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An Approach for the Development of Nature-Based Planning and Design for Disaster Management Graduate Program

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Abstract: It is crucial to make proper planning and design decisions when it comes to reducing the risks of disasters. To achieve this, planning and design practices that focus on nature-based solutions are becoming increasingly important in creating disaster-resilient cities. However, there is a shortage of qualified personnel who can effectively integrate disaster risk management, nature-based solutions, and planning/design practices holistically. As a result, this study aims to develop the framework of an interdisciplinary graduate program to support the training of competent and qualified personnel in the field of nature-based planning and design solutions for disaster management implementations. To accomplish this goal, the study examined national and international studies, nature-based solutions, planning/design approaches for reducing disaster risks, and similar graduate programs and courses. Based on the findings, a basic framework and draft program outputs were developed for the 'Nature-Based Planning and Design for Disaster Management' master program (NPDDM).

The contribution level of the existing graduate programs and courses under the Departments of Earth Sciences and Remote Sensing and Geographical Information Systems, Institute of Graduate Programs, Eskişehir Technical University were also determined on a 3-point scale. Finally, new courses and course contents that could not be covered or supported by the existing programs were proposed. Although the study only considered the potential contribution of the programs of Earth Sciences and Remote Sensing and Geographical Information Systems, it put forward an exemplary approach to benefit from the existing educational frameworks efficiently for the development of new programs.

Keywords: Disaster risk reduction, Nature-based solutions, Planning and design

Introduction

Rapid urbanization, industrialization, and population growth, which ignore proper and sustainable physical planning, implementation, and resource management activities, seriously impact the environment, natural systems, and physical infrastructure, causing pollution, deforestation, and loss of productive soils. As a result, societies face an increasing number of disasters and their devastating impacts, including socio-economic harm, today (Kanlı & Unal, 2004). From this aspect, the discussions on the necessity of adopting different planning and design approaches, including nature-based solutions (NBS), to create resilient, healthy, and sustainable cities and infrastructures to provide more effective disaster risk reduction become increasingly important (Seddon et al., 2021).

The application of NBS is not new and has been welcomed by old societies. However, over time, rapid and unplanned growth processes have led to its neglect, mostly in the planning of living spaces and cities. The critical urban challenges and crises we face today, such as climate change-induced problems, demonstrate the inevitable need to apply NBS more effectively. As a response to that, the European Union (EU) underlined the significance of adopting and investing in NBS to overcome the problems of the era (Maes & Jacobs, 2017).

According to the EU, NBS includes "*solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience*" (Kumar et al., 2021).The International Union for Conservation of Nature (IUCN) defines NBS as "*the actions to protect, manage, and restore natural or modified ecosystems to address societal challenges"* (Young et al., 2019).The NBS framework is made of various components that are holistically aimed at creating harmony between the natural dynamics and settlements (Kumar et al., 2021) and supporting biodiversity and ecosystem services (Bulkeley, 2020). NBS helps preserve the ecological processes in the cities and develop sustainable infrastructures to provide urban resilience. Planners and designers play a critical role in this process by designing and planning the built environment to be sustainable, functional, resilient, and aesthetically pleasing. Therefore, physical planners and policymakers have recently shown a growing interest in the integration of NBS into their works (Frantzeskaki, 2019), so that the negative impacts of the current implementations and the disaster risks are mitigated (Gilrein et al., 2021). In Europe, NBS is promoted as an adaptive measure against hydrometeorological hazards such as heat waves and floods that cause significant loss of life and economic damage (Kumar et al., 2020).

The main purpose of nature-based physical planning and design is based on an integrated and multidisciplinary working environment to develop proper, innovative, and sustainable plans and design solutions to create disaster resilience (Albert et al., 2019; Asare et al., 2023; Faber et al., 2014). This requires the involvement of trained, skilled, and qualified professionals equipped with a diversity of knowledge and competencies, including the ability to understand, analyze, and evaluate the complex structure of the environmental systems, disaster dynamics, disaster management cycles, and resilience requirements. The reflection of this training and qualification expectation can be tracked in the efforts put forward by the United Nations (UN) (Sakurai & Sato, 2016) and the HYOGO Framework. UN's Sendai Framework for Disaster Risk Reduction promotes national and local post-secondary education to identify disaster risks, develop early warning systems for disaster risks, and create a disaster resilience culture (Faber et al., 2014; Witt & Lill, 2018). Besides, as (Zhou et al., 2014) noted, several higher education institutions worldwide have developed their disaster management and sustainable development curricula in line with the HYOGO Protocol. Abas et al. (2020) and Chandra et al. (2013) gave examples from the social awareness evaluation surveys against disasters in Sri Lanka, Thailand, and Malaysia. However, applying NBS to physical planning and design frameworks to tackle disaster challenges requires more than raising awareness about the disasters. It necessitates raising professionals and practitioners in specified areas, including the basics of planning, NBS, and disaster resilience. Therefore, well-designed and developed education programs are crucial. Literature also shows that the most critical step to ensuring disaster

risk reduction is closely associated with education. Various curriculum development activities, especially in the European region, focus on the adoption of NBS for fighting against hydrometeorological disasters (Faber et al., 2014; Meyer et al., 2018; Tong et al., 2012).

