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MULTI CRITERIA DECISION MODELLING: CRUCIAL ISSUE IN BACKCASTING SCENARIO DEVELOPMENT ASSESSMENT

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Abstract: In Bosnia and Herzegovina, sustainable development and climate change is increasingly considered as a matter of key strategic importance, especially by local authorities and the academic community. The State development vision is that by 2030 Bosnia and Herzegovina (B&H) will be a sustainable and progressive 'green economy'. Backcasting approach, having in mind its descriptive character and the problem solving at the very beginning, is much more convenient for solving long–term problems and offering long–term sustainable solutions. Therefore, it is better to consider backcasting as an approach rather than a method. Furthermore, backcasting studies should provide decision–makers and the public in an entirely acceptable and interesting picture of the future of the whole society on which an opinion should be formed for quality decision making. Therefore, the scenarios of the development using the backcasting approach should provide a broad description of the solutions that should be considered for the adoption of final options of different futures. It has been confirmed that the backcasting approach is particularly promising in cases of complex problems, the need for radical changes, in cases where dominant trends are part of the problem and external influences that cannot be sufficiently addressed in the current market. The aim of this article is the identification of the optimal scenario in the selected sectors using the backcasting approach, and their analysis through the Multi–Criteria Decision Modeling (MCDM), by application of DEXi software, to evaluate their acceptability and the possibilities of their use in B&H.
Keywords: Backcasting, scenario development, MCDM, DEXi

1. INTRODUCTION

In Bosnia and Herzegovina (B&H), climate change is increasingly considered as a matter of key strategic importance, especially by local authorities and the academic community. The state development vision is that by 2025 B&H will be a sustainable and progressive "green economy" [1,2]. When B&H joins the European Union (EU), it will have low emissions, high quality of life for all, preserved natural ecosystems, sustainable management of natural resources and a high level of resistance to climate change as a member state. Increased levels of energy efficiency, increased use of renewable energy and improved energy and transport infrastructure and services will lead to attracting international investment, job creation and business entrepreneurship in an economy based on the efficient use of resources. Negative impacts of climate change will be minimized by reducing the level of sensitivity and exploiting climate change opportunities [1,2]. Unlike many other environmental issues, the impact of climate change is not geographically related to their causes. Thus, although B&H is among the countries with the lowest greenhouse gas emissions per capita in Europe (five tons of equivalent carbon dioxide per capita per year, about half of the EU average value), climate change has already been observed [2]. B&H is particularly vulnerable to climate change due to its geographical position, the economic importance of the agriculture and forestry sector, as well as its limited capacity to adapt to climate change.

Implementation of measures for reduction of emission of greenhouse gases (GHG) is optimal opportunity and chance to start, with international professional and financial help, technological transition. However, the problem is many barriers: from ignorance and distrust, to inadequate legal regulations. It is therefore appropriate and necessary to demonstrate technology transfer in B&H, with all their aspects: technical, economic, environmental, market, legal and social. It is very important that after the beginning of the implementation of certain technologies to establish monitoring, to track results and remove all difficulties with introducing new projects [1,2]. Use of renewable energy sources and implementation of energy efficiency measures in the state's energy dependence and improvements in the quality of the environment, as well as increasing the competitiveness of B&H's economy. With properly designed programs, these measures will result in the development of the entire economy. In the last few years, more companies in B&H direct their own activities in the field of production of equipment and systems for the use of renewable energy sources.

2. BACKCASTING SCENARIO DEVELOPMENT

Backcasting approach started in the early 1970s and was originally developed as an alternative to traditional forecasting and planning methods [3]. The focus was on the analysis of energy planning policies and later on examining sustainable solutions in the future, while stakeholder involvement and achievement goals through the implementation of action plans became a significant part of this approach at the beginning of the 21st century. This enables such an approach to be used at the level of organizations, local communities, the region, the industry and other spheres of social development, as well as at the state level and globally [4]. However, backcasting approach is not the only approach that uses descriptive or desirable visions of the future, but it is also possible to recognize it in other approaches that combine descriptive scenarios with stakeholder involvement [5]. In this way, backcasting approach can be viewed as a philosophical concept, both as a study, both as an approach, both as a methodology, and as an interactive process between participants, as an analysis, and as a specific retrograde step (from the desired future) in the whole planning process [4], All this means that backcasting is used to determine whether it is a conceptual or holistic model, a level of sociological and intercultural processes, a level of overall approach and methodologies that contain multiple steps, methods and instruments as well as the level of specific steps, methods and instruments within such approaches and methodology.

