Using the Stream Visual Assessment Protocol (SVAP) to Evaluate the Streams and their Riparian Areas of Lake Volvi in Greece

Valasia Iakovoglou[1], Antonios Koutsoumis[2], George N. Zaimes[3], and Dimitrios Emmanouloudis[4]

[1]PhD, Researcher, DEMETER-Forest Research Institute, Thessaloniki, Greece; [2]Forester, Nea Apollonia, Greece; [3]Professor of Technological Applications, Eastern Macedonia and Thrace Institute of Technology, Institute of Technology, Dept. of Forestry and Natural Environment Management, Drama, Greece; [4]Vice-President, Professor, Eastern Macedonia and Thrace Institute of Technology, Institute of Technology, Dept. of Forestry and Natural Environment Management, Kavala, Greece.
E-Mail: zaimesgeorge@gmail.com

***Abstract**:*

Lake Volvi despite being under the protection of international and European treaties continues to degrade. One of the major problems is water pollution. To face such problems, management measures have primarily focused on Lake Volvi and its immediate surroundings. To effectively minimize pollution (especially nonpoint sources), a holistic watershed management approach is necessary. The numerous torrents that end in the lake can be a major source of sediment and pollutants. The purpose of this study was to investigate the condition of the torrents of the Volvi Lake watershed. The Stream Visual Assessment Protocol (SVAP) was used that is widely accepted and used in the United States. The protocol is based on the visual assessment primarily of the physical conditions of the area and provides a basic level of stream health evaluation. The protocol was modified to suit the Greek streams/torrents. All 14 torrents that end in the lake were assessed. Each torrent was separated in three different types of reaches; the mountainous, semi-mountainous and plains. In each reach the SVAP was applied in three different sub-reaches. The scores indicated that in most cases, the plain (4.4) and semi-mountainous (4.8) reaches had lower scores than the mountainous (6.6). The plain and semi-mountainous reaches were primarily adjacent to agricultural fields or towns and experienced more anthropogenic pressures compared to the mountainous reaches that were primarily forested and/or shrublands. Overall, the scores indicated that the torrents were not in very good condition. This suggested that conservation management measures need to be taken into consideration to improve the conditions of the torrents. Otherwise the torrents can be a source of pollution for Lake Volvi.

Key Terms: healthy streams, holistic watershed approaches, visual protocols, riparian ecosystems.

Introduction:

Managing freshwater water bodies has been and will continue to be a priority for all human societies. Sustainable management of these resources can enhance the well-fare and survival of civilizations Botkin and Beveridge 1997). In contrast, unsustainable management can lead to civilizations demise. Still, despite knowing their importance, human societies have caused major modifications to freshwater resources that include pollution, water abstraction, riparian simplification, bank alteration, channel straightening, dam construction and species introduction (Sala et al., 2000).

Climate change will also have major impacts on freshwater resources (IPCC 2007). The new hydrologic regime that will be established will lead to more frequent and greater magnitude floods as well as unexpected and longer periods of droughts (Sabater and Tockner 2010). The Mediterranean region in particular, is considered a “hot spot” (Giorgi and Lionello 2008). “Hot spots” are regions that climate change will threaten their sustainable development of freshwater resources in the decades to come (Kundzewicz et al. 2008). Southern Europe is already facing water scarcity problems that are expected to intensify with more frequent droughts (Environmental European Agency 2008). In the Balkans, most rivers have experienced substantial reductions in their discharge (Skoulikidis et al. 2009).

The increase in the population in conjunction with the increase in the per capita needs, the current climate and the future climate changes in the Mediterranean Sea region make it a priority to develop management plans for its freshwater resources (Zaimes and Emmanouloudis 2012). The only way the region will be able to maintain its well-fare in regard to its freshwater resources is through holistic watershed management plans. The European Union based on the Water Framework Directive (2000/60/EU) that has been developed for the management and protection of waters, requires its Member-States to standardize and monitor the European waters for their hydrologic basins as well as to develop holistic management plans for the protection of the surface waters (Kalabouka et al. 2011). *Holistic Watershed Management* engages all aspects of the watershed in the decision making process (Brener et al. 1999). These aspects include the physical aspects as well as the human resources, the economic development, the environmental quality, the infrastructural development and the public safety.

