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Implementing non-motorised transport in urban space within strategic planning

Aleš Ruda
Fakulta veřejnosprávních a ekonomických studií v Uherském Hradišti, Vysoká škola Jagiellońská v Toruni, Studentské náměstí 1531, 686 01 Uherské Hradiště, Česká republika;
email: Ales.Ruda@seznam.cz

Oldřich Hájek
Fakulta veřejnosprávních a ekonomických studií v Uherském Hradišti, Vysoká škola Jagiellońská v Toruni, Studentské náměstí 1531, 686 01 Uherské Hradiště, Česká republika;
email: hajek.oldrich@gmail.com

Abstract

Actual lifestyle and society organization consider optimization and restructuralization of system approach and need reliable support for further planning and decision-making. Branches supporting development within economic issues and public administration use well-known procedures and techniques of decision-making. Speaking about strategical planning, proposing new cycle paths is based on both quantitative evaluating and qualitative respecting strategic intent of the city. The main goal of the paper is to extend currently accepted approaches in modelling of non-morised transport and highlight key issues of implementing these findings into strategic concepts. The issue of spatial decision making implementation into information management depends mainly on the suitably chosen purpose of use and the nature of information system in the organization. In connection with the above mentioned, we offer the use of both web-based applications and the implementation of stand-alone program solutions or the use of both in the form of on-line services.

Keywords: transportation; decision making; strategies

1. Introduction

1.1. Non-motorised transport

In the past, vehicular movement used to be concerned only as a subject in urban transportation planning, which nowadays is evolving into a discipline that deals with multimodal systems, where transit and non-motorised means of transport such as cycling and walking are getting more and more attention. This so called active transportation has become an essential component of many cities' transportation systems being used both as the only mode and in combination with other modes, providing access to or from the transit network. Modal share of pedestrians and bicyclists has been growing in many parts of the world taking its part in sustainable urban transport systems (e. g. Strauss et al., 2015; Griswold et al., 2011;

Rybarczyk and Wu, 2009; Lerman et al. 2014). There are numerous benefits of non-motorised transport. It has positive effect upon urban life quality - emissions and noise reducing, safety increase, higher social group independence (children and senior) (Zampieri and Rigatti, 2007). Alleviating automobile congestions is also an important factor as this has become a critical problem in cities worldwide. Traffic related problems such as growing climate change as well as energy and health concerns are causing a shift away towards greener and healthier modes which also help reducing the dependency on fossil fuels (Lerman et al, 2014; Nordström and Manum, 2015). Regarding to the negative externalities of vehicular movement, sustainable transport has become an important goal in transportation planning (Rybarczyk and Wu, 2010). Distribution of pedestrians or bicyclist movement volumes within the area present key information affecting transportation engineering, planning and design of transportation projects, as well as decision making and allocation of financial resources and policy evaluation. Several techniques have been used for measuring bicycle and pedestrians traffic such as manual and automated counts taken either long- or short term, GPS tracking devices and mobile phones data or various survey techniques (Ruda, Flokova, 2017). There is an urge not only to know the current numbers of pedestrians and bicyclists but also to be able to predict and estimate their movement so many researches focus on modelling these flows.

1.2 Strategic planning

Strategic planning and management is considered as a crucial activity, which determinates a success of a given organization in the future. When talking about strategic planning and management, it is mostly regarding commercial organizations. Unlike this, public or non-profit sector do not aim primarily for profit maximization, nevertheless these subjects can use these kind of strategies similarly to private sector. The goal of strategic management in these cases is to make an effort to upraise work efficiency and keep or possibly improve services with lowering costs. Of course certain specifics can be found especially in the field of property rights, controlling, outbound influences etc. Decision making is also often influenced more by political conditions than factual state of the environment.

One of the basic instruments used for strategic planning and management are strategic documents. Their purpose is to set a complex system of implementation, coordination and sustainability of strategic planning and management in an organization, using a wide range of tools, such as consultation, impact assessment of regulations, using alternatives for traditional ordering and controlling directives etc.

