Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management, **4** (2017) (4) 235-243

International Symposium on Soil and Water Bioengineering in a Changing Climate, 7th-8th September, 2017, Glasgow, Scotland, UK

UNESCO CHAIR CON-E-ECT: PROMOTING CONSERVATION IN RIPARIAN AND DELTAIC ECOSYSTEMS*

Dimitrios Emmanouloudis, George N. Zaimes, Valasia Iakovoglou**

UNESCO Chair Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems, Drama, Greece

Abstract

Riparian areas and deltaic ecosystems are essential to humans because of the many services they offer that have been over utilized by humans for thousands of years, especially in the Mediterranean region. This is evident by the many riparian areas and deltas that are protected by international (e.g. Ramsar Convention) and European Union (Natura 2000 Network) treaties and agreements. The significance of these ecosystems has also been recognized by UNESCO that led to the establishment of the new Chair "Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems" that was awarded to the Department of Forestry and Natural Environment Management of the Technologiko Ekpedeftiko Irdyma Anatolikis Makedonias and Thrakis (EMaTTech) of Greece. The reason for establishing this Chair in the specific region of Eastern Macedonia and Thrace of Greece is because of its unique ecosystems in Europe that stretch over a length of 200 km and consist of five major riparian and deltaic ecosystems. The aim Con-E-Ect is to collaborate with national, regional and international stakeholders to create an international framework of common strategy for the conservation of riparian and deltaic ecosystems worldwide. Con-E-Ect focus on global matters for riparian and deltaic ecosystems, such as the protection of rare ecosystems, their endangered species, its cultural uniqueness, climate change implication, as well as the growth of their local communities based on environmentally friendly approaches. This framework is being implemented through four axes that are 1) Research, 2) Conservation – Sustainability, 3) Dissemination – Education – Training and 4) Best Practices, so that, ultimately, all stakeholders harmonize their actions towards the sustainable management of riparian and deltaic ecosystems. One such best practice for the sustainable management of these ecosystems is the application of econengineering methods that have gained more acceptances in the Mediterranean.

Key words: climate change, ecoengineering, ecosystem services, sustainability

---

* Selection and peer-review under responsibility of the ECOMED project consortium

** Corresponding author: e-mail: zaimesg@teiemt.gr

1. Introduction

Riparian and deltaic areas are semi-aquatic ecosystems that are unique because they are transitional zones. These ecosystems are called ecotones (Naiman et al., 2005) and characterized by high biodiversity along with increased ecosystem services despite occupying a smaller area of the watershed (Sabo et al., 2005). Their three main characteristics are the: a) greater water availability, b) young, frequently disturbed soils and c) dense hydrophyllic vegetation. Their uniqueness has been recognized by their protection through international treaties (e.g. Ramsar Convnetion) and EU Networks (e.g. Natura 2000) (EC Directive, 2007). Worldwide a great emphasis has been given to their conservation or re-establishment though different management activities and plans especially in human-modified environments (NRC, 2002).

Riparian areas can be found in all biomes and vary from region to region leading to many differing definitions. The term riparian is derived from the Latin word *riparius* that means stream bank. Still many of the definitions describe certain common characteristics (NRC, 2002; Schultz et al., 2000). Firstly they are adjacent to water courses or bodies (lentic and lotic) with perennial and intermittent flows although some definitions also include ephemeral. Such water courses and bodies include torrents, streams, rivers, wetlands, lakes, and estuarine–marine shorelines and typical riparian area examples are floodplains, stream banks, and lake shores. Their boundaries are linear in nature but are not always clearly defined and may change from year to year depending on the hydrologic conditions. They are transitional zones between aquatic and terrestrial ecosystems connecting water bodies with their adjacent uplands. Thus they include parts of the terrestrial ecosystems that are significantly influenced by exchanges of energy and matter with aquatic ecosystems and exhibit gradients in biophysical conditions, ecological processes and biota. Finally, they are disturbance driven ecosystems since they frequently have floods and droughts.

