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Master Programme on
"Environmental Management, Policy and Sustainability"
EPMS - TEMPUS

JEP_19075_2004

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5. University College Dublin, Faculty of Agri-Food and the Environment, Dept. of Environmental Resource Management

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EPMS – Short Intensive Course: NTUA-Athens (22 September – 4 October, 2008)

"Tools and Methods in Environmental Management and Planning"

Sunday 21.9			Arrival
Monday 22.9	9.00-13.00	Prof. Maria Giaoutzi	"Introduction to Environmental Planning and Management"
	13.00-14.00		Lunch Break
	14.00-16.00		"Introduction to Environmental Planning and Management"– Review / Questions
Tuesday 23.9	9.00-13.00	Dr Anastasia Stratigea	"Scenario Analysis in Planning"
	13.00-14.00		Lunch Break
	14.00-16.00		"Scenario Analysis in Planning"
Wednesday 24.9	9.00-13.00	Dr Anastasia Stratigea	"Scenario Analysis in Planning"
	13.00-14.00		Lunch Break
	14.00-16.00		"Scenario Analysis in Planning" – Review / Questions

Thursday 25.9	9.00-13.00	Prof. Maria Giaoutzi	"Evaluation in Environmental Management and Planning "
	13.00-14.00		Lunch Break
	14.00-16.00		"Evaluation in Environmental Management and Planning " – Review / Questions
Friday 26.9	9.00-13.00	Dr. Dimitris Papakonstantinou	Environmental Impact Assessment
	13.00-14.00		Lunch Break
	14.00-16.00		Environmental Impact Assessment- Review / Questions
Saturday 27.9			Proposed holiday options
Sunday 28.9			Proposed holiday options
Monday 29.9	9.00-13.00	Prof. Marinos Kavouras	"Information Systems in Environmental Management and Planning"
	13.00-14.00		Lunch Break
	14.00-16.00		"Information Systems in Environmental Management and Planning" – Review / Questions
Tuesday 30.9	9.00-13.00	Prof. Marinos Kavouras	"Information Systems in Environmental Management and Planning"
	13.00-14.00		Lunch Break
	14.00-16.00		"Information Systems in Environmental Management and Planning" – Review / Questions
Wednesday 1.10	9.00-13.00	Dr Thomas Hatzichristos	"GIS and Environmental Management"
	13.00-14.00		Lunch Break
	14.00-16.00		"GIS and Environmental Management" –

			Review / Questions
Thursday 2.10	9.00-13.00	Dr Papadopoulou Maria	"Optimization Techniques in Environmental Management"
	13.00-14.00		Lunch Break
	14.00-16.00		"Optimization Techniques in Environmental Management" – Review / Questions
Friday 3.10	9.00-13.00	Dr Stamatis Kalogirou	"Geostatistics in Environmental Management"
	13.00-14.00		Lunch Break
	14.00-16.00		"Geostatistics in Environmental Management" – Review / Questions
Saturday 4.10			Open
Sunday 5.10			Departure

CONTENT OF LECTURES

1. “Introduction to Environmental Planning”

The present module is laying the grounds for the work in the rest of the modules.

In the first part a thorough presentation of the environmental planning process will provide the frame for the presentation of tools and methods used in the context of Environmental Management and Planning.

Environmental planning is a relatively new field of study that aims to merge the practice of urban planning with the concerns of environmentalism. Essentially speaking, while urban planners have traditionally factored in economic development, transportation, sanitation, and other services into their decisions, **environmental planners** add sustainable (social, ecological & economic) outcomes as important factors in the decision-making process. What exactly constitutes the "Environment", however, is somewhat open to debate among these practitioners, as is the exact scope of the intended environmental benefits. Chief concerns among environmental planners include the encouragement of sustainable development, green building technologies, and the preservation of environmentally sensitive areas.

A rigorous environmental process has to be undertaken to examine the impacts and possible mitigation of any construction project. The environmental assessments encompass areas such as land use, socioeconomics, transportation, economic and housing characteristics, air, noise, wetlands, endangered species, flood zones, coastal zones, visual studies among others.

In the second part sustainability issues will be presented that provide support for conflict resolution and formulation of models in the study context.

Finally, the 'state of the art' will be presented, in Integrated Environmental Modeling (IEM).

