Policy Research Initiative | Projet de recherche sur les politiques

SUSTAINABLE DEVELOPMENT
BRIEFING NOTE

Integrated Landscape Management Models for Sustainable Development Policy Making

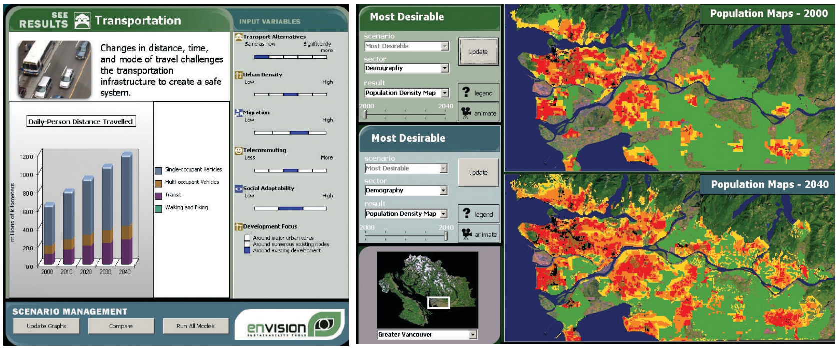
Highlights

- Integrated landscape management models (ILMMs) are approaching a stage of maturity where they could be required for environmental impact assessments of large projects.
- ILMMs combine social, economic, and biophysical sub-models to produce comprehensive scenarios for decision makers.
- ILMMs allow different management scenarios to be evaluated over different spatial and temporal scales.
- Most ILMMs are developed for a specific area and focus on a theme.

Background

Integrated water resource management and other landscape-based approaches to land-use planning require highly integrative evaluations of the often complex effects of various management options. Technological advances have allowed for the development of complex analytical systems to support decision making, performance evaluation, and strategic planning. These computer-modelling systems have a wide range of applications, are quantitative, and are designed to incorporate science and risk analysis into policy decision making. As such, they represent a way of evaluating alternative policy choices, testing various outcomes, assessing impacts, and projecting future outcomes.

Figure 1: Scenario results for the Georgia Basin from the Quest model.



A: Possible future transportation scenario. The right hand window shows which input choices influenced the results.
B: Population scenario showing changing population density in the lower mainland, surrounding Vancouver.

New analytical methods and technology, notably the growth in the use of geographic information systems, have contributed significantly to the evolution of increasingly integrative, complex models, many of which are spatially explicit. In fact, during the past few years, ILMMs have evolved from single issue models, focusing on individual industrial plants, reservoirs, etc., to more integrative forms aimed at identifying potential conflicts and cumulative effects of broad-scale land uses that

Canada

might be overlooked on an issue-by-issue analysis. Such models have been developed to identify:

- the economic drivers affecting land-use decisions;
- the opportunity/risk of various policies over short and long time frames; and
- the best management approaches for sustainable development goals.

Among the models in use in Canada, the two largest – QUEST and ALCES –have been developed through joint ventures between private agencies, government, and academic institutions. These models use quantitative data; however, QUEST is based on a backcasting approach that identifies a desirable future and examines trade-offs necessary to achieve it, while ALCES is a forecasting model designed to provide information on the relative outcomes of various policy scenarios. Both approaches are being used to inform policy and engage community members in the decision-making process.

ILMMs as Policy Tools

Integrated landscape management models are already in use in areas with high potential for conflicting land use and management objectives, where they are being developed to identify strategies to meet standards, reduce conflict, and predict and mitigate cumulative effects.

A principle use of ILMMs is to involve stakeholder groups in the development and evaluation of strategies for integrating socio-economic objectives and environmental protection. The objective is to co-ordinate goals among stakeholders and identify the potential for conflict and cumulative effects. This approach has been applied broadly, in areas such as population growth planning, economic development, agricultural development, conservation initiatives, and watershed management.

Existing models fall into four broad categories, corresponding with the interests of decision makers.

- Integrative models incorporate specific data and sub-models on all indicators deemed to be important, ranging from economic indicators (e.g., natural gas production), to environmental data (e.g., species diversity).
- Planning models focus on planning or co-ordinating how different models may be integrated into a single system.
- Objective-specific models may consider multiple parameters, but only within the focus of a specific objective; various economic and environmental inputs and outputs may exist, but these are targeted to a specific context of interest, such as water management, forestry, agriculture, or climate change.
- Alternative futures models focus on predicting the outcomes of different policy strategies, thereby developing a suite of scenarios or "futures." The outcomes of the alternative scenarios are used to facilitate discussion among stakeholders, notably for identifying acceptable and unacceptable futures, relative impacts, and emerging issues under widely different scenarios.

