Possible Climate Change Impacts on Freshwaters in Slovenia; Biodiversity Aspect in Lowland Ecoregions

Gorazd Urbanič[1, 2], Maja Pavlin[2]*

[1-] University of Ljubljana, Biotechnical Faculty, Dept. of Biology, Večna pot 111, 1000 Ljubljana, Slovenia
[2-] Institute for Water of the Republic of Slovenia. Hajdrihova 28c, 1000 Ljubljana, Slovenia

Abstract. The possible effects of climate change on biodiversity were studied at the ecosystem and species levels. Two lowland ecoregions – Pannonian lowland and Po lowland were considered, as both are characterized by low precipitation and significant agricultural activity. Reduced precipitation and higher temperatures – a result of climate change causing hydrological and agricultural drought, could have a direct impact on freshwater organisms. In addition, also indirect, human-induced impacts due to higher water abstraction and building of impoundments might influence freshwater organisms. Ecosystem diversity was defined as the number of river types and the number of heavily modified rivers in four bioregions. All rivers classified as class 5 according to Hydrological Modification Index were assessed as heavily modified. In general, higher ecosystem diversity was observed in both ecoregions compared to the reference value, but there were differences between bioregions. On the other hand at the species level, the results depended on the selected diversity metrics and the river type. For all the six tested river types, the number of EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa and the number of EP (Ephemeroptera nad Plecoptera) taxa was statistically lower ($p<0.05$) in the corresponding heavily modified rivers compared to natural river types. This was not confirmed for the number of taxa, where for two types of large rivers and one type of small river significant differences were not observed. Moreover, for both large river types, the values of Simpson index, Shannon-Wiener index and Evenness were significantly higher ($p<0.05$) at heavily modified river sections.

Keywords: bioindicator, benthic invertebrates, ecosystem diversity, species diversity, drought, river types, heavily modified water bodies

1 INTRODUCTION

The climate is changing and several possible climate-change scenarios have been prepared (Bernstein et al., 2007). While all of them have similar predictions, they differ in the level of the change. Climate change impacts on inland aquatic ecosystems will range from effects of the rise in temperature to effects through alterations in the hydrology resulting from the changes in the regional or global precipitation regimes and the melting of glaciers and ice cover (Cubasch et al., 2001; Meehl et al., 2007). In all regions the negative impacts of climate change on water resources and freshwater ecosystems outweigh the positive impacts (Fischlin et al. 2007). Moreover, changes in climate will place additional pressures on already-stressed ecosystems (Naiman et al., 2005).

In Europe, water stress will increase over central and southern Europe. The percentage area under high water stress is likely to increase from 19% today to 35% by the 2070s, and the additional number of people affected by the 2070s is expected to be between 16 million and 44 million (Alcamo et al., 2007). The most affected regions are southern Europe and some parts of central and eastern Europe, where summer flows may be reduced by up to 80%. In Slovenia, there is a trend of reduction in summer precipitation (Dolinar, 2008). As most rivers in Slovenia

* E-mail: maja.pavlin@izvrs.si

have pluvio-nival, nivo-pluvial or even pluvial water regime with lowest flows in the summer, most rivers might be affected by climate change. Furthermore, in ecoregions Pannonian Lowland and Po Lowland (Urbanič, 2005a, 2007, 2008) agriculture is an important land use and most rivers are hydromorphologicaly altered due to habitat changes and water abstraction. Therefore, climate change might have additional negative effects on freshwater ecosystems.

Climate change in combination with present and future land-use change and associated landscape fragmentation will alter the structure and perturb the functioning of most ecosystems as well as reduce biodiversity (Fischlin et al. 2007). However, biodiversity can be identified at different levels and ecologists usually identify it at three levels: within species (genetic diversity), between species (species diversity) and of ecosystems (ecosystem diversity) (Heywood & Watson, 1995). Kappelle et al. (1999) concluded that climate change leads to loss of biodiversity on all three levels, but assessing the impact of climate change on biodiversity is difficult, because effects of climate change interact with other stress factors. On the other hand, Urbanič (in press) concluded that climate change will have direct effects (raised water temperature and drought) and indirect effects (human activities, e.g. water abstraction, impoundments) on running water biodiversity. Moreover, in agricultural areas freshwater biodiversity and benthic communities are already influenced by human-induced environmental changes (Urbanič, 2006a).