Deltaic ecosystems are landforms located at the endpoints of a river. They form as a result of the sediments that originate from the rest of the watershed and are carried by the river to its mouth (Elliot, 1986). At its mouth the slower moving or standing waters lead to the sediment being deposited. This typically occurs when the river reaches an ocean, sea, estuary, lake and reservoir. Sometimes it can also occur as it enters a larger river. The name originates from the Greek letter Δ (δελτα) because of the characteristic shape they have. The supply of sediment and the watershed processes control the size and shape of the delta (Pasternack et al., 2001). Important for the evolution of the delta are the watershed characteristics such as its size, location, slope and land-uses (Pasternack et al., 2001). These ecosystems are also disturbance driven, since flooding quite frequently occurs, while they also have greater soil water availability and vegetation that is hydrophyllic.

While riparian and deltaic ecosystems are different they also have many similarities. This is the reason why the offer many similar ecosystems services. Some of these services include (Naiman et al., 2005; Schultz et al., 2000): a) support for animal habitat that in many cases includes endangered species, b) enhancement of fish habitat, c) support to a great diversity of vegetative species assemblages thus increasing biodiversity, d) filtration and retention of sediments and nutrients from terrestrial upland runoff or out-of bank floods, e) reduction of chemical inputs from terrestrial uplands by immobilization, storage and transformation, f) stabilization stream banks and build-up new stream banks, g) mitigation of stream bed downcutting and gully formation, h) storing water and recharging subsurface aquifers, i) reduction of floodwater runoff, j) provide coastline defense to erosion and inundation, k) impact drinking water, l) provide recreational and ecotourism opportunities, m) use as a transportation mode and n) increase in agricultural production.

These services have been known and utilized by humans for thousands of years and these are the reasons why major agricultural centers and populations centers had and

continue to be established in and adjacent to these ecosystems. These increasing anthropogenic activities have rapidly altered these natural landscapes (Corbacho et al., 2003) and have led to them being considered as some of the most degraded ecosystems (NRC, 2002). The anthropogenic activities that have led to the degradation of these ecosystems can be separated in four major categories (Anthony, 2015; Baker et al., 2004; NRC, 2002). The first category is the hydrologic and geomorphic alterations that include: a) construction of dams, b) withdrawal of surface and ground water, c) vegetation removal, d) channelization and e) construction of bank stabilizing structures. The second is agriculture and include: a) grazing by domestic livestock and b) production of agricultural crops. The third category urban, recreational and industrial is quite broad and includes: a) expansion of urbanized centers, b) recreational activities, c) construction of roads and railroads, d) mining activities and e) industrial water uses. Finally there are other activities that cannot really be categorized such as invasive species.

Another important factor that should be incorporated in regards to the effective management of riparian and deltaic ecosystems is climate change. The new thermal conditions will change the rainfall amounts and intensities, number of days of precipitation, ratio of rain to snow that will impact plant biomass production, plant residue decomposition rates, soil microbial activity, evapotranspiration rates and potentially cause shifts in land-uses (Nearing et al., 2004). Overall increases in extreme weather events are expected, particularly increased rainfall intensity and extended drought periods compared to past conditions (Giupponi and Shechter, 2003). These new extreme conditions should lead to higher surface runoff and stream flows, higher sediment transport capacity and increased soil erosion. These changes in the hydrologic regimes of the water bodies and courses should also impact the adjacent riparian and deltaic ecosystems. In addition, along the coastal areas where many of the major deltas are, an increase in the adverse consequences of hazards such as coastal erosion and sea-level rise related to climate change are expected (Blum et al., 2000; Bakker et al., 2008; Nicholls et al., 2007). These hazards can cause irreversible damages to the deltaic ecosystems.