Recommended Additional Reading

- Beer, R. Anne and Higgins, Catherine (1998), **Environmental Planning for Site Development**, (2nd ed.), E and ENSpon, London UK.
- Chadwick, George (1971), **A Systems View of Planning**, Pergamon, Oxford.
- Faludi, Andreas (1973), **Planning Theory**, Pergamon Press, London.
- Hall, Peter (1974), **Urban and Regional Planning**, Pelican Books, London.
- McLoughlin, J. Brian (1973), **Control and Urban Planning**, Faber, London.
- McHarg, Jan (1992), **Design by Nature**, 25th ed., John Wiley and Sons, Canada.
- O'Riordan, Timoth (1995), **Environmental Science for Environmental Management**, Longman Publishers.
- Ortolano, Leonard (1984), **Environmental Planning and Decision Making**, John Wiley and Sons, Canada.

2. "Scenario Analysis"

The increasing complexity and uncertainty involved in problems faced nowadays call for the use of new approaches and methodologies for medium to long-term strategic planning. Among these approaches, scenarios and scenario analysis gain increasing emphasis in many problems that planners deal with.

Evidently environmental problems fall within such a context. Scenario analysis can prove a valuable approach to deal with environmental policy in order to face future environmental challenges.

The present theme involves the following aspects of scenario analysis:

- ✓ Approaching the Future – The concept of scenarios
- ✓ Definition of scenarios
- ✓ Classification of scenarios
- ✓ The concept of scenario planning
- ✓ Aspects of scenario planning
- ✓ Traditional vs scenario planning approaches – Forecasting vs Backcasting
- ✓ Structuring scenarios - Scenario planning methodology
- ✓ Applications: A Methodological Framework – The LIPSOR Approach – Example

Recommended Additional Reading

- Godet, M. (2001), **Creating Futures: Scenario Planning as a Strategic Management Tool**, Economica, London, UK.
- Lindgren, M. and H. Bandhold (2003), **Scenario Planning: The Link between Future and Strategy**, Palgrave MacMillan, New York.
- Ralston, B. and I. Wilson, (2006), **The Scenario Planning Handbook: Developing strategies in uncertain times**, Thomson Learning Academic Resource, Ohio, USA.
- Ringland, G. (2006), **Scenario Planning**, John Wiley & sons, West Sussex, UK.
- Stratigea, A. and M. Giaoutzi (2007), Scenario Planning as a Tool in Foresight Exercises: A Methodological Framework, Paper presented at the COST A22 Conference "From Oracles to Dialogue: Exploring New Ways to Explore the Future", National Technical University of Athens, Athens, July 9-11.

3. “Evaluation in Environmental Management and Planning”

The evaluation of the environmental and other impacts of human actions is a focal point of much research in both the natural and social sciences. It has also been a legal requirement induced by the concern over the sustainability of our environment. When referring to this evaluation, a distinction has been introduced by both the theoretical and applied research practice between the *quantitative assessment* of impacts and the *qualitative evaluation* of assessed impacts.

While much attention has be paid to the former, it is the latter which provides the basis for an *ex ante* (a) determination of the comparative advantage of alternative plans for an action; (b) recommendation of whether an action must be approved; or (c) formulation of policies to limit the environmental degradation expected from certain actions.

In this module we accept this distinction and focus on environmental evaluation. To better highlight our approach to the subject, we find it necessary to draw the following differentiation between environmental impact assessment and evaluation.

Environmental impact assessment is facilitated by special research agendas that almost all fields of science and engineering have developed for understanding and *quantitatively* assessing old and new environmental threats, e.g., by eco-toxicology, environmental chemistry, environmental economics, environmental engineering, environmental law, environmental microbiology, environmental toxicology (health risk assessment), etc.

Environmental evaluation, on the other hand, draws from the fields of decision theory, economics, ethics, philosophy, political and social sciences to deal fundamentally with the task of determining a measure of acceptability or "value" of the impacts of an action. This value may basically be derived either by integrating the individual values of all impacted or by analyzing the negotiation and bargaining strategies that those impacted can follow to reach agreement on the acceptability of the impacts.

In either case, there are complications stemming from the fact that the impacts of any action are numerous, they are measured with a variety of scales, if they can be measured at all, they are often uncertain, they are not equitably distributed among all those impacted, they do not materialize over the same time period, and they do not invoke the same reaction of approval or disapproval by those interested in the final decision. Hence, environmental evaluation must develop appropriate methodologies to cope with these complications.