Generally, the process of the strategic document creation can be divided into several consecutive phases: (i) identification of the need for a new strategy, (ii) project settings, (iii) analytical and prognostic phase, (iv) setting of the basic strategic direction, (v) plan development, (vi) setting the strategic plan interpretation, (vii) strategic plan adoption (MRD CR, 2013a). In the process of the strategy plan creation, decision making has to be employed several times. In the beginning, it is a decision about initiation of a strategy creation, and a decision about work-flow, which is necessary for project settings. Then, setting of the basic strategic direction is done based on the decisions about vision and strategic goals variants. This is followed by decisions about objects variants. Various methods with different level of subjectivity or objectivity and involvement of expert and/or public opinion can be used in all stages of the strategic planning creation.

In the past, strategic documents even on the highest level were often created completely without using a specific methodology, it usually came out from previous experiences and proposals from workers. Documents such as Security strategy of the Czech Republic (MoD,

2003), National Strategic Framework 2001 – 2013 (MRD, 2006), Economic Growth Strategy (Government Office Czech Republic, 2005) or Strategic Framework for Sustainable Development (ME CR, 2010) were created this way. Individual strategic documents are crated in the basis of different principles and are aiming different purposes. Another problem, besides not keeping a united methodology, is inconsistent terminology. A search of Ernst & Young company shows, that out of 22 examined documents only 3 have a drawn-up methodology for creating of strategy documents (MRD CR, 2011). The governments became aware of the problems and the necessity of taking an action. For example, since May 2013 the Methodology for Public Strategies Creation has come into effect in the Czech Republic (MRD CR, 2013a), which set a basis for actualization of previous documents, e. g. Strategy for Regional Development 2014 – 2020 (MRD, CR, 2013b) and Strategic Framework Czech Republic 2030 (ME CR, 2016). This methodology is created in the cooperation of representatives of all ministries, Government Office of the Czech Republic, Association of Regions of the Czech Republic, Union of Towns and Municipalities Czech Republic and Czech Statistical Office. It states recommended procedures for creating strategic documents and a proposal of specific methods that should be used. The SMART method is suggested for initial goal definition. This method is recommended also in other countries, e g. Moldova (RDA, 2010). On the other hand, impact assessment, cost benefit analysis, mind maps, PESTLE analysis, tree diagram, feasibility analysis and SWOT analysis are suggested for analytical and prognostic phase. Brainstorming and other team work methods are recommended for identification of solution variants. Assessment and measurement selection is recommended to be realized using multiple-criteria decision methods, when different weights can be set for individual criteria. However, the process is not described in detail and so can vary dramatically case to case.

2. Heading Modelling non-motorised flows in urban space

Creating predictive models of bicycle and/or pedestrian volumes in urban areas is challenging as it is considered extremely complex issue. But they are widely used for safety analysis and calculation of crash risks, identifying priority locations for facility improvements or estimating changes in volumes following up infrastructure changes and new projects (Griswold et al, 2011).

Used methodologies can be divided into two groups, first of them traditional transport models which use aspatial regression techniques. The most prominent example of traditional transport models is the travel-demand based Four-Step-Model which usually follows these four steps - trip generation, trip distribution, transport mode choice, route choice.

In the first step various socio-demographic, economical and structural data are considered employing statistical routines, which require independent samples, and are fed into a model. Then travel demand based on trip production and trip attraction is calculated. This is usually done for spatial entities - traffic analysis zones which are characterised independently form each other and spatial association or dependency is largely neglected (Loidl et al., 2016). The trip distribution is done in the next step. Origin-destination matrices are created and according to them the generated trips are distributed over the whole study area using for example gravity models. At this stage spatial characteristics and relations are highly abstracted (Loidl et al., 2016). However this four step model was used by Milakis and Athanasopoulos (2014) for cycle network planning in Athens where participative multicriteria processes were implied to help plan bicycle routes in the city. 11 criteria which describe infrastructure

properties such as comfort, travel safety, directness, surrounding environment and functionality were chosen. Weighting process essential for multicriteria analysis was done comprising participative evaluation of prospective users and suggested scenarios were tested by them.

Also various forms of regression analysis for traffic modelling can be found in the literature.

