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Communication

The Development of an Online Decision Support System to Select Optimal Nature-Based Solutions to Protect Streams and the Sea

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Abstract: Nonpoint source pollutants primarily originate from agricultural areas, settlements, and contaminated lands. Soil erosion and deposition are the means of transportation of pollutants since soil particles not only absorb but also transport contaminants through the stream network. Nature-based solutions (NbSs) are quite popular around the world to mitigate soil erosion and deposition, which has accelerated due to climate change and other anthropogenic activities. To promote their adoption, we developed an online decision support system (DSS) to provide land and water managers and particularly stakeholders with the optimal NbSs and ecosystem-based approaches (EbAs) that could help protect watersheds, streams, and consequently seas from pollutants. This DSS incorporates a descriptive data management system to handle datasets (questions, answers/criteria, outputs/solutions) from various stakeholders (e.g., policymakers, urban planners, environmentalists) and other non-experts. The questions of the DSS are related to different characteristics (criteria) of the areas of interest for the NbS or EbA. The questions provide various answers (which serve as descriptive data) in order to weigh the criteria/characteristics and, ultimately, the proposed NbS. The NbSs of the DSS were recorded based on a bibliographic review and from stakeholders' responses via forums, meetings, workshops, etc. The primary testing results by stakeholders showed that the online DSS has the potential to be used as a complementary service in the near future. Specifically, it can provide the optimal NbS based on the participants' answers about the study area. This communication paper may act as an invitation to reach a greater audience of stakeholders for the improvement of the online DSS.

Keywords: decision support system; ecosystem-based approaches; management tool; nature-based solutions; nonpoint source pollutants; online platform; stakeholders tool

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1. Introduction

Decision-making is the process of selecting one alternative activity from a set of alternative possibilities in order to ensure the achievement of the expected goals [1]. The existence of an issue or problem that requires analysis is an obligatory rule in order to implement a decision-making process. An issue or problem is defined as a situation where a deviation between the existing and the desired state is found [2]. Whether decisions are critical or less important, as well as the complexity that certain problems present, are key factors for decision-making. A decision is usually made on the basis of multiple relevant criteria [3]. Overall, decision-making is a demanding process since the different relevant criteria entail the evaluation of many attributes [4]. The elements that make up the set of information regarding the decision problem can be quantitative and/or qualitative [5]. The main difficulty in the second case lies in the quantification of some qualitative data, which increases the difficulty of objective evaluation [6]. This means that, in decision-making, in many cases, a compromise by the decision-makers is required in relation to the goals that have been determined [7,8]. So, typically, the systematic support of a decision demands the utilization of methods that can incorporate quantitative and qualitative data to provide objective criteria [9]. Such methods are used to solve problems related to the evaluation of projects, plans, programs, and policies [10].

The need to support decision-making, either for everyday problems or in solving complex and more critical problems (especially where there are multiple contradicting criteria), has led to the study and development of a specific set of methods. These methods are commonly referred to under the general term of multi-criteria decision-making or multi-criteria decision analysis (MCDM/MCDA) [11]. Another term found in international literature is multi-criteria decision aid [12]. The objective of MCDM/MCDA methods is to help decision-makers organize the information they have collected and significantly facilitate their final decision/selection [13]. Overall, MCDA is a major analytical and decision-making tool that has many applications in both the public and private sectors [14]. In MCDA problems, a reasonable number of parameters/criteria are usually involved. These parameters are weighted based on their influence on the decision-making [15]. Their examination in MDCA leads to the most rational possible decision that is the closest to the ideal, although it must be noted that this does not always imply that they are an excellent or optimal solution [16,17].

Furthermore, decision support systems (DSSs) have been developed to support MCDA methods and facilitate the decision-making process [18]. A DSS is a software-based tool designed to analyze complex data and provide the relevant information necessary to develop, assess, and execute actions to solve a given problem/situation [19]. The history of the implementation of such systems begins in the mid-1960s with the development of minicomputers [20]. Nowadays, there are many software available for multiple decision analysis. Some of them are commercial, while others are free (e.g., 1000 Minds, BENSOLVE, Expert Choise, DECISIONARIUM, PROMETHEE-GAIA, Super Decisions, Expert Choice, etc.) [21,22]. Recently, various DSSs have been developed to support individual decision-makers, workgroups, and virtual users through internet web technologies on online platforms [23–25]. These online platforms can be based on model-driven DSSs, data-driven DSSs, communication-driven DSSs, document-driven DSSs, and knowledge-driven DSSs [26–29]. Various technical methodologies and algorithms exist for DSSs to evaluate and design energy systems based on the optimization of either single or multiple criteria [30]. Table 1 presents a number of popular decision analysis methods found in the literature (the list is not exhaustive):

Table 1. A list of examples of decision analysis methods found in the literature.

Nr	Method	Abbreviation
1	Aggregated indices randomization method	AIRM
2	Analytic hierarchy process	AHP
3	Analytic network process	ANP
4	Data envelopment analysis	DEA
5	Dominance-based rough set approach	DRSA
6	Élimination et choix traduisant la réalite	ELECTRE
7	The evidential reasoning approach	ER
8	Goal programming	GP
9	Grey relational analysis	GRA
10	Inner product of vectors	IPV
11	Multi-attribute global inference of quality	MAGIQ
12	New approach to appraisal	NATA
13	Nonstructural fuzzy decision support system	NSFDSS
14	Potentially all pairwise rankings of all possible alternatives	PAPRIKA
15	Preference ranking organization methods for enrichment of evaluation	PROMETHEE
16	Superiority and inferiority ranking method	SIR Method
17	Value analysis	VA
18	Value engineering	VE
19	Weighted product model	WPM
20	Weighted sum model	WSM

Nature-based solutions (NbSs) involve a group of solutions based on natural practices and ecosystem services to resolve diverse societal challenges, such as green infrastructure, ecological engineering, ecological restoration, forest landscape restoration, area-based conservation, ecosystem-based management, natural infrastructure, ecosystem-based adaptation, ecosystem-based disaster risk reduction, ecosystem-based mitigation, and climate adaptation services [26,27]. The term NbS has evolved through time, involving low-impact developments (LIDs), best management practices (BMPs), water-sensitive urban design (WSUD), sustainable urban drainage systems (SuDs), green infrastructure (GI), blue–green infrastructure (BGI), and ecosystem-based adaptation (EbA) [28]. The European Commission (EC) has defined NbS as "...living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits" [29,30]. The restoration of degraded landscapes using NbSs has proven to be more sustainable and effective than common engineering solutions [31]. In some cases, the implementation of green and blue infrastructure strategies alone is not enough, so the adoption or coupling with grey infrastructure as a hybrid approach is necessary [32]. Engineering structures provide instant and quantifiable impacts to reduce immediate threats, but in most cases, they are costlier and do not have the ability to deliver environmental benefits [33]. On the other hand, NbSs take a longer time to provide the mitigating or restoration results but are less expensive, more sustainable solutions and provide additional benefits such as livelihood and ecotourism opportunities compared to engineering solutions [34,35]. These are solutions that can also modify engineering structures to make them more environment-friendly, for example, by incorporating vegetative aspects into pre-existing engineering structures [36]. NbSs are a "must" management practice due to the increasing urbanization, climate change phenomena, and long-term mitigating effects and sustainability [37,38]. Still, effective management for entire watersheds using NbSs requires joint decision-making across multiple government agencies that manage agriculture, fisheries, forest, and water resources, as well as engaging with stakeholders to address their needs [39,40].

