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AN APPROACH FOR ECOLOGICAL WATER BODIES' ENVIRONMENT MODELING

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The study presents an approach for modeling ecological water bodies' protection in order to support the transformation of agricultural land surrounding water springs into woodlands. Google Earth Pro was chosen for its enhanced capability to import Geographic Information System (GIS) data. It enables the measurement of ground area, radius, and circumference, along with the creation of high-resolution screenshots and offline videos for sharing. SketchUp, a 3D modeling tool, offers various drawing applications and features an extensive online library of free model assemblies. The combined use of these tools allows the creation of file formats that can be accessed in Google Earth Pro for virtual presentations. The efficacy of the proposed approach was illustrated using data from two springs located in the region of North Macedonia, which are utilized for bottled water.

Keywords: Google Earth Pro, SketchUp, EU Water Framework Directive (WFD)

2020 Mathematics Subject Classification: 68U07

CCS Concepts:

• Computing methodologies~Modeling and simulation~Model development and analysis~ Modeling methodologies

1. Introduction

The EU Water Framework Directive (WFD) aims to support the restoration of water bodies in EU countries as well as across Europe. The aim is to gain water with a "good quality status" by 2027, which is already achieved in many EU countries. Many activities were undertaken in and outside the EU countries in this goal. The objective is to create mechanisms and practices for sustainably restoring water

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bodies without utilizing costly chemical technologies and purification methods. The purification methods raise the cost of water and result in low-quality drinking water for the population in Europe. Planning the water bodies' protection is the best way of achieving this goal. It is one of the most effective sustainable solutions to the issue of providing a reliable, high-quality water supply. The protection of water bodies involves the use of effective technologies for accurate planning and safeguarding of water springs, river flows and other water reservoirs. According to COST Action PASFOR-W recommendations, the gradual transformation of agricultural land into woodland and planned planting and management of certain types of trees are one of the most sustainable ways of water bodies' protection [24].

This paper proposes an approach for modeling ecological water bodies' environment according to recommendations of EU WFD directives. It is used for creating scenarios for transforming agricultural land around water springs into woodlands. Additionally, it offers benefits to society, including the contribution of companies that utilize springs for bottling water. For this purpose, Google Earth Pro and SketchUp are utilized as user-friendly tools for planning and modeling the land surrounding water bodies.

For nearly two decades, the Republic of North Macedonia has been without integrated policies to address water resource management [12,14]. Consequently, the water quality and quantity of drinking water for the population constantly decreased. The separation of authorizations for water resources protection affects the occurrence of many problems with water resources [25]. The responsibilities are fragmented among water management companies, sanitary inspection services, the Ministry of Ecology and the Ministry of Economy. Some uncertainties in the legal regulations that refer to water management also influence the current conditions. Another worrying factor is the evasive cutting of forests throughout the territory and their usage for heating. Bad policies with the forests that have been carried out over the past two decades have produced damage to the forest fund and a growing absence of cutting control. This arises due to poverty of the population, insufficient control of the forest fund, deliberate forest fires and the lack of effective state mechanisms for protection, unpunished executors and non-application of law. The influence of illegal landfills and low ecological awareness of the population is also high [3]. All these consequences have a negative impact on the water supply and quality of drinking water. In order to meet the needs for drinking water, water wells are included, but they cause a decrease in water quality. It is therefore not surprising that according to the latest statistics [22], the percentage of people with diseases is tending to a steady increase. Citizens are facing eco-problems every day and there is no integrated solution.

The depletion of the forest reserve in recent years has resulted in a consistently high level of air pollution. It additionally affects the quality of water through polluted atmospheric influences (precipitation). The contaminated soils with heavy metals and pollutants also have a significant impact on water quality. All these pollutants are the reasons for the external threat to human life, as exposome [20]. The inadequate policies of the previous government for massive tree planting have resulted in only 11% success [24] despite the huge resources spent on afforestation.

