	$\Xi_{SA nm}$

**Table 3.** Excerpt of the database of expert reviews

Group of criteria	Criteria	West			
		Trnava region (SK) - $e_1$	Pomeranian Voivodeship (PL) - $e_{25}$	Hajdú-Bihar County (HU) - $e_{31}$	Liberec region (CZ) - $e_{34}$
$G_1$	$K_{11}$	Strongly disagree	Agree	Neither agree nor disagree	Strongly disagree
	$K_{12}$	Neither agree nor disagree	Agree	Neither agree nor disagree	Strongly disagree
	$K_{13}$	Disagree	Strongly agree	Neither agree nor disagree	Strongly disagree
	...	...	...	...	...
	$K_{16}$	Disagree	Strongly agree	Neither agree nor disagree	Strongly disagree
$G_2$	$K_{21}$	Strongly disagree	Strongly agree	Disagree	Disagree
	$K_{22}$	Disagree	Strongly agree	Strongly disagree	Disagree
	...	...	...	...	...

**Table 3.** Continued

Group of criteria	Criteria	Trnava region (SK) - $e_1$	West	Hajdú-Bihar County (HU) - $e_{31}$	Liberec region (CZ) - $e_{34}$	
			Pomeranian Voivodeship (PL) - $e_{25}$			
$G_{12}$	$K_{29}$	Strongly disagree	Strongly agree	Disagree	Disagree	
	...	...	...	...	...	
	$K_{12.1}$	Strongly disagree	Strongly agree	Disagree	Disagree	
	$K_{12.2}$	Strongly disagree	Strongly agree	Disagree	Disagree	
$m_{TD}$	$K_{12.3}$	Strongly disagree	Strongly agree	Disagree	Disagree	
	<b>Indicators of the type of disability or mobility restriction</b>					
	$m_{1TD}$	Disabled in a wheelchair, Chronic disease	Disabled in a wheelchair	With barrels/mallet, Physical disability	Without compensatory aid, Chronic disease	
	$m_{2TD}$	5%	100%	80%	60%	

**Table 4.** Excerpt of the results of the calculation by the fuzzy method  $M_{SA}$

	Trnava region (SK)	West Pomeranian Voivodeship (PL)	Hajdú-Bihar County (HU)	Liberec region (CZ)
$\sigma_1$	0.4	0.9	0.6	0.2
$\sigma_2$	0.6	1	0.4	0.4
$\sigma_3$	0.5	0.6	0.4	0.4
$\sigma_4$	0.4	0.85	0.7	0.4
$\sigma_5$	0.63	0.96	0.6	0.4
$\sigma_6$	0.68	0.7	0.23	0.4
$\sigma_7$	0.5	1	0.3	0.4
$\sigma_8$	0.6	1	0.2	0.4
$\sigma_9$	0.46	1	0.46	0.4
$\sigma_{10}$	0.52	1	0.36	0.4
$\sigma_{11}$	0.36	1	0.2	0.4
$\sigma_{12}$	0.2	1	0.4	0.4
$\bar{\sigma}$	0.48	0.92	0.4	0.38
$\mu_{1TD}$	0.944	1	0.944	0.944
$\mu_{2TD}$	1	0	0	0.056
$\overline{m_{TD}}$	0.972	0.5	0.499	0.527

**Table 4.** Continued

	Tnava region (SK)	West Pomeranian Voivodeship (PL)	Hajdú-Bihar County (HU)	Liberec region (CZ)
$\bar{\varepsilon}_{SA}$	0.49	0.96	0.63	0.6
$LC$	$lc_3 =$ "Average level of comfort at the destination for a PwD (Disabled in a wheelchair, Chronic disease) and its percentage (5%)"	$lc_1 =$ "High level of comfort at the destination for a PwD (Disabled in a wheelchair) and its percentage (100%)"	$lc_2 =$ "Level of comfort at the destination for a PwD (With barrels/mallet, Physical disability) and its percentage (80%) above average"	$lc_2 =$ "Level of comfort at the destination for a PwD (Without compensatory aid, Chronic disease) and its percentage (60%) above average"

**Table 5.** Results of aggregated impressions of experts regarding accessibility by region

	$\Omega_1$	$\Omega_2$	$\Omega_3$	$\Omega_4$	$\Omega_5$	$\Omega_6$	$\Omega_7$	$\Omega_8$	$\Omega_9$	$\Omega_{10}$	$\Omega_{11}$	$\Omega_{12}$
$R_1$	0.5	0.8	0.35	0.2	0.21	0.2	0.2	0.2	0.2	0.64	0.32	0.8
$R_2$	0.8	0.82	0.75	0.8	0.88	0.8	0.8	0.8	0.87	0.8	0.78	0.8
$R_3$	0.2	0.22	0.35	0.35	0.6	0.2	0.6	0.6	0.57	0.2	0.52	1
$R_4$	0.6	0.91	0.8	1	0.91	0.9	1	1	1	1	1	1
$R_5$	0.4	0.57	0.58	0.68	0.75	0.55	0.8	0.8	0.79	0.6	0.76	1
$R_6$	0.83	0.8	0.75	1	1	0.6	0.5	0.75	0.8	0.84	0.48	0.8
$R_7$	0.43	0.51	0.3	0.3	0.55	0.55	0.55	0.5	0.54	0.56	0.52	0.47
$R_8$	0.63	0.66	0.53	0.65	0.77	0.58	0.525	0.63	0.67	0.7	0.5	0.63

