SUSTAINABLE DEVELOPMENT – AN ARTIFICIAL INTELLIGENCE APPROACH

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Abstract
In mid 20s Carson (1963) raised the question of environmental issues in economics as one that should be discussed by practitioners and researchers. From that point, the environmental issues from the analysis of exhaustible and productive resources to its economic role and consequentially its impact, were examined. Environment affects must be considered as human activity-based processes which repercussions effect economy in general. Thus, the long-term decision-making processes in economy must take into account future generations as well. Furthermore, tourism as an economic activity is growing rapidly and one must take into consideration, that it is based on, primarily, natural environment and man-made resources. Degradation of basic tourism resources can lead to decrease of tourism demand. Therefore, the analysis of environmental impact on tourism, and vice versa, the impact of tourism on environment is crucial. With the development of information technology sector, new and innovative methods for analysis and forecasting have emerged such as artificial intelligence. The main hypothesis of this paper is to research how artificial intelligence can contribute to analysis and investigating environmental aspect of tourism. Therefore, the paper provides a theoretical overview of possible fields of artificial intelligence usage in sustainability, in the context of tourism development.
Keywords: artificial intelligence, environment, sustainability, modelling, tourism

1. INTRODUCTION

The increasing number of population, urbanisation and industrialisation, faced by our planet during this century, have forced society to consider a change for the very conditions essential to life on Earth (Thomson 1997). The problem of global environmental issues is complex and can be explained by interactions between humans and environment itself. Information technologies have played an increasing and central role in this interaction with planning, predicting, supervising and controlling environmental processes at many different scales and within various time spans (Cortés et al. 2000). Worldwide, organisations, industries, governments but also researchers have started to take into consideration a more proactive interaction with the environment, by introducing the environment in all crucial planning and decision-making processes regarding its impact on the economy. Rapid developments in the information technologies sector in recent decades obtained new and faster hardware's that enabled interdisciplinary research links between environmental and computer scientists possible (Cortés et al. 2000). The impact of information technologies sector in environmental research resulted in a new discipline, known as Environmental Informatics, that combines research fields such as Artificial Intelligence (AI), Geographical Information Systems (GIS), Modelling and Simulation, User Interfaces, etc. (Radermacher et al. 1994). Crucial but difficult task for this area is to serve as a catalyst for the integration of data, information, and knowledge from various sources in the environmental sector (Avouris and Page 1995). International business and holiday tourism travel, according to the World Trade Organization (WTO, 2019) has grown at the rate of 3.9 % and total of 1.4 billion arrivals what presents a major economic, environmental and social impacts. Except the natural resources, man-made resources such as accommodation, transport facilities, shops, restaurants and other facilities create physical change and expand economic activities in general that

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consume resources (Koncul 2007). Tourism is the most propulsive economic activity in the world, with the rough contribution of 10.4% of worldwide income (WTTC 2019). Regarding that tourism is a human based activity, major issue is the waste that is appearing (Stabler and Goodall 1996) as a consequence. As Cater and Goodall (1992) emphasized, the concentration of tourism is neglected in certain destinations in a long-term decision-making process. Its results thereby led to over exploitation of natural resource base and the generation of non-priced effects, as it is the case of many mass tourism dominating destinations such as Croatia, Greece, Spain etc. that base on natural environment. Furthermore, the overcrowding and overdevelopment distorts the destination itself especially in the peak season when visitors outnumber the resident population. The results of tourism are majorly regarded in numbers but still, are fragile to the environment of the destination. Violation of natural environment leads to degradation of its basics due to tourism expansion. The fragility of environment has become an issue of concern and recognized by stakeholders and others involved in tourism (Goodall 1992; Jenner and Smith 1992). Thus, the need for sustainable, instead of mass tourism, is necessary. This means a planned balance between need of the customer but primarily, needs of future generations nature wise. Some authors underline that the issue is the influx of tourists with different life-styles, financially above-average and non-indigenous services what can consequentially destroy cultures and environment altogether (Pearce 1989). Most visible changes in tourism, when talking about environment, are in tourism destinations. Issues such as pollution from transit, waste and mass energy production, arise in the 1990s but were not addressed seriously. Having in mind that tourism is majorly dependent on environment, interdependence between the two and accordingly, economic activities and quality of life is crucial. Furthermore, besides environment, tourism also depends on man-made resources that raise political, social and scientific issues in addition to those that are directly economic (Koncul 2007).