Overall the continued increase in human populations that should lead to more detrimental anthropogenic activities along with the compounding effects of climate change make it imperative to develop new management plans and more comprehensive cooperation for the future sustainability of these unique ecosystems. This is the reason why UNESCO established the new Chair "Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems" (Fig. 1) at the Department of Forestry and Natural Environment Management of the Technologiko Ekpedeftiko Irdyma Anatolikis Makedonias and Thrakis (EMaTTech) of Greece. The Chair consists of the academic and research staff of EMaTTech and associate collaborators who work on a volunteer basis to fulfill its objectives and it aspires to bring together distinguished international researchers to share their knowledge and experiences and to work on innovative solutions of riparian and deltaic management. In the following sections the objectives, location and activities of the Chair are described in detail.

2. Objectives

The objective of Con-E-Ect is joining forces with national, regional and international stakeholders, in order to elaborate an International Common Strategy Framework for the Conservation and Ecotourism of Riparian and Deltaic Ecosystems. This Common Strategy Framework will govern sustainably the protection, study, development and ecotourism of deltaic and riparian environments, initially in the Balkans and the Mediterranean regions and in the long-term worldwide. The Framework's goals will be accomplished through the promotion of research by collecting and assessing data, dissemination of research findings, training and awareness-raising activities addressed to various target groups, so that, finally,

all stakeholders will harmonize their actions towards the sustainable management of the riparian and deltaic ecosystems via the development of ecotourism.

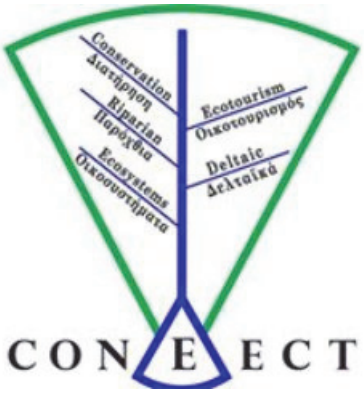

Fig. 1. The logo of UNESCO Chair "Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems"

The Strategy Framework for the deltaic and riparian environments will serve initially as an Assessment Tool of Ecosystems for Greece. In order to expand its applicability to the Balkans, Mediterranean and worldwide, Con-E-Ect will engage its wide Network of Partners on a regional and international level and implement cutting-edge ecohydrological, geomorphological, financial and agrotechnological models, taking into consideration the different prevailing conditions in those parts of the world where this assessment tool could be put into practice, in a way that it will not conflict with the local and/or regional educational, scientific and cultural contexts, nor with the UNESCO's mandate and principles. Furthermore, the UNESCO chair will promote the application of soil and water bioengineering techniques to improve the degraded riparian and deltaic ecosystems of the Mediterranean that should replace the typical structural engineering technology that is mosy commonly utilized.

3. Location of Con-E-Ect

Con-E-Ect is located in Eastern Macedonia and Thrace of Greece that is part of Southern Europe (Fig. 2). In this region most riparian and deltaic ecosystems have experienced an extensive history of intensive land-use changes and other human disturbances (Corbacho et al., 2003) thus maintaining and re-establishing them is a difficult and important task. Most remaining riparian habitats, that are narrow forested strips located along streams and rivers, and deltas of the region have been heavily impacted by anthropogenic activities (Rodewald and Bakermans, 2006; Zaimes et al., 2011a). Overall in arid and semi-arid regions, such as the Mediterranean Basin, maintaining or re-establishing riparian ecosystems are essential to maintain biodiversity and ecosystems services (Ferreira and Moreira, 1999; Rottenborn, 1999).

The Chair Con-E-Ect will primarily be active in the region it is located; a region with a unique ecosystem in Europe, which stretches over a length of 200 km and consists of five major riparian and deltaic ecosystems. In the long-term the goal is also to highlight concerns that involve global matters for riparian and deltaic ecosystems sustainability and promote the growth of their local communities based on "green" (e.g. ecotourism) approaches. The specific ecosystems that Con-E-Ect will initially focus its efforts on include: a) Nestos River Delta, b) Evros River Delta, c) Lakes Vistonida and Ismarida, d) Frakto Virgin Forest, e)

Dadia Forest e) Nestos Corridor (Fig. 2). By establishing Con-E-Ect in this region it capitalizes this natural "laboratory," in order to develop and evaluate an Assessment Tool that will enable the sustainable conservation of these ecosystems by focusing on the populations of their endangered species.

