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Keywords
Environmental Education, Systems Science, school extracurricular programmes, environmental web-tools, Secondary Education

AN APPLICATION OF SYSTEMS SCIENCE FOR THE USAGE OF WEB–TOOLS IN ENVIRONMENTAL EDUCATION: THE CASE OF WESTERN ATTICA, GREECE

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Abstract

Geography plays a leading role in developing the objectives of Environmental Education. Through Geography lessons, applications and tools, pupils should learn about the significant environmental and developmental problems through issue-based learning. They must be given opportunities to explore how these issues relate to their everyday lives and what is the impact on the quality of the natural and social environment. Teachers can promote a holistic outlook, through developing a multidimensional study of environmental problems on a variety of scales, e.g., through historical maps, which are of significant value, because through them students gain perspective on the living environment and the changes caused by the human intervention in coastal areas and habitat.

The purpose of this paper is to propose new, modern and up-to-date web-tools, for example, Geographic Information Systems and remote sensing applications, generally applicable for any geographical area although demonstrated in the field of Western Attica (Greece), to improve pupils' knowledge and skills on Environmental Education issues. Additionally, a framework of Systems Science is suggested for planning the didactics of this multidimensional approach, for facilitating teachers in their related educational duties.

Introduction

The Greek Ministry of Education, through the local Secondary Education Directorates, every school year suggests teachers implement mainly extracurricular programs of Environmental Education, according to specific instructions. Such a Directorate is the Western Attica's Secondary Education Directorate (WASED), located in an environmentally stressed region (Western Attica, Greece) that includes the industrial area of Thriasio Plain (Salvati & Mavrakis, 2014; Karakiozis et al., 2015: 173), oversees 46 secondary general and vocational schools. The pupils' population is different in their origins and their characteristics: usually, the pupils of general senior high-schools (Lyceums) come from the local municipalities. On the contrary, Vocational Lyceum pupils come from the ex-soviet regions settled in the area in the mid-'90s. Pupils of general high-schools are mainly interested in everyday life problems at local municipalities. Precisely the opposite is the approach of vocational education pupils: they are interested in what they see and less in related issues (Papavasileiou & Mavrakis, 2013).

The pedagogical goals of the extracurricular programs/activities, such as the Environmental Education, are included in the instructions of the Greek Pedagogical Institute (recently recognized and renamed to Institute of Educational Policy), and they are referred to articles, which constitute guidelines (Skoullos, 2004; Kousoulas, 2008), and among them are [i-iii]:

i. to understand what is meant by sustainable development and to learn to live in such a kind of way that will allow a contribution to sustainable development;

ii. to develop skills to work in groups;
iii. to improve a critical way of thinking.

The teaching methods are usually standard, and the implemented teaching method requires students to work in groups. Teachers divide students into small teams of four/five pupils. Each team must undertake a different task. Environmental Education programs usually implemented by using lectures, field research, bibliographic survey, open space study, final report text, and a PowerPoint presentation.

Environmental Education

Environmental Education has been the first category of extracurricular programs established in Greek education (Law 1892/1990: Article 111), while the objective of the European Union's policy is to integrate it into the "formal school curriculum so that this type of education can be provided to all pupils" (Spyropoulou et al., 2008: 199). Pupils may work on the following issues, arranged in fifteen [15] major topics (Ministry of Education, 2017):

1. Sustainable school – courtyard of school (energy sources in school and the school community's behavior to save energy; initiatives to improve the quality of the relationships between school community members and the environment at school; marking for cleanliness; care and responsibility for the courtyard and the classroom; "I envision the school of the future").
2. Sustainable residence (design of buildings, settlements, cities within the planet's carrying capacity; bio-climatic architecture; material safety & hazardous furniture, oil paintings, etc.).
3. Energy issue – ecological/energy footprint at school and home (our daily transportation; alternative forms of energy for heating-cooling; what do we spend on energy).
4. Local environment; home, school, community (acquaintance with the local ecosystem; waste management in the city we live in; personal and collective responsibility for protecting the flora in our immediate environment; activities and everyday habits that affect the bearing capacity of gorges, forests, and beaches).
5. Free spaces; exploitation – configuration – protection (playgrounds – sports and entertainment venues; suitability of premises in terms of cleanliness, materials, care, voluntary participation to control and maintenance; "We adopt and protect a grove or a beach of our country").
6. Conservation and protection of urban and suburban green areas (change of land use; urbanism and unemployment; ecological burden; the importance of Land Registry in Land Use Management).
7. Biotechnological applications and the environment (Genetically Modified Organisms: GMOs; production of food from genetically modified organisms; hybrids, wild plant varieties, genetically modified plants; effects of GMOs on the environment, health, economy, and society; traditional local crops and their relationship to the local economy and the environment).
8. Natural resources management (intensive forms of exploitation of natural resources; forests, deforestation, soil erosion; water resources; agriculture, livestock farming, overexploitation; the relationship between the economy and the protection of the local environment; the emergence of exemplary local economically-friendly land uses concerning the environment).