Linear and logistic regression to estimate traffic volumes on low volume roads in Wyoming was applied in the study of Apronti et al. (2016). 14 potential predictors were defined reflecting land use, road surface, population, number of households, access to highway, income per capita and housing units. Different subsets of variables were tested and the best subset of predictors was then utilized. To overcome issue of non-constancy of error variance the response variable was log transformed. Models were verified against observed counts. The linear regression model is recommended in applications where precious estimates of average daily traffic are desired, the logistics regression model for applications where level of traffic is desired as it enables predicting the probability of a road belonging to one of traffic volume thresholds. In spite of the fact that non-motorised traffic is influenced by many other factors than motorised there is a matter of correcting generally used methods for non-motorised count. Figliozi et al. (2014) defined regression-based correcting function to improve accuracy of annual average daily traffic estimation methods used for motorised counts so that they can be used for non-motorised, in their case bicycle, traffic estimation. The correcting function accounts for weather (regarding temperature or precipitation) and activity (holiday, weekday, weekend) factors which influence bicycle volumes observed and cause error in bicycle annual daily traffic estimation.

Lowry and Dixon (2012) presented own GIS tool to estimate average annual daily traffic based on ordinary least square regression employing functional classification, number of lanes and connectivity importance index as explanatory variables which were found significant for the case study of Moscow, Idaho presented by them. The connectivity importance index was also developed by Lowry and Dixon (2012) and is based on the space syntax technique which is getting more attention in transport planning nowadays.

Loglinear least square regression was used in the study of the Alameida County, California (Griswold et al., 2011). Dependent variables were transformed using natural logarithm before creating the model. Comparing to negative binomial form of regression model which was also tested in this study similar model coefficient was obtained but loglinear form is easier to apply and interpret. Besides bicycle counts there were variables referring to intersection site characteristic (average slope, bicycle lanes and markings), surrounding land use (number and network distance to certain points of interests) and surrounding transportation system (intersection density, connectivity) included in the modelling process. The models showed that bicycle activity tends to be higher at intersections which are in a flat terrain, surrounded by more commercial properties, closer to major university, are marked as a bicycle facility and well connected to the roadway network.

Multiple regression analysis was used for example by Mohamad et al. (1998) to estimate AADT on county roads in Indiana. The linear model used four explanatory variables: county population, total arterial mileage of the county, whether the road is urban or rural, and whether the road is close to a state highway or not. They examined also six other variables but no enhancement of the model was achieved. Similarly Xia et al. (1999) specified a model with functional classification, number of lanes, area type, auto ownership, whether the road is close to a state highway or not, and nearby employment.

Straus et al. (2015) considered regression models for the purpose of estimating average annual daily bicycle (AADB) in the city of Montreal combining long- and short-term bicycle

counts and GPS data. Linear model for predicting AADB was chosen because it provides a better fit than alternative Poisson model. Variables were generated combining the number of cyclists and facility type so that the effect of bicycle facility (no facility, bicycle path or cycle track) can be captured. When comparing estimated parameters from manual count and GPS data the results show that they are very similar. Also a distance to downtown was taken in account in the model.

Zhao and Chung (2001) applied and compared four different regression models in the study of Florida. They set four groups of variables regarding to roadway characteristics, socioeconomics characteristics, accessibility to expressways and regional accessibility to employment. Based on previous analysis they included six variables, which seemed to be suitable, for the model building – function classification, number of lanes, direct access to expressway, accessibility to regional employment centre, employment in a variable-sized buffer and population in variable-sized buffer. Combining these six variables, four models were generated. Validation of the models proved that the more variables they used, the better result was obtained and the most significant variables class and number of lanes.

Many authors realise the necessity of reflecting spatial patterns and focus on comparison of spatial and aspatial approaches. Cardoso et al. (2012) proposes a direct forecasting model that uses geographically weighted regression (GWR) and compares the results with ordinary least square (OLS) multiple regression model. Nine variables were considered as possible predictors but only four – employment, workers, number of lines and suburban bus lines- were included. The weights of the model were generated from kernel function. They proved that incorporating spatial autocorrelation measures and GWR in the modelling process gives better results than the use of traditional statistical methods which do not take into account spatial variations in the relationship between variables.

Sarlas and Axhusen (2016) examined AADT predictive accuracy of several models such as traditional four-step model, spatial lag model, negative binomial regression, three variations of OLS models, GWR model which is able to provide also localized estimates and interpolation technique using ordinary kriging method where three semivariogram functions were evaluated (exponential, Gaussian and spherical). Variables related to the road type and population density were considered. They also introduced a new variable called accessibility-weighted centrality which enables the inclusion of network-based theory in the model formulation. The results show that GWR has the highest predictive accuracy and using network theory can also lead to significant enhancement on the predictive accuracy. But still the traditional four-step model can constitute a trustworthy alternative to this more advanced models, which are much more computationally burdensome and data demanding.