The region has a rich variety of rare and unique flora. The mountainous areas are covered by *Abies* ssp*, Fagus* ssp*, Quercus* ssp*, Quercus coccifera L., Rubus* ssp*, Rosa canina, Fraxinus* ssp*, Acer* ssp*, Cornus* ssp, etc.;

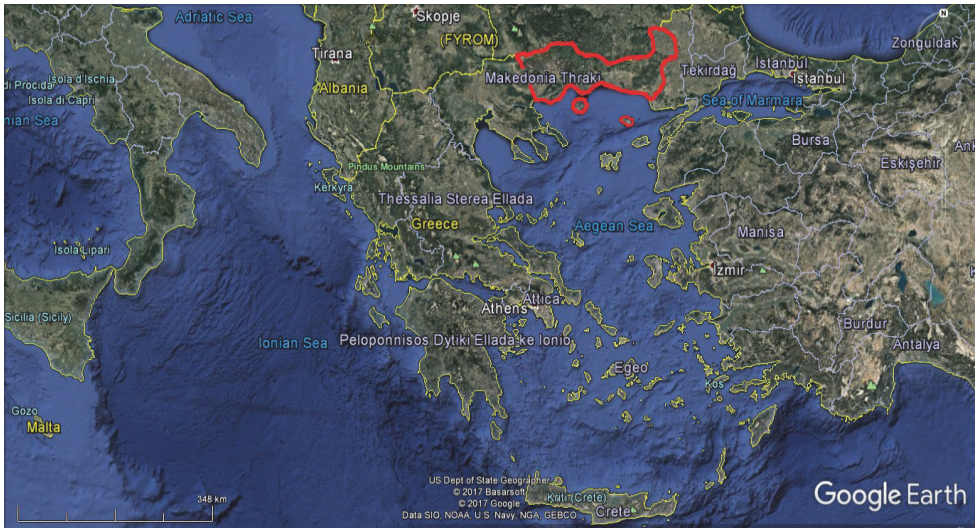

Fig. 2. The region of Eastern Macedonia and Thrace region of Greece (with a red line) where the majority of the activities of the UNESCO Chair Con-E-Ect take place

Fig. 3. The specific ecosystems that Con-E-Ect will initially focus its efforts in Eastern Macedonia and Tharce, Greece.

These include deltas (yellow font), riparian forests along rivers/streams (red font) and lakes (blue font) while at lower altitudes *Alnus* ssp*, Populus* ssp*, Fraxinus oxycarpa, Sambucus nigra, Vitex agnus-castus, Salix* ssp, and vines (Climbers) such as *Hedera* ssp*, Humulus luputus, Clematis flammula* are more common. Moreover, the areas close to the mouths of the rivers are surrounded by sand dunes, hydrophyllic, and halophytic, semi-aquatic and aquatic vegetation. The fauna of the ecosystem of the region are also one of the rarest in Europe, hosting a plethora of endangered wildlife species. The endangered species that need attention are the following: *Pelecanus onocrotalus, Pelecanus crispus, Recurvirostra avosetta, Ardea cinerea, Phoenicopterus ruber, Hoplopterus spinozus, Haliaeetus albicilla* and *Phasianus colchicus*.

4. Implementation axes

To implement the Chair's objectives the strategy centers upon the following four Axes: 1) Research, 2) Conservation – Sustainability, 3) Dissemination – Education – Training and 4) Best Practices.

The "Research" Axis produces as outcome the development and results of research projects on issues related, among others, to ecohydrology, management of riparian and deltaic areas, ecotourism, ecophysiology, aquatic environments, effectiveness and implementation of ecoengineering works, transport and deposition of nonpoint and point organic and inorganic pollutants in and outside the river channel, published in scientific journals and presented at international conferences. This research will be carried out by the Scientific Team of the Chair and funded under programs funded either by the EU or by national bodies. The research results will enrich the scientific knowledge worldwide in the field of deltaic and riparian ecosystems, which will lead to the adoption of guidelines and the publication of operational checklist references that will contribute to their better protection and their ecologically-balanced management.