Originally, experts in traditional disciplines, dealt with the dimensions of the problem of environmental evaluation by developing methodologies according to the narrow tenet~ of their expertise. Economists, for example, were reaching beyond their responsibility of assessing the economic impacts of human activities to also attempt the assigning of a, monetary value to all impacts as a foundation of evaluation and choice. Naturally, they were not forced to exclude those impacts that could not be valued in monetary terms and actually ignore the issue of the inequitable distribution of impacts, which calls for subjective judgments of the type avoided by economic theory.

Moreover, planners were attempting to devise methods of quantitatively weighing and integrating various impacts but without assistance from their discipline in dealing with the conflicts among the value perspectives of those impacted or interested in the final decision.

Finally, other scientists were resorting to "scientific judgment" as an "objective" basis for determining the acceptability of impacts without being equipped to deal with the consequences for individual and collective decisions or of scientific conflicts and uncertainty as well as of the facts-values dichotomy.

The present module will elaborate on the above issues.

When completed, the aim is to provide the skills for:

- ✓ Explaining the role of environmental evaluations free of misconceptions about its function as a necessary input to any decision making process;

- ✓ Identifying the circumstances that call for an environmental evaluation;
- ✓ Distinguishing the issues that theoretical and methodological debates may raise regarding an environmental evaluation; and
- ✓ Explaining the considerations for a valid environmental evaluation.

Recommended Additional Reading

- Bingham, G. (1986), *Resolving Environmental Disputes: A Decade of Experience,* The Conservation Foundation, Washington, D.C.
- Chechile, R.A. (1991), Introduction to Environmental Management. In Chechile, R.A. and Carlisle, S. (Eds.) **Environmental Decision Making: A Multidisciplinary Approach,** Van Nostrand Reinhold, New York, N .Y. I.
- Davos, C.A. and Hatfield, T.H. (1987a), Hazardous Waste Facility Sitting: Large Group I Value Analysis, **The Environmental Professional 9**, 10-26.
- Davos, C.A. and Hatfield, T .H. (1987b), Hazardous Waste Facility Sitting: Large Group Attitudes towards Uncertainty, **The Environmental Professional 9**, 153-164.
- European Commission (1997), Report on the Progress of the Integrated Coastal Zone Management Demonstration Programme, COM (97) XXX.
- Greenberg, M. and Anderson, R.F. (1984), **Hazardous Waste Sites: The Credibility Gap.** Rutgers, New Brunwick, N .J.
- Lindblom, C.E. (1980), **The Policy Making Process** (2nd Edition), Prentice-Hall, Englewood Cliffs, N .J.
- Long, N.E. (1966), **Environmental Quality in a Growing Economy**, John Hopkins, Baltimore, MD.
- Portney, K.E. (1991), Public Environmental Policy Decision Making: Citizen roles. In R.A. Chechile and S. Carlisle (eds.) **Environmental Decision Making: A Multidisciplinary Perspective**, Ch. 9, pp. 195-216. Van Nostrand Reinhold, New York.

- Socolow, R.H. (1976), "Failures of Discourse." In Tribe, L.H., Schelling, *C.S.,* and I Voss, J. (Eds.), **Men Values Conflict: Essays on Environmental Analysis, I. Discourse, and Decision**. Ballinger, Cambridge, Massachusetts.
- Tribe, L.H., Schelling, *C.S.,* and Voss, J. (Eds.), 1976, **Men Values Conflict: Essays on Environmental Analysis, Discourse, and Decision**. Ballinger, Cambridge, Massachusetts.

4. Environmental Impact Assessment

EIA is applied around the world in many different ways. EIA is not always introduced as a result of a political demand from within the society, but it is imposed by supra-national legislation. For instance the Member States of the European Community are forced to implement Directive 85/337/EEC which requires EIA procedures. Some Member States stand behind the goals of this Directive and others perceive it more as a threat to their traditional ways of decision-making. Still other countries have no formal EIA system.

These very differing situations result in variable commitments of governments towards the outcome of the EIA procedure. For some it is just one more bureaucratic burden, while others spend a lot of time, money and energy to improve EIA. This situation shows the need for an evaluation of EIA.

EIA is often very complex, takes a lot of time and requires a substantial investment. This stands in contrast with the fact that it is not clear what the result of EIA is. There is, in fact, growing concern about the effectiveness and efficiency of EIAs at the technical and administrative levels and about the role of impact assessment in the broader process of planning and undertaking development.