The goal of the paper is to present how artificial intelligence in general, and artificial neural networks in particular, are an alternative tool for analysing, modelling and forecasting in planning and a long-term decision-making processes for environment. Various environmental issues, such as air and water pollution and global climate changes, have a large and crucial impact on tourism. This raised the question of environmental impact of tourism, and vice versa, since both have a significant role in the world and local economies. Hence, new and innovative techniques that combine mathematics and information technologies are being used as a successful alternative to get more information. This is supported by the fact that even more publications and research projects are paying attention to this topic.

2. RESEARCH METHODOLOGY

Although this paper is purely theoretical, it raises the question of artificial intelligence usage in environment issues and its benefits in long-term analysis and forecasting. Therefore, to elaborate the papers issue, an extensive desk-research of the existing literature was carried out to highlight the impact of artificial intelligence implementation in environmental issues and its effects on tourism.

In the paper, publications released on use of artificial intelligence in general, and artificial neural networks in particular, in analysing and forecasting environmental issues that impact tourism, were examined. More precisely, in the publications which were examined, new and innovative methods and techniques of analysing and modelling versus the traditional methods were used. The authors investigated approximately hundred papers from the last four decades. Papers from recent years, that use new and innovative methods for analysis and forecasting are in minority. This research doesn't understate previous researches, but emphasizes the importance of the question how usage of artificial intelligence can contribute to future decision-making processes in the cooperation of environment and tourism. The authors conducted an extensive desk-research in scientific important databases WOSS Core Collection, Scopus and Google Scholar. Mentioned papers are references to obtain the main objectives of this paper. Around hundred papers were found from which, papers that combine traditional and artificial intelligence models were included in further analysis. There are no sufficient scientific proof that new and innovative ways, such as artificial neural networks, should be used in analysis and forecasting of tourism and environmental issues. The dominance of the traditional quantitative methods compared to the artificial ones is observed.

The magnitude of the research results lies largely in the fact that advanced techniques, are still not used enough in combining environmental and tourism issues. Obtained paper results can be used as a starting point for

further research, not just scientific ones but also applicative ones to generate sustainable development of tourism.

3. ARTIFICIAL INTELLIGENCE AND ENVIRONMENTAL ISSUES

Cortés et al. (2000) emphasized almost two decades ago that an effective protection of the environment is largely dependent on the quality of the available information used to make an appropriate decision. Computers have been seen as a centre of contemporary environmental protection as they are capable of solving tasks such as monitoring, data analysis, communication, information storage and retrieval so, it was a matter of time when artificial intelligence will be integrated in mentioned tasks. There has been an evident technological shift in tourism that was coined by realisation that advanced technologies, as Gretzel et al. (2015) stated, can transform data into enhanced experience and business value-propositions with a clear focus on efficiency, sustainability and enriched experience in tourism. By properly collecting and analysing big data and by forecasting them, for which artificial neural networks can be used, the quest experience can be enhanced.
Pioneer in this field are Robertson et al. (1991) that presented Eco-Logic approach to the issue and was furthered by the work of Zannetti (1994). From that point artificial intelligence has been developed. Usual artificial intelligence techniques that are applied to environmental issues are divided into three broad categories as shown in Table 1.