Surficial freshwater bodies can be separated into two major categories *lotic* and *lentic*. Lotic are those with running water e.g. streams, rivers, torrent etc. In contrast, lentic surficial water bodies have standing waters e.g. lakes, ponds, wetlands etc. These different types of water bodies have significant physical characteristic differences that have led to the development of two scientific fields; stream ecology (Allan and Castillo 2007) and limnology (Kalff 2001). Since these fields have major differences, in many cases collaboration has not been achieved or pursued. In order to have holistic watershed management plans, these scientific fields need to develop better collaboration.

Typically, the limnologist will focus on the lakes, while the stream ecologists on the rivers or streams. This is not optimal because of the strong interconnections between these surfical lotic and lentic freshwater bodies. In many cases the endpoint of streams and rivers are lakes that might not be included in the watershed management plans. The watershed area of the lake, typically includes streams and rivers that are the “highways” for the movement of biological and non-biological material. Without incorporating the contributions of the tributaries to the lake, no sustainable management plan for a lake can be achieved. Streams, especially low order streams that are more in number than higher order streams, produce most of the sediment and nutrients that end downstream (Alexander et al. 2007).

The many kilometers of streams, rivers and lake shorelines make it impossible to monitor their entire lengths with methodologies that are detailed-oriented and time consuming. In contrast, at the beginning, methods that allow an easy and quick initial assessment should be used. An example of such a tool that is used extensively in the United States is the Stream Visual Assessment Protocol (SVAP) that has been developed by the USDA-NRCS (Bjorkland et al. 2001). This is a visual method that allows the quick assessment of extensive river reaches. Based on this initial assessment, a more detailed follow up assessment could be used for the focal areas where more descriptive monitoring measurements could take place.

Lake Volvi is the second largest lake in Greece and is a major source of freshwater for the region of central Makedonia, Greece. Sustainable management is necessary when considering the potential climate change impacts as well as the increased anthropogenic impacts. The condition of the lake has been degrading during the last years (Gantidis et al. 2007) and it is necessary to determine what the main causes are. This study focuses on its tributary torrents, something that has not been the focal point in past studies. The objective was to evaluate the condition of all the tributary torrents of Lake Volvi with the SVAP. This will allow determining potential problematic areas that management plans should focus on the sustainability of the lake.

Study Area:

Lake Volvi is located in the prefecture of Thessaloniki in Northern Greece (Figure 1). It is situated just north of the Halkidiki peninsula. It is the second largest lake of Greece, it is near the Aegean Sea and 37 m above sea level. The total surface water area of the Lake is 70.3 km^2 with a perimeter of 54.5 km and its maximum depth ranges from 10 to 24.5 m. The maximum length and width of the Lake are 21.5 km and 5.5 km, respectively. There are several communities built on the shores of the lake or nearby with the most significant being Rentina, Madytos, Apollonia, Egnatia, and Sochos. Around the lake the anthropogenic activities that take place are mostly agricultural. Finally, an interesting fact is that this area is one of few areas in Greece where buffalos are still raised.

Lake Volvi along with its neighboring lake of Koronia, are of great environmental interest. Together they belong to European Union Natura 2000 Network for protected areas but also the International Convention Treaty of Ramsar for wetlands. Along the shores of the two lakes, 336 plants species have been recorded with 13 of them being considered rare. In Lake Volvi 24 fishes species have been recorded, while in its wetlands and