Also, although this approach is described as a phase (step by step) and in some way linear it certainly is not. It is possible to repeat individual cycles, and there is a mutual influence of the two phases (steps) that accompany each other [5]. Furthermore, the backcasting process has a dynamic nature, which means that at one time there may be a change in the main actors. Backcasting is normative in nature and problem–oriented, multidisciplinary and involves the participation of all stakeholders, which makes it even transdisciplinary. Interested stakeholders are very important, not only because of their specific content–related knowledge, but also obtaining consent for the results obtained and the implementation of the proposed activities [6].

Backcasting approach, having in mind its descriptive character and the problem solving at the very beginning, is much more convenient for solving long–term problems and offering long–term sustainable solutions. Therefore, it is better to consider backcasting as an approach rather than a method. Furthermore, backcasting studies should provide decision–makers and the public in an entirely acceptable and interesting picture of the future of the whole society on which an opinion should be formed for quality decision making [7]. Therefore, the scenarios of the project (in our case, water management scenarios) using the backcasting approach should provide a wide description of the solutions that should be considered for the adoption of final options of different future [5]. It has been confirmed that the backcasting approach is particularly promising in cases of complex problems, the need for radical changes, in cases where dominant trends are part of the problem and external influences that cannot be sufficiently addressed in the current market. Sustainable development issues clearly combine all the above–mentioned features, and then it is clear why the application of backcasting approaches from the initial energy sector has spread to all sectors of sustainable development [8]. What we refer to as backcasting in the modern world is the so–called participatory backcasting approach. It requires the participation of all stakeholders in the planning process, as already stated at the very beginning of this paper.

Although most literary approaches show certain deviations in the applied methods, the method of involving stakeholders and the number of steps, it is possible to generalize and group them into a single methodological framework for participatory backcasting approach consisting of five stages (steps) [9]:

1. Orientation towards the strategic problem;
2. Developing sustainable vision of the future or scenarios;
3. Backcasting;
4. Development, analysis and defining of all activities with the development of an action plan;
5. Include results and generate later activities and implementations.

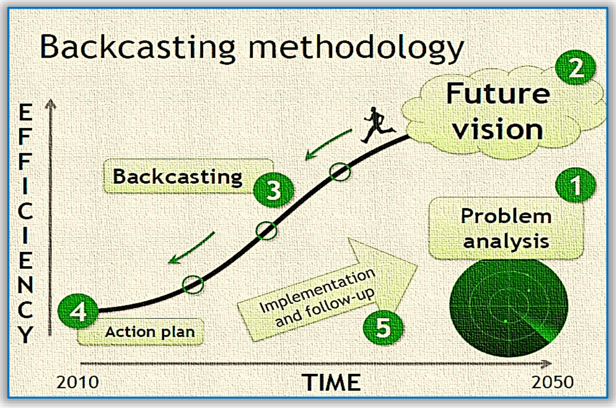

Figure 1. Steps in backcasting

A wide range of methods and tools is necessary when using a participatory backcasting approach and can be divided into four groups of actors, which together constitute the basic backbone of the necessary tools in the process. Participatory tools and methods make the first group [10]. This includes all the tools and methods that are useful for the active involvement of actors and the achievement of an appropriate interaction between them. This includes the specific tools needed to organize and run the workshop, the creative tools and tools needed by the actors in certain backcasting activities, as well as the tools needed to develop a participatory vision and develop scenarios. The second group consists of the tools and methods needed for creation. This is not just about creating scenarios, but also about developing and embedding details of all system elements and creating process tools. The third group consists of analytical methods and tools. This does not only apply to the assessment of scenarios and studies, such as economic analysis or environmental impact analysis, but includes methods for process analysis and assessment, identification of actors and their analysis and analysis of their impact. Since the backcasting approach also requires effective management, coordination in communication, these methods, tools and skills are the fourth group. This includes the methods and skills necessary for effective communication, networking among actors and management of that network. It must be emphasized that each stage of the backcasting approach generally requires some of the methods and tools listed, while some specific methods and tools are used in some specific phases of the process [11].