9. The concept of Conservation of the Natural Environment (ecosystems, structure, and operation of terrestrial and aquatic ecosystems; biodiversity, threatened species and protected areas).
10. The concept of Environmental Degradation (atmosphere – air pollution, greenhouse effect, ozone hole; water pollution; soil pollution; radioactive pollution; waste and waste management).
11. Environmental risks (climate changes; natural disasters and human intervention; environment and war).
12. Space organization and use (urban environments, urban development, uses, urban and suburban green, road networks, noise pollution, school and indoor environment; residential development, public space and the environment; natural environment, space planning, rural development, tourism, alternative tourism and ecotourism, area adoptions; environment and monuments, archaeological and historical sites; landscape and habitation, degradation of the landscape; Geological monuments and monuments of nature).
13. Anthropogenic environment; parameters & degradation (environment and communication, paths – natural routes, transportation; environment and History, Local History, movement History, Natural History, History of towns and rural facilities, natural elements, Mythology, and Folklore. The environment as a source of inspiration and a forum for dialogue, environment, and Arts; the environment as an exhibition, museums of natural sciences and technology, natural history, collections, exhibits, environmental data in collections, permanent and periodical exhibitions of museums; the environment as a narration. Nature and environmental issues in literature; environment, perceptions and ideas, Nature and Religion, Environmental Ethics, Democracy, environmental actions, and environmental consciousness, Consumerism, and the Environment; the environment as the meeting-place of Cultures – Intercultural references).
14. Quality of life (suitability-risk of materials and structures; safety at school and at home in relation to objects; environmentally friendly materials – ways of precaution; industrial pollution, agricultural pollution; heavy metals, insecticides, pesticides, bioaccumulation; solar radiation, electromagnetic radiation; noise, sound volume, noise map; hidden pollution, sick buildings, indoor pollution, combustion systems, smoking, building materials, radioactive radon, cleaning materials).
15. Human Rights – Democracy (problems of poverty and illiteracy; democratic rights, citizens' & children's rights; social exclusion, equal opportunities, gender equality, racism, xenophobia, etc.).

Each major topic is divided into sub-topics; questions usually arise from the respective team of pupils. Initially, the pupils say whatever reasons they believe that have to do with the selected topic (brainstorming). Finally, each team presents its sub-topic. In some cases, a Google Team is created to facilitate coordination and collaboration among teams, and all pupils' work is uploaded there. (Solbes & Vilches, 1997; Aikenhead, 2002; Schreiner & Sjoberg, 2005; Edelson, 2007; Holubova, 2008; Smart & Marshall, 2013; Lemoni et al., 2013). Also, the emphasis is given to the pupils' experimental approach (field study). Excursions to local sites of interest can be an enriching educational component of an environmental science course. Despite the difficulty of arranging these and incorporating them into the course's curriculum, they should be strongly considered (Goodwin, 2003).

Purpose and Means

The purpose of this paper is to suggest and propose the usage of new, modern and up-to-date web-tools and applications, for example, Geographic Information Systems and remote sensing applications, to improve knowledge and skills related to environmental studies. The Geographic Information Systems is vital because the usage of such tools can promote the required basic understanding of environmental education to pupils, providing them with opportunities to understand major global environmental problems and develop pupils' teaching and learning methods about the environment within a geographical framework.

For the above purpose, a survey of some freely accessible web-tools and applications are presented and proposed for use by secondary education teachers and pupils. This material below was chosen according to free web access, friendly interface environment and how easily can be implemented to secondary educational procedures (Koutsopoulos, 2011; Jahn et al., 2011; Wibeck, 2014; Papapanousi et al., 2015a).

Global Forest Change

Global Forest Change (Hansen et al., 2013) is an interactive, remote sensing application, a useful tool for understanding deforestation, land degradation and desertification (Fig. 1). It is also a valuable tool for environmental studies in secondary education. Users can easily find Landsat satellite images and make combinations between channels. It results from the time-series (2000–2012) analysis of 654,178 Landsat images in characterizing forest extent and change. Trees are defined as any vegetation taller than 5m and are expressed as a percentage per output grid cell, as 2000 Percent Tree Cover. Forest Loss is defined as a stand-replacement disturbance or a change from a forest to non-forest state. Forest Gain is defined as the inverse of loss or a non-forest to forest change entirely within the study period. Forest Loss Year is a disaggregation of total Forest Loss to annual time scales. Reference 2000 and 2012 imagery are median observations from a set of quality assessment-passed growing season observations.

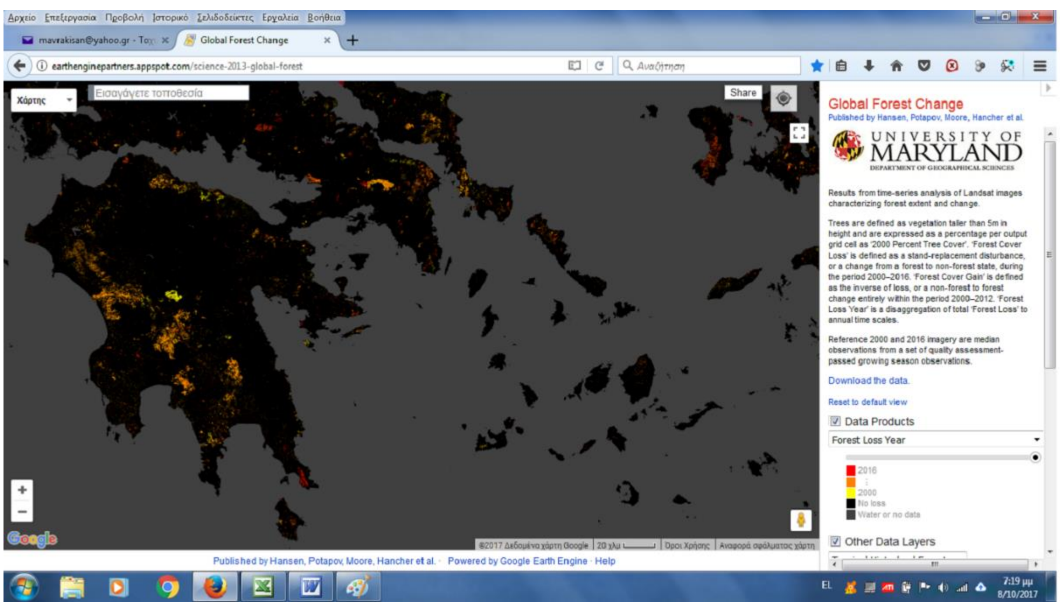

Fig. 1: *Global Forest Change*

Climate Interactive – Tools for a thriving future

This website (Climate Interactive, 2019; Climate Change Institute, 2019) is a useful tool for understanding weather, climatic parameters and climatic change (Fig. 2). Pupils using this application may participate in a simulated debate about climate change, as members of United Nations delegations. Through this process, they can also see the results of the negotiations. The educational material has been produced using Open Source software, with R language as a primary tool. R is a free software environment for statistical computing and graphics (The R Foundation, 2019). Part of the same project was the Climatic Maps for Europe application, as well, which is not active anymore. Univariate and multivariate interpolation techniques, implemented in R add-on packages, are applied for deriving surfaces of observed weather data. YouTube videos showing climatic parameters for the entire planet and maps were updated daily, with a delay of two days.