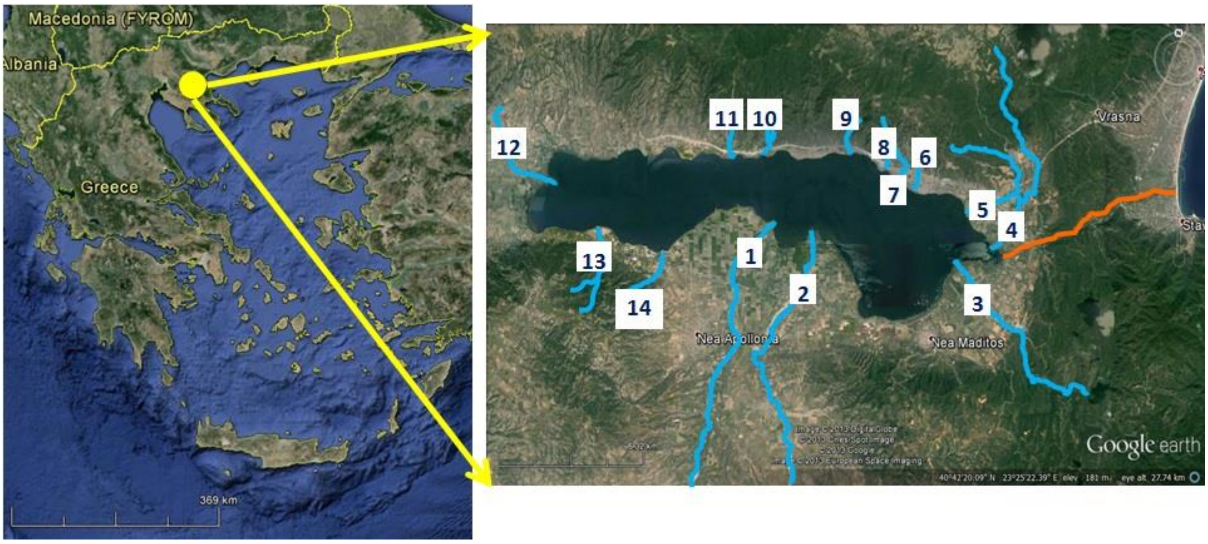

***Figure 1**. The map indicates the location of Volvi Lake in Macedonia, Northern Greece. The blue lines indicate the torrents that are numbered. The orange line indicates the canal that connects the lake to the Aegean Sea.*

riparian areas 19 amphibian-, 34 mammal- and over 200 bird- species have been recorded. Many migratory birds spend the winter or reproduce along the lake.

Both lakes belong to the Mygdonia Basin that has an area of approximately 1247 km^2. The Basin extends from Axios River Basin to Strymonas River Basin. Fifteen running water bodies end in Lake Volvi. Fourteen of these are torrents (depicted in blue in Figure 1) and the other is the channel of Redina (# 14, depicted in orange in Figure 1) that is human made and connects the lake with the Aegean Sea. Two of the larger streams are the "Altsaliotikos (#1)" and the "Bazariotikos (#2)" (Figure 1). Both have their headwaters in Xolomonta Mountainous. The rest of the torrent headwaters originate in smaller mountainous formations, such Mavri Petra. The urbanization and the agricultural production that is concentrated in the plain areas that surround the lake are a major concern in regards to the health of the lake (Gerakisa and Kalburtji 1998).

Materials and Methods:

To investigate the condition of the torrents that end in Lake Volvi, the Stream Visual Assessment Protocol (SVAP) was used. This protocol has been developed by the USDA-NRCS and is widely used and accepted in the United States (Bjorkland et al. 2001). It provides a basic visual assessment of the stream health with an easy-to-fill-in two-page worksheet. Most importantly, it requires minimal training or experience in the aquatic biology or hydrology. It needs to be pointed that this protocol is best suited for assessing physical conditions and problems within a specific area but not beyond that area that is assessed. The above mentioned characteristics make it a suitable assessment tool to be used even by landowners to get a quick overview of the condition of the stream.

Several parameter need to be filled out in the SVAP worksheet that is separated in two main sections. The first section covers the general identification characteristics of the study area. These include: owners name, evaluator's name, date, stream name, waterbody ID number reach location, ecoregion, drainage area, stream gradient, applicable reference site, land use percentages within drainage, current weather conditions and the past conditions 2-5 days prior, active channel width and dominant substrate. It must be noted that the stream sub-reach that will be assessed should be representative of the stream of interest. In addition, the length assessed needs to be twelve times the width of the active channel.

The second section includes the parameters that will be assessed. In the original protocol there are fifteen assessment elements that are evaluated (Table 1). Out of these fifteen, five are assessed only when applicable. Each of these fifteen assessment element are rated with a value of 1 to 10 (1 indication the worst condition while 10 the best). The overall assessment score is determined by adding the values for each element and dividing the total score with the number of assessed elements. The overall score provides the information regarding the status of studied stream.