Recommended Additional Reading

- Cook, E.A. and Van Lier, H.N. (eds.) (1994), **Landscape Planning and Ecological Networks**, Elsevier, Netherlands.
- Elabbar, M. Mohamed, (2008), The Libyan Experimental on the Environmental Impact Assessment for Desalination Plants, **Desalination** 220, pp. 24-36.
- Fabos, Julios (1979), **Planning the Total Landscape: A guide to intelligent land use**, Westview Press, Colorado, USA.
- Frenzel, Peter, Corinna Borrmann, Beate Lauenburg, Bjorn Bohling and Jan Bartholdy (2008), Environmental Impact Assessment of Sediment Dumping in the Southern Baltic Sea using Meiofaunal Indicators, **Journal of Marine Systems** (in press).
- Geneletti, Davide (2008), Impact Assessment of Proposed Ski Areas: A GIS approach integrating biological, physical, and landscape indicators, **Environmental Impact Assessment Review** 28, pp. 116-130.
- Giaoutzi, M. and P. Nijkamp, (1993), **Decision Support Models for Regional Sustainable Development**, Ashgate Publishing Limited, London.
- Harvey, D. (1973), **Explanation in Geography**, E. Arnold Ltd, London.
- Koornneef, Joris, Andres Faaij and Wim Turkenburg (2008), The Screening and Scoping of Environmental Impact Assessment and Strategic Environmental Assessment of Carbon Capture and Storage in the Netherlands, **Environmental Impact Assessment Review** 28, pp. 392-414.
- Liamsanguan, Chalita and Shabbir, H. Gheewala (2008), LCA: A Decision Support Tool for Environmental Impact Assessment of MSW Management Systems, **Journal of Environmental Management** 87, pp. 132-138.
- Lewis, H. Philip Jr (1996), **Tomorrow by Design**, John Wiley and Sons, Canada.

- Nuriye Peker Say, Muzaffer Yucel and Mehmet Yilmazer (2007), A Computer-based System for Environmental Impact Assessment (EIA) Applications to Energy Power Stations in Turkey: CEDINFO, **Energy Policy** (35), pp. 6395-6401.
- Petts, Geoffrey and Calow, Peter (1996), **River Restoration**, Blackwell Science, Oxford UK.
- Preece, R. A. (1991), **Design on the Landscape**, Belhaven Press, London UK
- Randall Thomas (1996) (ed), **Environmental Design**, E and EN Spon, London UK.
- Renou, S., J. S. Thomas, E. Aoustin and M. N. Pons (2008), Influence of Impact Assessment Methods in Wastewater Treatment LCA, **Journal of Cleaner Production** 16, p.p. 1098-1105.
- Ruddy, F. Thomas and Lorenz, M. Hilty (2008), Impact Assessment and Policy learning in the European Commission, **Environmental Impact Assessment Review** 28, pp. 90-105.
- Sanchez, E. Luis and Solange, S. Silva-Sanchez (2008), Tiering Strategic Environmental Assessment and Project Environmental Impact Assessment in Highway Planning in Sao Paulo, Brazil. **Environmental Impact Assessment Review** (in press).
- Smith, S. Daniel and Hellmud, Cawood Paul (eds) (1993), **Ecology of Greenways**, Univ. of Minnesota Press USA
- Turner, Tom (1998), **Landscape Planning and Environmental Impact Design**, UCL Press, London UK
- Zimmermann, E. (1964), **Introduction to World Resources**, Harper and Row, New York.

5. "Information Systems in Environmental Management and Planning"

The Geographic Information Systems (GIS) seminar will cover fundamental issues related to the collection, processing, analysis, interpretation,

representation, visualization, and management of geographic information. More specifically, the purpose of the seminar is to familiarize the participants with the following topics:

- ✓ Basic principles and components of GIS
- ✓ Data collection technologies
- ✓ Models and structures for the Representation of geographic information
- ✓ Design of Geographic Information Systems - spatial database design
- ✓ Processing and Analysis of Geographic Information
- ✓ Applications of Geographic Information Systems