Guided by these problems, we propose an approach for modeling and planning eco-design of water springs and water bodies in accordance with the EU Water Framework Directive using Google Earth Pro and SketchUp. This software provides a highly detailed, interactive 3D map of the world, using satellite imagery, aerial photography, and other geospatial data, while SketchUp is a 3D modeling software that allows users to design and create detailed 3D models. The combination of Google Earth Pro and SketchUp offers a powerful toolset for creating and visualizing 3D models in a geospatial context. The tool also allows for measuring the area, radius, and circumference of the ground. This approach provides printing high-resolution screenshots and makes compelling offline movies to share. SketchUp is a 3D modeling software for a wide range of drawing applications. It can work with ready-made objects or models that can be embedded in the proposed approach. It supports importing objects created with many other 3D modeling tools such as Autodesk 3DS Max [23] or others. Furthermore, an online library of free model assemblies and 3D Warehouse can be used. This library has a possibility for contributing models by adding some layout functionality.

The paper is organized as follows. After the introduction and related works, we present the aims of the proposed approach according to EU WFD policy. The next section describes the general framework for creating an approach based on the GIS system. The created approach for selected locations around the water springs is explained in the fourth section. It is created as scenarios for selected springs for two locations. Concluding remarks highlight the benefits of applying the proposed approach and some possible scenarios and plans for future work.

2. Related works

Many efforts were made by EU countries to provide an ecological framework for good water status. The EU WFD aims to assist in the restoration of water bodies in Europe to achieve "good ecological status" by 2027. In this context, the catchments of EU rivers must be protected from agricultural pollutants as well as other forms of pollution. Accumulating evidence shows that recent improvements to agricultural practices can be very effective in water quality improvement, but not sufficient. The COST action PASFOR-W proposed a framework for obtaining growing support for land use change. The purpose is to help bridge the gap, with a particular focus on tree planting to intercept and reduce the delivery of diffuse pollutants to water [24].

The PESFOR-W recommendations consolidate and expand knowledge on the potential reach and scope of F4W PES schemes. In addition, they provide PES environmental effectiveness [24], PES cost-effectiveness and agreed standards and guidance. The platform has to link research findings to frontline users in water [24], forestry, agriculture, and environmental finance sectors. It considers supporting tools such as GIS, Decision support systems (DSS), CAD, and tools such as SketchUp. SketchUp is one of the user-friendly tools for creating 3D objects in the GIS environment.

GIS systems have a wide range of applications, especially when ecosystems have to be analyzed, protected and planned [9]. Taking into consideration GIS systems, some researchers [7] interpret GIS as GISy – Systems, GISc – Science and GISt – Studies. GISy focuses mainly on technology for the acquisition and management of spatial information. GISc is connected and focused on conceptual issues of representing spatial data, achieving a deeper understanding of the meanings and creative analysis. GISt is focused on social, legal and ethical issues taking into consideration their complexity. The researchers figured out increasing of the market of cheap software, and raster systems on very basic hardware. This fact provided GIS education with great tutorials and video materials. They also empowered broader usage of GIS systems [7] due to various factors that facilitate the use of GIS in marketing data. User-friendly software with distributed data and wider computer adoption was provided. Ever since, when environmental issues are considered, GIS has been widely utilized as a strategic tool. GIS is suitable for planning the agriculture economy with exploratory spatial analysis [8], human capital knowledge analysis [6], health care analysis [17], government issues, e-commerce and e-government support [1, 6, 7, 19].

Many projects bring symbiosis of GIS with other technologies such as remote sensing activities, providing information for ecosystems for wider communities [13]. Some academic researchers are focused on creating local and hybrid models [13], providing cloud options and accessibility for a wider population. Some of them are moved into the cloud with a semantic specification for spatial data infrastructure. In this way, interoperability and framework for web applications based on open geospatial standards were provided [5]. All activities and steps already provide a frame for geospatial web services, cloud GIS and semantic web for GIS, allowing data to be shared and reused. These steps provided interoperability and spatial data infrastructure (SDI) with Geography Markup Language (GML) or Extensible Markup Language (XML) [10].

Nowadays, many Earth Observation (EO) data are available on the web. They are provided by government agencies that support additional measures and results as a benefit of increasing technological capacities [2, 5]. They support the next steps of GIS system development as a connection to creating standards as OGC Web Services (OWS). In this way, Cloud services quality requirements set by INSPIRE directives (EU directives) are met [4]. These activities aim to provide compatible Geospatial Open Source Software standards and semantic interoperability with tracking changes possibilities [28]. All these factors provide support for numerous projects, standards and various GIS software tools [5].