Table 1. *The elements that are assessed by the original SVAP and the modified SVAP to fit Mediterranean Greek torrents*

SVAP Assessment Element	Abbreviation	Original	Modified
Channel condition	CC	Always	Always
Hydrologic alteration	HA	“	“
Riparian zone	RZ	“	“
Bank stability	BS	“	“
Water appearance	WA	“	“
Nutrient enrichment	-	“	Omitted
Barriers to fish movement	-	“	“
Instream fish cover	-	“	“
Fish Habitat	FH	Does not exist	Always
Pools	PO	“	“
Invertebrate habitat	IH	“	“
Presence of water	WP	Does not exist	Added
Presence of livestock units	LP	“	“
Presence of garbage	GP	“	“
Biological waste treatments in close proximity to the torrent	BW	“	“
Canopy cover	CA	If applicable	If applicable
Presence of manure	MP	“	“
Salinity	-	“	Omitted
Riffle embeddedness	-	“	“
Macroinvertebrates	-	“	“

This protocol was developed for more humid conditions in the United States compared to the Mediterranean climate of Greece. While a modified SVAP for Greece has been cited in the literature it was developed to fit more mountainous regions (Zogaris et al. 2009). Since in the study area the water bodies are torrents, modifications were required. Table 1 provides all the modifications to the elements (additions or omissions) to meet the ecological niches that are present in Greek areas. These modifications made the protocol more suitable for Greek torrents, since those torrents have intermittent or ephemeral flow and are a very common type of streams that are found in the Mediterranean region (Emmanouloudis et al. 2011).

Finally, since it would be impossible to assess all the bank lengths of all 15 torrents, stratification was done. The stratification was based on the River Continuum Concept (Vannote et al. 1980). Each torrent was separated in three reaches: a) the mountainous, b) semi-mountainous and c) the plain (flat areas). In each reach of each torrent the modified SVAP was applied to three different sub-reaches. Each torrent had a total of nine SVAP assessments. The difference in topography, stream characteristics and watershed land-use led the authors to speculate that the stream conditions might also differ in these three reaches.

Results and Discussion:

The average and the range of scores for the 14 torrents among the three reaches differed (Table 2, 3 and 4). The plain had an average SVAP value of 4.4 that ranged from 3.2-6.0. The semi-mountainous had an average SVAP value of 4.8 that ranged from 3.0-6.0. The mountainous reaches had an average SVAP value of 6.6 that ranged from 5.7-7.6. This is something that was expected since the more mountainous areas have less anthropogenic impacts. The plain reaches are primarily in agriculture with also human settlements that can degrade the riparian area and stream.

In the plain reaches, torrents 2, 3 and 4 were in the worst condition (lowest scores), while torrent 7, 9, 12 were in the best conditions (highest scores) (Table 2). The three torrents that were the most degraded are on the south and southeast side of the lake with small towns in the vicinity. The torrents that were in best condition were on the north side of the lake. Overall, the scores were 6.0 or below indicating that management efforts need to be made for their improvement. Out of all the elements assessed it seems that there have been many hydrologic alterations to the streams and there were very few pools. This was expected since these are reaches that are occupied or utilized by humans that typically impact adjacent streams. One the plus side, there were limited biological waste treatments (almost none), livestock units and presence of garbage in close proximity to the torrents.

Table 2. The SVAP assessment scores of the plain reaches of the torrents. Three different sub-reaches were assessed at each torrent.