In the present study we discuss the relation between ecosystem diversity, benthic invertebrate species diversity and climate change trends and other human-induced environmental changes as well as their possible impacts in two lowland ecoregions.

1.1 Study Area

In Slovenia two lowland ecoregions, the Pannonian lowland and the Po lowland, are present (Urbanič, 2005a, 2007, 2008). Pannonian lowland extends over the eastern part of Slovenia, whereas the Po lowland comprises a small part of western Slovenia (Fig.1). In the Pannonian lowland three bioregions were defined as a combination of biogeographical and ecological characteristics of the area whereas one bioregion was defined in the Po lowland (Urbanič, 2006b, 2007, 2008, Table 1).

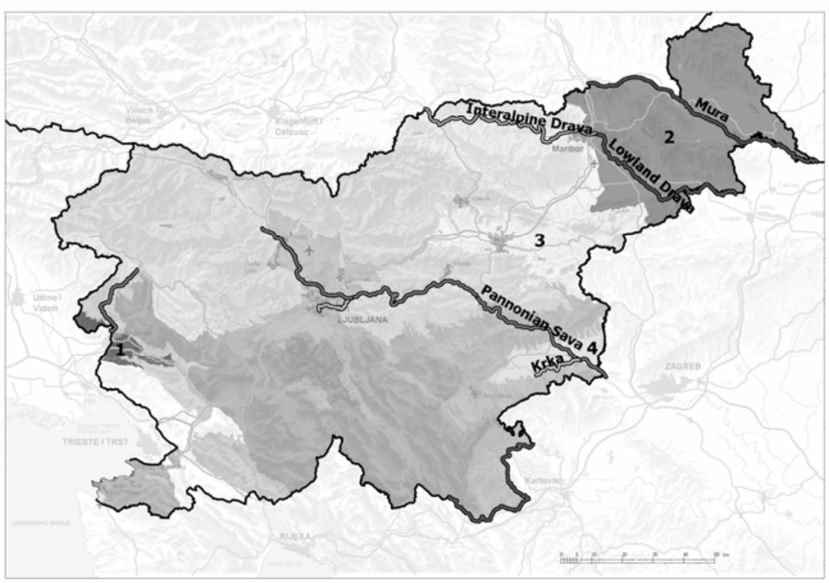


Figure 1. The study area and Inland aquatic Bioregions and large rivers of Slovenia (Urbanič, 2006b). Large rivers of lowland ecoregions in Slovenia are named. Lowland Bioregions of Slovenia are marked with numbers (1 - Lower Vipava valley and Brda hills, 2 – Pannonian hills and plains, 3 - Pannonian plains with alpine influence, 4 - Krško-Brežice basin).

Table 1. Inland aquatic Bioregions and Large rivers of lowland ecoregions in Slovenia and their main characteristics.

Bioregion	Ecoregion (Urbanič, 2005a)	Altitude range (m)	Dominant geology	No. of river types
1. Lower Vipava valley and Brda hills	Po lowland	0 – 200	Flysch	2
2. Pannonian hills and plains	Pannonian lowland	100 – 400	Silicate	2
3. Pannonian plains with alpine influence	Pannonian lowland	200 – 400	Silicate (and carbonate)	3
4. Krško-Brežice basin	Pannonian lowland	100 – 200	Silicate and carbonate	3
Large river				
5. Pannonian Sava river	Pannonian lowland	100-200	Carbonate	1
6. Krka river	Pannonian lowland	100-150	Carbonate	1
7. Interalpine Drava river	Pannonian lowland	200-400	Silicate	1
8. Mura river and lowland Drava river	Pannonian lowland	100-200	Silicate	1

2 MATERIAL AND METHODS

2.1 Freshwater Types

Biodiversity of bioregions was defined as ecosystem diversity and species diversity. Ecosystem diversity was defined as a number of natural river types. River types were defined according to the system B of the European Water Framework directive (EU 2000). Only rivers with catchment area larger than 10 km^2 were regarded. Types of running waters were described as a combination of bioregion and size class and the special type "large rivers" was defined. Urbanič (2005b) defined large rivers as rivers with catchment area >2500 km^2 and/or mean annual discharge >50 m^3/s. In addition to river types, the presence of heavily modified rivers (HMR) was defined. A heavily modified river was defined when a river section was classified as class 5 according to Hydological modification index (HLM) (Urbanič & Tavzes, 2006). Most rivers were altered due to river impounding.