Many research projects have developed DSSs in the fields of agriculture, environmental, and landscape management, although, unfortunately, these tools often fail to be adopted by the targeted end users [41,42]. Still, their implementation is rapidly progressing, including the involvement of stakeholders [43,44]. Although there are many MCDA applications, including NbSs for risk management and green space planning [45], these are only a few early attempts by DSSs to propose the optimal NbS [46,47], with only one that is online focusing on wastewater treatment [48]. This paper describes a web-based DSS that integrates stakeholders' input and data to support effective decision-making in the selection and implementation of NbSs. The DSS incorporates a simple descriptive data management system to handle datasets (questions, answers/criteria, outputs/solutions) from different stakeholders (e.g., policymakers, urban planners, environmentalists) and non-experts. The goal was to provide an intuitive, user-friendly interface with interactive features that would result in higher user engagement and satisfaction. Furthermore, this DSS includes mechanisms for continuous monitoring, feedback, and editing and is more adaptable to changing conditions and new information, thereby improving the long-term success of NbS projects. To our knowledge, this is the first attempt to develop an online DSS focused on NbSs to mitigate nonpoint source pollutants. This system could be applied in different study areas to recommend the optimal NbS to mitigate nonpoint source pollutants and enhance climate resilience.

2. Materials and Methods

2.1. The Online DSS System

There are many developed DSSs for common uses (e.g., farmers use crop-planning tools to determine the best time to plant, fertilize, and reap). Such DSSs require a mix of descriptive and quantitative datasets in order to provide the best decisions. Most such systems share a common attribute: the decisions are repetitive and based on known data. A model-driven DSS, using data and parameters provided by decision-makers, was selected for the scope of this study. Specifically, the presented DSS tool uses descriptive data (input from the users) gathered through certain relevant questions that are highly correlated with the description of the area of interest for the implementation of an NbS. The questions provide various options as answers (which serve as descriptive data) in order to weigh the relevant criteria. The weights can be either on a scale (e.g., low to high erosion) or a yes/no selection. Each selection/answer is correlated to an NbS while the multiple flow paths lead to a logical correlation with the optimal NbS that should be implemented based on the general data of the area of interest. This is different from a business-model DSS system (such as a SWOT analysis, decision matrix, Pareto analysis, or cost–benefit analysis), which can provide the strengths or weaknesses of certain proposed options. This specific DDS contains an online questionnaire that allows the participants to easily follow it, and also record all their responses in a log file automatically. The DSS was developed on a free website and functions similarly to a personality test form. The DSS helps users select the best management practices and specifically recommends optimal NbS and EbA. The user of this system will determine the different parameters and input them in the system based on selected questions concerning the area of interest for the implementation of the NbSs. Each answer is an input parameter associated with specific outcomes (NbSs). This online system will propose best management practices focusing on the Black Sea region countries. As a result, this system is triggered by the user's selection and is able to propose, based on data from both the online database and the multi-criteria decision analysis (data that were collected/resulted from the previous activities of the BSB963 project), the optimal best management practice. The system is online, free, user-friendly (also providing images to be more easily understandable to stakeholders), and easy and quick to use. It also has shared options for the results, and the link can be distributed to many different social accounts (Facebook, Twitter, WhatsApp, Pinterest, Reddit, Tumblr, and LinkedIn). There are also many options for embedding it in websites as a link or a direct application (see next sections). Finally, there is the possibility to provide feedback or discuss with other users on social media after the completion of the process. The link to the online DSS is provided on the project website (http://websites3.teiemt.gr/p4sea/index.php/deliverables/dss, accessed on 8 April 2024).

2.2. Questions for the DSS

To select the best management practices, a simple and representative questionnaire was developed that used different criteria to provide the necessary data for optimal decisions. Specifically, there were nine questions/criteria highly related to pollution from soil erosion/deposition and other disastrous phenomena. Each question had different potential answers to select that were associated with specific outcomes. The questions were accompanied by clear images to be user-friendly to participants, particularly those who do not have the necessary background. The criteria/questions are presented in a step-by-step procedure below (see Figure 1):

- What is the general type of your study area?
  - Urban;
  - Agricultural;
  - Forests;
  - Pastures/Grasslands;
  - Wetlands/Lakes/Ponds;
  - Coastal.
- What is the average elevation range of your study area?
  - 0–50 m;
  - 50–300 m;
  - 300–1000 m;

- ◦ >1000 m;
- ◦ Do not know/answer.

- What is the average slope gradient of your study area?
  - ◦ Flat area (0–3%);
  - ◦ Gentle slope (3–10%);
  - ◦ Moderate slope (10–15%);
  - ◦ Steep slope (15–30%);
  - ◦ Extremely steep slope (30–60%);
  - ◦ Excessively steep slope (>60%);
  - ◦ Do not know/answer.
- What is the type of hydrographic network in your study area?
  - ◦ Mountain gullies;
  - ◦ Torrential/ephemeral flow;
  - ◦ Ephemeral or intermittent streams;
  - ◦ River (perennial flow);
  - ◦ Constructed channels/irrigation network;
  - ◦ Do not know/answer.
- What is the streambed/streambank material of your study area?
  - ◦ Solid rock formation;
  - ◦ Boulders (diameter: 256–4096 mm);
  - ◦ Cobbles (diameter: 64–256 mm);
  - ◦ Pebbles (diameter: 2–64 mm);
  - ◦ Granules (diameter: 2–64 mm);
  - ◦ Sand (diameter: 0.0625–2 mm);
  - ◦ Silt (diameter: 0.002–0.0625 mm);
  - ◦ Clay (diameter: <0.002 mm);
  - ◦ Do not know/answer.
- What are the vegetation conditions of your study area?
  - ◦ Dense high/low vegetation;
  - ◦ Sparse vegetation/bare land;
  - ◦ Do not know/answer.
- What are the geologic/soil conditions of your study area?
  - ◦ Rock/sand;
  - ◦ Loam/clay;
  - ◦ Do not know/answer.
- Have you noticed any erosion/deposition phenomena or degradation in your study area?
  - ◦ Yes;
  - ◦ No;
  - ◦ Do not know/answer.
- Have you noticed any climate-change-induced extreme events in your study area?
  - ◦ Yes;
  - ◦ No;
  - ◦ Do not know/answer.