Element	Torrent													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CC	2.3	1.0	1.6	7.0	3.0	3.0	3.0	5.6	7.0	1.6	4.3	4.3	2.3	7.0
HA	3.0	1.0	1.0	3.0	2.3	1.0	1.6	1.0	3.0	1.0	1.0	1.0	3.0	4.3
RZ	1.6	2.3	3.6	3.6	4.3	4.3	4.3	5.0	9.3	6.0	1.6	7.0	10.0	3.6
BS	1.6	3.0	4.3	1.6	5.6	3.0	7.0	4.3	7.0	7.0	2.3	1.6	5.6	5.6
WA	3.0	2.0	1.0	0.3	1.0	2.0	3.0	2.0	2.0	1.0	3.0	7.0	2.7	3.0
WP	2.0	0.6	1.3	0.6	0.3	0.6	4.3	5.0	3.0	4.0	4.0	10.0	3.0	2.0
FH	4.3	1.6	2.3	1.6	3.6	3.0	5.0	3.6	7.0	1.6	4.3	8.6	3.6	1.6
LP	3.3	10.0	7.7	2.3	7.7	10.0	10.0	9.0	8.3	7.0	10.0	8.0	3.3	10.0
IH	7.6	4.3	3.0	1.6	4.3	3.0	8.0	7.0	10.0	4.3	2.3	8.0	6.7	3.0
PO	1.0	1.0	1.0	1.0	1.6	1.0	1.0	1.0	1.0	1.0	1.6	5.6	1.6	1.0
CA	1.0	1.0	1.0	2.3	4.3	2.3	5.6	3.0	5.6	1.6	1.6	3.0	3.0	1.6
MP	2.3	3.0	1.6	2.6	2.3	3.6	2.3	3.6	1.6	1.0	5.0	1.6	1.0	4.3
GP	9.0	8.0	9.0	7.0	9.0	8.0	10.0	5.6	9.0	4.3	10.0	7.0	10.0	4.3
BW	10.0	10.0	10.0	10.0	8.3	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Average	**3.7**	**3.5**	**3.5**	**3.2**	**4.1**	**3.9**	**5.4**	**4.7**	**6.0**	**3.7**	**4.4**	**5.9**	**4.7**	**4.4**

Table 3. The SVAP assessment scores of the semi-mountainous reaches of the torrents. Three different sub-reaches were assessed at each torrent.

Element	Torrent													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CC	1.6	1.6	2.3	4.3	10.0	7.0	7.0	7.0	4.3	2.1	1.6	3.0	5.6	4.3
HA	3.0	1.0	1.0	3.0	1.6	1.0	1.6	1.0	3.0	1.0	1.0	2.3	3.0	1.6
RZ	1.0	4.3	3.0	4.3	5.0	4.3	3.6	7.0	6.0	7.0	3.0	3.0	5.0	3.0
BS	3.0	3.6	3.0	4.3	3.0	5.6	3.0	7.0	5.6	1.6	1.6	5.6	7.0	4.3
WA	5.0	2.0	1.0	2.0	1.0	1.0	7.0	4.0	4.0	3.0	5.0	9.0	5.6	7.0
WP	3.6	1.3	2.0	1.3	0.6	2.0	2.0	3.0	4.0	3.0	3.0	10.0	6.6	10.0
FH	3.6	1.6	4.3	1.6	4.3	4.3	3.6	5.0	3.6	4.3	3.0	10.0	5.0	3.6
LP	2.3	6.7	6.7	10.0	10.0	8.3	1.6	8.3	10.0	10.0	8.3	10.0	7.0	6.7
IH	7.0	5.6	1.6	3.6	7.0	5.6	8.3	10.0	9.0	3.0	5.6	10.0	8.0	8.0
PO	5.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3	9.0	4.3	4.3
CA	1.6	4.3	2.3	2.3	3.0	3.0	3.0	4.3	4.3	2.1	4.3	7.0	7.0	2.3
MP	3.6	4.3	1.0	5.0	3.6	3.6	2.3	1.0	5.0	5.0	1.0	3.6	2.3	1.0
GP	8.0	5.6	2.3	3.6	10.0	3.0	8.0	9.0	10.0	5.6	8.0	9.0	6.6	9.0
BW	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Average	**4.2**	**3.9**	**3.0**	**4.0**	**5.0**	**4.3**	**4.4**	**5.5**	**5.7**	**4.2**	**4.1**	**7.3**	**5.9**	**5.4**

In the semi-mountainous reaches, torrents 2, 3 and 4 had the lowest scores, as in the plain reaches (Table 2). It appears that the human settlements are still impacting them even in the semi-mountainous reaches. Torrents 9 and 12 had the highest scores as in the plain reaches. Torrent 7 surprisingly had a slightly lower value in the semi-mountainous reach compared to the plain reach. This was not expected since as you move to the more mountainous reaches less anthropogenic impacts were expected. Torrent 13 on the southwest side of the lake also had one of the highest values. Again, most scores were below 6.0 (except for torrent 12) indicating that measures need to be taken to improve the health of the torrents and its riparian areas. Similarly to the plain reaches, the hydrologic alterations to the torrents and the pools had the lowest scores, while the biological waste treatments were absent and livestock units and garbage were very limited near the torrents.