Recommended Additional Reading

- Agouris, P. and Croitoru, A. (Eds.), (2005), **Next Generation Geospatial Information: From Digital Image Analysis to SpatioTemporal Databases**, ISPRS Book Series, Taylor & Francis, London, UK.
- Egenhofer, M. J. and Gollege, R. G. (eds.), (1998), **Spatial and Temporal Reasoning in Geographic Information Systems**, Oxford University Press, New York, USA.
- Heywood, I. Cornelius, S., and Carver, S., (2006), **An Introduction to Geographical Information Systems**, Pearson Education Limited, Edinburgh, UK.
- Kavouras, M. and Kokla, M., (2008), **Theories of Geographic Concepts: Ontological Approaches to Semantic Integration**, CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.
- Lo, C.P. and Yeung, A. K. W., (2007). **Concepts and Techniques in Geographic Information Systems**, 2nd Edition, PH Series in Geographic Information Science, Keith C. Clarke, Series Editor, Pearson Prentice Hall, New Jersey, USA.
- Worboys, M. and Duckham, M., (2004), **GIS: A Computing Perspective**, CRC Press, Boca Raton, Florida, USA.

6. "GIS and Spatial Analysis Methods in Environmental Management"

The topics to be covered in this day of the seminar are:

- ✓ GIS Vector Analytical Tools (buffer, overlay, model builder)
- ✓ GIS Raster Analytical Tools (map algebra)
- ✓ Introduction in Fuzzy Logic
- ✓ Fuzzy Systems

A case study will be used, the site selection of landfills in Cairo municipality in Egypt, in order to present the use of the above methods in Environmental Management. The construction of landfills is a no alternative option, since a landfill is always necessary independently of the specific waste management system that will be developed. The criteria that must be met to allocate a landfill are various and in many circumstances conflicting. For that reason the result is not univocal, it depends on the criteria and the methodology used together with its restrictions.

In this one day lesson several methods will be utilized for the site selection of landfills, as mentioned. More specifically GIS technology will be used for the input, the management and the visualization of the geographic data. The basic analytical tools of GIS for raster and vector data will be used. The modeling tools of GIS will also be covered. The basic elements of the fuzzy logic methodology as well as its potential in the specific problem will be presented. Finally, the results drawn up by fuzzy logic will be compared with that of the classical Boolean approach of data analysis.

Recommended Additional Reading

- Goodchild, F. Michael, Bradley O. Parks, and Louis T. Steyaert, eds, (1993), **Environmental Modeling with GIS,** Oxford University Press.

- Goodchild, F. Michael, Louis T. Steyaert, Bradley O. Parks, Michael P. Crane, Carol A. Johnston, David R. Maidment, and Longley Paul, Michael F. Goodchild, David J. Maguire, David W. Rhind, and Michael Goodchild, (eds) (2005), **Geographical Information Systems and Science**, John Wiley & Sons Inc.
- Hatzichristos, Thomas and Maria Giaoutzi, (2004), Landfill Siting Using Fuzzy Logic and the Delphi Method, **International Journal of Environmental Technology and Management**, Vol. 6, Nos ½, pp. 218-231.
- Karkazi, A., Hatzichristos, T, Emmanouilidi, B., Mavropoulos, A., (2001), Landfills Siting Using GIS and Fuzzy Logic, 8th International Waste Management & Landfill Symposium, Sardinia, Italy.
- Klir, G.,and B. Yuan, (1995), **Fuzzy Sets and Fuzzy Logic: Theory and Applications**, Prentice Hall.
- Sandi, Glendinning, (1995), **GIS and Environmental Modeling: Progress and Research Issues,** Ft. Collins, Co: GIS World, Inc.

7. "Optimization Techniques in Environmental Management"

Classical optimization methodologies based on mathematical theories have been developed for the solution of various constrained environmental management design problems such as:

- ✓ the optimal water resources management in coastal regions due to the increscent demand and water quality deterioration,
- ✓ the decontamination of a physical system (i.e. aquifer, river, lake) by maximizing the contaminant mass removal

Numerical models have been widely used for more than three decades to accurately represent the behavior of an environmental system. However, these models introduce a high computational cost if they have to be successively

applied for the evaluation of various candidate solutions during an optimization procedure. The last few years derivative-free optimization techniques, (for example Genetic Algorithms, Artificial Neural Networks or other stochastic optimization methodologies) were put on the table among the researchers due to their versatility, ease of implementation, robustness, fully automated implementation and ease of parallel implementation. However, these methodologies, despite of their advantages, usually require excessive CPU time, due to the large number of candidate solutions/scenarios that need to be evaluated.