"Conservation-Sustainability" produces a series of behavior code publications on sensitive ecosystems of interest, taking first into account the specific biogeoclimatic zone of Eastern Macedonia and Thrace. As the Chair continues to function, other biogeoclimatic zones on a global scale will be incorporated in these publications. These behavior codes will provide advice and guidance on the maintenance of the ecosystem health through optimal management methods that ensure that the ecosystems remain undisturbed within a context of a strong environmental sustainability. Soil and water ecoengineering methods can sustainably help maintain these ecosystems. This axis also involves the creation, through research and recording, of a "Culture Ark" that will include data related to the intangible cultural heritage of the region of Eastern Macedonia and Thrace (traditional occupations and professions, local know-how, traditions, literary production, legends, oral history, local linguistic idioms, local vocabulary related to the specific ecosystems and the relevant local activities), in an attempt to showcase and safeguard, on one hand, the cultural wealth of the region and to optimize it, on the other hand, to the benefit of sustainable environmental management. The role of local women as main practitioners of many of these traditional occupations and essential bearers of knowledge and know-how will be duly acknowledged and highlighted.

The "Dissemination – Education – Training" axis generates both a series of educational material and a variety of training practices and procedures related to the studied ecosystems. In particular, the familiarization with these ecosystems, the establishment of a culture of respect towards them and the mild touristic development within the surrounding area of these ecosystems, will constitute the basic focal areas. Special thematic sections will include civil protection assistance (addressed to those populations affected by different sorts of natural hazards and disasters, namely floods and droughts that live near riparian and

deltaic areas), ecotourism development guidelines (mainly addressed to youth and unemployed local populations who want to get involved in the field), correct implementation of ecoenginering practices in Mediterranean riparian and deltaic areas (geared towards professionals and agencies) and on awareness-raising activities concerning the conservation of these ecosystems (mainly addressed to school students).

"Best Practices" generate a series of text books presented either during awareness-raising events hosted at the EMMaTech or in other relevant international events. The first in the series of text books will be based on the specific case study of the riparian and deltaic ecosystems of the region of Eastern Macedonia and Thrace and will be accompanied by a relevant Manual Guide. Subsequent editions of text books will provide information on case studies of particularly disturbed and degraded riparian and deltaic ecosystems, which were managed effectively and gradually restored, due to special handling and the use of Best Practices.

One of these editions will focus on the application of ecoengineering in the Mediterranean region to protect or re-establish riparian and deltaic ecosystems. Case studies of balanced and optimally conserved ecosystems from the very beginning, that have implemented mild touristic development and management, will also be presented. In both cases, the text books written will contain the relevant Manual Guides that will also be freely available on the Chair's website.

5. Ecoengineering as a best practice

One of the major problems that degrade both riparian and deltaic ecosystems is erosion that includes surficial, gully, stream bank and stream bed erosion (Zaimes at al., 2011b). These types of erosion in these ecosystems have accelerated primarily due to anthropogenic activities (Naiman et al., 2005). Soil- and fluvial ecoengineering are sustainable tools to improve resilience against soil loss and soil degradation. These techniques are widely implemented in the Atlantic and Eurasian ecoregions but are also gaining more acceptances within the Mediterranean ecoregion.

Ecoengineering is the use of living plants or cut plant material, either alone or in combination with inert structures, to control soil erosion and the mass movement of land in order to fulfill engineering functions (Schiechtl, 1988). It combines technical (protection and stabilization), ecological (ecosystem-based restoration), landscape (integration of landscape aspects) and socioeconomic (more efficient and new sources of employment) scientific aspects. The plants and parts of plants are used as living building materials, and as they grow in combination with inert materials (e.g. soil, rock, timber), ensure the long-term protection and mitigation against all forms of soil loss and erosion. The use of these living materials in Mediterranean environments, such as Greece, involves many difficulties, notwithstanding the climate, since it differs significantly from the Atlantic and Continental ecoregions from where the current research and publications mainly originate from. Furthermore, given the semi-empirical nature of ecoengineering structures, it is crucial that the know-how of successful and failed ecoengineering interventions of the region be known and this knowledge transferred to the other professionals of the region (Tardio et al., 2017). Through the Best Practices, scientifically sound guidelines in regards to the particularities faced by this kind of works in a Mediterranean climate that are related to the aridity of the climate and the selection of both plant material and plantation techniques will be provided.