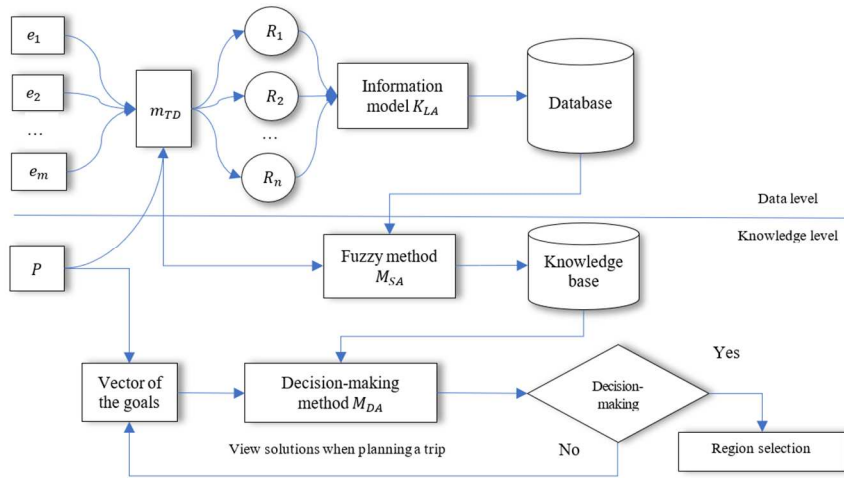
**Table 6.** Relative estimates of the proximity of the evaluated regions to the vector of the potential tourist's goals

	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$z_7$	$z_8$	$z_9$	$z_{10}$	$z_{11}$	$z_{12}$
$R_1$	0.5	0.5	0	0	0	0	1	0.67	0	0.6	0.87	0.5
$R_2$	1	0.44	0.4	0.75	0.85	1	0.25	0.33	0.32	0.33	0.37	0.5
$R_3$	0.33	0.92	0.9	0.59	0.69	0.58	0.25	0.33	0.54	0.67	0.4	0
$R_4$	0.72	0.86	0.7	0.56	0.71	0.63	0.59	0.63	0.82	0.5	0.83	0.92
$R_5$	0.72	0.89	0.8	0.63	0.61	0.79	0.5	0.5	0.79	0.53	0.47	0.67

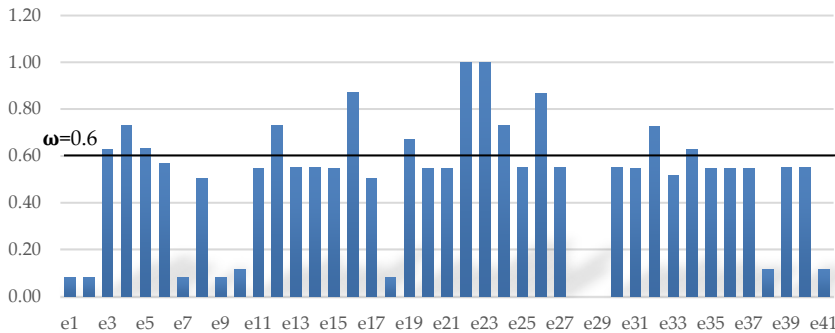
**Table 6.** Continued

	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$z_7$	$z_8$	$z_9$	$z_{10}$	$z_{11}$	$z_{12}$
$R_6$	0.67	0	0.2	1	0.9	0.67	0	0	0	0	0	0
$R_7$	0.67	1	1	0.5	0.49	0.67	0.5	0.67	1	0.67	0.67	1
$R_8$	0	0.5	0.2	0.25	0.24	0.33	0.75	1	0.5	1	1	0.5

**Figure 1.** Structural diagram of the decision-making support system



**Figure 2.** The results of calculating the relative estimates of the proximity of 41 participants of the tourist movement to a potential tourist by the level of limitation



## Appendix

Data from the evaluation of 41 participants of the tourist traffic with disabilities.

[https://docs.google.com/spreadsheets/d/1HliTn-GwQDQIFLFTAUbbhM3cPg9W3G-a/edit?usp=share\\_link&ouid=111497346858387909549&rtpof=true&sd=true](https://docs.google.com/spreadsheets/d/1HliTn-GwQDQIFLFTAUbbhM3cPg9W3G-a/edit?usp=share_link&ouid=111497346858387909549&rtpof=true&sd=true)