It is believed that environmentally, economically, and culturally sustainable planning and design projects can be effectively realized by integrating NBS, ensuring the participation of stakeholders from various sectors and levels. From this perspective, the main goal of this paper is to introduce the main frameworks and results of a research project focusing on developing the "Nature-Based Planning and Design for Disaster Management" master program (NPDDM), under the Institute of Graduate Programs of Eskişehir Technical University. Although the area and field of practice itself are multidisciplinary, the core of the proposed graduate program is aimed at the disciplines that are more intensely involved in planning, design, and engineering implementations. The importance of the project is not only reflected through the development of various components of the draft graduate program, such as the program outputs, courses, course contents, and course learning outputs but also through the evaluation of the existing graduate programs and courses to determine their potential contributions to NPDDM master program proposal. In this way, it was also aimed to determine the adequacy of the existing infrastructure, know-how, and academic staff for the proposed new program, which are critical elements for starting and sustaining successful programs.

Material and Method

The project has been designed under three primary phases to develop a master program proposal that will equip the candidates from the target disciplines with the awareness, basic knowledge, and abilities to integrate NBS efficiently into physical planning and design processes to ensure disaster resilience. The first phase covers the analysis of literature, existing relevant programs, and best practices to develop the program goal, objectives, and outcomes for the NPDDM. The second phase includes the determination of the relation between the outputs of existing graduate programs of Eskisehir Technical University, Institute of Graduate Programs, and NPDDM. The last phase targets to propose new courses to ensure that all program outputs for NPDDM are efficiently met. This section gives brief information about the primary materials used and the overall methodology applied to develop the program proposal.

Material

The primary material of the research comprises websites and program/course information relevant to the main pillars of the NPDDM. These include;

- national academic programs and their content reached through the YOK Atlas website (Turkish Higher Education Council Atlas, https://yokatlas.yok.gov.tr/),
- international academic and professional courses, training, and education programs and their content (mainly program objectives and outputs) reached through various websites,
- existing graduate programs' outcomes, courses, and contents presented under the Institute of Graduate Programs, Eskişehir Technical University.

The graduate programs of Eskişehir Technical University are selected from two departments: (a) the Department of Earth Sciences, and (b) the Department of Remote Sensing and Geographical Information Systems.

Method

The main goal of this research is the development of a master program proposal, namely NPDDM. As previously summarized, this research's method is based on three phases. During the first phase, national and international examples and existing programs/courses are searched and analyzed to develop draft program outputs that would embrace the physical planning and design, disaster management, and NBS domains, as well as their unique intersecting areas. The second phase includes the comparison of the existing graduate programs with the draft program in terms of program outcomes, and the third phase contains efforts to propose new courses to cover all necessary knowledge, ability, and competency areas for NPDDM. Figure 1 illustrates the basic workflow, and the following parts provide detailed information about each phase.

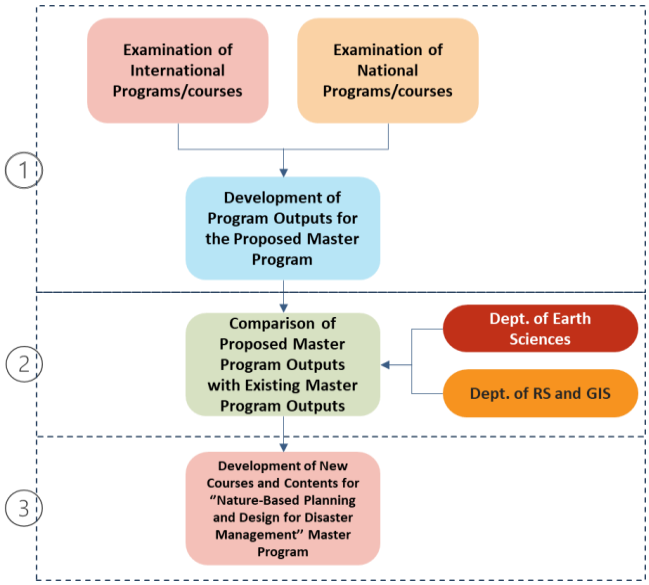

Figure 1. Workflow of the study

Determination of Program Outcomes for Nature-Based Planning and Design for Disaster Management Master Program

This process includes searching various international and national websites for relevant academic and training programs and courses using keywords in harmony with the NPDDM's scope. For searching through the international samples, keywords such as NBS, disaster management, disaster risk mitigation, physical planning etc. were used. The detected relevant program/course websites were examined to determine their goals and program outputs followed by the production of a draft program output list.