GIS filtering approaches are used within Woodland for Water (W4W) projects to determine the possibilities for woodland creation. It is used in the first phase of understanding catchment issues and opportunities [15]. Using GIS technology, the W4W measure can be targeted strategically at particular sites. This is important because GIS can assist in regional woodland creation schemes by providing spatial information on the existing woodland occurrence. It can assist environmental managers who wish to connect existing sites or create new woodlands in largely treeless landscapes [16]. By implementation of GIS, a method of identifying spatial components for regional conservation planning is developed [18]. An ecological conceptual model of a landscape can be combined with assessment methods to evaluate ecosystem service functions. They can also establish a spatial analysis model for urban minimum ecological land using GIS [27]. GIS-based landscape planning and cost-benefit analysis can be applied in a methodology for designing and implementing PES systems [11]. A suitable method for identifying key eco-spaces using GIS is proposed in [26].

All these uses of the GIS system have prerequisites for high skills in GIS modeling and usage of specific complex tools for planning landscapes. They can be used only by planning experts with high IT skills. For this reason, we proposed an easy-to-use approach. This approach considers using a simple combination of GIS and 3D tools, in a way that non-IT experts can use it with a short course. It will empower planners and foresters in forestry and water supply. This simulation tool can be used to plan the transformation of land into woodland or forest.

3. Aims of the proposed approach for planning woodland modeling

The knowledge gained from the research conducted in COST Action PESFOR-W [24] can enhance the design and environmental effectiveness of planning activities for the protection of ecological water bodies. This paper focuses on the use of a combination of the GIS system Google Earth Pro and SketchUp, which enhances planning efficiency in addressing the issue of diffuse water pollution [24]. This is in accordance with the report on sustainable forest management in Europe: to "develop appropriate policies and strategies for managing forests and water resources sustainably to adapt to climate change and contribute to its mitigation" [21]. We consider the four principal research objectives [24]:

1. Characterize and critically evaluate the governance models and design structure of EU WFD schemes;

2. Evaluate the environmental effectiveness of targeted woodland planting in reducing a range of agricultural diffuse pollutants;

3. Develop a European repository of Case Studies that investigate lessons from existing EU WFD schemes;

   and

4. Develop User Guidance on the suitability of pollutant, ecosystem service and catchment scale models to quantify the effectiveness of tree planting to reduce diffuse pollution.

The focus was on the second principle, proposing an approach for planning the afforestation of landscapes around the springs. The combination of these software tools is chosen due to the synergy they offer in modeling the environment of ecological water bodies. The user-friendly combination can bring numerous benefits to the water protection sectors.

4. Proposed ecological water bodies' protection approach for modeling

Considering the aims of the approach for modeling ecological water bodies' environments for planning woodland around water resources, we use the powerful and easy-to-use combination of tools – Google Earth Pro and SketchUp.

Firstly, we consider the water springs in the Republic of North Macedonia and choose two of them to examine the real situation. We identified and analyzed their GIS coordinates along with the requirements of the four main research objectives [24].

The main steps that we differentiate in our approach are given in the following.

- Choosing the object that should be explored. For our purpose, we choose agricultural land surrounding water springs.
- Setting the location and directional orientation by importing an image from Google Earth. The SketchUp model is set to the same latitude and longitude as the chosen location. The imported terrain image is aligned with the axes in SketchUp.
- Modeling using SketchUp tools (selecting the tree type and layout, determining the spacing between trees, and defining the area size).
- Uploading the model into Google Earth.

This synergy enables users around the globe to populate the virtual Earth with 3D models, and the living Google Earth is a testimony to this vision.

In practice, the forest engineers have to follow the steps of the scenario proposed in Figure 1 to gain the best results.