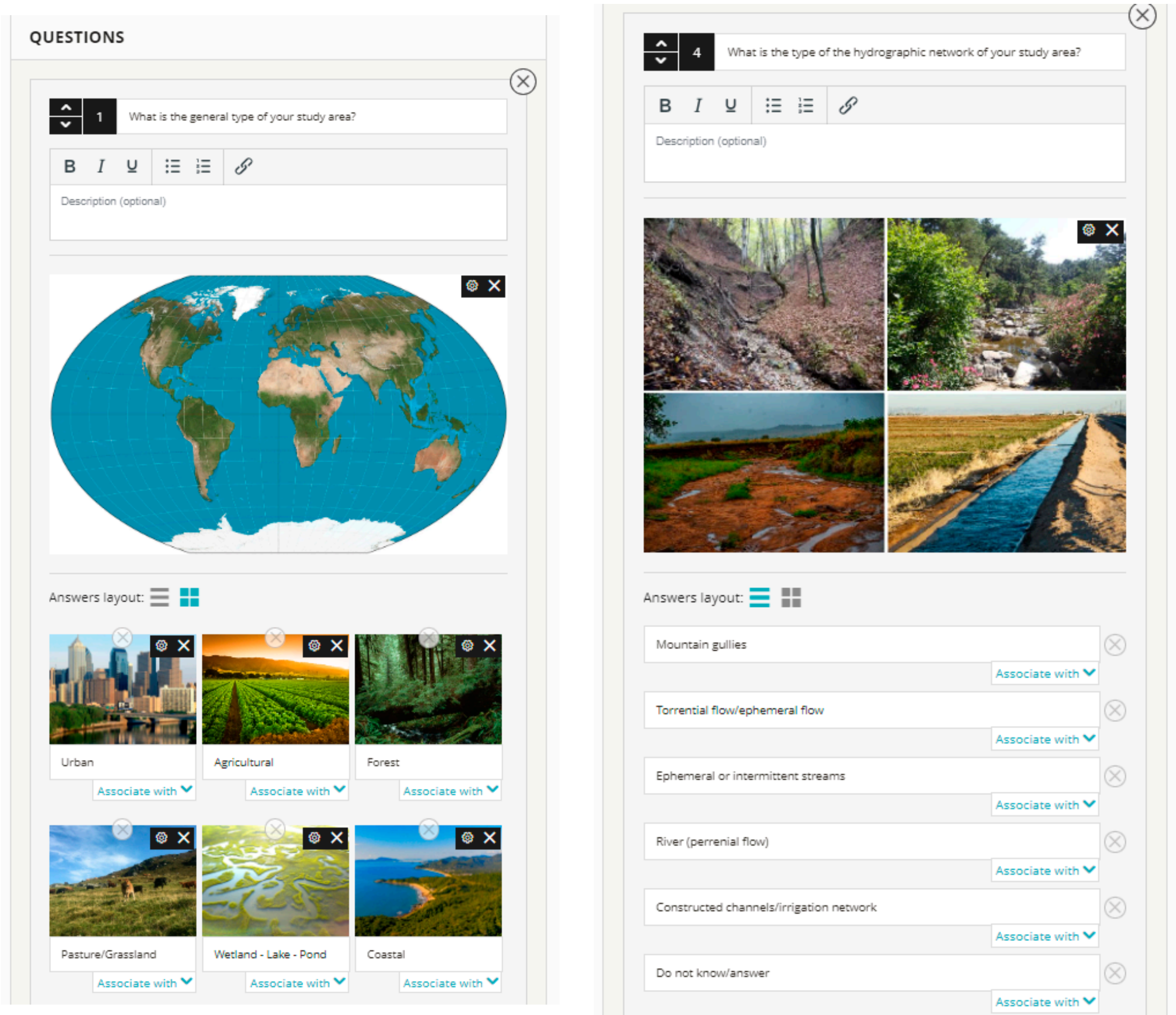

Figure 1. An example of DSS questions: (**a**) the general type of the study area; (**b**) the type of hydrographic network in the study area.

2.3. Best Management Solutions Proposed by the DSS

The proposed best management solutions are highly associated with the specific answers from the online questionnaire. The questionnaire consists of nine questions concerning the area of interest, as described in the previous subsection. The proposed best management solutions (see Figure 2) were found based on the activities of the BSB963 project. These activities included a thorough review of best management practices for the Black Sea region, a discussion forum with the project network members, feedback from stakeholders during the project's international conference, five workshops, and ten awareness events. The DSS grouped the optimal NbSs into the following categories: (a) coastal—solutions focused on coasts; (b) agricultural—solutions focused on pastures and terraces; (c) land and water—solutions for the entire watershed; (d) mixed blue–green–grey—solutions focused on urban environments; but also (e) policies and (f) stakeholders' participation. In the following paragraphs, we describe the pressured and potential NbSs for these categories:

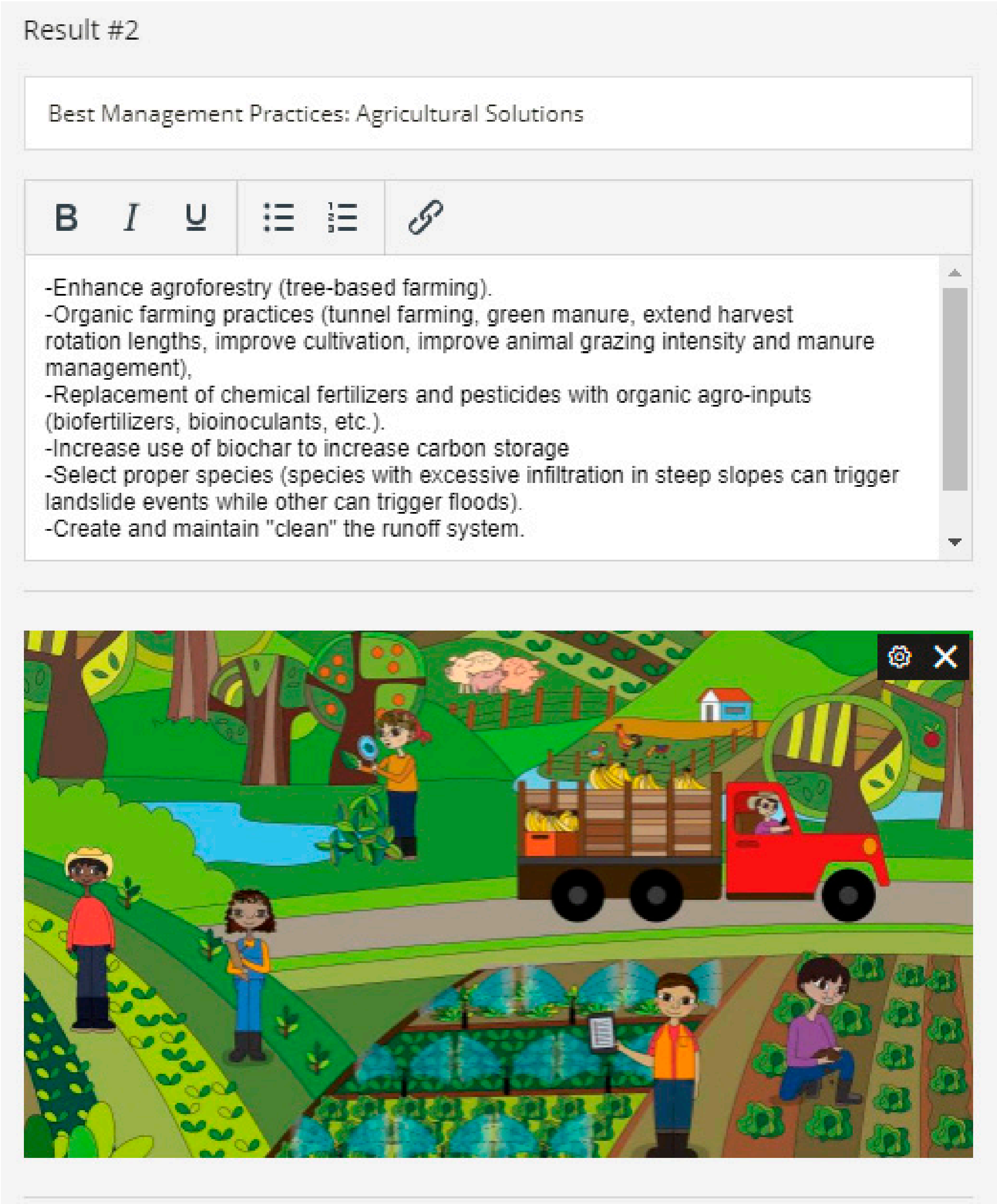

Figure 2. An example of a potential outcome related to "agricultural solutions" containing different best management practices.