For examining the national programs, the graduate programs under the departments of architecture, city and regional planning, and landscape architecture were scanned through the YOK Atlas website to detect the courses, course objectives, contents, and learning outcomes associated with the selected keywords; NBS and disaster management. The selected ones were then evaluated by the project team in a workshop to determine the level of 'disaster management' and 'NBS' inclusion in the curricula. The same process was also applied to examine the graduate programs and online courses offered by Edinburgh University, Helsinki University, Parma University, and Purdue University. These efforts helped determine the NPDDM program outputs by making comparisons, brainstorming, and evaluations again through a workshop attended by the project team members.

Determination of Existing Programs' Contribution

The Institute of Graduate Programs of Eskisehir Technical University offers 286 graduate programs under 34 departments. These range from architecture to recreation and biology to logistics. 23 of them are interdisciplinary. Within the scope of this research, the program and learning outputs of master of science programs under the Earth Sciences Department and the Remote Sensing and Geographical Information Systems Department were compared with the outputs of the NPDDM. This comparison was based on a 4-point scale matrix scoring method through which each output was scored according to its potential contribution level. Within this rating, 3 showed the highest contribution rate (full coverage), whereas 0 was assigned when no contribution was detected. This method was applied to compare the;

- program outputs of the NPDDM with the program outputs of the Earth Sciences Master Program (with thesis)
- program outputs of the NPDDM with the program outputs of the Remote Sensing and Geographical Information Systems Master Program (with thesis)
- program outputs of the NPDDM with the learning outputs of 12 relevant courses in the Earth Sciences Master Program (with thesis)
- program outputs of the NPDDM with the learning outputs of 7 relevant courses in Remote Sensing and Geographical Information Systems Master Program (with thesis)

Table 1. Program outputs

Earth Sciences Master Program (with thesis)	**Remote Sensing and Geographical Information Systems Master Program (with thesis)**
ES_PO1.Ability to contribute to scientific literature (publications, patents, projects, etc.) in the field	RSGIS_PO1.Ability to evaluate basic theoretical concepts and applications in the field of remote sensing and geographical information systems
ES_PO2.Ability to identify and solve engineering problems related to the field	RSGIS_PO2.Ability to discuss the data, methods, and applications required for solving real earth problems in the field of remote sensing and geographical information systems
ES_PO3.Ability to take team leadership/membership responsibilities in collaborative studies carried out in the investigation of human and/or natural hazards	RSGIS_PO3.Ability to produce spatial data required in the field of remote sensing and geographical information systems
ES_PO4.Ability to apply the methods used in the field	RSGIS_PO4.Ability to use spatial data and analysis methods effectively
ES_PO5.Competency to contribute to sectoral activities related to the field	RSGIS_PO5.Ability to use data, methods, and applications used in remote sensing and geographical information systems in solving problems encountered in different disciplines
ES_PO6.Ability to contribute to the disaster management process by developing risk reduction-oriented approaches	RSGIS_PO6.Ability to use remote sensing and geographical information systems software
ES_PO7.Ability to collaborate in energy efficiency and sustainability efforts with an environmental focus	RSGIS_PO7.Ability to follow innovations and current literature in the field of remote sensing and geographical information systems
ES_PO8.Ability to develop sustainable and qualified outputs in smart and resilient urbanism approaches	RSGIS_PO8.Ability to organize written, oral, and visual reports related to studies in the field of remote sensing and geographical information systems
ES_PO9.Competency to use techniques and modern devices required in the subject	RSGIS_PO9.Ability to interpret the results of analysis obtained by remote sensing and geographical information systems
ES_PO10.Competency in using and developing relevant software	RSGIS_PO10.Ability to work in a team within the scope of remote sensing and geographical information systems projects

Table 2. Selected courses

Earth Sciences Master Program (with thesis)	**Remote Sensing and Geographical Information Systems Master Program (with thesis)**
Earth Sciences	Interpretation and Analysis Techniques in Geographic Information Systems
Theoretical Soil Mechanics Soil Models	Special Topics in Urban Information Systems
Introduction to Earthquake Engineering	Environmental Management and Geographic Information Systems Integration
System Diagnostics and Building Health Monitoring	Automated Mapping and Facility Management Systems
Seismology	Basic Map Information and Geographic Information Systems
Earth Systems	Geographic Information Systems and Health
Digital Methods in Geotechnical Engineering	Microzoning
Spectral Analysis of Earthquake Waves	
Structural Earthquake Engineering	
Engineering Properties of Soils	
Geological Disasters	
Microzoning for Municipalities	

The project team evaluated all course titles, outputs, and contents before selecting the courses to be included in the comparison. The academic staff of the selected courses then scored the courses, and the contribution levels were calculated for the programs and courses. Table 1 gives the program outputs of the Earth Sciences Master Program (with thesis) and the Remote Sensing and Geographical Information Systems Master Program (with thesis), while Table 2 summarizes the selected courses whose outputs are compared with those of the NPDDM.