TABLE 1. APPLYING ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL ISSUES

Process	Possibilities
Data Interpretation and Data Mining techniques	• screening data to detect patterns • identifying potential issues or opportunities • discovering similarities between current and past situations • understanding relevant factors and their relationships • discovering non-obvious features in the data possibility to learn new situations
Problem Diagnosis techniques	• recognising characteristic symptoms in order to develop and confirm hypotheses about possible causes used to suggest strategies for repairing or recovering based on the available knowledge and/or on past experiences
Decision Support techniques	• evaluating alternatives to explore their possible consequences • comparing relative costs and benefits recommending appropriate action plans

Source: Adopted from cortés et al. (2000)

Advantages of artificial intelligence presented in table 1 made this alternative method become more popular in scientific researches as they are designed to simulate and forecast specific issues and are recognised as a beneficial tool in engineering applications (Topçu and Sarıdemir 2008). It is especially a strong tool for data models with low regression coefficients (Esteban et al. 2009) and for modelling complex operations in many engineering fields in this case, environment and tourism.

4. ARTIFICIAL INTELLIGENCE AND ENVIRONMENTAL MODELLING

Environmental models can be explained as a simplified view of nature in order to solve scientific or management issues that include features essential to describe a given environmental issues. As the awareness of the environment grows, so does environmental modelling. There were numerous methods that derived from the attempt to model environment from numerical, mathematical, and statistical methods to alternative methods of a new age such as artificial intelligence. These methods are able to deal with complexity of environment and provides more flexibility in its modelling. Lek and Guegan (1999) emphasized that with the growing development of computer-aided analysis that is easily accessible to all researchers, the applications of artificial neural networks have facilitated itself in environmental modelling. With that in mind, artificial neural networks

allow environmental researchers to obtain relevant results in solving the issue of variables in environmental data. The various applications of artificial neural networks in environmental modelling is presented in a paper by Liu et al. (2010) from modelling effects of climate change on hydrological-ecological environments, air quality and greenhouse gas emissions to modelling forest ecosystems, vegetation, and soil change projections. All of the mentioned issues directly affect tourism.

With the development of artificial intelligence, the field has widened its research requirement to other environmental issues like forestry, horticulture and waste disposal. Thus, began the development of expert systems for environmental issues in the 80s. Papers by Lapointe et al. (1989), Guariso and Werthner (1994), Page (1989), Hushon (1987), Sriram and Adey (1986) and Maeda (1985) should be mentioned when discussing the development of expert systems for environmental issues. With the beginning of the 90s artificial intelligence enabled the development of Knowledge-Based Systems (KBS) introduced by Aarts (1992), Serra et al. (1993), Okubo et al. (1994) and Gabaldon et al. (1998). As some names appear multiple times above and throughout this paper, they can be considered as pioneers of the field. Combining KBS with environmental issues different derivatives emerged such as Decision Support Systems (DSS) (Bender and Simonovic, 1994) or Environmental Decision Support Systems (EDSS) (Rizzoli and Young, 1997). However, of the mentioned models, EDSS is most interesting for this paper. The authors have chosen EDSS as it is an important tool for reducing risks obtained from the human-environment interaction. On one hand, benefit of using EDSS is that it takes into consideration the multidisciplinary nature of environmental issues as each module is specialised for a given topic. These specialised modules may include empirical knowledge about the environment, situational knowledge about local environmental and their interaction with the global environment, judgemental knowledge about humans or theoretical knowledge about phenomena taking place in the environment. On the other hand, the system provides fast solutions despite the complexity of environmental issues. This process consists of combining physical and biological aspects in relation to socio-economic conditions and applicable legal frameworks in limited time (Cortés et al. 2000). From the above mentioned, EDSS is an intelligent information system that helps reduce the time in which decisions are made and improves the consistency and quality of those decisions (Cortes 2001). The decision-making process in EDDS is shown in Figure 1.

