IAIA07 Training course 11

Multi-criteria decision analysis tools for managing complex environmental challenges

Section 1

Title: Multi-Criteria Decision Analysis Tools for Managing Complex Environmental Challenges

Level: Intermediate.

Prerequisites for participants: N/A

Language of delivery: English

Duration: 1 day

Minimum and maximum number of participants: 15 (Minimum) – 50 (Maximum)

Name and contact details of each trainer

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Section 2 – Course description

(a) Summary of the purpose

This one-day training course will explore decision analysis as an advanced approach to formulating and implementing effective environmental and ecosystem management. Decision-making in environmental projects is typically a complex and confusing exercise because people (1) have different objectives with different priorities and (2) expect different outcomes from management decisions. Furthermore, the system in which decision makers operate is subject to inherent uncertainty associated with management actions. Three important questions in decision

making are (1) how do we balance the *many objectives* described in monetary and non-monetary units and evaluate their trade-offs?; (2) how do we include the *risk and uncertainties* relevant to environmental management that are important to decision makers and stakeholders?; and (3) could explicit consideration of possible adaptation actions such as monitoring alter choices being made by managers and what is the value of better information from those adaptive actions? Cost-benefit analyses (CBA) are often used, occasionally in concert with comparative risk assessment, to choose between competing alternatives. However, management objectives involve multiple criteria such as cost, benefit, environmental impact, safety, and risk that may not be easily condensed into a single monetary value. Consequently, alternatives or trade-offs may be incomparable on a CBA basis. Even in cases where it is possible to convert multiple criteria into a common single unit, this approach would not always be desirable because competing or mutually exclusive stakeholder group preferences may be lost in the decision process. As an alternative to CBA, multi criteria decision analysis (MCDA) and Comparative Risk Assessment (CRA) offer scientific and theoretically sound analytical decision methods. Recent workshops of federal stakeholders (US Army Corps of Engineers, EPA, NOAA) have constructed basic frameworks that are applicable to environmental projects in which decision makers and stakeholder participation are of crucial concern. Participants learn a basic overview of CRA and MCDA techniques and tools with some time allowed for work/consultation on specific issues of concern to participants.

(b) Detailed description of the course structure and content (2 pages minimum), including an outline of participatory and/or case-study based exercises.

The management of environmental risk and uncertainty issues is one of the most controversial and expensive tasks. Because of the multiple uses of sites, as well as the involvement of different stakeholders, competing interests are often brought to bear on any decision. Increasingly, no single best alternative is likely to emerge from complex problems; rather, different alternatives are likely to be preferred by different stakeholder groups.

Failures to understand the consequences of management actions and the lack of tested techniques for integrating the multiple management objectives and risks inherent in decision making hamper efforts to deal with land use and watershed management at military sites. There is a need for effective tools based on sound science that allow decision makers to evaluate the likely success of each alternative and compare them with potential alternatives. This effort aims to develop the use

of decision support and analysis tools that will integrate existing information to enable managers and stakeholders to better understand the probable consequences of various considered alternatives.

Decision analysis offer scientific and theoretically sound analytical decision methods for environmental management, but they have not been formalized in a framework readily applicable to environmental projects where risk assessment and stakeholder participation are of crucial concern. It is desirable to develop decision-making tools for use by government agencies and private firms that may otherwise be hesitant to adopt or test new environmental technologies, such as beneficial reuse, sediments or in-situ treatments of contaminated sediments, or prioritization of ecosystem restoration projects.

The conceptual foundations of risk and uncertainty are based in the fields of engineering (e.g., structural and nuclear engineering) and the environmental sciences related to chemical pollution (e.g., environmental toxicology). The application of risk and uncertainty principles to address environmental problems is focused in approaches and methods for conducting risk assessments. More recently, interest has been building to apply these same principles and approaches to a broader collection of environmental problems (e.g., habitat loss, modification and restoration, natural resource management, threatened and endangered species management).

Along with increased interest for a broader application of structured, systematic and quantitative risk assessment, emphasis is also being given to performing such evaluations within a comparative framework to provide a more comprehensive analysis of management alternatives being considered by decision makers. Within this larger context, systematic strategies for investigating and addressing uncertainty and its effect on modeling results and decision-making are given particular priority.

To facilitate the transfer and use of quantitative information from risk and uncertainty analyses within decision making processes, linkages should be established with multi-criteria, decision analysis. Such linkages will serve as a basis for developing a versatile framework for combining risk assessments and stakeholder valuation of management alternatives. This framework will provide for integrating information about risk, uncertainty, ecological processes and endpoints, socioeconomic factors and stakeholder values to organize and structure decision processes about risk management.

This course covers principles of decision making when there are conflicting objectives and uncertainties. Methods reviewed include multiattribute value theory, pairwise comparison methods, and the analytic hierarchy process. The emphasis is on case study. Applications to environmental and ecosystem problems and public participation processes are reviewed. The course structure as follows:

8am:	Introduction
8:30am:	Decision Analysis: Regulatory Challenges and Needs
9am:	Introduction to Multi-Criteria Decision Analysis
10am:	Coffee Break
10:30am:	Decision Analysis and Risk Analysis
11:30am:	Discussion
Noon	Lunch
1:30pm:	MCDA Applications and case studies Different decisions …different software … different approaches Weight of Evidence Evaluation in Ecological Risk Assessment --Expert Choice Integrating several information sources and uncertainty – CriteriumDecisionPlus Integrating disparate decision factors and conflicting groups – DecisionLab
3pm	Coffee Break
3:30pm	Discussion
5pm:	Conclusion

(c) Description of the materials participants will receive during the course.