Course Development Process

The last phase of the study includes developing new courses and contents in accordance with the NPDDM program outputs. The courses were designed harmoniously with the target outputs and their calculated coverage rate compared to the existing program courses (Phase 2). The course names, learning outputs, and contents were also developed within this context. Then, the contribution levels of course learning outputs to the program outputs of the NPDDM were determined. A 4-point scale was used to fulfill this aim, and the contribution levels were calculated using the total number and percentage values.

Results and Discussions

This section gives the results obtained from three phases of the methodology.

NPDDM Program Outputs

Following the methodology explained in the relevant section, the draft program output proposal list for NPDDM was listed and elected during a workshop held by the project team. The selected outputs were related to the NPDDM's cores: NBS, physical planning and design, and disaster management. The resulting program outputs are illustrated in Figure 2.

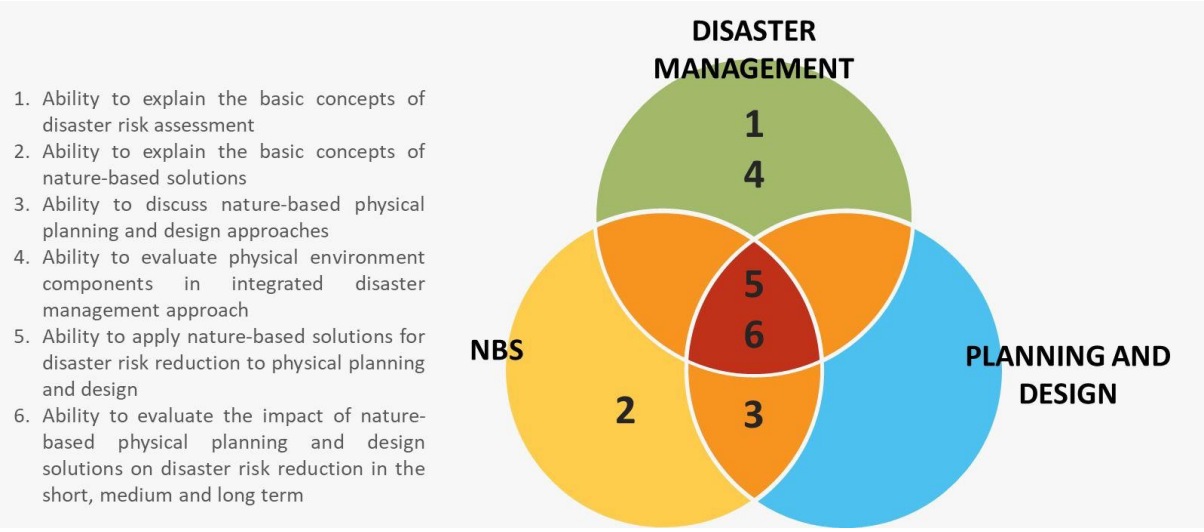

Figure 2. NPDDM program outputs and their relationship with the key component

As illustrated in Figure 2, two NPDDM program outcomes are related to disaster management (output 1 and output 4), and one of them (output 2) is to NBS. While program outcomes 5 and 6 are associated with all core areas being addressed holistically, outcome 3 mainly focuses on the knowledge and skills required to integrate NBS with planning and design practices. It is critical to note that the NPDDM program outputs have been drafty determined, and a comprehensive and participatory review (including feedback from various stakeholders) and improvement process are essential.

Comparison Results

As explained in the Method section, the degree of fulfillment of the NPDDM program outcomes by the Earth Sciences and Remote Sensing and Geographical Information Systems master program outcomes was determined

by assigning scores ranging between 0 and 3. The results were then calculated as a total contribution score and percentage of each program outcome. The same process was carried out for the pre-selected courses in the Earth Sciences and the Remote Sensing and Geographical Information Systems master's programs. The primary objective at this stage was to reveal the potential benefits and support existing programs could provide NPDDM, thereby enabling a more effective and optimized use of available resources. Figures 3-6 show the results of the program output comparisons.