In the mountainous reaches, torrents 4, 10, 11 and 12 had the lowest scores, while torrents 5, 7 and 9 had the highest scores (Table 2). The torrents with the lowest scores were on the northwest and east sides of lake, while the torrents with the highest scores were on the northeast side. Interestingly, although torrent 12 that had one of

Table 4. The SVAP assessment scores of the mountainous reaches of the torrents. Three different sub-reaches were assessed at each torrent.

Elements	Torrent													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CC	7.0	4.3	5.6	7.0	9.0	8.0	9.0	4.3	7.0	4.3	5.6	5.6	7.0	7.0
HA	1.0	1.6	1.6	3.0	3.0	3.0	1.0	3.0	1.0	2.1	3.0	3.0	3.0	3.0
RZ	7.0	7.0	6.0	9.3	8.0	6.0	7.0	10.0	9.3	10.0	4.3	4.3	7.0	9.3
BS	4.3	7.0	7.0	4.3	7.0	7.0	9.0	4.3	4.3	7.0	5.6	1.0	3.0	9.0
WA	3.0	5.6	3.0	2.3	5.3	7.0	4.6	7.0	7.0	8.0	7.0	7.0	4.3	4.3
WP	5.0	10.0	10.0	4.0	6.6	3.3	3.3	10.0	10.0	5.0	8.3	10.0	10.0	5.0
FH	5.3	6.0	5.0	3.6	8.0	7.0	8.0	7.0	9.3	3.6	5.0	8.6	7.0	5.3
LP	10.0	10.0	5.3	10.0	10.0	10.0	10.0	10.0	9.0	8.0	9.0	2.6	9.0	10.0
IH	9.0	9.0	5.6	5.6	10.0	7.0	8.0	5.6	10.0	7.0	5.6	6.0	4.3	7.0
PO	4.3	7.0	7.0	2.3	5.3	4.3	5.6	2.3	5.6	1.0	2.3	7.0	8.0	3.6
CA	9.0	4.3	9.0	9.0	9.0	7.0	10.0	8.0	7.0	1.0	9.0	5.6	5.6	8.0
MP	4.3	4.3	4.3	3.6	5.0	5.0	5.0	3.6	1.6	3.6	1.0	3.0	1.6	4.3
GP	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.0	10.0	9.0	8.0	8.0	8.0	10.0
BW	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Average	**6.4**	**6.9**	**6.4**	**6.0**	**7.6**	**6.8**	**7.2**	**6.7**	**7.2**	**5.7**	**6.0**	**5.8**	**6.3**	**6.8**

the highest scores in the previous two reaches, it had one of the lowest scores in the mountainous reach. In these reaches most scores were above 6.0 (except torrents 10 and 12) indicating that they were in better condition than the other two reaches. The highest score was still only 7.6, indicating that additional measures are needed to improve these torrents. From all the assessment elements, hydrological alterations had again the lowest score indicating humans' impacts. These areas have had civilizations for thousands of years, so torrents and riparian areas have always been utilized. The presence of manure had the second lowest score of assessment elements indicating that the mountainous reaches and their riparian areas are used more heavily as rangelands for livestock compared to the other two reaches. Finally near the torrents, there were also no biological waste treatments and limited livestock units and garbage present (highest scores).

Conclusions:

The results indicated that the condition of the torrents was not very good, particularly in the semi-mountainous and plain reaches. These were reaches that the anthropogenic activities were quite extensive. Most reaches of these torrents received scores lower than 6.0. In contrast, most mountainous reaches of the torrents had scores mostly greater than 6.0, indicating healthier torrent and riparian area conditions. This was expected since human activities decrease in the mountainous reaches. Still, even in the mountainous reaches of the torrents, the highest score was 7.6. Another major difference between the mountainous reaches and the plain and semi-mountainous was the presence of manure. The presence of manure had the second lowest score in the mountainous reaches indicating their use as rangelands for livestock. In contrast, the riparian areas of the semi-mountainous and especially the plain reaches of the torrents were used for cropping activities. Overall, the scores indicated that the torrents and riparian areas needed to be enhanced in order to improve their ecosystems services, particularly in reducing sediment and nutrient movement to lake. Without reducing the upstream pollutants no management plans can improve the water quality of the Lake Volvi in order to meet its requirements as a protected area.