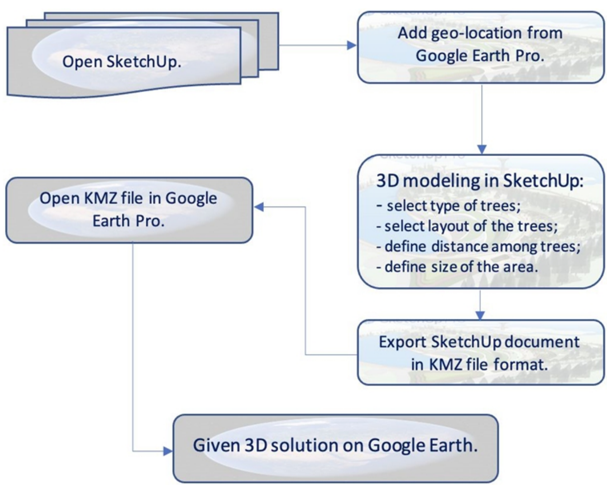

Figure 1. Proposed PES F4W approach for woodland planning

The proposed approach can be illustrated with the following use case scenarios. Their aim is to support the transformation of agricultural land surrounding water springs “Dobra voda” (Figure 2) and “Medzitlija” (Figure 3) into woodlands.

Figure 2. Google Earth Pro Map of the spring “Dobra voda”

Figure 3. Google Earth Pro Map of the spring “Medzitlija”

- To geolocate a model in SketchUp, it is necessary to import terrain using the Add Location tool. We import terrain that enables the creation of the model based on the site where it is planned to be built (or just display it on Google Earth).
- In SketchUp, we select the type of trees as a 3D model (appropriate to the area and height of the location, a decision made by the forest engineer), define the distance among trees, and the size of the area to be reforested or protected. There are a number of websites available on the internet that offer ready-to-use SketchUp models. The layout of the trees can be different. In the first case, we used a rectangular and in the second use case, we used a circular layout. These parameters must be previously known and defined by forest engineers.
- When placing a model created in SketchUp, it is essential to ensure the model's dimensions are exact so that its scale aligns proportionally with the surrounding landscape or buildings in Google Earth. Previewing a SketchUp model in Google Earth is a great way to see how the created model looks in the context of its surroundings. When the model is ready for a preview, it is needed to export it as a Google Earth KMZ file. The KMZ format is a zipped form of Google Earth's proprietary Keyhole Markup Language (KML). A KMZ can contain location data (latitude and longitude) along with other information, such as SketchUp geometry. A KMZ file allows you to view a model in Google Earth without needing SketchUp installed. Furthermore, it allows sharing of the model for viewing in Google Earth in SketchUp's 3D Warehouse.
- When a 3D model is imported into Google Earth, it can be translated, rotated, and scaled to fit into the Earth coordinate system. Within Google Earth, Google Earth's navigation tools can be used to move around the area and see how your model looks on its intended site. The created use case in Google Earth Pro of the spring "Dobra voda" after opening the KMZ file gained by SketchUp can be seen in Figure 4. The same approach is applied in the next case study for the spring "Medzitlija", shown in Figure 5.

It is important to note that the use of this approach for modeling the environmental protection of ecological water bodies is not solely limited to afforestation. It can be used with different Google Earth Pro locations as well as different ready-to-use 3D objects from SketchUp. Because of their user-friendly usage and flexibility, they can be used for modeling GIS-connected plans from a different scope of interest. Planning of river protection with woods, barriers, bridges and other objects, planning the protection of springs, wells and watercourses, as well as urban planning suitable to the concept of smart cities can also be performed.

4.1. Benefits from the PES F4W approach for the society

In general, several stakeholder groups can profit from this user-friendly approach. First, the Ministry of Agriculture, Forestry and Water Management can use