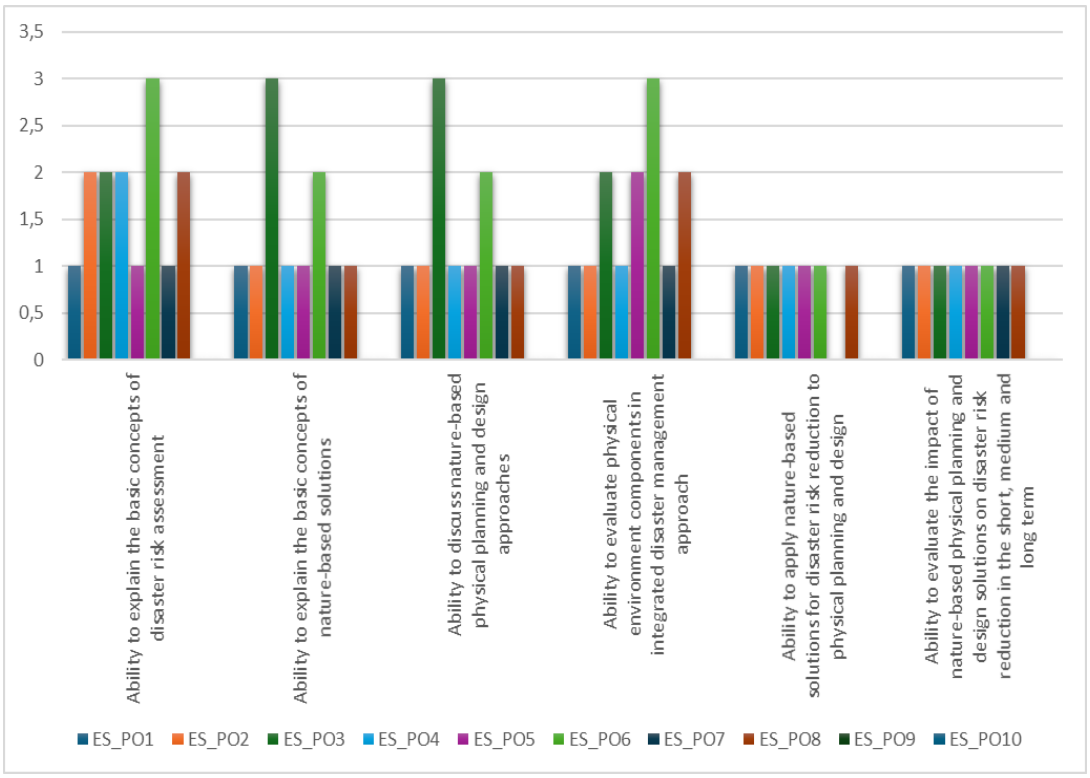

Figure 3. Contribution of Earth Sciences master program outputs to NPDDM program outputs (total score)

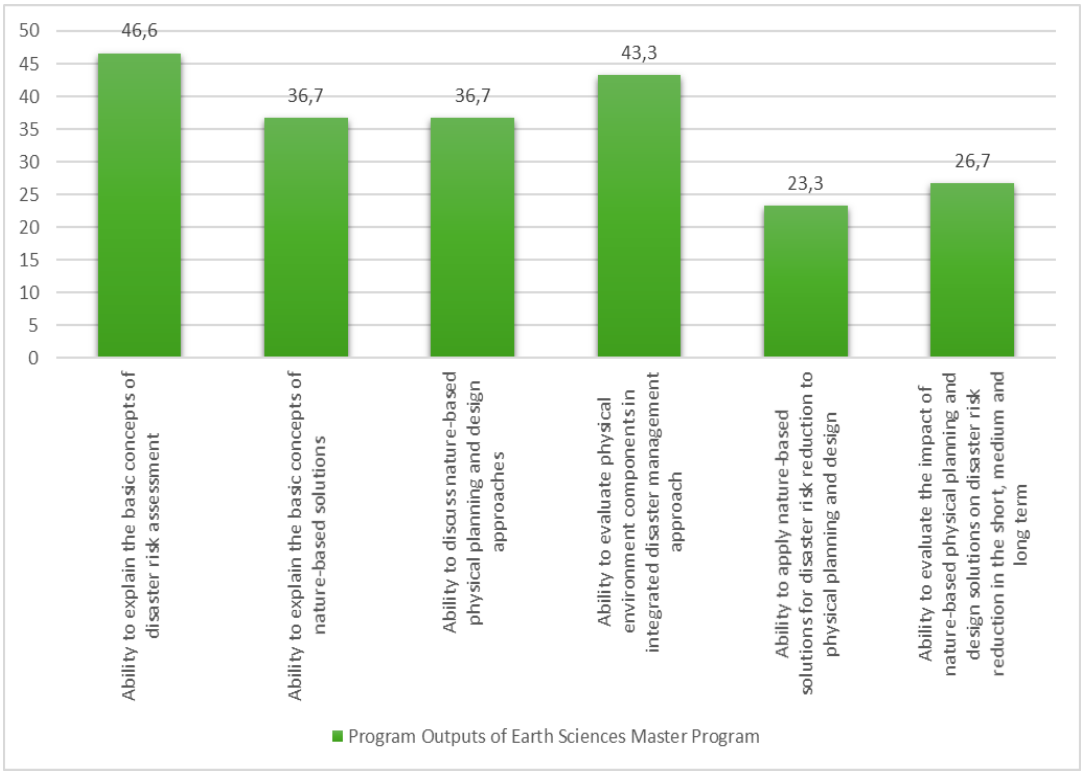

Figure 4. Total contribution of Earth Sciences master program outputs to NPDDM program outputs (percentage)