In this course, an introduction of the main classical optimization methodologies and derivative-free optimization techniques applied to constrained environmental management problems will be presented.

Recommended Additional Reading

- Baran, Benjamın, Christian von Lucken and Aldo Sotelo, (2005), Multi-objective Pump Scheduling Optimisation Using Evolutionary Strategies, **Advances in Engineering Software** *36,* pp. 39–47.
- Borchers, Brian and John E. Mitchell (1997), A Computational Comparison of Branch and Bound and Outer Approximation Algorithms for 0-1 Mixed Integer Nonlinear Programs, **Computers Ops Res.** Vol. 24, No. 8, pp. 699-701.
- Douglas, A. Haith (1982), **Environmental Systems Analysis**, John Willy & Sons.
- Hillier, S. Frederick and Gerald J. Lieberman (1995), **Introduction to Operations Research**, McGraw-Hill, 6th Edition.
- Liang-Cheng Chang, Hone-Jay Chu, Chin-Tsai Hsiao (2007), Optimal Planning of a Dynamic Pump-treat-inject Groundwater Remediation System, **Journal of Hydrology** *(2007) 342,* pp. 295– 304.

- Jiabao, Guan and Mustafa M. Aral (2004), Optimal Design of Groundwater Remediation Systems Using Fuzzy Set Theory, **Water Resources Research**, Vol. 40, W01518, doi: 10.1029/2003WR002121.
- Gupta, I., A. Gupta and P. Khanna, (1999), Genetic Algorithm for Optimization of Water Distribution Systems, **Environmental Modelling & Software** *14*. pp. 437–446.
- Karterakis, M. Stefanos, George P. Karatzas, Ioannis K. Nikolos and Maria P. Papadopoulou, (2007), Application of Linear Programming and Differential Evolutionary Optimization Methodologies for the Solution of Coastal Subsurface Water Management Problems Subject to Environmental Criteria, **Journal of Hydrology** 342, pp. 270– 282.
- Kosmidis, D. Vassileios, John D. Perkins and Efstratios N. Pistikopoulos (2005), A Mixed Integer Optimization Formulation for the Well Scheduling Problem on Petroleum Fields, **Computers and Chemical Engineering** 29, pp. 1523–1541.
- Krishna, B., Y. R. Satyaji Rao and T. Vijaya (2008), Modelling Groundwater Levels in an Urban Coastal Aquifer Using Artificial Neural Networks, **Hydrological Processes**, doi: 10.1002/hyp.6686 (In press).
- MarkErick son A., Alex Mayer A. and Jeffrey Horn (2002), Multi-objective Optimal Design of Groundwater Remediation Systems: Application of the niched Pareto genetic algorithm (NPGA), **Advances in Water Resources** 25, pp. 51–65.
- Ravelle, S. Charles, E. Earl Whitlatch and Jeff R. Wright (1997), **Civil and Environmental Systems Engineering**, Prentice Hall.
- Srdjevic, B., Y. D. P. Medeiros and A. S. Faria (2004), An Objective Multi-Criteria Evaluation of Water Management Scenarios, **Water Resources Management** 18: 35–54.
- Summanwar, V.S., V.K. Jayaraman, B.D. Kulkarni, H.S. Kusumakar, K. Gupta and J. Rajesh, (2002), Solution of Constrained Optimization Problems by Multi-objective Genetic Algorithm, **Computers and Chemical Engineering** 26, pp. 1481–1492.