2.2 Benthic Invertebrates

In addition to ecosystem diversity, species diversity of benthic invertebrate communities was also defined. Data on 274 samples were collected from 6 river types and 6 heavily modified water body types. Benthic invertebrates were sampled using river microhabitat sampling approach (Urbanič et al., 2005a) and underwent a subsampling procedure according to Urbanič et al. (2005b). In the laboratory only ¼ of the whole field sample underwent the whole identification and enumeration procedure. All benthic invertebrates were determined to the required taxonomic level used for assessing ecological status of rivers in Slovenia (Urbanič et al., 2005b). Most taxa were determined to species and genus levels, and rarely to family (Brachycera, Tubificidae).

2.3 Data Analyses

A comparison of natural rivers (classified as class 1 according to HLM index) versus heavily modified rivers (rivers classified as class 5 according to HLM index) was performed. Seven species diversity measures were calculated: number of taxa, number of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa, number of EP (Ephemeroptera, Plecoptera) taxa, Shannon diversity index according to the equation

$$(H') \ D_{S-W} = \sum_{i-1}^{s} (\frac{n_i}{A}) \ln(\frac{n_i}{A}) \qquad ...(1)$$

where A – abundance and n_i-abundance of the i-th taxon, Evenness (Pielou's) (Krebs, 1989) according to the equation

$$Evs = \frac{D_{S-W}}{\ln(t)} \qquad ...(2)$$

where t – number of taxa and D_{S-W}-Shannon-Wiener diversity index (Shannon in Weaver, 1949), Margalef index (Margalef, 1984) according to the equation

$$D_M = (i-1)/\ln A \qquad ...(3)$$

where A – abundance and i-number of taxa, and Simpson index (Simpson, 1949) according to the equation

$$D_{Simpson} = 1 - \sum_i \frac{n_i(n_i - 1)}{A(A-1)} \qquad ...(4)$$

Where A – abundance and n_i – abundance of the i-th taxon. Student t-test was used to determine statistically significant differences in diversity measures between HLM class 1 and class 5.

3 RESULTS

3.1 Ecosystem Diversity

Fourteen river types were defined in lowland ecoregions, two in Po lowland and twelve in Pannonian lowland (Table 2). In the latter ecoregion four large river types were defined, whereas no large river types were defined in Po lowland. Bioregions "Pannonian plains with alpine influence" and "Krško-Brežice basin" were most diverse with three river types each, but "Pannonian hills and plains" and "Lower Vipava valley and Brda hills" had two river types each (Table 1). On the other hand, heavily modified rivers were recorded at 8 river types. Only in the bioregion "Krško-Brežice basin" no heavily modified rivers were recorded, whereas of large rivers only Krka river is not heavily altered but most types of small rivers and large rivers are heavily altered.

Table 2. River types in lowland ecoregions of Slovenia and presence of heavily modified rivers (HMR). sQs-mean flow.

River type-code	River type	Size class (km^2)	HMR
VIP_1	Small rivers of the Lower Vipava valley and Brda hills	10-100	+
VIP_2	Medium sized rivers of the Lower Vipava valley and Brda hills	100-1000	-
PN_gr_1	Small rivers of the Pannonian hills and plains	10-100	+
PN_gr_2	Medium sized rivers of the Pannonian hills and plains	100-1000	+
PN_KB_1	Small rivers of the Krško-Brežice basin	10-100	-
PN_KB_2	Medium sized rivers of the Krško-Brežice basin	100-1000	-
PN_KB_3	Medium to large rivers of the Krško-Brežice basin	1000-2500 or sQs >50 m^3/s	-
PN_zal_1	Small rivers of the Pannonian plains with alpine influence	10-100	+
PN_zal_2	Medium sized rivers of the Pannonian plains with alpine influence	100-1000	-
PN_zal_3	Medium to large rivers of the Pannonian plains with alpine influence	>1000	+
VR6	Pannonian Sava river	>2500 and/or sQs >50 m^3/s	+
VR7	Krka river	>2500 and/or sQs >50 m^3/s	-
VR8	Interalpine Drava river	>2500 and/or sQs >50 m^3/s	+
VR9	Mura river and lowland Drava river	>2500 and/or sQs >50 m^3/s	+