3. PARTICIPATORY BACKCASTING

The proposed modules for the participatory backcasting framework [12] include 13 modules as explained by Quist in the five–step approach to participatory backcasting discussed earlier in this paper [3] using the module definitions proposed by Baldwin and Clark Participatory Backcasting Modules backcasting were developed on the basis of previous experiences of using participatory backcasting in different conditions, including case studies described in the literature and earlier works of different authors, as well as certain requirements according to planned frameworks and activities. This includes, for example, the recognition of the boundaries within which to act in a certain sector, the roles of different participants in defining the problem, the research of possible available techniques in the given sector through the analysis of different scenarios, and more. Table 1 describes each module of participatory backcasting, its primary goal as well as potential methods that can be applied within the intended module.

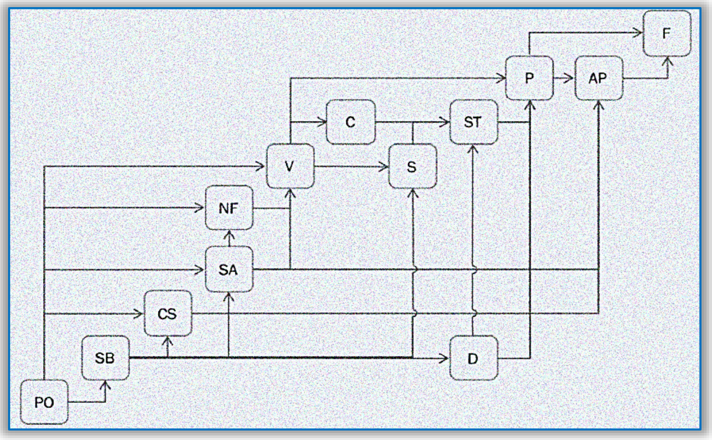

Figure 2. Logical matrix of participatory backcasting and internal connections between modules

Table 1. Participatory backcasting modules

Module	Goal/outputs	Input	Examples of methods
Problem orientation/PO	Formulation and specification of problems within the sector in question	–	Analysis of trends, sustainable assessment of current solutions
System boundaries/SB	Description of different socio–technical boundaries of the system in addition to the already formulated problem (e.g. space, time, socio–political conditions)	BY	Process–based system description, life cycle approach
Current situation/CS	Analysis of the current state of the observed System/sector	PO, SB	Statistics, diagrams
Stakeholder analysis/ SA	Defining the key participants who can influence the problem or can be subjected to the influence of the defined problem	PO, SB	Analysis of the influence of participants, their roles and power to influence solutions
Needs and functions/NF	Examining the current and future functioning of the system and the socio–economic needs that need to be met	PO, SA	Asking the question "What?"
Vision/V	Creating a desirable vision of the future	PO, NF, SA	Exchange of experiences, Brainstorming
Criteria/C	Definition and quantification of the criteria involved in the vision	V	Brainstorming, quantification
Solutions/S	Generation of all possible solutions	V, SB	Exchange of experiences, morphological methods
External factors/D	Identification of external influences that may have an impact on the system, identification of trends and key uncertainties	SB	Brainstorming, analysis of influences that affect system uncertainty, modeling
Solution testing/ST)	Selection of appropriate solutions for eventual application/implementation	S, C, D	Criterion testing, system evaluation and sensitivity testing, sustainability testing, modeling
Pathway/P	Identification and elaboration of identified changes that are necessary and necessary in terms of achieving the desired vision and according to the selected solutions	CS, SA, ST, V	Brainstorming, modeling
Action plan/AP	Creation of a short–term action plan that leads to the realization of designed solutions	CS, SA, P	Project management techniques
Feedback/F (Follow–ups)	Preparation of activities in accordance with possible feedback as well as internal monitoring of implementation and monitoring of project results	P, AP	Brainstorming, implementation monitoring, monitoring, interviews

4. MULTI–CRITERIA (MCDA) ANALYSIS AS A DECISION–MAKING TOOL

Decision–making, i.e. the need for it, is constantly present in all areas of human activity, regardless of whether it is an individual, a group of people, a company, a state, etc. Therefore, the scientific study of the decision–making process, i.e. the development of decision–making theory as a separate scientific discipline, is fully justified.