One of the most significant services of natural ecosystems is the maintenance/improvement or regulation of freshwater quality. There are multiple benefits to the application of NbSs and EbA in freshwater ecosystems and the surrounding habitats (microbes, algae, plants, invertebrates, fish, reptiles, amphibians, and mammals) [49]. Using organisms to assess and monitor the freshwater quality and the assessment of environmental flows to conserve habitats and biodiversity are indicators used for ecosystem health that are related to the implementation of NbSs [50]. Human civilizations are closely connected with water buffer zones (wetlands, coasts, rivers), and these have co-evolved to meet human survival and sustenance needs. So, water buffer zones have the capacity to provide multiple services of great social, economic, and environmental value to humankind and mitigate water-mediated disaster risk [51]. NbSs can be applied in diverse environments and at various scales, from small-scale (ecosystem elements, a small pond) to large-scale (entire coastal stretches or floodplain restoration with small dams and weirs made of natural materials like gabions) [52–54]. Coastal areas include river estuaries, beaches and dunes, salt marshes, seagrass beds, and mangroves [55]. These environments are characterized as vulnerable spots due to climate change and the associated sea-level rise, together with drivers such as land subsidence, reduced sediment supply (due to dams), and coastal squeeze [56]. All the above represent major risk factors for coastal system sustainability. A hybrid approach combining NbSs and soft eco-engineering is optimal as a coastal defense measure to mitigate these risk factors [57,58].

Vegetation planting is the most common NbS practice applicable in every environment since it plays an important role in ecosystem services and is relatively easy to implement [59]. The increase in areas of grassland, fast-growing, high-biomass-yielding fodder trees, and deep-rooted plants (trees, shrubs, and herbs) can increase soil infiltration, reduce surface runoff, and enhance slope stability [60–62]. In most cases, slope stabilization and mitigation of landslide risks can be achieved more effectively by a hybrid approach: a combination of civil engineering, ecoengineering, bioengineering, and NbSs (e.g., bioengineering-based gabions and wire check dams to control gully erosion) [63,64]. Different vegetation species with high potential for slope stabilization have been identified (e.g., trees: *Acer campbellii*, *Alnus nepalensis*, *Pinus wallichiana*, *Rhododendron arboreum*, and *Tsuga Dumosa*; shrubs: *Artemisia nilagirica*, *Arundinaria maling*, *Coriaria nepalensis*, *Daphne papyracea*, *Euphorbia sikkimensis*, and *Pipthanthus nepalensis*; herbaceous species: *Ageratum conyzoides*, *Oplismenus compositus*, *Persicaria capitata*, *Pilea umbrosa*, *Plantago erosa*, *Polygonum hydropiper*, *Polygonum molle*, *Primula bracteosa*, *Primula denticulata*, *Rumex nepalensis*, and *Urtica dioica;* and climber species: *Celastrus paniculatus*, *Dioscorea bulbifera*, *Hedera nepalensis*, *Holboellia latifolia*, *Periploca callophylla*, *Philadelphus tomentosus*, *Rubia cordifolia*, *Stephania glandulifera*, and *Thladiantha cordifolia* [65]. While tree planting is typically an effective NbS to mitigate climate change, there are occasions, especially when planting non-native species, that can negatively impact both biodiversity and ecosystem services, displacing native species [66]. As an example, *Prosopis juliflora* was planted in Northwest India to reduce the desert cover, but it led to negative consequences by dominating native plant species, particularly in grasslands [67]. It must be noted that each area has unique characteristics based on geographic, structural, and environmental parameters (e.g., geology, soil, hydrology, climate, topography, land cover, cultural influences, and land-use practices) that need to be accounted for [68].

NbSs can deliver triple benefits in agricultural production and resilience by mitigating climate change and enhancing both nature and biodiversity. Organic farming practices, such as the use of green manure, biofertilizers, bioinoculants, and the replacement of chemical fertilizers and pesticides with organic agro-inputs, are considered the best NbS for farmlands [69]. Furthermore, agroforestry is considered a successful example of achieving the Sustainable Development Goals (SDGs) [70]. Agroforestry enhances farmers' ability to adapt to climate change while delivering multiple ecological, social, and economic benefits [71]. Tree-based farming provides high income by increasing farm productivity and profitability in combination with the many ecosystem benefits [72]. Farming techniques such as terraces, natural fallow, or regeneration can also increase ecological health. Green infrastructure in country houses/warehouses (e.g., grass strips, hedgerows, or terraces using natural materials) are also good practices for slope stabilization and eco-sustainable planning [73]. Overall, green infrastructure performs equally or even better than grey infrastructure for water purification and flood protection, even though costs are similar, while also providing additional benefits (e.g., wildlife support and ecosystem recreation) [74].

NbSs have also been extensively used for planning in urban/semi-urban environments. Examples include the increase in naturally vegetated areas and/or urban water bodies, the restoration of natural landscapes, the creation of permeable pavements, stormwater management, etc. [75–79]. In urban environments, the demographic profile may play a vital role in selecting the optimal NbS. People who live in close proximity to a biodiversity-rich landscape are highly related to these ecosystems in terms of their lifestyle and traditions [80]. In such environments, there can be cultural and ethnic diversity in the local population's labor and needs, which are highly connected to the ecosystem services (e.g., agricultural labor, hunting, gathering, fishery, working with wood, etc.) [81]. Such labor activities should be promoted by public authorities along with ecotourism initiatives (e.g., birding, rafting, camping, trekking, etc.) since they can provide real-life examples to promote ecosystem conservation to a greater audience [82].

Decision-makers demand clear and coherent principles and standardized, evidence-based frameworks [83]. The policy framework for the implementation of NbSs has to be effective in addressing knowledge gaps, multiple goals, and social challenges in their adoption across different sectors [84]. Worldwide, more focus is given to economic instruments (e.g., taxation, trading systems, etc.) than regulation, restriction, prohibition measures, or infrastructure also necessary to achieve the greener development objectives [85].

Furthermore, NbS implementation involves the engagement of various stakeholder groups, as their opinions play a vital role in the selection of the optimal NbS [86]. Furthermore, the stakeholders need to be better informed and educated in order to achieve sustainability. Examples can be training awareness programs, educational programs, demonstrations of NbS case studies, promotion of environmentally sustainable materials, environmental techniques, and ecotourism activities [87–90].

3. Results and Discussion

The online DSS provides suggestions after the required questions are answered. The user can distribute the results, if he/she wants, through social media. The suggestion provided by the DSS is the best management practices (NbS and/or EbA) for each case study (determined by the answers). This is a general pathway to be followed based on the given category (e.g., coastal solutions for coasts). More focused plans and specific measures need to be developed, as each site is unique with its own environmental, social, political, and ethical aspects. The results of the DSS can be exported as reports and Excel sheets to also receive the statistical analysis. This is one of the specific DSS advantages since it provides a database with all inputs/outputs. This can be performed by storing all records of the users for a selected period in an Excel file. This function enables easy access and analysis of the outputs by non-experts, especially for beginners with no prior experience in managing data or spreadsheets. The system is stored online and promoted to gather more answers in the future. This should improve the DSS functionality and provide better results. Finally, another important advantage is that the system can be updated and enhanced.