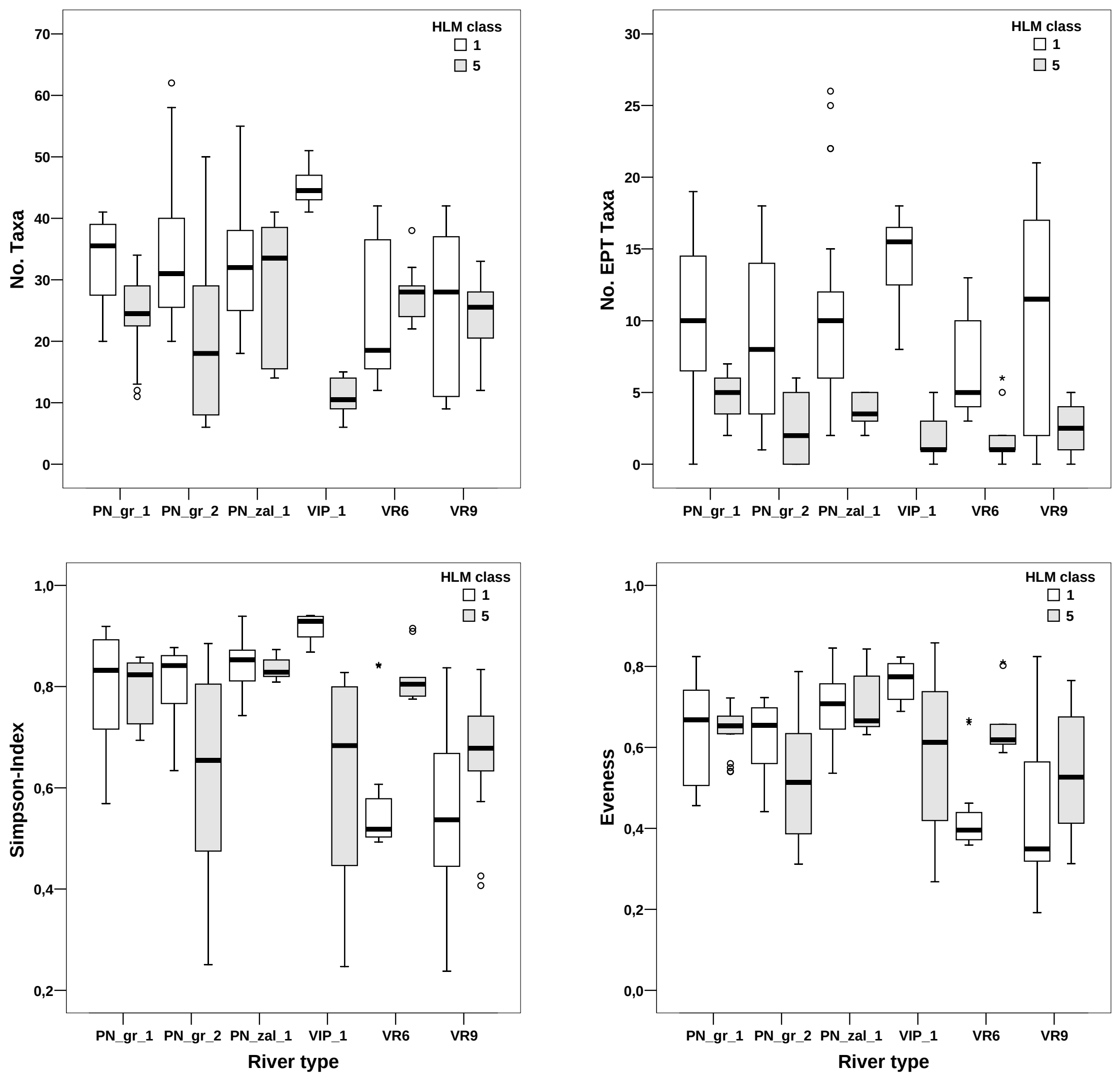
3.2 Species Diversity

Seven diversity metrics were tested but only the number of EPT taxa and the number of EP taxa were significantly ($p \leq 0.001$) higher in all river types in comparison to corresponding heavily modified rivers (Fig. 2). Moreover, for river types "Small rivers of Lower Vipava Valley and Brda hills" and "Medium sized rivers of Pannonian hills and plains" values of all diversity metrics were significantly ($p<0.005$) higher in comparison to corresponding heavily altered river sections (Table 3). On the other hand, for river type "Small rivers of Pannonian plains with alpine influence" besides number of EPT taxa and number of EP taxa, only Margalef diversity index was significantly ($p<0.05$) higher than in corresponding impounded sections. When statistically significant ($p<0.05$) differences were observed between HLM=1 (river types) and HLM=5

Table 3. Student's t-test t values of differences between river types and responding heavily modified rivers and level of statistical significance (*) p<0,05, (**) p<0,005, (**) p<0,001 and (ns) - non – significant difference.