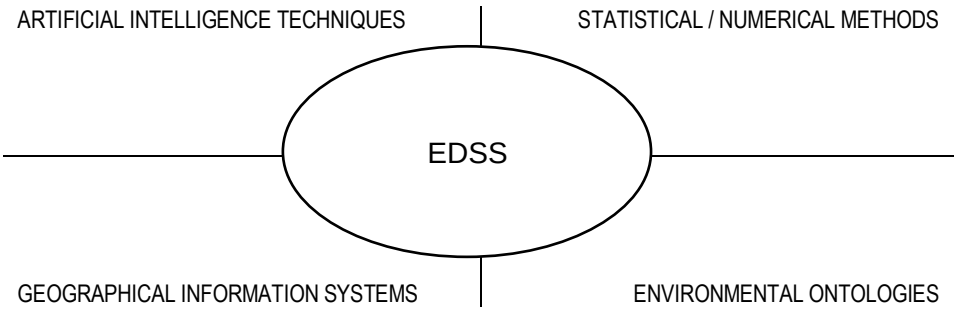

FIGURE 1. EDSS CONCEPTUAL COMPONENTS

Source: Poch et al. 2002.

To obtain a proper decision that is expected a deviation is required, meaning that awareness of the issue based on information, experience and knowledge must be present. As shown, systems such as EDSS are an integration of artificial intelligence techniques, components of geographical information system, statistical or numerical methods, and environmental ontologies. All of above mentioned makes an adequate base for a decision-making process with an appropriate modelling tool which can bring together knowledge of different disciplines and ability to compare them. Furthermore, as Özesmi and Özesmi (2004) accentuated, it helps simulate different policy options, allowing the stakeholder to identify advantages and disadvantages of possible decisions.

5. METHODS USED IN MODELLING ENVIRONMENT IN TOURISM USE

As Britton (1982) and Krippendorf (1986) emphasized two decades ago, low-cost mass tourism, creation of large-scale resorts, frequent travelling and powerful international tour operators were criticized by academics as exploiting people and destinations. Bramwell and Lane (1993) continued on this issue explaining that the problems caused by this type of tourism ranges from environmental destruction to serious impacts on society and traditional cultures, what outweighs tourisms economic benefits. Therefore, since the 1990s major attention in tourism researches has been put on tourism's negative impact and because of that, its development has become refocused through the lens of sustainable tourism (Bramwell and Lane 2003). This led to an innovative collaboration of artificial intelligence and sustainable tourism to reduce negative effects of tourism and to improve service effectiveness by using destination resources in a more sustainable way (Fuchs et al. 2013). Taking into consideration economy with the nature of environmental issues, most researchers use cost-benefit analysis (CBA) as an adequate framework for assessing monetary and non-monetary costs and benefits, long side large capital outlays, over a long period over which both occur. Another method that has been used is the planning balance sheet analysis (PBSA), designed in 1950s to overcome the fact that many CBA were not measured easily in money terms (Koncul 2007). At that time, multi-criteria analysis (MCA) was considered as the best approach because it used ranks according to criteria as Nijkamp (1975) described. Later, Saaty (1987) developed, what was widely used, a mathematical approach in decision-making between alternatives called analytic hierarchy. The mentioned methods and techniques, as it can be seen by the date were, so to speak, outdated so the search for alternative and innovative methods and techniques was conducted.