Some more studies are trying to employ the network-constrained function. The study of Yu and Ai (2014) proposes the method to discover functional patterns of points of interests (POI) in the urban area using network distances rather than Euclidean ones. They propose a computational method of Kernel density estimation on a network. Combining the effect of the street network structure and land-use patterns is the aim of the study of Omer and Kaplan (2017), who suggested the agent-based model for predicting pedestrian movements. When using space syntax and agent-based approach for modelling, they claim better prediction results comparing to multiple regression analysis models especially in local scale environments.
Spatial interpolation of traffic counts using Kriging-based (in this case Ordinary Kriging) methods on network instead of Euclidean distances is discussed in the paper of Wang and Kockelman (2009). They found reliance on network distances helpful particularly for small datasets.

To investigate existing correlations or patterns Bagheri et al., (2012) used several tools such as Moran's I index, Hot-Spot analysis, Average Nearest Neighbor and Kriging methods to demonstrate how traffic growths are distributed in the area. The correlation analysis revealed the space patterns and clustering tendencies which need to be taken in account in AADT estimation. Appropriateness of various interpolation techniques to estimate bicycle volumes was studied by Ruda and Flokova (2017). In this case, the best fit of examined techniques was proved for Empirical Bayesian Kriging.

The aforementioned studies emphasise the role of spatial aspects which lead in general to better results and that fully accords the "First law of geography" formulated by Tobler (1970) which says that "everything is related to everything else, but near things are more related than distant things". This approach helped develop concepts for spatial analysis such as spatial dependence, spatial autocorrelation, inverse distance weighting, spatial interpolation or kriging. As the relevance of the geographical space has become acknowledged there is a shift from "traditional" to "alternative" traffic models which implement spatial statistics and analysis (Loidl et al., 2016). Lopez et al. (2014) used Moran's I Index which indicates the similarity of each area to its neighbour instead of regression equations in the initial stages of the four step model. Enhancement to regression models was presented by Straus and Miranda-Moreno (2013) in the study of Montreal using spatial lag regression. The main factors they considered were land use mix, cycle track presence and employment density and they conclude that models that account for spatial lag have lower standard error values that those which ignore spatial effects. The overall comparison of spatial and aspatial methods is proposed also by Selby and Kockelman (2012). They used universal kriging and GWR taking account both Euclidean and network distance. The input data included traffic counts and variables such as speed limit, number of lanes, functional class and accessibility. The results show that spatial methods definitely outperformed the spatial ones. The best result was obtained when using kriging model with exponential semivariogram. Euclidean-distance methods perform nearly same results as network-distance based methods but they are much easier to use in practice. Another way to involve the network distance into the analysis was proposed by She et al. (2015). They used weighted network Voronoi diagrams in the study of Jianghan district, China, where two types of spatial analysis methods were used – network-constrained kernel density estimation and the local Moran's I method. Unspecified generators (origins) and events (destinations) were used to produce weights to the street segments and in the constructed weighted Voronoi network the characteristics of how the structure of a street network affects the distribution was considered.

3. Planning and decision making in the public administration

A regional development sets a complex framework of processes, which are applied inside defined regions, and which are connected with a positive growth of economic, social and environmental aspects. Regarding this fact, it is spoken about sustainable development of a region. The vision of sustainable development is based on a long-term process, during which it is necessary to accept an array of decisions. They depend mostly on the accessibility of data, information and knowledge and their appropriate coordination on the local, regional and global level. Generally, the development is defined and a process of positive changes which usually aim to improve quantitative (extensive development), but also qualitative (intensive development) characteristics of a given region. A decision can be simply defined as a process of choice between two or more variants. For each decision making, it is important to specify system, its boundaries and surroundings, in which the decision is to be made. For each system,

it is also important to define inputs, outputs, processes and a "human factor", which becomes and active component of the system.

Considering the system of decision making process in the field of public administration and self-government activity, input data and information are gained in the form of agenda carried out by many institutions. Ways of communication and data transferring is set among them. Nevertheless, it cannot be alleged, that all necessary data for regional development planning are available at this management level. Many of them, e. g. data about tourist movement, are missing and are often deducted for example based on economic results. The processual part of the system is represented both by legislative and/or financial tools of regional policy, and certificated methodology and procedures, which are implemented in many assessment processes (e. g. SEA). Their outputs are basis for partial decision making in the form of assessment reports, map outputs and table spreadsheets, or a number of processed strategies and marketing studies for regional development. Besides a professional management, an important role is also played by public, which is, on various level of importance, involved into the discussion about important issues.