	River type-code					
	PN_gr_1	PN_gr_2	PN_zal_1	VIP_1	VR6	VR9
No. samples	44	68	54	32	22	54
No. Taxa	4,480***	4,753***	ns	29,777***	ns	ns
Simpson Index	ns	4,668***	ns	4,044***	-5,582***	-3,234**
Shannon diversity index (H')	ns	5,705***	ns	8,920***	-4,273***	-3,433**
Margalef Index	5,362***	5,284***	2,204*	37,819***	ns	ns
Evenness	ns	3,214**	ns	2,636***	-5,163***	-2,189*
No. EPT Taxa	4,902***	5,734***	3,797***	14,037***	3,895**	5,006***
No. EP Taxa	5,019***	8,499***	4,206***	10,293***	8,948***	4,674***

(heavily modified rivers), lower values were found in heavily modified river sections, but for large river types, the Simpson index, Shannon-Wiener index and Evenness had statistically higher ($p<0.05$) values at heavily modified river sections (Table 3).



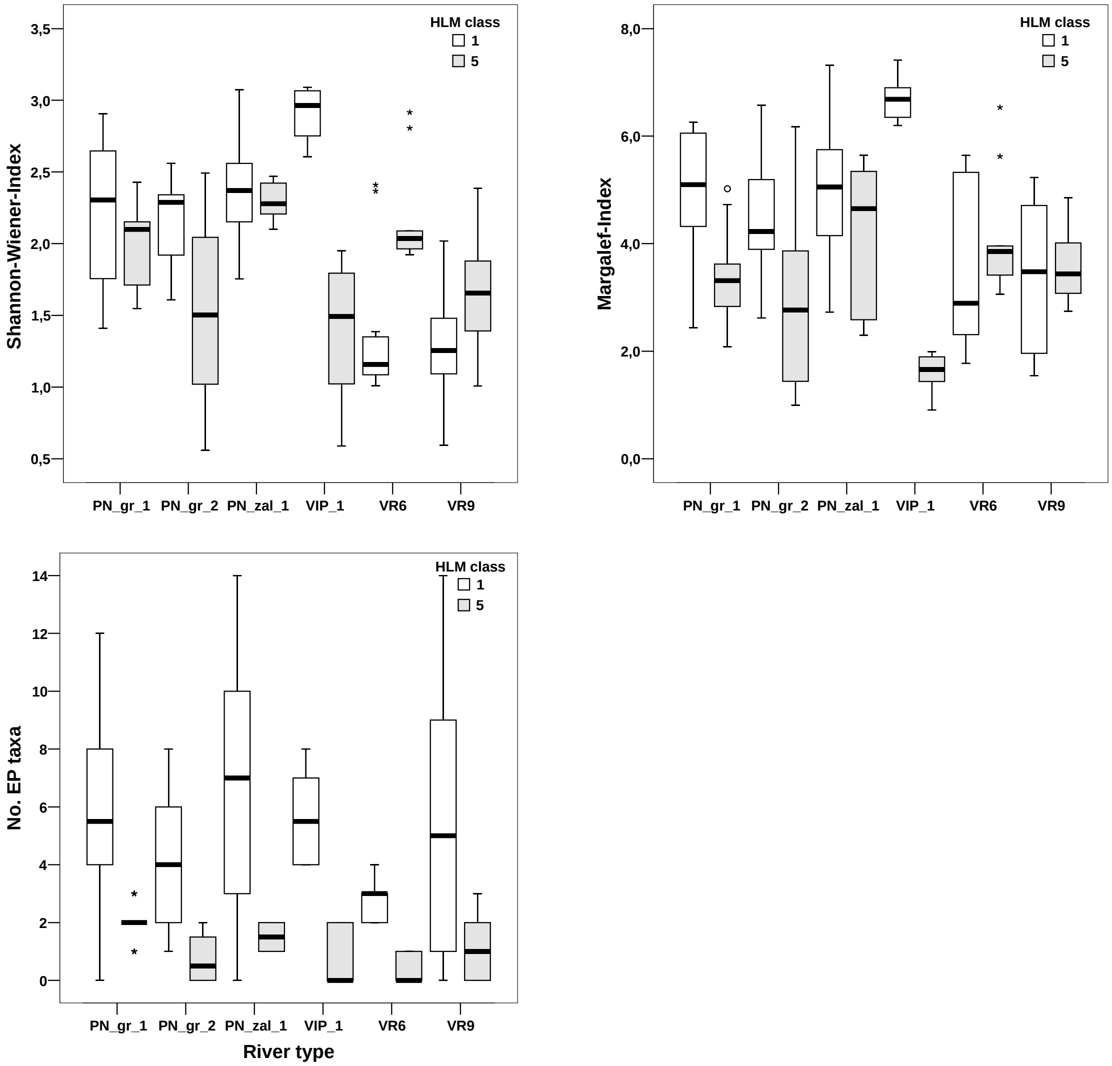


Figure 2. Species diversity measures for some river types of lowland ecoregions (PN_gr_1 - Small rivers of the Pannonian hills and plains, PN_gr_2 - Medium sized rivers of the Pannonian hills and plains, PN_zal_1 - Small rivers of the Pannonian plains with alpine influence, VR6 - Pannonian Sava river, VR9 - Mura river and lowland Drava river). Range bars show maximum and minimum of non-outliers; boxes are interquartile ranges (25 percentile to 75 percentile); bars in boxes are median; open circles are outliers.

4 DISCUSSION

Biodiversity is a resource that is increasingly recognised to sustain many of the goods and services that humans enjoy from ecosystems (Fischlin et al. 2007). However, climate change will have the adverse impacts on biodiversity, which was stressed in many studies (e.g., Gitay et al., 2002; Hannah and Lovejoy, 2003; Lovejoy and Hannah, 2005; Schröter et al., 2005; Thuiller et al., 2005b; van Vliet and Leemans, 2006). Urbanič (in press) concluded that climate change will have direct effects (raised water temperature and drought) and indirect effects (human activities, e.g. water abstraction, impoundments) on the running water biodiversity. In the present study human-induced indirect effects on the ecosystem and species level biodiversity were assessed. Ecosystem diversity expressed as number of freshwater types in most lowland bioregions is higher in comparison to the reference value due to impounding of rivers. Kappelle et al. (1999)