- Andrew J. Higginsa, Stefan Hajkowicza, Elisabeth Bui (2008), A Multi-objective Model for Environmental Investment Decision Making, **Computers & Operations Research** (in press).
- Nguyen, V. Thoai (2000), A Class of Optimization Problems over the Efficient Set of a Multiple Criteria Nonlinear Programming Problem, **European Journal of Operational Research** 12 , pp. 58-68.
- Nikolos, K. Ioannis, Maria Stergiadi, Maria P. Papadopoulou and George P. Karatzas, (2008), Artificial Neural Networks as an Alternative Approach to Groundwater Numerical Modelling and Environmental Design, **Hydrological Processes,** DOI: 10.1002/hyp.6916.
- Theodossiou, P. Nicolaos (2004), Application of Non-Linear Simulation and Optimisation Models in Groundwater Aquifer Management, **Water Resources Management** 18: 125–141.
- Papadopoulou, P. Maria, George F. Pinder AND George P. Karatzas (2007), Flexible Time-varying Optimization Methodology for the Solution of Groundwater Management Problems, **European Journal of Operational Research**, Vol. 180, No. 2, pp. 770-785, doi: 10.1016/j.ejor.2006.02.041.
- Papadopoulou, P.M., G.F. Pinder and G.P. Karatzas (2003), Enhancement of the Outer Approximation Method for the Solution of Concentration-Constrained Groundwater-Remediation Optimal-Design Problems, **Water Resources Research**, Vol. 39, No. 7, 1185, doi: 10.1029/2002 WR001541.
- Psilovikos, Aris and Christos Tzimopoulos, (2004), Comparison of Quadratic and Non-linear Programming (QP and NLP) Optimization Models in Groundwater Management, **Journal of Hydroinformatics**.
- ReVelle, Charles (2000), Research Challenges in Environmental Management, **European Journal of Operational Research** 121, pp. 218-231.

8. "Geostatistics in Environmental Management"

The topics that will be covered in this module of the seminar are:

- ✓ Exploratory Spatial Data Analysis
    - Geostatistics in General
    - Spatial autocorrelation
- ✓ Explanatory Spatial Data Analysis
    - Understanding spatial processes using spatial modeling
    - Introduction to the Geographically Weighted Regression (GWR)
    - GWR: theory and applications

The methods of Exploratory Spatial Data Analysis (e.g. spatial autocorrelation) together with the methods of Explanatory Spatial Data Analysis (e.g. local regression) are cutting edge scientific methods in geography and geosciences. The former methods are trying to identify hotspots and define areas of specific interest whereas the latter are trying to answer questions referring to spatial variations of the relationships between a phenomenon and its explanatory factors. The application of these methods allow for the better understanding of spatial processes. The results of such applications may assist policy makers to make informed decisions.

In this one day seminar the trainees will be introduced to the theory and applications of the above methodologies and familiarized with the corresponding software (GeoDa, GWR 3.0). Examples that will be presented are in the areas of natural resources management, hazard management and environmental issues (e.g. pollution). Some examples will cover the impact of the environment on human activity and decision making. For instant, the effect of climatic factors to internal human migration will be discussed.

Finally, an extended list of literature references as well as a modern agenda for research using these methodologies will be provided.

Recommended Additional Reading

- Anselin, L. (1988), **Spatial Econometrics: Methods and Models**, Dorddrecht: Kluwer Academic Publishers.
- Brunsdon, C., McClatchey, J., and Unwin, D.J. (2001) Spatial Variations in the Average Rainfall-Altitude relationship in Great Britain: An Approach Using Geographically Weighted Regression, **International Journal of Climatology**: A Journal of the Royal Meteorological Society, **21** (4), pp. 455 – 466.
- Cliff, A.D. and J.K. Ord (1981), **Spatial Processes: Models and applications**, London: Pion.
- Fotheringham, A.S., Brunsdon, C., and Charlton, M.E (2000), **Quantitative Geography**, London: Sage Publications.
- Fotheringham, A.S., Brunsdon, C., and Charlton, M. (2002), **Geographically Weighted Regression: The analysis of spatially varying relationships**, Chichester: John Wiley and Sons.

ΥΠΕΥΘΥΝΗ ΠΡΟΓΡΑΜΜΑΤΟΣ:
ΜΑΡΙΑ ΓΙΑΟΥΤΖΗ, ΚΑΘΗΓΗΤΡΙΑ Ε.Μ.Π.

ΤΟΠΟΣ ΔΙΕΞΑΓΩΓΗΣ:
ΣΧΟΛΗ ΑΓΡΟΝΟΜΩΝ ΤΟΠΟΓΡΑΦΩΝ ΜΗΧΑΝΙΚΩΝ
ΤΟΜΕΑΣ ΓΕΩΓΡΑΦΙΑΣ ΚΑΙ ΠΕΡΙΦΕΡΕΙΑΚΟΥ ΣΧΕΔΙΑΣΜΟΥ
ΜΟΝΑΔΑ ΧΩΡΙΚΟΥ ΣΧΕΔΙΑΣΜΟΥ ΚΑΙ ΑΝΑΠΤΥΞΗΣ
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