The main characteristics of the participants during this trial period (June 2023 to January 2024) are listed below:

- 424 engagements (number of times clicked);
- 298 views (number of times viewed/displayed);
- 76 started runs (26% compared to views);
- 46 completed (61% compared to started);
- 1:43 min average time of use.

The following graphs (Figures 3–11) present the answers of the individuals who completed the DSS runs. The participants are mainly local stakeholders from the following countries: Greece, Romania, Armenia, Turkey, and Moldova. There are differences in the number (e.g., 21, 40, or 46 runs/votes) because the system was upgraded during the trial period, including more questions/answers during the six-month trial period.

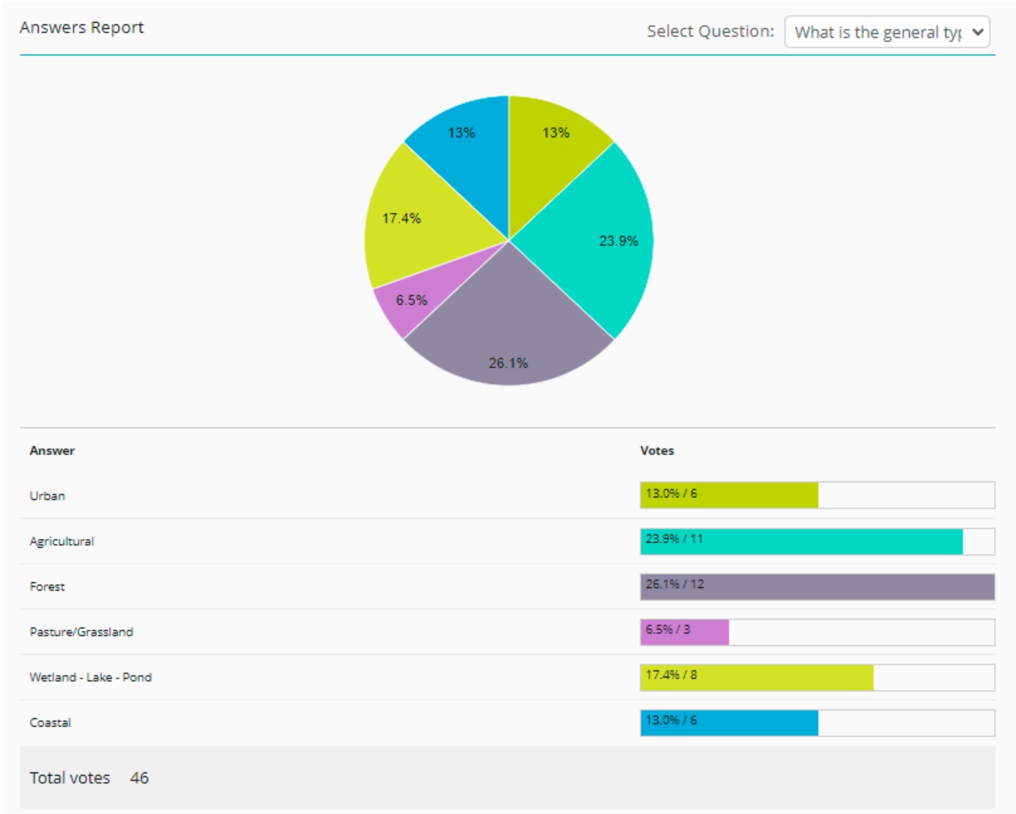

Figure 3. The statistics (answer report) concerning the general category of the study area.

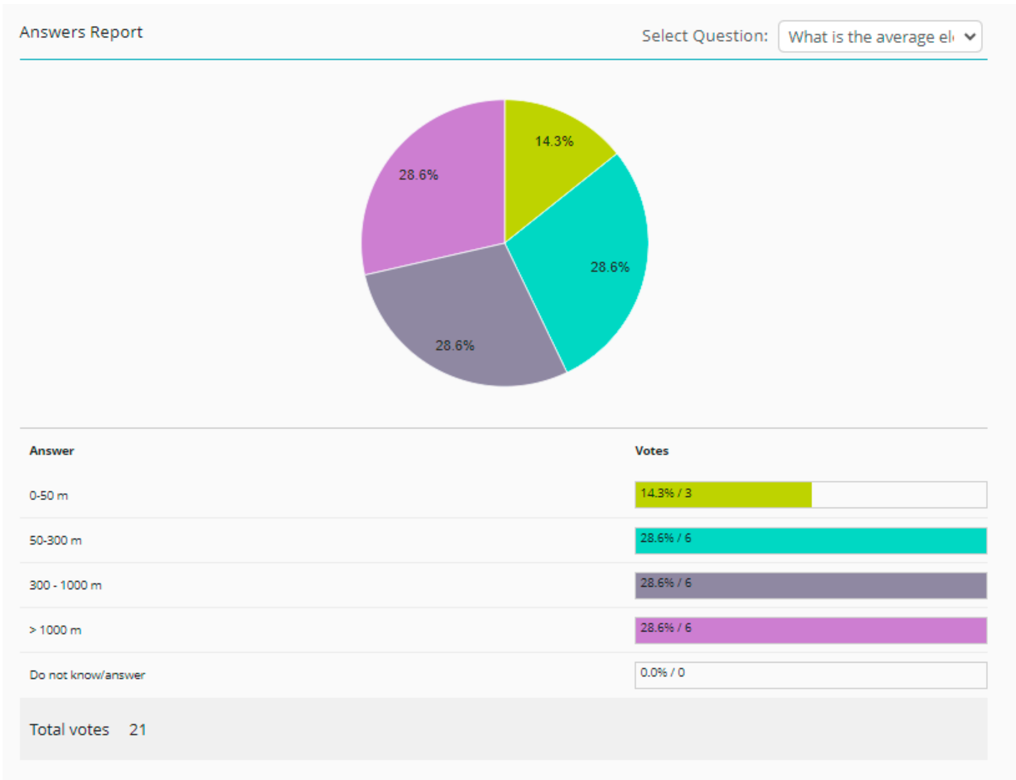

Figure 4. The statistics (answer report) concerning the average altitude of the study area.