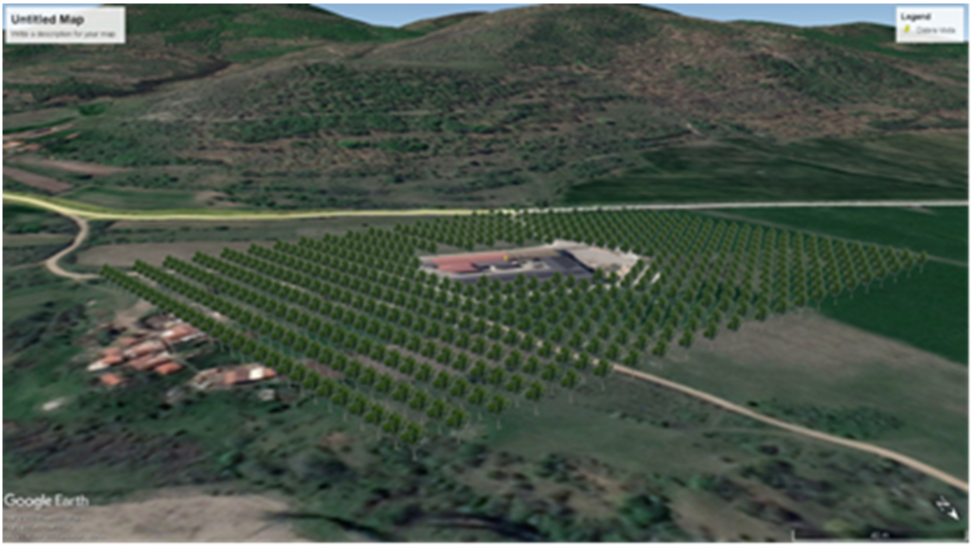

Figure 4. Google Earth Pro Map of the spring "Dobra voda" after opening the KMZ file gained by SketchUp

Figure 5. Google Earth Pro Map of the spring "Medzitlija" after opening the file gained by SketchUp

it for planning and modeling the spring and the water body's protection. In general, several stakeholder groups can utilize this user-friendly approach. Firstly, the Ministry of Agriculture, Forestry, and Water Management can use it for planning and modeling the protection of springs and water bodies. In addition, it can be used for planting suitable trees or forest around the springs, basins, and rivers. It is important because it has to provide clean water and protect the citizens, according to the EU demands and the EU WFD. The WFD aims to ensure that all surface water and groundwater are in good quality status by 2027. They will benefit from this approach in short and long-term planning. They can prepare the needed seedlings, appropriate for the properties of the land and solve the land ownership.

The Ministry of Ecology can benefit from the usage of this approach to protect the environment around the water springs, supporting the EU WFD. The Ministry of Economy, as the entity responsible for granting water concessions to companies, will also benefit. The companies that bottle and sell drinking water, food, and beverages will benefit from meeting EU standards for clean water by using this approach.

The Ministry of Healthcare can benefit from the implementation due to a reduction in diseases linked to issues caused by polluted water sources. This is related to the use of artificial fertilizers, other fertilizers, insecticides, and pesticides around springs, sources, and rivers. This approach can be used to protect all water sources utilized for food production and agricultural irrigation.

Citizens will benefit from the approach implementation with improved living conditions by having access to "water with a good quality", without pollutants from land (agriculture or insecticide). In the end, this is the main goal of the EU WFD.

5. Conclusions

In this paper, we propose an approach for modeling the environmental protection of ecological water bodies based on the goals of the EU Water Framework Directive. The main aim is to gain water with a "good quality status" by 2027. This framework intends to provide activities in planning the protection of water bodies as recommended. The most effective sustainable way to protect water bodies is effective and precise planning of their protection in areas around water springs, river flows, and other water accumulations. As advised in [24], the gradual transformation of agricultural land into woodland is another sustainable way of water bodies' protection.

The combination of the GIS system Google Earth Pro and the 3D modeling SketchUp tool is used for this approach for modeling plans and creating scenarios for transforming agricultural land around water springs into woodlands. This approach demonstrates the virtual afforestation implemented in the selected area surrounding the springs. It is demonstrated using two selected springs, "Dobra voda" and "Medzitlija," which serve as case studies for bottled water.

It is worth mentioning that the approach is applicable to a wide range of GIS planning and modeling activities using different 3D objects. Applications include but are not limited to planning river protection with woods, barriers, bridges, springs, wells, and watercourses. It is also suitable for urban planning, essential for implementing the concept of smart cities.

As future work, we plan to develop a framework for calculating Payments for Ecosystem Services based on the recommendations of PASFOR-W [24]. These schemas are connected with gaining easy-to-use calculation expert system intended for forester and water experts in the process of decision-making in woodland and water bodies protection. Specifically, a tool is needed for planning the type of trees, the spacing between them, and the number of tree seedlings. This can be determined based on factors such as the land's geology, sea level, weather conditions, and other relevant factors.

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