A highly specialized knowledge triangle (new processes, methods and services) within this sector is needed for the Mediterranean (Zaimes et al., 207). In addition, this type of works demand comparisons between the original and the current state and throughout the design life of the construction site in terms of biodiversity, soil evolution, plant anchorage, ecosystem resilience etc. (Bischetti et al., 2009; Tardio and Mickovski, 2016). The solution

to these problems is to implement a monitoring stage in the works and generate a knowledge transfer network involving the Mediterranean stakeholders. Currently, there is an absence of such preceding tools and such text book for Greece and the Mediterranean. Overall, potential types of soil and water ecoenginnering structures that could be implemented successfully in riparian and deltaic ecosystems of the Mediterranean include: log erosion barriers, log cribwalls, mixed check dams, live stakes, hydroseeding, branch packing, brush layering, brush mattress, coconut fiber logs, erosion control fabrics, live fascines, live posts, log breakwater, plant mats, root wads, terraced cribs, tree and log revetments, spilling walls and vegetated geogrids.

6. Conclusions

Riparian and deltaic ecosystems are important to humans because of the many services they offer and need to be restored because they have been heavily degraded by anthropogenic utilization. The UNESCO Chair "Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems" has been established with the purpose to help govern sustainably the protection, study, development of these ecosystems initially in Greece and the Balkans and in the long-term in the Mediterranean and worldwide. This will be accomplished with the development an International Common Strategy Framework for the Conservation and Ecotourism of Riparian and Deltaic Ecosystems. To achieve this, Con-E-Ect has joined forces with national, regional and international stakeholders and is implementing the following four Axes: 1) Research, 2) Conservation – Sustainability, 3) Dissemination – Education – Training and 4) Best Practices.

One of the Best Practices that Con-E-Ect is focusing on is ecoengineering. Ecoengineering that is the use of living plants or cut plant material, either alone or in combination with inert structures can help control soil erosion a major problem in riparian and deltaic ecosystems. These methods have not been used as extensively in Greece and the Mediterranean and Con-E-Ect will promote guidelines specific to the Mediterranean ecoregion, on how to sustainably implement them that should promote their adoption.

Acknowledgements

This project has been support by the UNESCO Chair "Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems." This publication reflects the views only of the authors, and UNESCO cannot be held responsible for any use which may be made of the information contained therein.

References

Anthony E.J., (2015), Wave influence in the construction, shaping and destruction of river deltas: A review, *Marine Geology*, **361**, 53-78.

Bakker M.M., Govers G., van Doorn A., Quetier F., Chouvardas D., Rounsevell M., (2008), The response of soil erosion and sediment export to land-use change in four areas of Europe: The importance of landscape pattern, *Geomorphology*, **98**, 213-226.

Bischetti G.B., Chiaradia E.A., D'Agostino, V., Simonato T., (2009), Quantifying the effect of brush layering on slope stability, *Ecological Engineering*, **36**, 258-264.

Blum M.D., Tornqvist T.E., (2000), Fluvial responses to climate and sea-level change: a review and look forward, *Sedimentology*, **47**, 2-48.

Corbacho C., Sanchez J.M., Costillo E., (2003), Patterns of structural complexity and human disturbance of riparian vegetation in agricultural landscapes of a Mediterranean area, *Agriculture, Ecosystems & Environment*, **95**, 495-507.

EC Directive, (2007), Nature & Diversity, On line at: http://ec.europa.eu/environment/nature/index_en.htm.

Elliot T., (1986*)*, *Deltas*, In: *Sedimentary Environments and Facies*, Reading H.G. (Ed.), Backwell Scientific Publications, Oxford, 113-154.