stated that biodiversity loss due to climate change is expected at all three levels. However, we observed higher freshwater ecosystem biodiversity at the regional level. But as human-induced changes will be even more frequent in the future, we can expect higher ecosystem diversity in the first phase of climate change, but totally altered ecosystems and lower ecosystem biodiversity in the second phase if the predicted climate change scenarios will come true. On the other hand, at the species level we calculated many different metrics and it seems that the effect of human-induced changes on species diversity depends on the selected metric. Only the number of EP taxa and the number of EPT taxa were significantly lower in impounded rivers in comparison to natural river types. This was not confirmed for the number of taxa, where for two types of large rivers and one type of small river significant differences were not observed. Moreover, for both large river types values of Simpson index, Shannon-Wiener index and Evenness were significantly higher ($p<0.05$) at heavily modified river sections (Table 3).

In the future agricultural droughts might raise the requirements for irrigation, which might lead to impounding of rivers and loss of biodiversity. In lowland ecoregions of Slovenia where agriculture is a dominant land-use rivers were not impounded only in the bioregion Krško-Brežice basin. However, the strategy of the Ministry of agriculture, forestry and food of the Republic of Slovenia is to support investments in irrigation systems and hydro-melioration systems (MKGP, 2008). All the mentioned activities represent a pressure to freshwater ecosystems and a major deviation from the reference-natural ecosystem conditions. On the other hand, one of the main objectives of the Water Framework Directive (Directive 2000/60/EC) is to achieve good ecological status of all surface water bodies before the end of the year 2015. Fulfilling this objective will help diminish the effects of climate change which might result also in droughts and floods. Moreover, implementation of the WFD will enable humans to enjoy the ecosystem goods and services and biodiversity plays a key supporting role. Nevertheless, this can only be achieved if the activities of different sectors and ministries are directed toward the same goal.