CLIM-RUN Project

CLIM-RUN Project (National Observatory of Athens, 2019) is a handy tool for understanding climatic change parameters (Fig. 3). This application can give results to the local level, so it's a very suitable tool, helping pupils to understand the effects of climatic change to their environment. CLIM-RUN Project aims at developing a protocol for applying new methodologies and improved modeling and downscaling tools for the provision of adequate climate information at regional to local scale that is relevant to and usable by different sectors of society (policymakers, industry, cities, etc.). The protocol is assessed by application to related case studies involving interdependent sectors, primarily tourism and energy, and natural hazards (wildfires) for representative target areas (mountainous regions, coastal areas, islands). CLIM-RUN is thus also intended to provide the seed for the formation of a Mediterranean basin-side climate service network, which would eventually converge into a pan-European network. The general time horizon of interest for the project is the future period 2010-2050, a time horizon that encompasses the contributions of both inter-decadal variability and greenhouse-forced climate change (Wibeck, 2014).

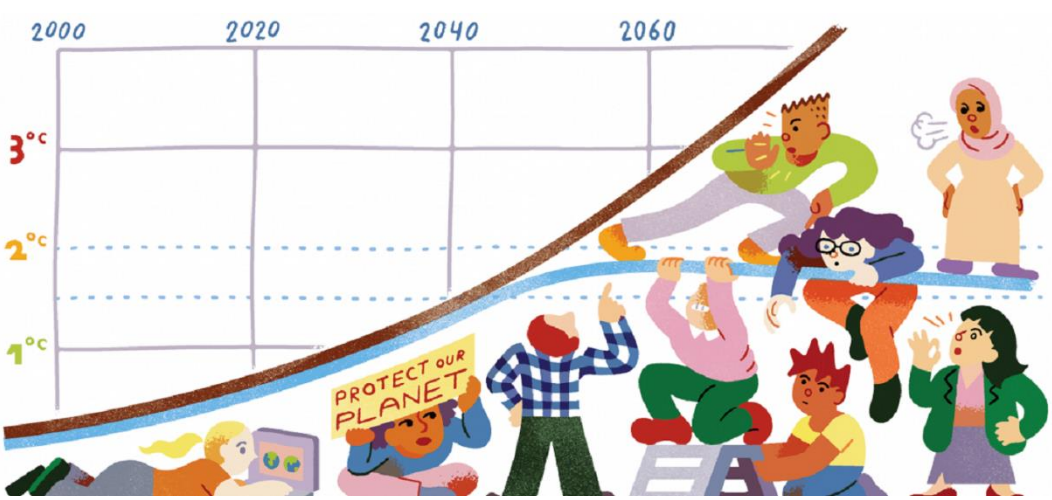

Fig. 2: *Climate Interactive*

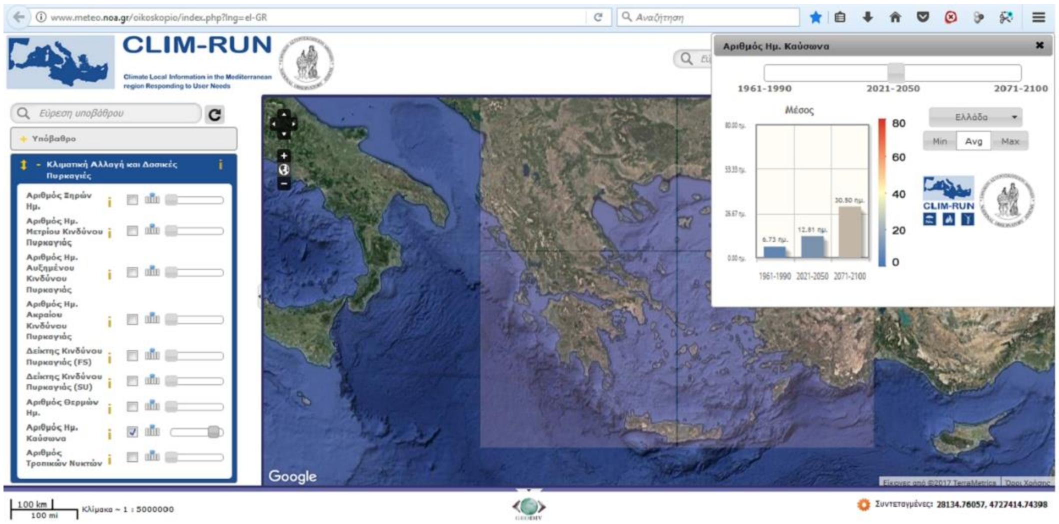

Fig. 3: *CLIM–RUN*

Change Matters Viewer

Change Matters Viewer (ESRI, 2019) is an excellent and handy tool for understanding land use changes, overpopulation, deforestation, land degradation and desertification, and urban expansion through issue-based learning (Fig. 4). It gives the opportunity of exploring how these issues are related to pupils' everyday lives and how they have an impact on the quality of the physical and social environment. This application can give results to the local level, so it's a very suitable tool, helping pupils and professionals to understand the effects of land use change to their environment. Change Matters Viewer use Landsat images and maps to understand earth changes that have happened over time. Advanced change detection tools are also available by clicking any full-screen button. The first two panels show a region for the selected years with the image chosen map applied. The third panel displays vegetation changes in vibrant green and magenta using NDVI (Normalized Difference Vegetation Index).