There are several definitions of the decision–making process itself, in which it is said that it is a process in which a choice is made between several alternatives through a series of interrelated and conditioned actions that take place consecutively towards the ultimate goal – making a certain decision. The decision as such is the result of the decision–making process and is made in order to fulfill the set goals in the observed problem.

The purpose of decision–making is to reach a certain decision. The term purpose implies the justification of the procedure, and the decision is the result achieved by that procedure. At the same time, the decision made, as a result of the process, can:

≡ fully achieve the set goal (fulfill the vision)

≡ partially achieve the goal

≡ not achieve the given goal

Since a decision is made in the present on the basis of a situation that occurred in the past, it follows that it is not independent of previously made decisions. Since its consequences will only be realized in the future, it is not independent of the decisions yet to be made. Therefore, the following parameters are usually taken into account when making a decision:

a) the importance or importance expressed through the goals to be achieved by the decision;
b) the time required to make a decision (the decision should be made in a timely manner);
c) costs that must be lower than the value of the decision itself, and it should be noted that the price of a bad decision can be very high;
d) the degree of complexity of the decision, which is determined by the analysis of a large number of data, their mutual dependence, reliability and completeness.

In real problems, requirements are often set for the achievement of multiple interrelated goals, where each individual goal is influenced by a large number of factors. Therefore, the decision is made by analyzing the most important factors at the moment – choosing the appropriate criteria and the desire to achieve as many goals as possible at the same time.

The backcasting approach is basically a participatory process in which all interested parties are given the opportunity to express their opinions and observations, as well as proposals for some decisions. Knowing that, in most societies, we often have a situation where the opinions of interested parties are often opposed (e.g. the situation surrounding the construction of small hydroelectric power plants, which is present in most countries, where on the one hand there are civil society organizations dealing with environmental protection and on the other hand individual investors/business sector and possibly competent ministries that want to increase the share of electricity production from renewable sources in this way), through the backcasting process and mediation between interested parties, it is necessary to reach a common solution. This can be a very long, demanding, arduous and expensive process that no one can guarantee will ultimately offer a solution that is acceptable to all parties. This means that, in practice, backcasting is very often not possible in its original