5 REFERENCES

Alcamo, J., J.M. Moreno, B. Nováky, M. Bindi, R. Corobov, R.J.N. Devoy, C. Giannakopoulos, E. Martin, J.E. Olesen and A. Shvidenko, 2007. Europe. *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*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 541-580.

Bernstein, L., P. Bosch, O. Canziani, Z. Chen, R. Christ, O. Davidson, W. Hare, S. Huq, D. Karoly, V. Kattsov, Z. Kundzewicz, J. Liu, U. Lohmann, M. Manning, T. Matsuno, B. Menne, B. Metz, M. Mirza, N. Nicholls, L. Nurse, R. Pachauri, J. Palutikof, M. Parry, D. Qin, N. Ravindranath, A. Reisinger, J. Ren, K. Riahi, C. Rosenzweig, M. Rusticucci, S. Schneider, Y. Sokona, S. Solomon, P. Stott, R. Stouffer, T. Sugiyama, R. Swart, D. Tirpak, C. Vogel and G. Yohe, 2007. *Climate Change 2007: Synthesis Report*, 52 pp.

Cubasch, U., G.A. Meehl, G.J. Boer, R.J. Stouffer, M. Dix,A. Noda, C.A. Senior, S. Raper and K.S. Yap, 2001. The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Projections of future climate change. *In Climate Change 2001*, Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 525- 582.

Dolinar M. 2008. Water Balance elements. *In Water Balance of Slovenia 1971 – 2000*, Frantar P., Ed. Ministry for Environment and Spatial Planning – Environmental Agency of the Republic of Slovenia, Ljubljana, 29 – 66.

[EU] European Union, 2000. *Directive 2000/60/EC of the European Parliament and of the Council* *establishing a framework for Community action in the field of water policy*. The European parliament and the Council of the European Union, Brussels.

Fischlin, A., G.F. Midgley, J.T. Price, R. Leemans, B. Gopal, C. Turley, M.D.A. Rounsevell, O.P. Dube, J. Tarazona and A.A. Velichko, 2007. Ecosystems, their properties, goods, and services. *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., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 211-272.

Gitay, H., A. Suarez and R.T. Watson, 2002. *Climate Change and Biodiversity*. *IPCC Technical Paper*, Intergovernmental Panel on Climate Change, Geneva, 77 pp.

Hannah, L. and T.E. Lovejoy, 2003. Climate change and biodiversity: synergistic impacts. *Advances in Applied Biodiversity Science*, **4**: 1-123.

Heywood V.H. and R.T. Watson (eds), 1995. *Global Biodiversity Assessment.* UNEP, Cambridge University Press, Cambridge, UK.

Kappelle, M., M.I.M van Vuuren and P. Baas. 1999. Effects of climate change on biodiversity: a review and identification of key research issues. *Biodivers Conserv* **8:** 1383–1397.

Krebs, C., 1989. *Ecological Methodology.* Harper Collins, New York.

Lovejoy, T.E. and L. Hannah. (eds), 2005. *Climate Change and Biodiversity.*Yale University Press, New Haven, Connecticut, 418 pp.

Margalef R. 1984. The Science and Praxis of Complexity. Ecosystems: Diversität and Connectivity as measurable components of their complication. *In Aida, et al. (Ed.).* United Nations University, Tokyo, 228-244.

Meehl, G.A., T.F. Stocker, W. Collins, P. Friedlingstein, A. Gaye, J. Gregory, A. Kitoh, R. Knutti, J.Murphy,A. Noda, S. Raper, I.Watterson, A.Weaver and Z.-C. Zhao, 2007. Global climate projections. *In Climate Change 2007: The Physical Science Basis. Contribution of WorkingGroup I to the Fourth Assessment Report of the Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L.Miller, Eds. Cambridge University Press, Cambridge, UK, p. 747-846.

[MKGP] Ministry of Agriculture, Forestry and Food of the Republic of Slovenia, 2008. Prilagajanje slovenskega kmetijstva in gozdarstva na klimatske spremembe.

http://www.mkgp.gov.si/si/splosno/cns/novica/article/943/5640/?cHash=b8e71ae577

Naiman, R.J., H. Decamps and M. E. McClain, 2005. *Riparia: Ecology, Conservation and Management of Streamside Communities*. Elsevier, Amsterdam, 448 pp.