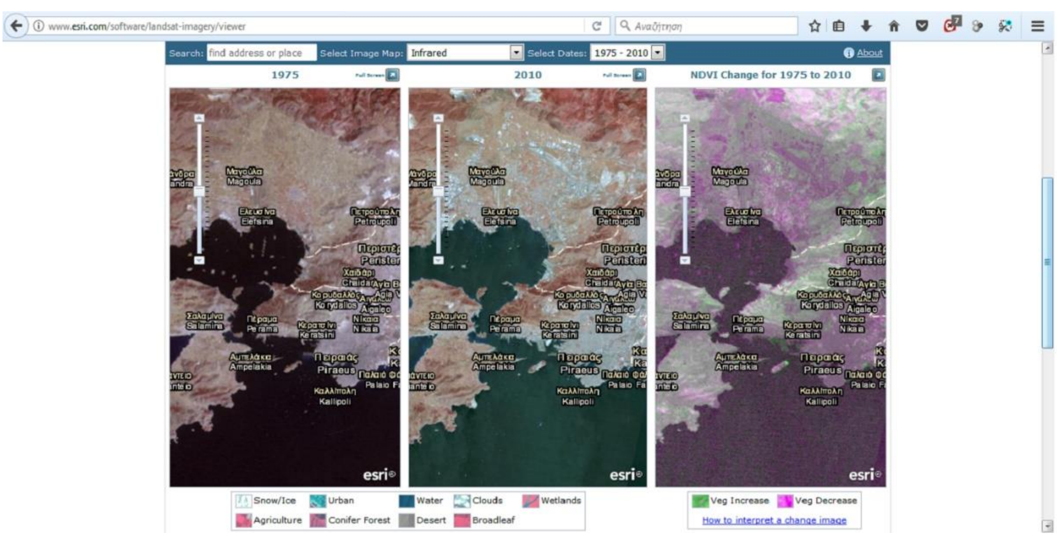

Fig. 4: *Change Matters (from esri)*

Geodata

Geodata (2019) is a useful tool for pupils and teachers because it introduces them to Geographic Information Systems and improves their knowledge and skills on using this kind of databases (Fig. 5). This tool is an official source of various information and used for studies regarding building the environment, land use changes, and urban expansion, through promoting a multidimensional (e.g., social, political, historical, cultural) research of an area of interest. Geodata, designed, developed, and is maintained by the Institute for the Management of Information Systems of the "Athena" Research and Innovation Center in Information, Communication and Knowledge Technologies, to provide a focal point for the aggregation, search, provision, and portrayal of open public geospatial information. Geodata is one of the Greek Government's "open-government" initiatives in the framework of the Open Government Partnership. Furthermore, its operation is included in the Road Map to support the enforcement of Law 3979/2011 for eGovernment, as a best practice example for the application of Information & Communication Technologies (ICT) in the public administration and as an open data repository for the provision of geospatial information. Finally, geodata.gov.gr provides technical support to the National Spatial Data Infrastructure, in accordance with the National Strategy for ICT and eGovernment.

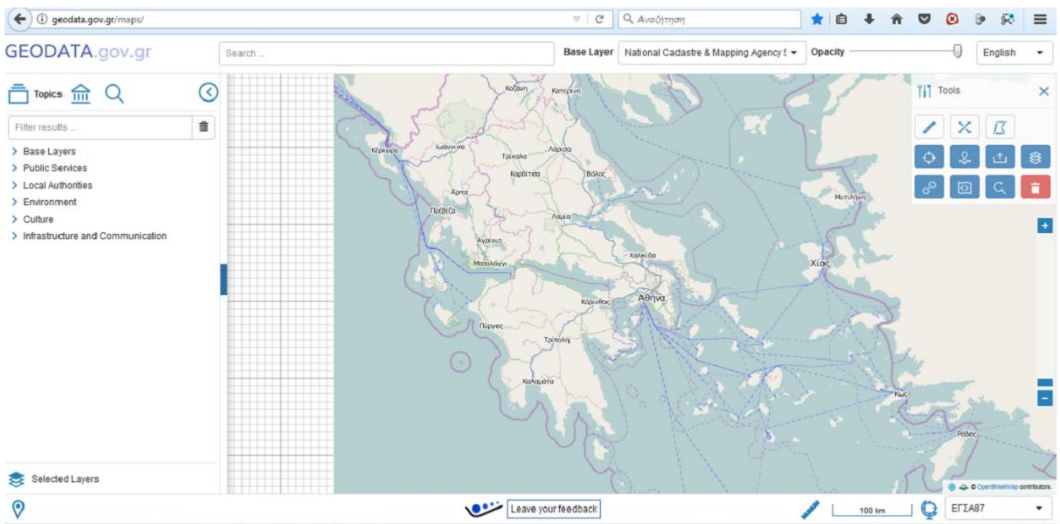

Fig. 5: *Geodata*

Global Risk Platform

The PREVIEW Global Risk Data Platform (UNEP/UNISDR, 2013) is a multiple agency efforts to share spatial data information on global risk from natural hazards (Fig. 6). Users can visualize, download or extract data on past hazardous events, human & economical hazard exposure and risk from natural hazards. It covers tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis, and volcanic eruptions. The data were collected from a wide range of partners. This was developed as a support to the Global Assessment Report on Disaster Risk Reduction (GAR) and replaced the previous PREVIEW platform already available since 2000. This application is a useful tool for pupils and teachers because it introduces them to Geographic Information Systems and improves their knowledge and skills to use this kind of databases. This tool is a source of various – simple or multilayered – information and can be used for studies regarding natural and anthropogenic risks (for example: fires, droughts, earthquakes, floods, landslides, tsunamis, volcanoes), socio-economic risks, built environment, land use changes and urban expansion, through promoting a multidimensional study of an area of interest.