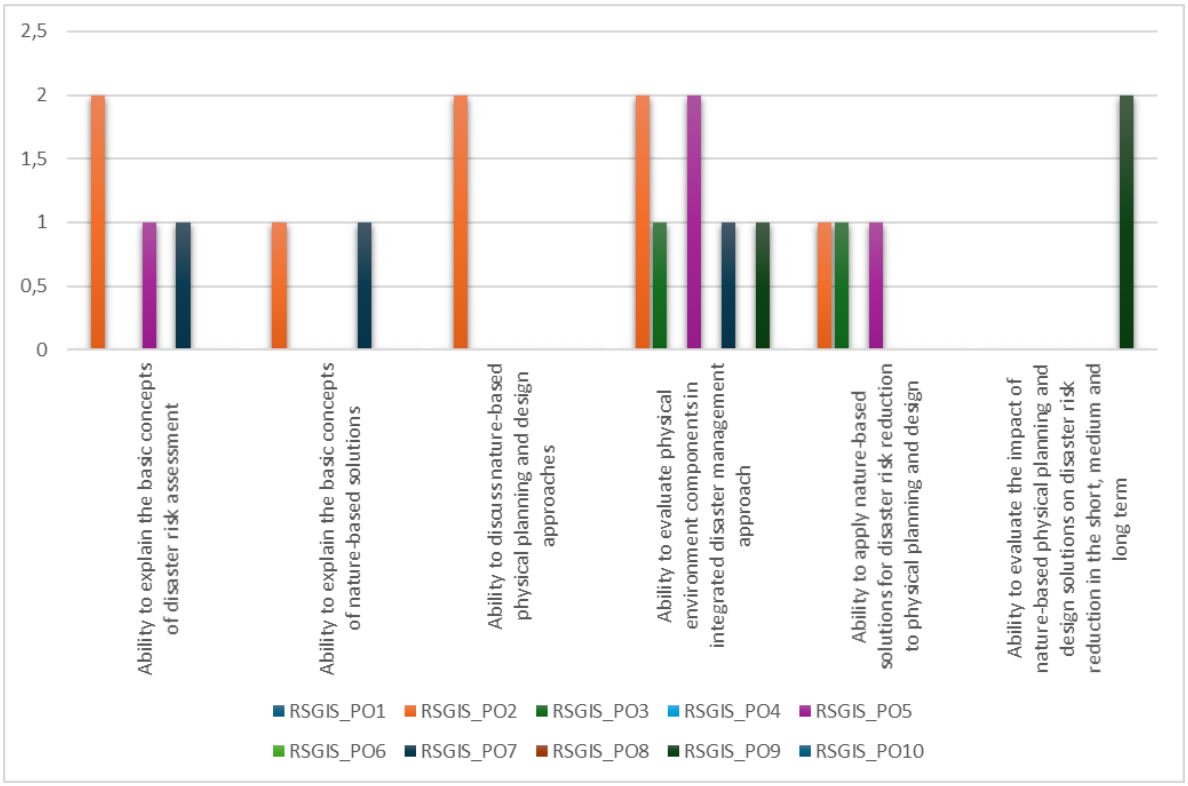

Figure 5. Contribution of remote sensing and geographical information systems master program outputs to NPDDM program outputs (total score)