Schröter, D., W. Cramer, R. Leemans, I.C. Prentice, M. B. Araujo, N. W. Arnell, , A. Bondeau, H. Bugmann, T. R. Carter, C. A. Gracia, A. C. de laVega-Leinert, M. Erhard, F. Ewert, M. Glendining, J. I. House, S. Kankaanpaa, R. J. T. Klein, S. Lavorel, M. Lindner, M. J. Metzger, J. Meyer, T.D. Mitchell, I. Reginster, M. Rounsevell, S. Sabate, S. Sitch, B. Smith, J. Smith, P. Smith, M. T. Sykes, K. Thonicke, W. Thuiller, G. Tuck, S. Zaehle, B. Zierl., 2005. Ecosystem service supply and vulnerability to global change in Europe. *Science*, **310**: 1333- 1337.

Shannon, C.E. and W. Weaver, 1949. *The Mathematical Theory of Communication.* The University of Illinois Press, Urbana, IL.

Simpson, E.H., 1949. Measurement of Diversity. *Nature*, **163**: 688 – 688.

Thuiller,W., S. Lavorel, M.B. Araujo, M.T. Sykes and I.C. Prentice, 2005b. Climate change threats to plant diversity in Europe. *P. Natl. Acad. Sci. USA*, **102**: 8245-8250.

Urbanič G., 2005a. Hydroecoregions of Slovenia. *In Ecological status of rivers and lakes. Report 2005*, Urbanič, G., Ed. Institute for Water of the Republic of Slovenia, Ljubljana, p 6–10 (in Slovenian).

Urbanič, G., 2005b. Running Water Type Regions in Slovenia. *In Ecological status of rivers and lakes. Report 2005*, Urbanič, G., Ed. Institute for Water of the Republic of Slovenia, Ljubljana, p. 11-14. (in Slovenian).

Urbanič, G., 2006a. Distribution and structure of Trichoptera assemblages in the ecoregion "Hungarian lowland" in Slovenia. *In Proceedings 36th International Conference of IAD, Vienna, Austria, 4-8 September 2006. Austrian Committee Danube Research / IAD*, Vienna, p 285–289.

Urbanič G., 2006b. Inland-water Ecoregions and bioregions of Slovenia. *In Tipology of rivers and lakes. Report 2006,* Urbanič, G., Ed. Institute for Water of the Republic of Slovenia, Ljubljana, p 12–18 (in Slovenian).

Urbanič, G., 2007. Freshwater Ecoregions– hydroecoregions in Slovenia; Completion of Delineation. Completion of Typology. *Report 2007,* Urbanič, G., Ed. Institute for Water of the Republic of Slovenia, Ljubljana, p. 4-8.

Urbanič, G., 2008. Redelineation of European Inland water Ecoregions in Slovenia. *Review of Aquatic Biology*.

Urbanič, G., in press. Inland aquatic bioregions of Mediterranean climate region of Slovenia; biodiversity and possible climate change impacts. *Aquatic Biology*.

Urbanič, G., Tavzes, B., 2006. *Assessment of hydromorphological alteration in the inland water ecoregion Alps in Slovenia based on benthic invertebrates according to the Water Framework Directive (Directive 2000/60/ES) (In Slovenian).* – University of Ljubljana, Biotechnical Faculty, Department of Biology, 295pp.

Urbanič, G., Tavzes, B., Toman, M. J., 2005a. Benthic invertebrate sampling in wadable rivers. *In Ecological status of rivers and lakes. Report 2005*, Urbanič, G., Ed. Institute for Water of the Republic of Slovenia, Ljubljana, p. 29–37 (in Slovenian).

Urbanič, G., Tavzes, B., Ambrožič, Š., 2005b. Laboratory processing of benthic invertebrate samples and determination level. *In Ecological status of rivers and lakes. Report 2005, Institute for Water of the Republic of Slovenia*, Urbanič, G., Ed. Ljubljana, p. 43–58 (in Slovenian).

van Vliet, A., Leemans, R., 2006. Rapid species responses to changes in climate requires stringent climate protection target. In Avoiding Dangerous Climate Change, Schellnhuber, H.J., W. Cramer, N. Nakićenović, T. M. L. Wigley, G. Yohe, Eds. Cambridge University Press, Cambridge, 135-141.

* _*E-mail:* gorazd.urbanic@bf.uni-lj.si
** _*E-mail:* maja.pavlin@izvrs.si