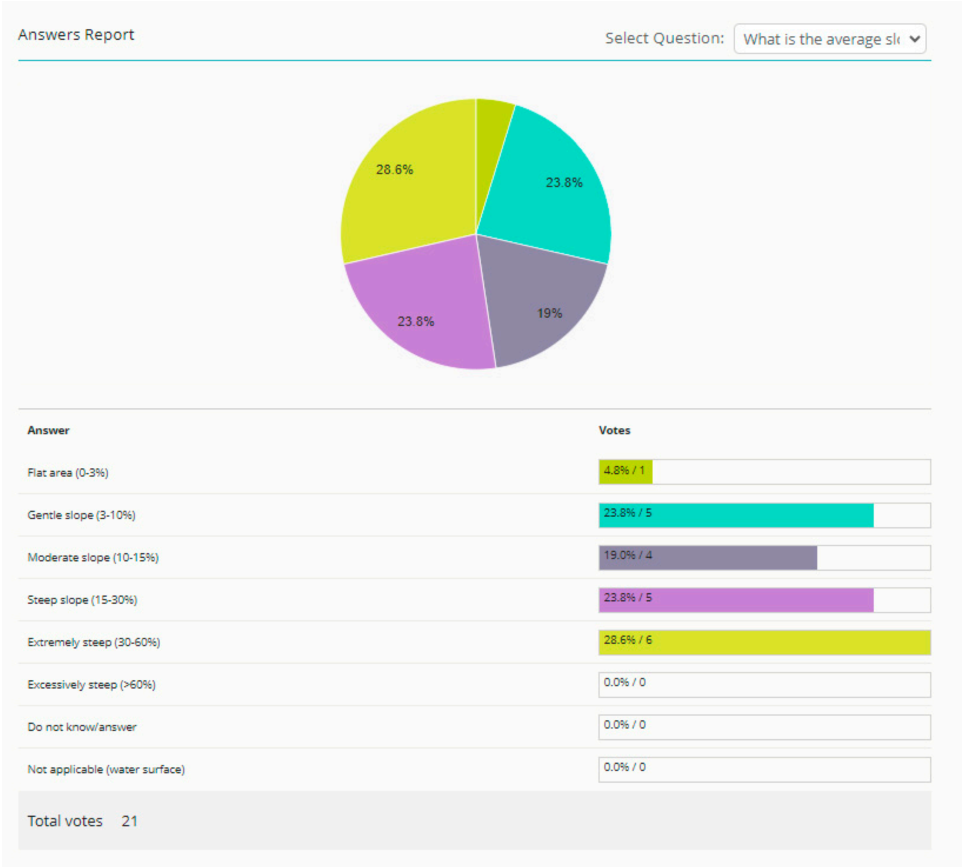

Figure 5. The statistics (answer report) concerning the average slope of the study area.

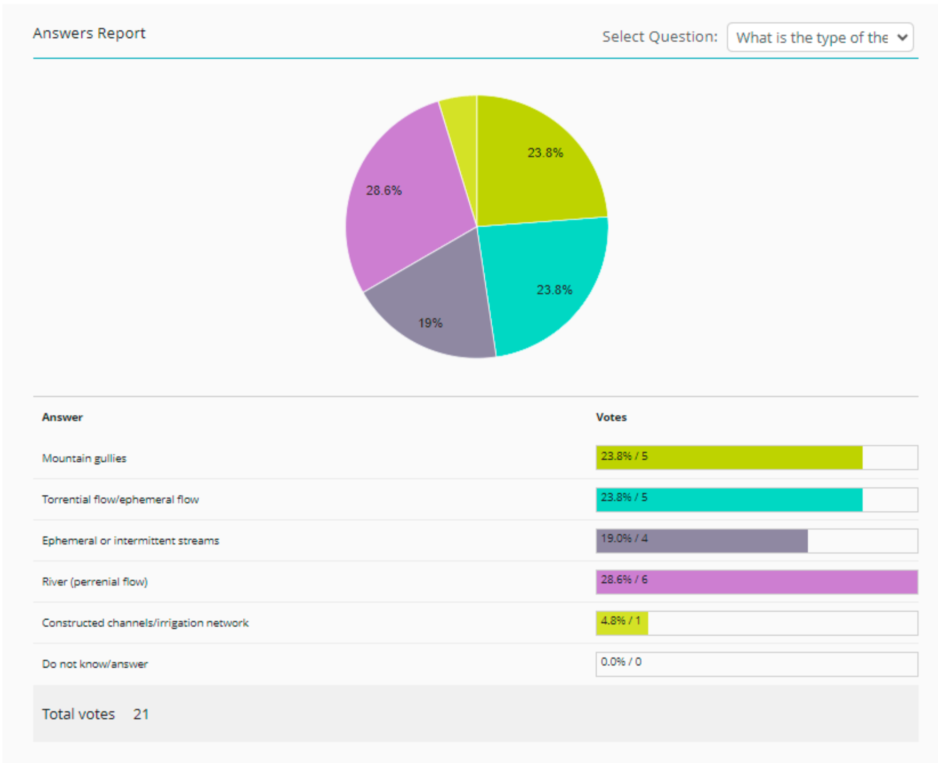

Figure 6. The statistics (answer report) concerning the type of hydrographic network in the study area.

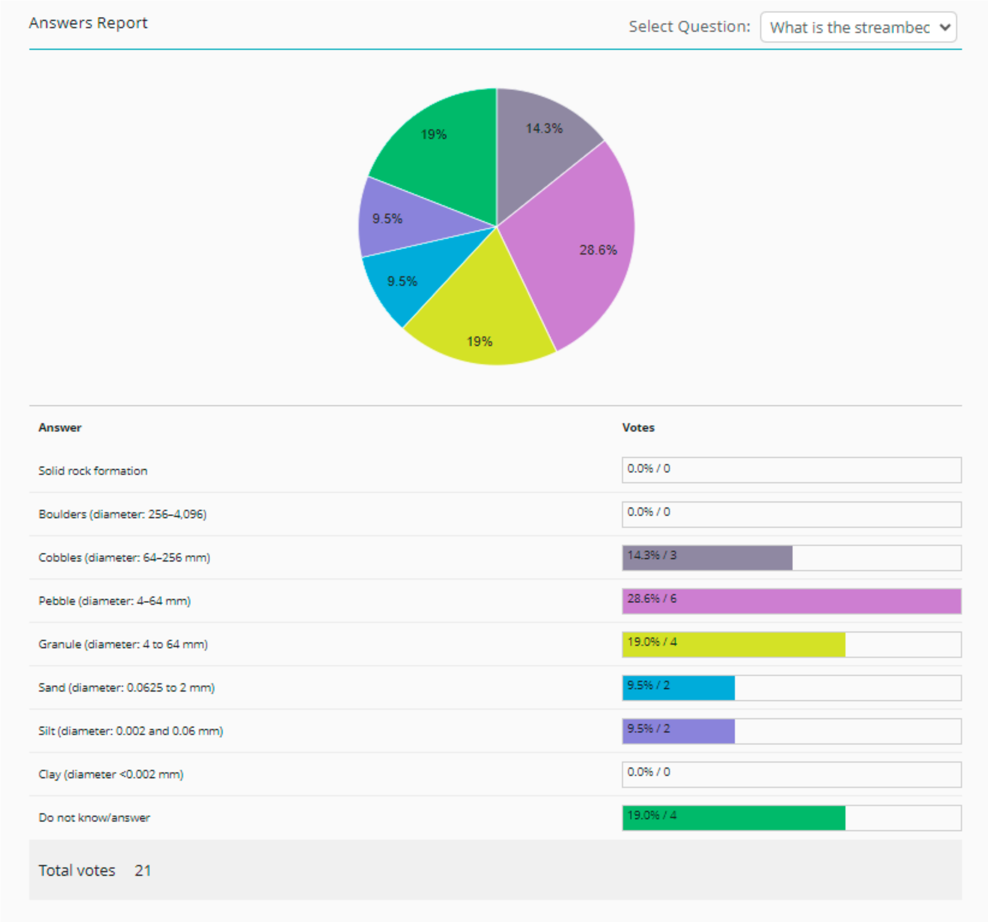

Figure 7. The statistics (answer report) concerning the type of streambed in the study area.