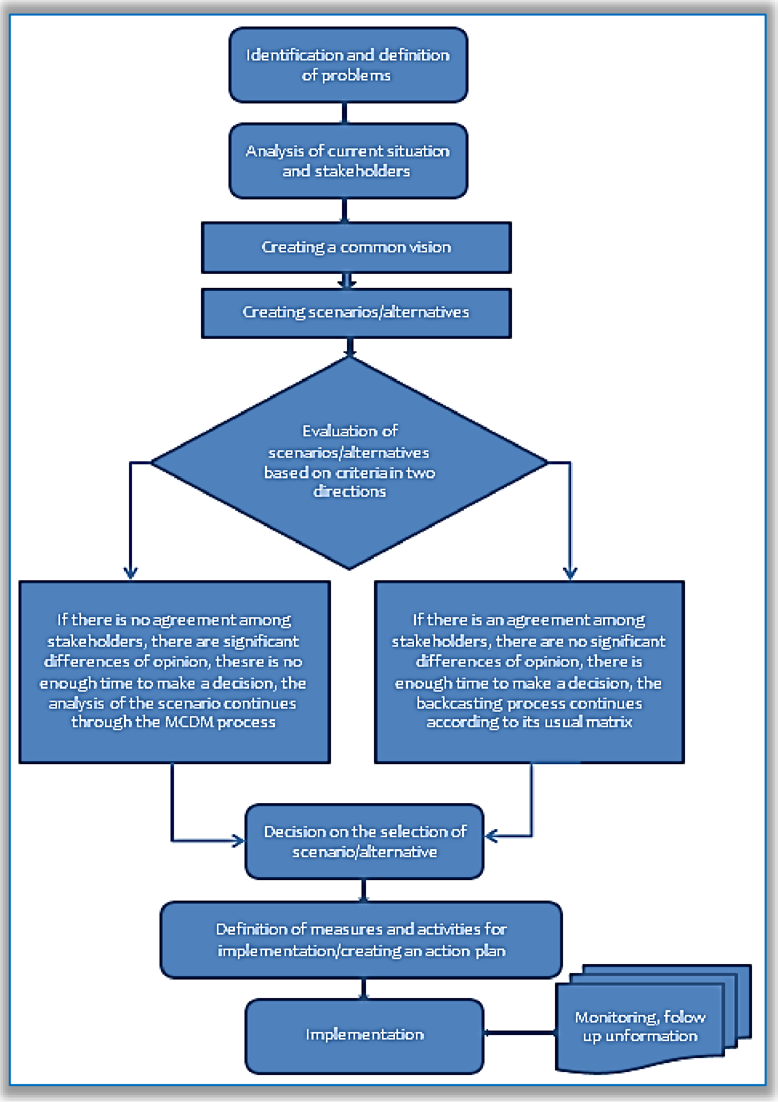

Figure 3. MCDM integration matrix in participatory backcasting

form, and in that case it is necessary to undertake measures and activities that can offer an optimal solution to all parties in the process in a clear and comprehensible manner.

For this type of problem, the Multi–Criteria Decision Modeling (MCDM) methods are used, analogous to the Multi–Criteria Analysis–MCDA, which evaluate decision alternatives using multiple criteria. Each alternative is first evaluated against each criterion, and each criterion is evaluated based on the associated indicators. These individual assessments are combined into a general assessment of the alternative, which provides the basis for comparison, ranking and analysis of alternatives, and eventual selection of the optimal solution.

After the stakeholders agree that the result of the MCDM is acceptable to all, further steps defined by the backcasting approach can be taken: defining the measures and activities required for implementation, that is, creating an action plan and implementing it.

The proposed process with MCDM modification can be represented by the following algorithm, presented in Figure 3.

Through work on this paper, the following facts were established in the process itself:

- the problem of sustainable development was identified and defined;
- climate changes were observed and defined, as well as their scenarios in the future period through reports sent to the UNFCCC Secretariat;
- during the drafting of strategic documents at the BiH level, a common vision was created and adopted;
- through the backcasting process during the preparation of these documents, different scenarios were created that meet the conditions of sustainable development and climate change;
- no joint decision was made on choosing the optimal scenario;
- defined measures and activities, that is, the proposed action plan does not have the consent of all interested parties involved in the process;
- insufficient cooperation of competent institutions and other bodies, bearing in mind the complex arrangement of BiH;
- political uncertainty, both locally and globally;
- lack of financial resources and insufficient allocations for this issue;
- time limits set by accepted obligations from the Paris Agreement, the Energy Community and other international treaties and agreements;
- the lack of a significant number of statistical data needed to monitor certain indicators and criteria;
- the vulnerability of BiH in relation to changes at the global level: pandemics, political events

Bearing in mind the above facts, it is quite clear that the process of developing the scenario that is the subject of the dissertation could not be done according to the usual matrix of participatory backcasting, but required intervention and the inclusion of MCDM methods in order to significantly speed up the process and evaluate the developed scenarios on the basis of available data .

5. MCDM MODELING

The basic software tool used for the purposes of MCD modeling in this paper is DEXi (http://kt.ijs.si/MarkoBohanec/dexi.html), which is a computer program for decision–making with multiple criteria/attributes. Like all other MCDM methods, it is aimed at evaluating and analyzing a set of decision alternatives $A = \{a_1, a_2, ..., a_m\}$. These alternatives are described by a set of variables $X = \{k_1, k_2, ..., k_n\}$, which are called criteria/attributes. Each criterion/attribute represents some observed or evaluated property of alternatives, such as "cost", "quality" and "efficiency".