5.1. Land scape and forest modelling

Tourism, as it is known, spreads over destinations as the market demands. With that in mind, land usage can result in complex changes that influence policies, management, economics, culture, human behaviour, and consequentially, the environment. The knowledge of land scape modelling is therefore crucial in case changes that can largely impact the environment occur. The simulation of land use/cover changes is important for a variety of management and planning issues as well as for academic research. Paper by Pijanowski et al. (2002) illustrated how combining geographic information systems (GIS) and artificial neural networks can aid in understanding the complexity of land use changing process. In one previous paper Pijanowski et al. (2000) explained how GIS-based Land Transformation Model (LTM) was developed in order to forecast land use changes over large regions by configuring a variety of socioeconomic, political and environmental inputs. The main advantage of LTM is that it can link changes in land use to ecological process models and provide crucial stakeholders with information's about the potential effects of this changes on the environment. Lambin (1997) and later Stephenne and Lambin (2001) defined that land use change modelling can be performed with (1) empirical models that base on an extrapolation of the change patterns being observed in the past including limited representation of parameters from which the changes derive and with (2) simulation models that base on the understanding the processes of change. Geographical forecast of this issue can be accomplished by models from the first category. As Mas et al. (2004) emphasized several studies have achieved good forecasting results of acceptable patterns of land scape change with multivariate models that represent the interactions between environmental variables that are controlling the changes. Spatial models attempt to identify explicitly the proximate causes of land use change usually using statistical approaches such as regression or weight of evidence as proven by Soares-Filho et al. (2002), Schneider and Pontius (2001) and Almeida et al. (2003). It is assumed that the interaction between the changes and the proximate is unchangeable over the time and therefor, can estimate short-term forecasts due to the complexity of the issue.

Artificial neural networks were more than successful in forest modelling. The importance of forests in environment is unquestionable, and a specific research was enabled by artificial neural networks. Some cases from practice such as studies by Guan and Gertner (1991) were carried out on individual tree survival probabilities, tree mortality (Hasenauer et al. 2001; Castro et al. 2013), tree heights (Diamantopoulou and Özçelik 2012), and bark volume estimation (Çatal et al. 2018). These studies showed importance in forecasting variables affecting forest modelling. Such as in the case of the invasion of so-called palm moths or palm weevil that devastated the Mediterranean costs of Spain, French Riviera and Croatia, some of the world's most significant tourism destinations. Deforestation is a global issue and has received a considerable attention in

recent years especially with eve more fires that are arising due to global warming. Deforestation is a long-term issue that effects the climate system and life as it is. Unfortunately, despite the importance of deforestation, there are no accurate statistical data. Therefore, a simple spatial model that enabled forecasting the geographical location of deforestation using artificial neural networks approach was developed. Furthermore, this model is important as the land use changes are consequentially a man-made result, taking into consideration tourism destinations that deforest the land in order to construct concrete beaches as the demand enlarges. Thus, tourism stakeholders should consider a model that can sufficiently satisfies the environment as well as tourism needs. However, variables used in its modelling may have some limitations as their interaction is complicated and usually results in noisy data regarding the complexity of the issue. To avoid non-linearity and noisy data artificial neural networks must be taken into account as they are able to obtain better results in this complex interaction as proven by Li and Yeh (2002) and Pijanowski et al. (2002). Planned land scaping and forest modelling presents a crucial role in restoring tourism attractions in which case artificial neural networks are most helpful in obtaining adequate results.

5.2. Agricultural modelling

As with all of the fields of environmental modelling mentioned in this paper, agricultural modelling is no exception in selecting an appropriate method or technique to model. Because of its dynamic changes, this field has its numerous unknown factors and thus is difficult to determine the relationship between inputs and outputs what prevents currently used methods in agricultural and biological sciences to obtain relevant results. Therefore, it is difficult to estimate which method is most suitable in any modelling case as there are insufficient results based on analysis on any given issue. Samborska et al. (2014) explain how the application of artificial neural networks in the field of biological and agricultural sciences is still very limited, but because of the opportunities that artificial neural networks offer when dealing with vast amounts of data, it is highly expected that artificial neural networks will become one of the major research tools in this field and help practitioners find solutions for i.e. plant production. Artificial intelligence has reached the field of horticulture by combining horticulture expertise with artificial intelligence making a breakthrough in fresh food production and reducing resources (Hemming et al., 2019). On one hand, this particular knowledge can be useful for tourism as guests are even more oriented on fresh ingredients, its origin and is it GMO free. On the other, as Hemming et al. (2019) continued, resources such as water or fossil fuel are becoming scarce and there is an urgent need for maximum resources efficiency.