References

Alexander, R.B., E.W. Boyer, R.A. Smith, G.E. Schwarz, and R.B. Moore, R.B. 2007. The role of headwater streams in downstream water quality. Journal of the American Water Resources Association 43;41–59.

Allan J.D., M.M. Castillo. Stream Ecology: Structure and function of running waters. Springer, Dordrecht.

Botkin, D.B., and C.E. Beveridge. 1997. Cities as environments. Urban Ecosystems 1;3-19.

Bjorkland, R., C.M. Pringle, B. Newton. 2001. A Stream Visual Assessment Protocol (SVAP) for Riparian Landowners. Environmental Monitoring and Assessment 68;99-125.

Brenner, A.J., L.A. Brush, J.S. Martin, K.Y. Olsson, P.L. Rentschler, J.K. Wolf. 1999. The Huron River Watershed council: Grassroots organization for holistic watershed management. Water Science and Technology 39;331–337.

Emmanouloudis D., J.L. García Rodríguez, G.N. Zaimes, M.C. Giménez Suárez, and E. Filippidis. 2011. Euro-Mediterranean torrents: Case studies on tools that can improve their management. In: Kevin E. Richards (ed.) Mountain Ecosystems: Dynamics, Management and Conservation. Hauppauge, NY: Nova Science Publishers Inc.

Giorgi, F., and P. Lionello. 2008. Climate change projections for the Mediterranean region. Global Planet Change 63;90-104.

Gantidis, N., M. Pervolarakis, and K. Fytianos. 2007. Assessment of the Quality Characteristics of Two Lakes (Koronia and Volvi) of N. Greece. Environmental Monitoring and Assessment 125; 175-181.

Gerakisa, A., and K. Kalburtji. 1998. Agricultural activities affecting the functions and values of Ramsar wetland sites of Greece. Agriculture, Ecosystems & Environment 70; 119–128.

European Environmental Agency (2008) Impacts of Europe's changing climate-2008 indicator-based assessment. EEA Report 4/2008 & JRC Report JRC47756. EEA, Copenhagen, Denmark.

IPCC (2007) Climate Change 2007: Impacts adaptation and vulnerability. Working Group II. Final Assessment Report, UNEP. Cambridge University Press, Cambridge, UK.

Kalampouka, K., G.N. Zaimes, and D. Emmanouloudis.2011. Harmonizing Member State Water Policies to the EU Water Directive 2000/60/EU: The Case of Greece 95-100 In Proceedings of 6th IASME / WSEAS International Conference on Water Resources, Hydraulics & Hydrology (WHH '11) Cambridge, UK, February 23-25, 2011, WSEAS Press. pp. 95-100.

Kalff, J. 2001. Limnology. Prentice Hall, Upper Saddle River, NJ.

Kundzewicz, ZW, LJ Mata, NW Arnell, P Doll, B Jimenez, K Miller, T Oki, Z Sen, I Shiklomanov (2008) The implications of projected climate change for freshwater resources and their management. Hydrological Sciences Journal 53:3-10.

Sabater S, K Tockner (2010) Effects of hydrologic alterations on the ecological quality of river ecosystems. In: S. Sabater, D. Barcelo (eds) S. Sabater, D. Barcelo (eds) Water scarcity in the Mediterranean, Perspectives Under Global Change, The handbook of environmental chemistry 8. Dordrecht, Netherlands:Springer, pp. 15-39.

Sala, O.E., F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall 2000. Global Biodiversity Scenarios for the Year 2100. Science 287;1770-1774.

Vannote, R.L., G.W. Minshall, K. W. Cummins, J.R. Sedell, and E. Gushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37;130-137.

Zaimes, G.N., and D.Emmanouloudis. 2012. Sustainable Management of the Freshwater Resources of Greece. Journal of Engineering Science and Technology Review 5;77-82.

Zogaris, S., Y. Chatzinikolaou and P. Dimopoulos. 2009. Assessing environmental degradation of montane riparian zones in Greece. Journal of Environmental Biology 30;719-726.