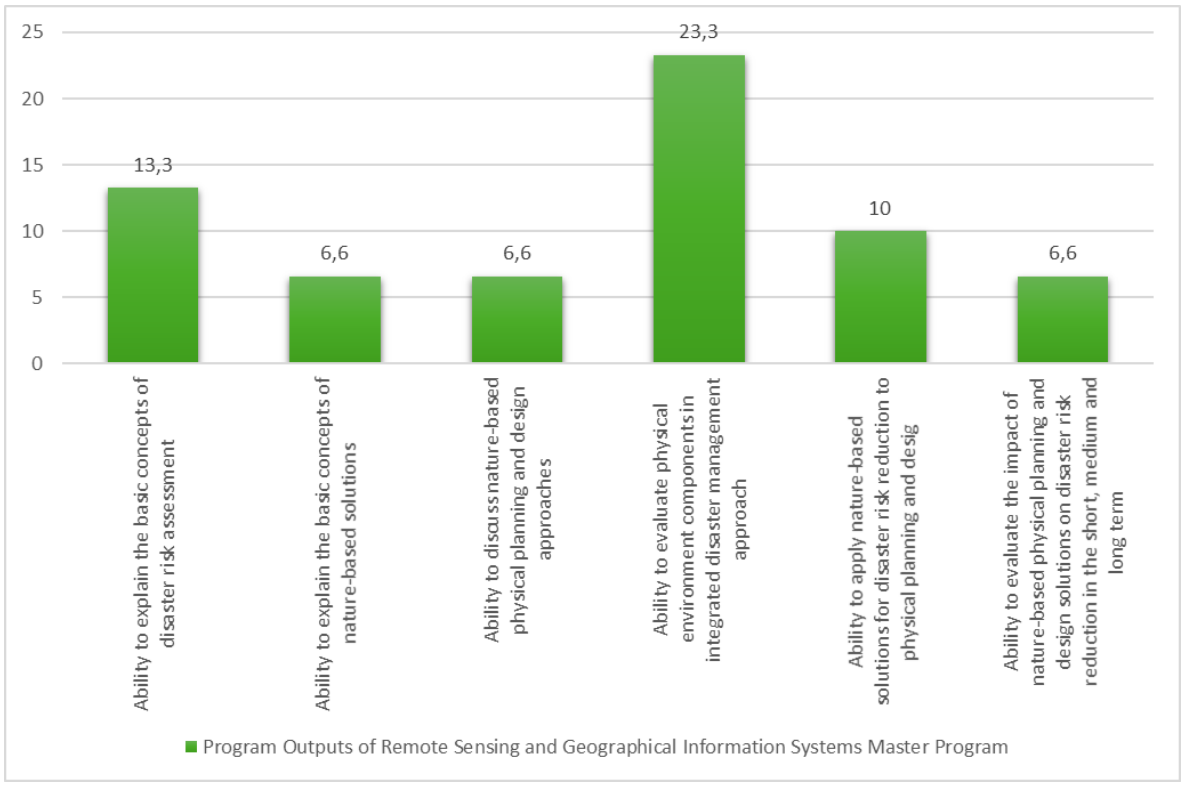

Figure 6. Total contribution of remote sensing and geographical information systems master program outputs to NPDDM program outputs (percentage)

The results show a considerable difference between the contribution levels of the Earth Sciences, the Remote Sensing, and Geographical Information Systems master programs, with the former supporting NPDDM more. The main reason for this is the more intense and specific disaster management and relevant subject contents included in the program. On the other hand, the program and the course learning outputs of the Remote Sensing

and Geographical Information Systems program cover either more overarching or specific area-based (health, environmental management, water resources management, etc.) knowledge and skills, which makes it difficult to associate them with those of NPDDM.

Considering the Earth Sciences program, ES_PO3 and ES_PO6 are the outputs with the highest rate of contribution, especially to the first 4 program outputs of NPDDM listed in Figure 2, while ES_PO9 and ES_PO10 have no contribution at all. When the total contribution percentage is analyzed, the highest contribution of the Earth Sciences program outputs is found as 46,6% to the "Ability to explain the basic concepts of disaster risk assessment", followed by rates of 43,3% to the "Ability to evaluate physical environment components in integrated disaster management approach", 36,7% to the "Ability to explain the basic concepts of nature-based solutions" and "Ability to discuss nature-based physical planning and design approaches", 26,7% to the "Ability to evaluate the impact of nature-based physical planning and design solutions on disaster risk reduction in the short, medium and long term" and lastly, 23,3% to the "Ability to apply nature-based solutions for disaster risk reduction to physical planning and design"

RSGIS_PO2 (Ability to discuss the data, methods, and applications required for solving real earth problems in the field of remote sensing and geographical information systems) is analyzed as the output with the highest total contribution score to the program outputs of NPDDM. RSGIS_PO5 follows this score. On the other hand, RSGIS_PO1, RSGIS_PO4, RSGIS_PO6, RSGIS_PO8, and RSGIS_PO10 have no contribution to the NPDDM outputs. Regarding the total contribution percentage, the highest contribution (23,3%) is to the "Ability to evaluate physical environment components in integrated disaster management approach" and the lowest (6,6%) to the "Ability to explain the basic concepts of nature-based solutions", "Ability to discuss nature-based physical planning and design approaches", and "Ability to evaluate the impact of nature-based physical planning and design solutions on disaster risk reduction in the short, medium and long term".

Considering the Remote Sensing and Geographical Information Systems master program course contribution rates to overall NPDDM outputs, the highest support levels have been received from "Basic Map Information and Geographic Information Systems" (22.2%) and "Microzoning" (22.2%), while the lowest has been detected as "Automated Mapping and Facility Management Systems". The contribution levels of Erath Sciences master program courses rank as follows:

- Spectral Analysis of Earthquake Waves (52.8%)
- Seismology (48.6%)
- Microzoning for Municipalities (47.2%).