5.3. Water quality modelling

The rapid development of numerical models provides a large number of models to be used in engineering of environmental issues. Number of methods and techniques that are quite advanced are available and mostly used in water quality researches. To select a numerical model most suitable for water modelling requires a specialised and detailed knowledge on the application and limitations of each model. Yet, an emphasis on algorithmic procedures to solve specific water modelling issues has occurred. Unfortunately, the models that are usually used are insufficiently user-friendly. Because of its complexity, an increasing demand for artificial intelligence has been raised to assist in selection and manipulation of mathematical models and variables. Moreover, the development of numerical modelling systems reinforced the trend of incorporating even more features based on the advanced computer technology (Chau 2006).

Water quality modelling considers flow and water quality issues for which, numerical models are frequently used in analysis of the coastal water process. This analysis usually involves empirical experience on coastal hydraulics and water quality and its affects through some simplifications and modelling techniques based on the specialist's experience (Yu and Righetto 2001). However, Martin et al. (1999) stated that the accuracy of the prediction depends on a great extent to the accuracy of the open boundary conditions, used model parameters and adopted numerical scheme. Selecting a suitable numerical model to solve a practical water quality issue is a highly specialised task that requires knowledge on the application and limitation (Chau 2006). The main goal of integrating coastal engineering with artificial intelligence is to acquire adequate simulation of models. Artificial neural networks were introduced in water quality modelling because of their ability to deal with a large quantity of information and to learn complex model functions i.e. training of the network using sets of

input and output data. The greatest advantage of artificial neural networks over other modelling techniques, as stated by Chau (2006), is their capability to model complex, non-linear processes without having to assume the form of the relationship between input and output variables. Because of their capability to deal with uncertain and complex situations, artificial neural networks have found their path to water quality modelling. Kralisch et al. (2003) employed this alternative approach for the optimization of watershed management to maintain a reasonable balance between water quality demand and consequent restrictions for the farming industry. Regarding the main issue of this paper, this type of modelling is useful to investigate the balance between water quality demand and tourism destinations that are overcrowded in peak season. Researches on coastal modelling are still insufficient, unlike researches on limnological systems (Recknagel et al. 1997; Yabunaka et al. 1997; Karul et al. 2000) or riverine systems (Whitehead et al. 1997; Maier et al. 1998). More attention should be paid to coastal modelling as it can be proven crucial in tourism modelling. Majority of destinations depend on their coast so modelling it can enable investigation on main variables in i.e. sustainable solution on coastal cleanliness. As coastal tourism has a growing trend, water quality modelling should be an issue to investigate. Moreover, numerous studies have not yet fully addressed the question of artificial neural networks effectiveness as a forecasting tool. Often the water quality was connected to other environmental variables simultaneously so the importance of real-time forecasting was diminished. Generally, in water quality modelling the majority of all possible environmental variables are implemented without a consideration about using only the adequate ones. One of artificial neural networks advantages is applicable in this case as it has the possibility to be trained and to choose optimal variables for adequate modelling. Thus, acknowledging the advantages that this technique offers can prove successful in its application on a certain issue.

6. CONCLUSIONS

Considering all the mentioned above, it can be concluded that environmental issues have become crucial in economics of tourism. Thus, the emphasise on sustainable development, rationalisation of resources use, discussion of negative consequence of tourism expansion, the need for adequate decision-making processes of all stakeholders in future development of tourism has emerged. Some of the main issues in environmental modelling arise primarily from the complexity of human and environmental relationship factor, secondly high degree of complication and lastly numerous conditions that can occur. Thus, the issue is dynamic by itself, involving numerous stakeholders and, consequently, has no right solution. There are some evidences of deterioration of tourism destinations which has been developed without adequate planning, that led to negative consequences of tourism on environment. As demonstrated in this paper, artificial intelligence has an important role in environmental modelling, especially in recent times. Furthermore, their usage can prove to be successful in modelling complex fields such as environment and tourism. More focus should be given in implementing artificial intelligence to environment and tourism modelling in order to successfully control the effects of this relationship to obtain results crucial for present and future generations.

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