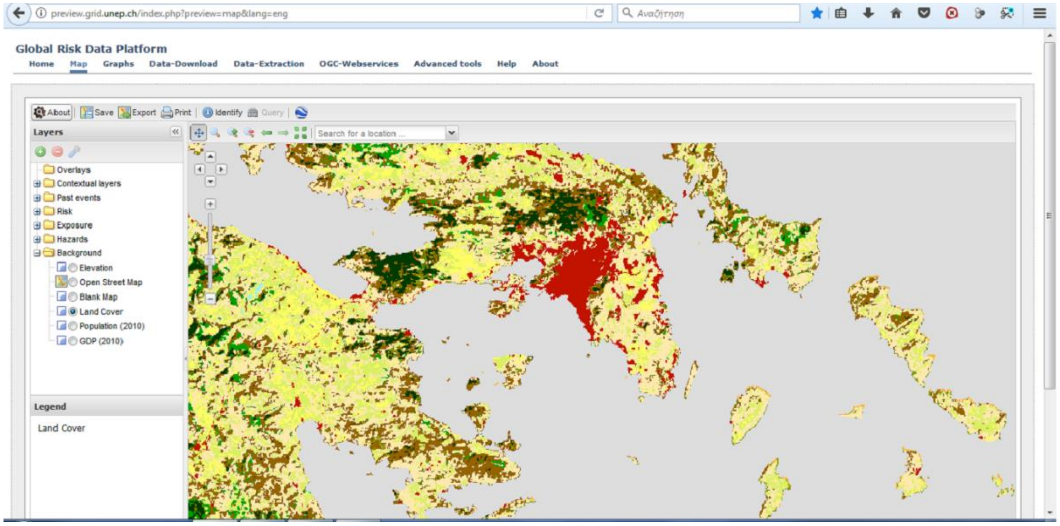

Fig. 6: *Global Risk Platform*

NOAA Education Resources

The NOAA (National Oceanic and Atmospheric Administration) Education Resources (NOAA, 2019) of the U.S. Department of Commerce is a unique web-tool that introduces scientific data to pupils (Fig. 7). The available specialized topics include Meteorology (e.g., climate vs. weather; climate change and global warming; the role of Oceans in weather and climate) and Oceanography (e.g., Oceans and Coast; sea water; layers of the Ocean).

ESA Eduspace

ESA (European Space Agency) Eduspace (ESA, 2019) is a website that aims at providing pupils and high school teachers with learning and teaching tool (Fig. 8). It is intended to be the first contact with space image data and with a wide range of Earth observation applications for education and training. The Eduspace website encourages teachers to use Earth observation data in their curriculum, providing works that are ready for use. It is rich in teaching material, mainly regarding local and global satellite remote sensing data. It is a source of ideas on how to present space-related topics in the classroom while giving full-scale examples (Koutsopoulos, 2011; Jahn et al., 2011).

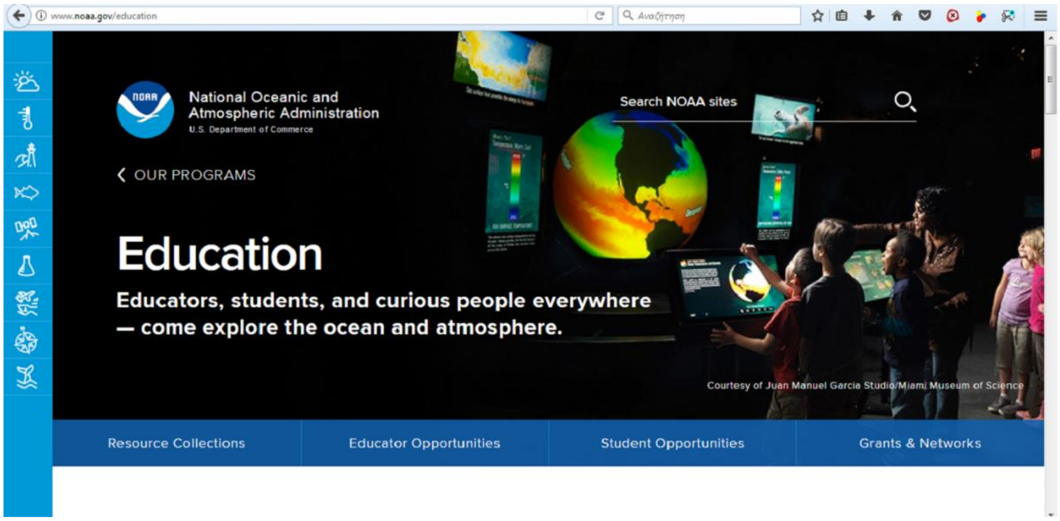

Fig. 7: *NOAA Education Resources*

Fig. 8: *The esa Eduspace website*

Flood Map

Flood Map (FloodMap.net, 2018) is a water level elevation map (Fig. 9). It is a useful game-tool for understanding the impacts of climate change to coastal and near coastal environments. As a web-application, it is a small contribution using our programming skills towards the fight against natural disasters, like floods, and could probably save lives.