Ferreira M.T., Moreira I.S., (1999), River plants from an Iberian basin and environmental factors influencing their distribution, *Hydrobiologia*, **415**, 101-107.

Giupponi C., Shechter M., (2003), *Climate Change in the Mediterranean: Socio-Economic Perspectives of Impacts, Vulnerability and Adaptation*, Edward Elgar Publications, Glos, UK.

Naiman R.J., Decamps H., McClain M.E., (2005), *Riparia - Ecology, Conservation and Management of Streamside Communities*, Elsevier Academic Press Publications, London.

NRC, (2002), National Research Council, *Riparian Areas: Functions and Strategies for Management*, National Academy Press, Washington.

Nearing M.A., Pruski F.F., O'Neal M.R., (2004), Expected climate change impacts on soil erosion rates: A review, *Journal of Soil and Water Conservation*, **59**, 43-50.

Nicholls R.J., Wong P.P., Burkett V.R., Codignotto J.O., Hay J.E., McLean R.F., Ragoonaden S., Woodroffe C.D., (2007), *Coastal Systems and Low-Lying Areas,* In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry M.L., Canziani O.F., Palutikof J.P., van der Linden P.J., Hanson C.E. (Eds.), Cambridge University Press, UK, 315-356.

Pasternack G.B., Brush G.S., Hilgartner W.B., (2001), Impact of historic land-use change on sediment delivery to a Chesapeake Bay subestuarine delta, *Earth Surface Processes and Landforms*, **26**, 409-427.

Rodewald A.D., Bakermans M.H., (2006), What is the appropriate paradigm for riparian forest conservation?, *Biological Conservation*, **128**, 193-200.

Rottenborn S.C., (1999), Predicting the impacts of urbanization on riparian bird communities. *Biological Conservation*, **88**, 289-299

Sabo J.L., Sponseller R., Dixon M., Gade K., Harms K., HeffernanJ, Jani A., Katz G., Soykan C., Watts J., Welter J., (2005)*,* Riparian zones increase regional species richness by harbouring different, not more, species, *Ecology*, **86**, 56-62.

Schultz R.C., Colletti J.P., Isenhart T.M., Marquez C.O., Simpkins W.W., Ball C.J., (2000), *Riparian Forest Buffer Practices.* In: *North American Agroforestry: An Integrated Science and Practice*, Garett H.E. (Ed.), American Society of Agronomy, Madison, 189-281.

Schiechtl H.M., (1988), Hangsicherungen mit ingenieurbiologischen Methoden im Alpenraum. Erosionbeckämpfung im Hochgebirge, *Jahrbuch 3 der Gesellschaft für Ingenieurbiologie*, **3**, 50-77.

Tardio G., Mickovski S.B., (2016), Implementation of eco-engineering design into existing slope stability design practices, *Ecological Engineering*, **92**, 138-147.

Tardio G., Mickovski S.B., Stokes A., Devkota S., (2017), *Bamboo Structures as a Resilient Erosion Control Measure*, Proc. of the Institution of Civil Engineers-Forensic Engineers, 170, 72-83.

Zaimes G.N., Gounaridis D., Iakovoglou V., Emmanouloudis D., (2011a), Riparian area studies in Greece: A literature review, *Fresenius Environmental Bulletin*, **20**, 1470-1477.

Zaimes G.N, Lee K-H., Tufeckioglu M., Long L.A., Schultz R.C., Isenhart. T.M., (2011b), *The Effectiveness of Riparian Conservation Practices in Reducing Sediment in Iowa Streams,* In: *Agricultural Research Updates. Volume 2* B.P. Hendriks (Ed.)*,* Nova Science Publishers, 117-166.

Zaimes G.N., Tardio G., Gimenez M., Iakovoglou V., Garcia-Rodriguez J.L., (2017), *ECOMED European Project: Tools and approaches to Enhance the Ecoengineering Sector in the Mediterranean Ecoregion*, Proc. of the 18th Panhellenic Forestry Congress & International Workshop, Edessa, Greece, 1389-1396.