Inhomogeneity in methodology for strategic planning can be found in all states both in Europe and worldwide in national and also supranational strategic documents. Documents are often created "ad hoc" using project approach, so that fast and flexible solution can be found and a political will can be implemented. Hence, political decisions are directly transposed to regulations without evidence-based instruments (Koprić, 2018). However, such solutions not always fit into wider framework – regional, national or supranational (Salet and Faudi, 2000). There are attempts of application unified methodological instructions for strategic document developers within the European Union. Methods suitable for strategic planning are proposed, so that efficient strategic planning can be reached.

Looking into strategic documents of European countries, the most often used method in all levels is SWOT analysis, e.g. Hungary National Smart Specialisation Strategy, (NIO, 2014), Croatia, Croatian smart specialisation strategy 2016 – 2020 (MRDEUF, 2016), Finnish national and regional strategies - Lapland's Arctic Specialisation Programme (RCL, 2014) etc. Among other often used methods belong PESTLE, benchmarking, internal capabilities profile analysis, impact analysis, cost benefit analysis, mind maps, comparative analysis or multi-criteria analysis. Also methods such as brainstorming, expert panel and other participative methods or future state index are widely used.

According to Potůček (2006) aforementioned methods are especially suitable for prognostic work. To depict development dynamics, he recommends trend extrapolation, megatrend analysis, Delphi, road maps for science and technologies, decision modelling, scenarios and other. These methods are called processual and require quantitative approach. On the other hand, qualitative methods are suitable for structure identification, here belong for example tree of significance, morphological analyses, future wheels, cross interaction, critical technology etc. Some other authors dealt with the problematics of strategic documents on the scientific level, Rentkova (2017) focuses on regional development support in Slovakia, Oprițescu and Blediman (2017) studied elimination or lowering of significant economic, social and regional disparities, which can be found inside Romania of between Romania and other EU states, Fellenhofer (2017) dealt with individual qualitative and quantitative methods used for strategy creation.

An example of methodology which deals with decision making methods, in the EU context is Guide to Research and Innovation Strategies for Smart Specializations (S3) (EC, 2012). This Guide provides methodology for creation National RIS3 documents (Research and Innovation Strategy for Smart Specialization) in six basic steps. At the initial part, there always

is analysis of regional context and potential, which is used for priority areas determination. No specific unified methodology is declared for this purpose. It is possible to use a lot of methods ranging from purely quantitative to qualitative, combination of both approaches is also often used. Recommended methods are divided into four following areas, but their implication varies in different countries.

Analysis of scientific and technological specialisation is a composite indicator representing quantitative approach. A representative of such composite indicator is used in. It is a composite indicator, which expresses comparative advantage of a region in a given field. It is set on the basis of research and development investment, publication activity and citations and patent application. An advantage of this indicator is, that it enables comparing with other regions, a disadvantage is, that it shows mostly scientific and technological potential than innovation potential for economic benefits.

Another quantitative analysis is used for analysis of regional economic specialisation. A degree of specialization of regional economies is calculated on the basis of employment data. It shows weather a significantly larger number of people are employed in a certain field comparing to other regions or states. However, critical masses of activity can be indicated rather than innovation-driven linkages.

It is important to put these indicators in a relation with other performance indicators such and monitor their time changeability. In the document Croatian smart specialisation stratégy 2016 – 2020 (MRDEUF, 2016) and National Sustainable Development Strategy of Romania 2013-2020-2030 (MESD, 2008), the criteria are compared to European average values.

'Cluster' in-depth case studies and peer reviews represents more qualitative method, which carries out relative specializations. This approach was used for the document Lithuanian Regional Policy, White paper for harmonious and sustainable development 2017- 2030. Value chain analysis, context conditions for the operation of the cluster or labour market situation and analysis of the linkages between the clusters are involved. Also Revealed Skill Relatedness (RSR) according to methodology can be used. It is based on a network analysis and job changes data and measures the degree of proximity between industries in terms of skill requirements. Involving mixed regional and international expert panels enable gaining a better overview in international competitiveness, whilst employing stakeholders from other clusters brings the added value of peer review.