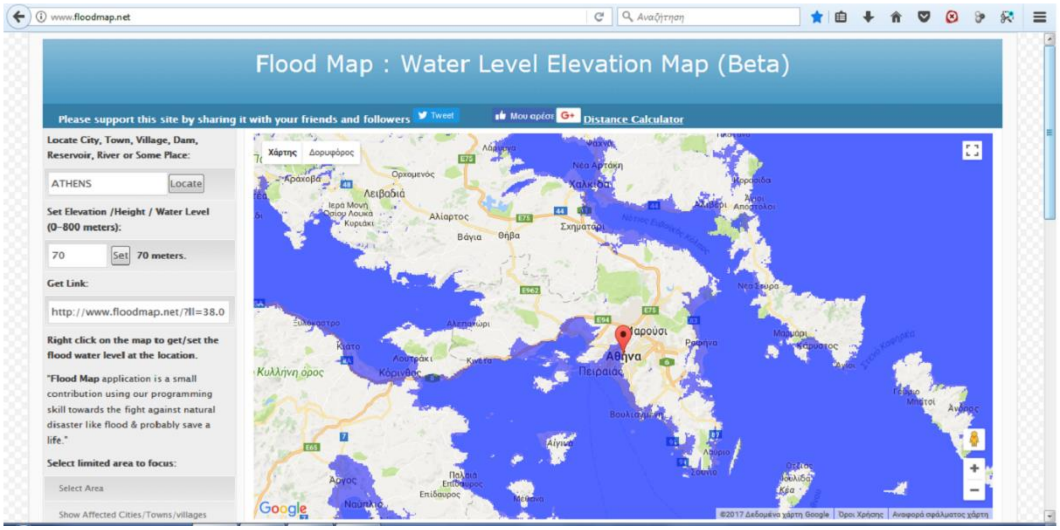

Fig. 9: *Flood Map: Water Level Elevation Map (Beta)*

Historical Cartography

Historical cartography can be a tool for studying the long-term changes that have taken place in an area. Especially for the Attica region (Greece), an example of such mapping is Kaupert's historical maps of the University of Heidelberg Library (Heidelberg University Library, 2019; Curtius et al., 1881-1900; Curtius & Kaupert, 1878). In their lithographic print, these maps have three and sometimes four colors. The color black is used for the geographical outlines, the buildings, the various configurations, the road network, current names, altitudes, geographic coordinates, contour lines, chart-framing lines, titles, design scales and various memos at the bottom of the sheets. Sepia is used for the terrain and cyan for the sea, lakes, alluvial and in some cases torrents. Finally, red is used to mark the ancient relics (or even traces), their names and other related information.

Data downloaded from the internet is not the maps themselves, but pictures of these maps in pdf format. The geo-reference of the images and the creation of a mosaic of Attica were done with the help of the Geographical Information System QUANTUM GIS 1.7.4 – WROCLAW, where an initial map of the entire Attica was made in a scale of 1:400000, based on the outline of its coastlines in WGS84. From the original mosaic, the area of Thriasio Plain and the Gulf of Elefsina (Fig. 10) were selected for some additional highlights that could be used in environmental education school projects (Papapanousi et al., 2015b).

In Fig. 10's map, the residential area of Elefsina can be seen, as well as the city of Aspropyrgos with its old name (Kalyvia), elements of the natural environment such as the lush oak forest Lisia (upper part of the image), the shape of the coastline, the bathymetry of the Gulf of Elefsina, etc. As in other areas of Attica, the coastal zone of the region has changed significantly (Verykiou-Papaspyridakou et al., 2004; Skilodimou et al., 2007; Seni et al., 2004; Dasaklis et al., 2012). The coastal zone of Attica is the part of the natural environment that first underwent changes and will still change in the future. Kaupert historical mapping is the tool, but also a unique element (Livieratos et al., 2013) that certifies the pre-existing environment and geo-relief used as an educational tool.

Also, the maps include geophysical elements, settlements, streets, harbors, quarries, crops, forest cover, and red-stained archaeological evidence. As Sakellaropoulos (1884) notes, commenting on these maps: "... It was necessary to have an illustration of the traces of the ancient formations on the ground as precise and comprehensive as possible” and “This is very urgent, since the ancient traces, hardly visible and only in relation to other important ones, have not yet been presented and because they are being destroyed year after year, due to the imprudent exploitation of the rocky Athenian hills as quarries and their fragmentation by explosive materials”. These archaeological traces are all the monuments of areas and eras, scattered ancient stones, ancient graves or tumuli, airing utility holes of underground aqueducts, old quarries, harbor works, traces of settlements, mining remnants, traces of ancient roads and so on. Another feature of the Kaupert maps is that they contain folklore information such as the many place-names that were denoted in the Arvanitika dialect (almost obsolescent nowadays), while others refer to settlements before they are formed into towns or villages (e.g., Kalyvia for Aspropyrgos, etc.).

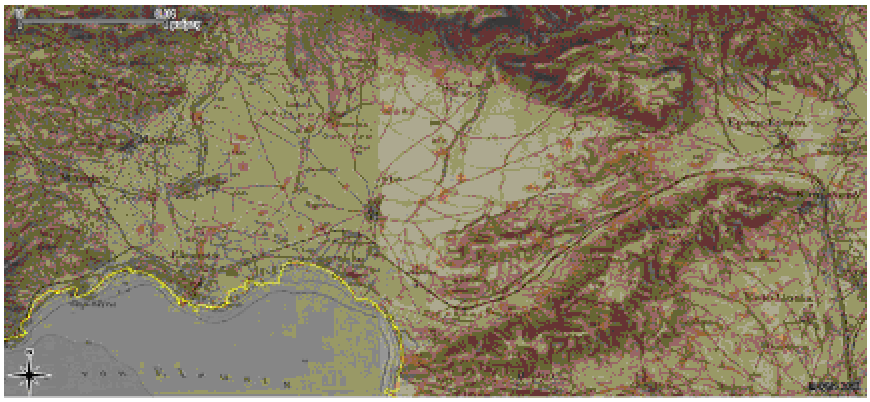

Fig. 10: *Picture of the Elefsina’s Map Sheet*

The analysis of the resulting image (Fig. 11) gives us some information about the area that cannot be perceived by the modern inhabitant. Thus, with light blue color the “Kalymbaki” area is highlighted, i.e., the outflow of the aquifer. Reiton Lakes are highlighted with dark blue, while the marsh on which the industrial area of Aspropyrgos Beach has been created is highlighted with light green. Another feature that is highlighted is the change in the shape of the coastline. Comparing the Kaupert map’s coastline with a modern map gives us immediate evidence of the places that we had human intervention.