It is characterized by the interactive development of qualitative decision models with multiple criteria/attributes and the evaluation of options, which can be very useful for supporting complex decision–making tasks, where there is a need to select a certain option from a set of possible ones in order to satisfy the goals of the decision–maker. A multi–criteria/attribute model is a hierarchical structure that represents the decomposition of a decision problem into sub–problems, which are smaller, less complex and probably easier to solve than the complete problem.

The models developed by DEXi are qualitative and generally consist of qualitative (discrete) criteria/attributes. This makes DEXi particularly suitable for solving sorting/classification decision–making and analysis tasks, where options must be placed into a finite number of pre–defined categories. This method is based on rules. The bottom–up aggregation of alternative values is defined in terms of decision rules, which are determined by the decision maker and are usually presented in the form of decision tables. Each aggregate criterion/attribute in the model has an associated decision table that defines how the value of that criterion/attribute is determined (aggregated) from the values of its immediate descendants in the hierarchy. Finally, after defining the criteria/attributes, their structure and corresponding indicators, scales (range of values) and decision rules, the model is ready for the evaluation of alternatives. In the case where all decision tables and alternatives are fully defined, this is a simple bottom–up aggregation procedure. Each alternative is described by the values of the basic criteria/attributes, using one qualitative value for each criterion/attribute. These values are gradually aggregated towards the roots of the hierarchy. The value of each aggregate criterion/attribute and its "weight" (the share of an individual criterion/attribute in the total evaluation of the proposed model) on that path is determined by a simple search in the appropriate decision table. For cases where decision tables or decision alternatives are not fully defined (due to uncertainty, missing information, or decision maker uncertainty), DEXi provides a set–based evaluation procedure.

The introduction of numerical attributes in DEXi aims to expand the use of the method, so that both discrete and numerical attributes can be used and combined in one model. The desire is to do this in a general and flexible way, with absolute certainty that the numerical attributes are well integrated into the existing framework. The goal is not to introduce any specific quantitative MCDA method into DEXi, but to provide a flexible scheme that allows the use of different quantitative methods to elicit numerical attributes, their weights, and utility functions.

Adding numeric attributes requires a number of representational and algorithmic extensions, such as adding numeric aggregation functions and handling transformations between qualitative and numeric values. The attribute value scale must be extended to include real numbers, integers, bounded intervals over real numbers, and bounded integer intervals.

6. MAKING A DECISION

Decision Analysis is a discipline popularly known as "Applied Decision Theory". It provides a framework for analyzing decision problems through:

≡ structuring and breaking down into parts that are easier to manage,
≡ explicit consideration of possible options (alternatives), available information, involved uncertainties and relevant preferences of decision makers,
≡ combining them to arrive at optimal or at least 'good enough' decisions.

Decision Analysis, like the DEXi software package, aims to support people in making decisions, not to make decisions themselves. For this purpose, they provide methods and tools for developing decision models and using them for evaluation and analysis of options.

In decision analysis, the decision problem is primarily understood as a choice problem, which is defined as follows:

≡ given a set of options (also called alternatives), which typically represent some object or action
≡ choose the option that best meets the goals (goals) of the decision maker, or
≡ rank the options according to these goals.
≡ making choices usually occurs as part of the decision–making process.

Decision analysis, as well as DEXs, are particularly interesting for complex decision–making problems, that is, problems that the decision–maker considers difficult for some reason and require careful elaboration and analysis. Complex decision problems are usually characterized by:

≡ News: the decision maker is facing a problem for the first time and does not have enough knowledge or skills to solve the problem;
≡ Ambiguity: unclear understanding of the problem and its goals, unknown or incompletely defined options;
≡ Uncertainty: the existence of possible events that cannot be controlled by the decision–maker, but may affect the decision or its consequences (for example: competition reaction, weather conditions);
≡ Multiple and possibly conflicting goals;
≡ Group decision–making: involving different decision–makers or groups that have different and possibly conflicting goals;
≡ Important consequences of the decision (such as possible large financial losses or environmental impacts);
≡ Limited resources for carrying out the decision–making process (most often: available time and expertise).