The lowest contribution rate has been calculated as 12.5% for "System Diagnostics and Building Health Monitoring". To sum up, the results show that the Earth Sciences master program has a higher potential to support the launching and execution of NPDDM.

New Course Proposals

It is necessary to design a diverse and high-quality curriculum to launch a new program meeting the requirements and equipping the individuals with the target knowledge, skills and competencies. As the existing courses have failed to cover all the necessary areas promised for NPDDM, new course proposals have been developed to meet the program outputs. Course goals/targets, contents, and learning outputs have also been proposed within this process. Still further evaluations and improvements are planned before finalizing the process. The proposed courses are summarized below:

- Ecological Planning and GIS Integration: The objective of this course is to gain an understanding of the principles of ecological planning and to learn how geographic information systems can be used. The course will cover various topics, including the conservation of natural resources, restoration of habitats, and biodiversity monitoring.
- Green Infrastructure Design and Management: This course examines strategies for designing and managing sustainable green infrastructure solutions in urban and rural contexts. It will focus on the role of geographic information systems (GIS) in green infrastructure planning and monitoring.
- Ecosystem Services and GIS Implementations: This course will examine GIS techniques for identifying, assessing, and monitoring the geographical distribution of ecosystem services. Topics such as ecological assessment and natural capital accounting will be included.

- Sustainable Infrastructure Planning and Analysis: The course will discuss the information, approaches, and GIS-based applications required to evaluate the environmental impacts of infrastructure projects and integrate sustainability criteria. It will also explain the role of GIS in infrastructure planning and management.
- Ecological Modelling: It will be a course aiming to teach GIS-based methods for spatial modeling of ecosystems, habitat prediction, and ecological risk analysis. It will be a course that deals with the applications of various ecological modeling techniques.
- Natural Resource Management and GIS Integration: The course will address the utilization of GIS in the monitoring, evaluating, and managing natural resources. It will examine the role of GIS in the effective management of natural resources, including forests, water resources, and agricultural lands.
- Ecologic Network Planning and GIS Implementations: The course will use GIS techniques to analyze and plan ecological corridors, habitat fragmentation, and ecological connectivity. Particular emphasis will be placed on the design and conservation of ecological networks.
- Sustainable Urban Planning and Green Infrastructure: The course will examine how GIS can be employed in sustainable urban planning and green infrastructure projects. Particular emphasis will be placed on the planning, monitoring, and managing green spaces in urban environments.
- Biodiversity Conversation Strategies: The course will investigate the potential of GIS for biodiversity conservation and monitoring. It will address topics such as the management of protected areas, species monitoring, and habitat analysis.
- Environmental Assessment and GIS Integration: This course will examine the potential for integrating GIS into environmental impact assessment processes. In this context, the role of GIS in project planning, monitoring, and evaluation will be elucidated.
- Nature-based GIS and Water Resource Management: This course will address the role of GIS in monitoring, managing, and protecting water resources. It will cover various topics, including modeling water basins, monitoring water quality, sustainable use of water resources, and managing water crises. By emphasizing integrating nature-based approaches and water resources with GIS, the course will provide students with a comprehensive perspective.

Conclusion

While nature-based solutions are employed in many fields and processes, they are particularly important in physical planning and design that seek to utilize all-natural and cultural resources optimally and efficiently to construct a sustainable future. Physical planning and design is a field of practice that is inherently multidisciplinary in nature. It prioritizes correctly understanding, using, and protecting natural resources and dynamics to benefit humans and the environment. However, particularly in the wake of the Industrial Revolution, this approach, which is at the core of the process and illuminates its intrinsic value, has been eschewed. One of the most evident consequences is the inability to guarantee resilience against disasters and significant losses. In this context, the optimal means of ensuring resilience against disasters is reinstating the original spirit and ethical standards associated with the physical planning and design profession and practice. It is, therefore, crucial to ensure that relevant professionals and practitioners are adequately equipped to fulfill their roles, particularly within this specific framework.

In light of the aforementioned considerations, a master's program proposal has been developed within the scope of the project presented in this paper to provide individuals with the requisite knowledge, skills, and competence in nature-based planning and design against disasters. The potential contributions of selected graduate programs and courses at Eskişehir Technical University, Institute of Graduate Programs, were also investigated to create the most appropriate content and outputs for the Nature Based Planning and Design for Disaster Management Graduate Program (NPDDM).

Sectoral needs and professional feedback will be gathered through multi-stakeholder workshops in the future to improve and enrich the draft program before finalizing the process to officially launch NPDDM. This program proposal will also form the basis of potential EU-based diploma and mobility programs in higher education.

Scientific Ethics Declaration

The authors declare that the scientific, ethical, and legal responsibility of this article published in EPESS journal belongs to the authors.

Acknowledgments or Notes

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