Foresight uses prognostic methods and enables systematic consideration of possible future variants and make them accessible to decision makers. The aim is to enlighten possible future trends and open a discussion about development paths. Among the most often used methods belong expert panel discussion and Delphi method, but a number of other methods either quantitative, qualitative or semi-quantitative can be found in literature.

Quantitative methods are according to Popper (2008) defined as the ones, which use measurable variables. Statistical analysis is employed and previous development is taken into account. Especially, benchmarking, bibliometric, composite indicators, time series analysis, modelling and simulation belong here. The use of quantitative methods such as trend extrapolation and impact assessment are recommended in Moldavian document “Methodology for preparation of strategic development programmes of central public administration authorities” (RDA, 2010). Fellnhofer (2018) places among them also a research study, survey, descriptive analysis, structural equations modelling, factor and cluster analysis, regression and correlation analysis, but also Delphi method. Quantitative approach was also employed for assessing the level of region development in the National Regional Development Strategy of

Republic of Bulgaria for the period 2012 – 2022 (MRDEUF, 2012), or National Sustainable Development Strategy of Romania 2013-2020-2030 (MESD, 2008).

Qualitative methods are generally used more often in strategic document elaboration, although they are considered to be less precise, as they are based on subjectivity and creativity, which are difficult to determine objectively. A cording to Popper (2008) methods such as backcasting, brainstorming, citizen panel, conferences/workshops, scenarios, expert panels, genius forecasting, interview, literature review, morphological analysis, relevance tree, role-play, environmental scanning, Science Fiction Scenario, survey, SWOT analysis, Wild Cards & Weak Signals. Other methods placed here are case studies, classification, theoretical models, road maps, framework analyses etc. (Fellnhofer, 2018). Among the qualitative methods a special attention to the participative methods has to be paid, as they are the most often used ones (Petrusel, 2013). They are namely citizen panel, conference/workshop or expert panel. Their application can be found in elaboration of National Smart Specialization Strategy in Hungary (NIO, 2014), Croatian Smart Specialization Strategy 2016 – 2020 (MRDEUF, 2016). Participative approach is also used on lower levels of government for example in Romania (Haruta and Radu, 2010), or Shannon region, Ireland (CCC, 2013) and higher, superregional, levels, e. g. the document Mediterranean Strategy for Sustainable Development 2016-2025 (UNEP/MAP 2016) was created via iterative dealing of several workgroups, which resulted in suggestions for the strategic document. Panels discussion and expert analysis, which was verified by national surveys of various stakeholders, was used in the case of Lithuanian S3 strategy (Mosta, 2016). The Brainstorming method is recommended in the process of creating the Sustainable Development Strategy of Latvia until 2030 (CM, 2002). Expert panel proposed main goals using the brainstorming method and created possible scenarios for each. After, a wide public discussion was made about proposed scenarios.

Sometimes, the difference between qualitative and quantitative methods is rather fuzzy. In some cases, mathematical principles for subjectivity, rational assessment and point of view quantification are employed in the decision making process. Hence a third group of methods, so called semi-quantitative, is set aside. Among these methods belong, according to Popper (2008), for example Delphi, key/critical technologies, multi-criteria analysis, road maps, quantitative scenarios, stakeholder analysis. Practical use of them have been already mentioned above, an example of application of multi-criteria analysis can be found in Regional Development Strategy of the Czech Republic, period 2014 – 2020 (MRD, 2013).

4. Summary

Qualitative and quantitative decision-making methods offer a wide range of decision-making apparatus, which find their main use mainly in economic and managerial fields. Their applicability in spatially oriented sciences (geosciences) is very well known in connection with multicriteria analysis, less is used game theory, linear programming and others. Both the general global mathematical apparatus and their local variants are described in detail in the literature. Despite constantly improving information technologies and our own methodological procedures, rational decision-making is still difficult and obtaining a uniform result is thus unrealistic. The decision-making process itself, supported by information technologies, must therefore properly process both objective information from the external environment (existing data necessary for decision-making) and the subjective approaches (preferences) of decision-makers. While the subjective attitudes of decision-makers cannot be directly influenced, the

processing of existing data into the required form suitable for decision-making can be set and objectified to some extent.

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