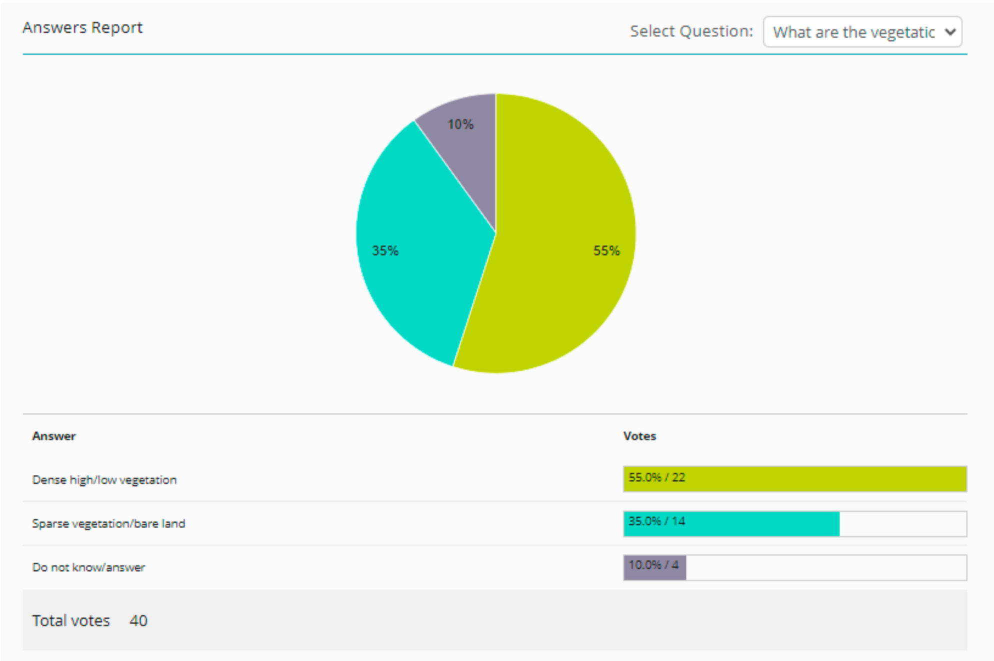

Figure 8. The statistics (answer report) concerning the average vegetation type in the study area.

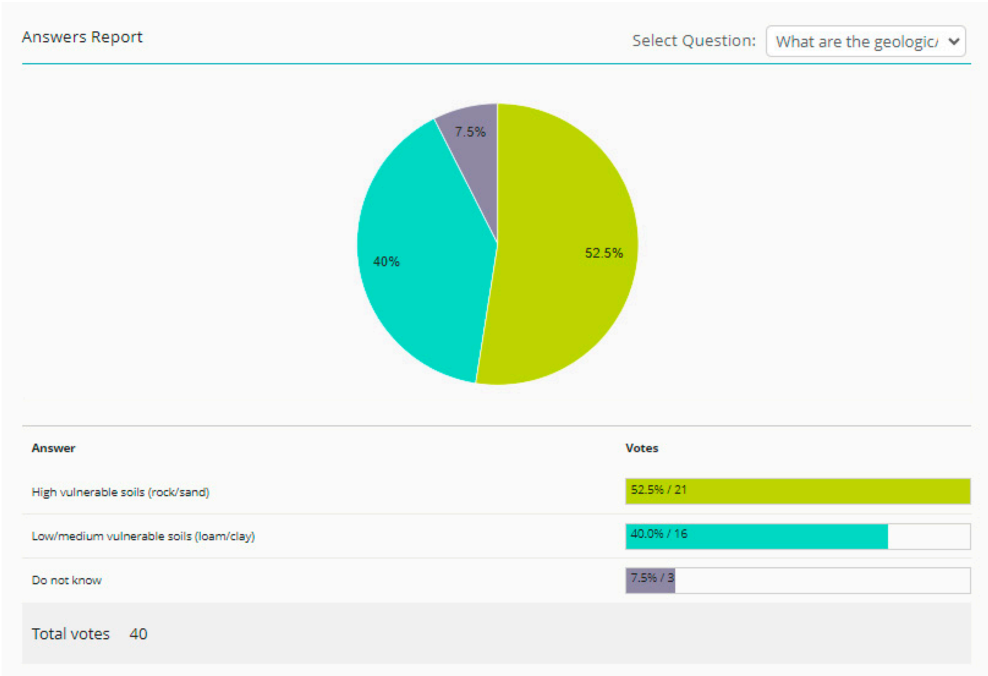

Figure 9. The statistics (answer report) concerning the geologic/soil conditions of the study area.

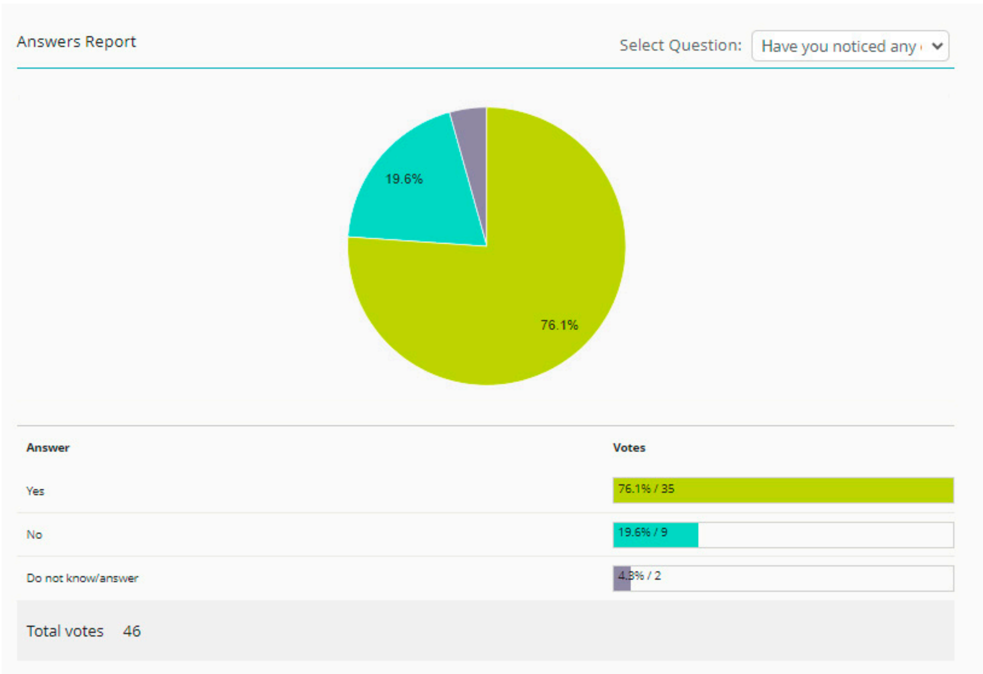

Figure 10. The statistics (answer report) concerning the existence of erosion/deposition phenomena or degradation in the study area.

The results according to the general category of the study area (Figure 3) show that most individuals selected forested (26.1%) and agricultural areas (23.9%), followed by wetland/lake/pond (17.4%), urban (13.0%), and coastal areas (13%). Although most attention and funds have been given to urban and coastal environments due to population density and infrastructure vulnerability [75,91], there is greater involvement of forest and rural areas in the answers. This may also be influenced by the fact that many NbSs are actually implemented in forest/rural areas [92].