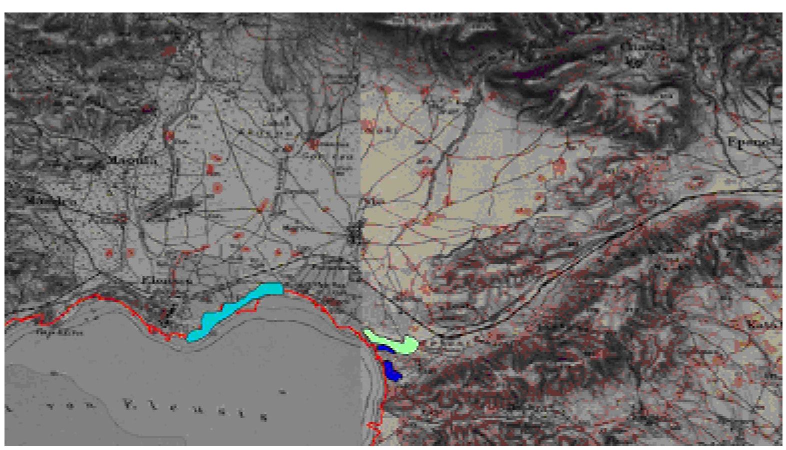

Fig. 11: *Details of the previous image (Fig. 10) that have been highlighted*

In both images (Fig. 10 and 11) there are scattered spots with antiquities (in red), as Kaupert himself recorded. These findings are useful for educational purposes because they are a monitoring tool that allows pupils to understand the changes that modern humans are making in the natural environment. The seaside setting is an environment in which many activities are developed, and the changes are immediate and rapid. Historic maps, along with web applications, are essential tools for understanding these changes, that additionally offers:

i. Geographic data;
ii. Historical, Folklore and Cultural Information;
iii. Scientific data;
iv. Historical photos/illustrations;
v. Ecological information;
vi. Ability to compare with the current situation.

Thus, the use of historical maps in environmental education programs is a holistic tool that allows the multifaceted study of ecological problems, in different space and time scales.

Implementation

Geography constitutes an essential tool in implementing innovative extracurricular programs in Environmental Education. The coastal environment is the site where a multitude of human activities is developed. This makes it a personal issue in the programs of innovative extracurricular activities are voluntarily implemented in Greek Secondary Education. The general pedagogical objectives set in the environmental programs are usually [iv-viii]:

i. to acquaint pupils with the natural, folklore and historical wealth of their area;
ii. to recognize the importance of habitats and ecosystems;
iii. to understand the environmental dangers that threaten their region;
iv. to raise awareness and to adopt lifestyles that contribute to sustainable development; and
v. to develop skills, to work collectively and to develop critical thinking.

The collection of informational material focuses mainly on geographic data, historical-cultural information, scientific data, pictures of past years, the specifics of the subject under consideration, its ecological significance, as well as the current situation (Iliadis et al., 2012; Papavasileiou & Mavrakis, 2013). The teaching place of the experimentation and implementation of those applications and tools are the computer labs of schools and not a classroom. The implementation of the method has two parameters:

(a) the difficulty of pupils to achieve this task, given the fact that they are not familiar with maps (Paraskevas et al., 2010; Apostolopoulou & Klonari, 2011; Klonari, 2012);
(b) pupils are very familiar with mobile and web applications, tools and games (Papavasileiou & Mavrakis, 2013).

The second one allows pupils to play with all those web applications and tools. Written instructions should be available and the use of a worksheet as a guide. An example of a worksheet is the following one (Table 1):

Table 1
Worksheet using maps

Data	Given five satellite images of the Thriasio Plain, downloaded from: http://changematters.esri.com/compare (Fig. 4)
Questions	1. Can you locate and draw the outline of Ano Liosia's waste area? 2. Can you locate and draw the outline of Fyli's landfill site? 3. Which year do you find their differentiation in? 4. What more general comments can you make?

The difficulty as mentioned above of pupils in using maps and the related challenge of teachers in utilizing them as an educational tool can be overcome by the usage of techniques from Systems Science. Such methods may assist teaching plans, mainly through the arrangement of the course's material in environmental topics, in a manner more easily understandable by the participants. The relevant conceptual framework that is suggested herein is Systems Inquiry (Banathy, 1988, 1991).

Systems Inquiry

A system is defined as a complex set of elements, along with their properties, relationships, and processes that may transform properties and relations. When these elements interact only with each other, then we have a closed system, while when they interact with their environment, then we have an open system. The idea of the systemic study of phenomena (Systems Science) originated from the classical work of Bertalanffy (1968) on natural phenomena and was later applied as well to social phenomena (Parsons, 1977; Luhmann, 1995; Laszlo & Krippner, 1998). Consequently, the two major categories of general systems are the natural systems that are popular in Science, Physics, Chemistry, Biology and Mathematics, and the social systems or systems of human activity (Stichweh, 2011). Therefore, any physical or social phenomenon is considered as a system described by an equivalent mathematical model (Heylighen & Joslyn, 1992).

Perhaps the most comprehensive conceptual framework for systems study is System Inquiry (Papakitsos et al., 2017b), which includes three cognitive areas: Systems Philosophy, Systems Theory and Systems Methodology (Bánáthy, 1997). In particular:

- Systems Philosophy explores in more general terms the issues of systems' implementation in the study of both theoretical and practical problems.
- System Theory explores the principles and models of a description of the phenomena in an interdisciplinary way, regardless of their nature or scale of existence (Heylighen & Joslyn, 1992).
- Systems Methodology explores methods of knowledge production for systems and the discovery of methods, models, and techniques for the study of complex systems (Banathy & Jenlink, 2001).

In the last case, such a method that is called Organizational Method for Analyzing Systems (OMAS-III) is suggested and applied herein for the first time in Environmental Education, to facilitate the teaching process of environmental issues.