Participants will receive a notebook with printed lecture notes and note spaces. In addition, several reprints of MCDA review papers will be placed in a technical appendix.

(d) Provisions for post-conference follow-up with participants.

The lecturers have encouraged post-workshop questions and follow-up questions. In some cases, we have discussed specific decision analysis challenges of interest to participants.

Section 3 – Trainers

Jongbum Kim

Dr. Kim, an environmental decision analyst, is working for the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi in conjunction with University of Florida. He obtained his bachelor's degree in environmental science from Yonsei University, S. Korea, master's degree in environmental management from Carnegie Mellon University, PA, and Ph.D. in systems analysis and economics for public decision making from the Johns Hopkins University. Dr. Kim joined the ERDC in 2005 after he worked at the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, in Santa Cruz, CA. for 2 years. His research interests and experiences include a multi criteria decision analysis, operational research, and Bayesian decision analysis, applied to water resource management, ecosystem management, and dredging operations.

Greg Kiker (gkiker@ufl.edu)

Dr. Greg Kiker is an assistant professor in the Agricultural and Biological Engineering Department at the University of Florida (UF) specializing in ecological and hydrological modeling. From 2002 through 2005, Dr Kiker conducted environmental risk research at the Engineer Research and Development Center (ERDC), US Army Corps of Engineers. While at ERDC, he was Team Leader of the Environmental Risk and Decision Analysis Team exploring multi-criteria decision analysis methods and ecological modeling for both civil and military applications. At UF, his current research projects include ecosystem and invasive species modeling, decision support systems and practical linkages of risk analysis, adaptive management and multi-criteria decision analysis. Dr Kiker was a Fulbright Scholar and received his PhD from Cornell University in Agricultural and Biological Engineering in 1998. From 1998 to 2002, Dr Kiker was a Senior Lecturer at the University of KwaZulu-Natal, South Africa where he conducted ecological/hydrological modeling and climate change research. He has consulted internationally in the use of ecological and environmental models for ecosystem management, crop yield prediction, nutrient-transport, and climate change.

Burton Suedel (Burton.Suedel@erdc.usace.army.mil)

Dr. Suedel is a research biologist at the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC), Environmental Laboratory in Vicksburg, Mississippi. He obtained his bachelor's degree in biology and master's degree in biology from the University of North Texas, and his Ph.D. in biological sciences from the University of Mississippi. Dr. Suedel joined the Corps of Engineers in 2005 as the Team Leader of the Risk Integration Team studying multi-criteria decision analysis methods. From 1993 to 2005, Dr. Suedel worked as a consultant in the ecological risk assessment, environmental toxicology and sediment hazard assessment fields. Dr. Suedel has considerable experience in aquatic and sediment toxicology and preparing ecological risk assessments at various CERCLA and RCRA sites. He has published over 20 peer-reviewed manuscripts on freshwater aquatic and sediment toxicology (i.e., PAHs, inorganics, PCBs); determining the fate and effects of contaminants in sediments; sediment characterization; and risk characterization of sediments. He has compiled an extensive toxicological database for terrestrial receptors that has been used in numerous investigations. Dr. Suedel was also involved in the development of the ASTM standard guide for Risk Based Corrective Action (RBCA) for chemical releases, and was chairman of the ASTM task group that developed the RBCA standard guide for the protection of ecological resources (ASTM designation E2205-02). At ERDC, his research has focused on a large scale risk assessment of dredged material, risk assessment of invasive species, multi-criteria decision analysis and beneficial uses of dredged material.

Igor Linkov (Linkov@cambridgeenvironmental.com)

Dr. Igor Linkov, a Senior Risk Assessor with Cambridge Environmental Inc. and Adjunct Professor in the Department of Engineering and Public Policy at Carnegie Mellon University. He received his PhD in environmental and occupational health from University of Pittsburgh. His educational experience also includes Post-Doctoral Fellowship at Harvard University. Dr. Linkov has managed ecological risk assessments and contributed to human health risk assessment at several Superfund sites. He has developed models and software to support ecological risk assessment and population modeling for contaminated sites. Dr. Linkov currently supports development of the Army Risk Assessment Modeling System (ARAMS). One of the focuses of his current research is integrating risk assessment and multi-criteria decision analysis tools in managing contaminated sites. He is currently developing the Questions and Decision (QnD) model for environmental management at contaminated and disturbed sites for the US Army Corps

of Engineers. He has published widely on environmental policy, environmental modeling, and risk analysis, including six books and over 70 peer-reviewed papers and book chapters. Dr. Linkov has directed and chaired seven international conferences on risk assessment and modeling and participated in organizing many others. Dr. Linkov serves as a Scientific Advisor to the Toxic Use Reduction Institute, a position which requires nomination by the Governor of Massachusetts. Dr. Linkov is President for the Society for Risk Analysis-New England. He is Founding Chair of the SRA Decision Analysis and Risk Specialty Group. He also is the Past Chair of the SRA Ecological Risk Assessment Specialty Group and participates in several SRA and SETAC Committees. Dr. Linkov has served on many review and advisory panels for US and international agencies.