The ultimate goal of the decision–making process is solving the decision–making problem that is, making a decision. In decision analysis, the decision process is understood as a process of careful and in–depth analysis of the decision problem. It involves the systematic acquisition and organization of knowledge about the decision problem by the participants in the decision process and usually includes:

≡ problem assessment,
≡ gathering and verifying information,
≡ recognition of options (alternatives),

- predicting the consequences of decisions,
- making choices using sound and logical judgment based on available information,
- explanation and informing others about the decision and its explanation,
- evaluating decisions and their consequences.

In general, such a process should:

- provide all the information needed for a 'good enough' decision,
- reduce the possibility of overlooking important information and making other mistakes,
- improve the effectiveness and efficiency of decision–making, and
- improve the quality of the decision itself.

Usually the decision process includes at least the following steps:

1. Problem identification
2. Modeling: development of decision models
3. Evaluation and analysis of options
4. Choice: making a decision
5. Implementation of the decision

The DEXi decision support tool is primarily used in steps 2 and 3.

7. RESULTS AND DISCUSSION

As already stated, the process of evaluating the sustainable development scenario can be represented by the following steps:

1. Selection of appropriate indicators and their grouping into criteria (economic, social, ecological, energy and climate)
2. Calculation of CAGR values for each indicator and assigning a corresponding description (converting quantitative to qualitative values): Significant progress/on track, Decent progress, but acceleration needed, Limited or no progress, Deterioration
3. Defining risks and corresponding values for each risk
4. Formation of a decision tree consisting of criteria and risks
5. Definition of service functions, which, based on the values of indicators and individual risks, calculate values for criteria (Goal met or almost met, Close to the goal, Moderate distance to the goal, Far from the goal, Very far from the goal) and risk (very high, high, moderate , low, very low) form ratings (the proposed scenario is not acceptable; the proposed scenario requires major corrections; the proposed scenario is acceptable with minor corrections, and the proposed scenario is optimal) for each proposed scenario, i.e. the scenario that is to be analyzed
6. Entry of options (indicator values) for each scenario that is the subject of analysis
7. Evaluation and analysis of results

Looking at the comprehensively obtained results, the following can be concluded:

- By adequately defining integral and sectoral strategies that will fully take into account climate change scenarios and the challenges of sustainable development through a backcasting approach, the set goals can be achieved and the vision can be fulfilled
- In cases where, due to justified reasons, it is not possible to fully implement participatory backcasting in its full form, the use of MCDM can adequately respond to the challenges and even speed up the whole process.
- By combining backcasting and MCDM tools, the process of defining appropriate scenarios is significantly accelerated, less resources are consumed and it enables the participation of all social actors, even those who do not have the necessary technical knowledge in the chosen sector.
- An optimal sustainable development scenario can be modeled using backcasting methods and appropriate MCDM tools in relation to the reference environment and supporting parameters
- With the appropriate selection of criteria and indicators with an adequate database, the developed model of combining backcasting with MDCM tools can be successfully applied in other countries, regardless of their development.
- The developed model for the selection of sustainable development scenarios should be made available to all social actors, especially decision makers, with constant improvement.

Experiences with the application of backcasting in the process of developing sustainable development scenarios with the use of MCDM tools can be summarized as follows:

- The MDCM methodology represents a solid framework for the systematic implementation of the process with a clear connection between the different steps in the process;

≡ the application of the MCDM methodology in Bosnia and Herzegovina was hampered by uncertainties and lack of information, which made it impossible to quantify certain elements and made the assessment of indicators less precise;
≡ the introduction of multi–criteria decision modeling (MCDM) into the scenario evaluation procedure gave a new quality to the entire process and offered a possible model for further consideration of sustainable development options in the country;
≡ tools and sources of information recommended by MCDM and DEXi software package facilitated the process, and at the same time, the need to improve information and technical solutions to support the process was identified;

Note: This paper was presented at International Conference on Applied Sciences – ICAS2022, organized by University Politehnica Timisoara, Faculty of Engineering Hunedoara (ROMANIA) and University of Banja Luka, Faculty of Mechanical Engineering Banja Luka (BOSNIA & HERZEGOVINA), in May 25–28, 2022, in Banja Luka (BOSNIA & HERZEGOVINA).

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