OMAS-III has been developed as a conceptual tool for the study and description of general systems (Papakitsos, 2010, 2013). It originates from the evolution of two previous techniques of systems' analysis that have been popular in Computer Science (Ross, 1977; Grover & Kettinger, 2000). Besides, it is augmented by concepts of human communication models (Mantoglou, 2007; Lasswell, 1991), for facilitating the application of Systems Inquiry on the phenomena under consideration. OMAS-III has been already proposed and used in several educational applications (Papakitsos et al., 2015, 2017a, 2017b; Papakitsos & Karakiozis, 2016; Foulidi et al., 2016, 2017; Papakitsos, 2016a, 2016b).

Systems Methodology in Environmental Education

According to the descriptive model of OMAS-III, the determinants (factors) of a system are seven. In brief, these factors identify issues of causality, outcome (system's output), resources (system's input), laws (natural or social), people, place and time (Papakitsos, 2013: 180). The application of the methodology to the issues of Environmental Education herein may correspond to the following classification [a-g]:

a. The causality factors correspond to the implementation of the national and international policies regarding Environmental Education, as expressed at the beginning of section Environmental Education (Law 1892/1990: Article 111; Spyropoulou et al., 2008: 199).

b. The outcome of this system corresponds to the achievement of the pedagogical goals of the extracurricular programs/activities ([i-iii]), as well as the general pedagogical objectives set in the environmental programs ([iv-viii]).

c. The factor of resources corresponds to the presentation/description of the technological methods of production of goods, services and energy and how they affect (positively or negatively) the natural and anthropogenic environment.

d. The factor of laws corresponds to the national legislation on environmental protection and the relevant international treaties. It also (and mainly for the herein purposes) includes the natural and social processes that affect the environmental conditions, as for example the social behaviors regarding environmental issues (e.g., the degree of environmental sensitization and the daily practices/habits of consumption/use of goods, services and energy) or the natural disasters. Educationally, it includes the pedagogical practices as well (and tools) that can be used for the achievement of this system's outcome ([b]).

e. The factor of people corresponds to the anthropogenic environment that includes the presentation/description of residential areas, land use and social conditions (e.g., unemployment).

f. The factor of place corresponds to the presentation/description of the natural environment itself in the studied area, namely, the local ecosystem with its natural resources (flora and fauna), the geophysical relief (mountains, valleys, etc.), wetlands (springs, rivers, lakes, lagoons), protected areas (land and marine parks), coastline, sea, atmosphere, weather, etc.

g. Finally, the factor of time is closely related to the previous one ([f]), because it corresponds to the diachronic picture of a local environment (place) that allows the comparison of the conditions of an ecosystem in different periods. This comparison reveals the repercussions of human activities to the local ecosystems (e.g., deforestation, land degradation, etc.).

The usefulness of factors [c-g] will be further exemplified, since the first two ([a, b]) are generic and their status is visible.

Results and Discussion

Teachers can use the previous systemic classification [c-g] for the arrangement of the environmental education topics [1-15] in a cognitively more coherent manner (Table 2).

Table 2

Systemic classification of the environmental education topics

Systemic factors	**Environmental education topics**	
	Entirely	***Partially***
[c]	[2, 7, 10, 14]	[3]
partially [d]	-	[6]
[e]	[1, 5, 11, 13, 15]	[3, 4, 6, 8, 12]
[f, g]	[9]	[4, 8, 12]

Indicatively, in Table 2 the issues of five environmental education topics [3, 4, 6, 8, 12] are scattered (Partially) to more than one systemic factor ([d] is partially considered, only regarding legislation). Since the utilization of web-tools (Fig. 1-10) aims at the achievement of the pedagogical goals of Environmental Education ([b]) in a more effective manner, the same systemic classification could apply to these web-tools, for estimating their potential efficiency regarding the coverage of the systemic factors (Table 3).

The classification of Table 3 about the usefulness of web-tools regarding the direct coverage of specific environmental factors, viewed systemically, may effectively assist teachers in planning a pedagogically efficient course. Thus ideally, it would minimize the difficulties that could be encountered by teachers and pupils in understanding complex environmental issues.

Table 3

Systemic classification of the presented web-tools

Web-tools	**Systemic factors**				
	[c]	[d]	[e]	[f]	[g]
Global Forest Change (Fig. 1)	-	+	+	+	+
Climate Interactive (Fig. 2)	-	+	-	+	+
CLIM-RUN (Fig. 3)	-	+	-	+	+
Change Matters Viewer (Fig. 4)	-	+	+	+	+
Geodata (Fig. 5)	-	+	+	+	+
Global Risk Platform (Fig. 6)	-	+	+	+	+
NOAA Education Resources (Fig. 7)	-	+	-	+	-
ESA Eduspace (Fig. 8)	-	+	-	+	-
Flood Map (Fig. 9)	-	+	-	+	-
Historical Cartography (Fig. 10)	-	+	+	+	+

Conclusion

In this study, teachers and pupils are encouraged to use web-based search methods (Baltzis & Koukias, 2009; Abd El-Salam et al., 2009; Paraskevas et al., 2010; Wibeck, 2014; Exarchou et al., 2015), gathering information that are focused on environmental, geographical, historical, cultural and scientific data, as well as historical maps, all of them with ecological significance. Pupils from both general and vocational secondary education schools are very familiar with new technologies: mobile applications, computers, websites, and software tools. This fact may cope with the pupils' difficulty with maps and even overcome it, by teaching them how to use maps with ease, since it is a necessary life-long ability/skill. Therefore, they can very easily access web-based literature for mining various kind of information, just playing with them.

The proposed new, modern and up-to-date software tools and applications can be used and implemented to secondary education procedures and more specifically to Environmental Education, to improve the knowledge, skills and the understanding of environmental issues both from secondary education teachers and pupils. These educational procedures can be better organized and conducted by using conceptual tools from Systems Science and particularly OMAS-III. The purpose of utilizing a systemic conceptual tool is both for covering the study of environmental phenomena holistically and for evaluating the potential contribution of specific web-tools in such studies, according to the particular didactic needs. It has demonstrated that the utilization of methodologies from Systems Science in planning the educational course could be proved very helpful regarding the achievement of the pedagogical goals of Environmental Education.

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