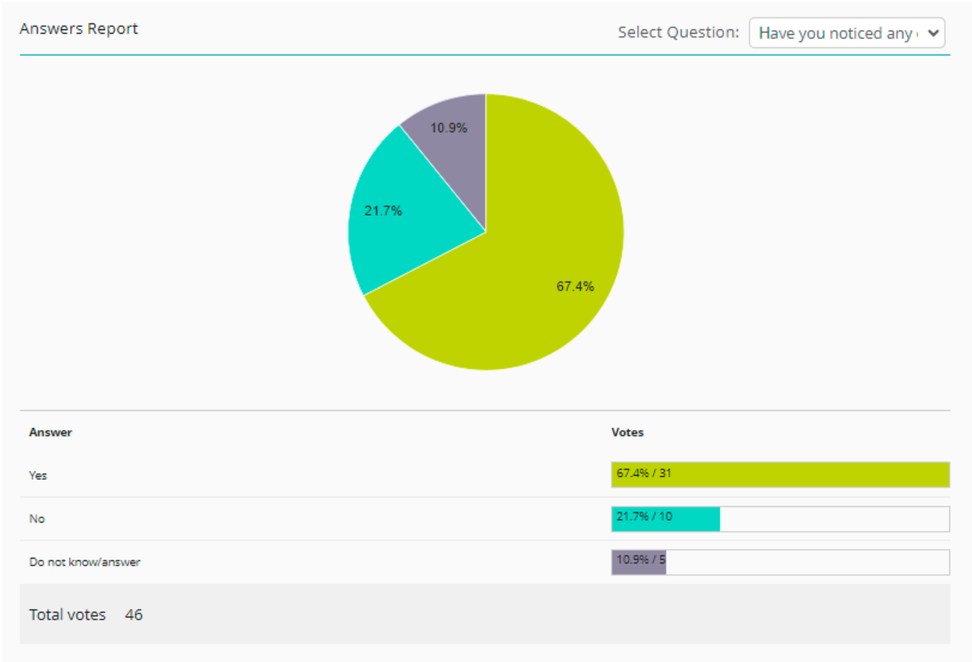

Figure 11. The statistics (answer report) concerning the existence of climate-change-induced extreme events in the study area.

Figure 4 presents the answers concerning the average altitude of the study area. The altitudes between 0 and 50 m had the fewest answers (14.3%), while the answers among the other three categories were equally distributed (28.6% in each one). The answer "Do not know/answer" was not recorded at all. The fewer answers at lower altitudes are highly correlated with the fewer answers concerning coastal areas. This indicates that hilly and mountainous areas (including urban and rural mountainous areas) are more commonly selected by individuals.

Furthermore, most answers about the slope of the study area (Figure 5) concerned extremely steep slopes (28.6%), followed by steep slopes (23.8%), gentle slopes (23.8%), moderate slopes (19.0%), and flat areas (4.8%). These answers, along with those about elevation, reinforce a higher interest in hilly and mountainous areas. The participating countries (Greece, Romania, Armenia, Moldova, and Turkey) have many such landscapes. In addition, most of the Black Sea coasts ascend rapidly (e.g., Rhodope Mountains, Pontic Mountains, Caucasus Mountains, Crimean Mountains) [93]. This can lead to extreme water flows, floods, and landslides.

Regarding hydrographic types, rivers had the highest percentage (28.6%), followed by mountain gullies, ephemeral flow streams, and intermittent streams (Figure 6). Finally, there was only one answer that focused on constructed irrigation channels.

The bed material (rivers and streams) was mainly cobbles, pebbles, and granules based on the previously identified character of the hydrographic network (Figure 7). Silt and sand were also recorded as bed materials. There was also a great percentage of individuals who were not aware of the bed material (19%). This was due either to limited geologic knowledge, lack of field measurements, or lack of visibility due to water presence being either unclear or very deep.

Regarding vegetative characteristics, most study areas (see Figure 8) had dense vegetation (55%), followed by sparse vegetation (35%), and no information about the vegetation (10%). This result is controversial since NbSs and EbA are commonly implemented in areas that lack vegetation. This might indicate that better management of the existing vegetation might be required in this region.

Most answers (see Figure 9) referred to highly vulnerable erodible soils (52.5%), followed by soils with low vulnerability to erosion (40%). Few answers indicated no information about the soil conditions (7.5%). Although the previous question indicated that there is a high percentage of vegetated areas, apparently (based on these answers), there is also a high percentage of highly vulnerable soils prone to erosion. This is probably the result of wildfire impacts and the torrential flows. Both occur frequently in the region and cause major negative environmental impacts [94].

The vast majority of participants answered that they had observed erosion/deposition phenomena or land degradation (Figure 10) in their study area (76.1%), while few recorded no such phenomena (19.6%). Only two answers did not provide information on this question (4.3%). This corresponds well with the answers to the previous question, which indicated that most study areas had highly vulnerable erodible soils. In general, the Black Sea region has severe erosion problems due to its topography, soils, human activities along the coastlines, and frequent wildfires [95].

As for climate change (see Figure 11), most participants answered that they had observed extreme events (67.4%), while 10 individuals reported the absence of such phenomena (21.7%). Five participants did not provide any information on this question (10.9%). Climate change reports highlight that heavy precipitation, floods, and intense soil erosion phenomena should be expected [96–98]. In addition, warmer winters have been reported to lead to a drier environment, negatively impacting crop growth and health and increasing wildfire occurrence. Finally, sea-level rise has been reported to impact coastal human settlements, infrastructure, and ecosystems [99–103].

To summarize, these are the primary results that were recorded during the period from June 2023 to January 2024. Funding to stakeholders from Greece, Romania, Armenia, Turkey, and Moldova is limited to participants in the funded project. Most areas are forested and agricultural land. Hilly and mountainous areas (including urban and rural mountainous areas) with intense slopes were mostly recorded by the participants. These areas also include waterways, especially torrents and rivers. The bed material of these torrential waterways is primarily "cobbles, pebbles and granules". The participant answers also indicate study areas with highly vulnerable erodible soils, with recorded erosion/deposition phenomena or land degradation. On the other hand, the vegetation was mostly dense (surprisingly) and sparse in other areas. Finally, climate change and extreme events have been recorded by the majority of participants.

Future improvements require more outputs and suggestions from stakeholders worldwide. Users' inputs are of high importance to enhance, improve, and update the DSS. This is the reason we decided to communicate these initial results to the scientific community. This is a way to invite the scientific community and others to participate by testing our DSS platform. Based on our preliminary results, the creation of more features (e.g., discussion forums or other feedback mechanisms) would further support stakeholder collaboration. More inputs will allow us to develop a systematic approach to evaluate and compare the different NbSs in a more targeted approach. In this way, the DSS will help identify cost-effective solutions that maximize benefits while minimizing costs. The enhancement of the DSS could also include a repository of case studies, guidelines, and best practices to support continuous learning and improvement.

4. Conclusions

The online DSS is user-friendly, free, and a valuable tool providing additional, useful information for decision-making concerning NbSs and EbA. The development and deployment of the online DSS have been a success, with many participants to date. At the same time, it is being communicated to wider audiences and will continue to be updated and improved. It is a unique and innovative tool for the Black Sea region that should help further promote the EU Green Deal and will enhance the awareness and adoption of NbSs and EbA. The adoption of these approaches will also help the region increase its resilience to climate change impacts.

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