Developing and Using an ILMM

The greatest challenge in developing an ILMM is a lack of information on the interactions between various factors. As such, many ILMMs are customized on a site-by-site or project-by-project basis using available information. The development and use of an ILMM is very iterative, and involves a high degree of user, developer, and stakeholder interaction.

While a model may be very site or project specific, particularly if it makes use of spatially explicit data, ILMMs are functional tools for simulating general patterns of behaviour, rather than tools for making specific predictions. In fact, a number of highly integrative models have been designed in a way that allows them to be adapted to different systems.

Since the environmental impacts of a given development will usually be restricted within a watershed, with the exception of such things as migratory species and air pollution, most ILMMs start with a hydrographic and topographic data set to which socio-economic and other natural environmental variables are then linked in a geographic information system. The analysis is usually restricted to the watershed(s) of interest with outside influences and impacts not made spatially explicit.

Major outputs such as land use, water pollution, or habitat alteration are often mapped, allowing a rapid assessment of the geographic distribution of the impacts, costs, and benefits of a given scenario. Since mapped results are often intelligible to interested members of a community rather than only to specialists, this allows various stakeholder groups to make use of this information in evaluating options and formulating their input. This, in turn, leads to a more informed debate on land use options, and makes ILMMs a potentially powerful tool for any participatory planning process, such as integrated water resource management.[1]

Application of ILMMs

Integrated landscape management models are used in large-scale development projects internationally. The US Army Corp of Engineers routinely applies and designs landscape modelling approaches to assess and ensure that corporations meet legal requirements with regard to human health and welfare, ecological integrity, and cumulative environmental effects. In addition to projects focusing on terrestrial issues and climate change, models are also being applied to water resource development, ecosystem restoration and wetland management projects.

Similar approaches are evolving in the United Kingdom, with the government recommending the use of scenario modelling and Monte Carlo-based sensitivity analysis for all new government policies, programs, and projects. Modelling approaches are also being applied in other regions of the world, with the United Nations Development Programme playing an integral role in the use of the Threshold 21 model, which has been used successfully to plan strategies for meeting objectives set during the 2002 United Nations World Summit for Sustainable Development in Johannesburg.

Although ILMMs are being used more and more in Canada, they are not required in an environmental impact assessment process. However, the value of ILMMs is increasingly recognized. For example, partnering among community, private, and government agencies has resulted in two large-scale projects: the Mackenzie River Basin Impact Study and the Georgia Basin Futures Study. The Georgia Basin QUEST model, the longest running of the two, was initiated five years ago to identify mutually beneficial sustainable development targets within the basin, and has supported policy decisions on several scales, including coastal fishery and resource management, biodiversity conservation planning, wetland conservation, and local stormwater run-off planning.

1 A Briefing Note on IWRM can be found at <http://policyresearch.gc.ca/doclib/SD_WaterManagement_E.pdf>.

In the Mackenzie River basin in northern Canada, an ALCES-based model is being developed to identify the potential effects of a proposed natural gas pipeline (the Northern Ecosystem Initiative or NEI), explore possible scenarios for mitigating such effects, and minimize the potential for conflict. Of particular concern are the societal impacts on the Deh Cho First Nation communities and the ecological impacts on the regional watershed that would occur in association with the construction and maintenance of the proposed pipeline.

The Future for ILMMs in Canada

The cost of developing and using an ILMM may be prohibitive for impact assessments for very small projects with a limited time frame or scope. However, for large or longer-term projects, including a series of small, evolving projects in a given watershed, ILMMs can be a useful and cost-effective approach for developing and presenting scenarios to stakeholders and evaluators who might have difficulty assessing the pros and cons of complex undertakings in sensitive environments.

In 2003, the Alberta Chamber of Commerce invested $4.5 million in the ALCES ILMMs with a target of reducing future industrial impacts. However, such future scenario modelling is also being used to evaluate various land use options and trade-offs between competing land uses, including watershed management, well sites, coal mines, seismic lines, agriculture, urban and rural uses, natural processes, insect outbreaks, land cover, and sector-specific development projections (see Appendix 2).

Given that the European Union recently legislated a requirement for its member states to conduct strategic environmental assessments on certain plans and programs (such as water, waste, and land-use planning), a role of ILMMs in strategic environmental assessments, particularly for supporting sustainable development decision making, should be considered in Canada.

Should the use of ILMMs become standard or even mandatory for large projects in Canada, as it appears set to do elsewhere, this would have several effects.

- Integrated landscape management model development would accelerate, and they would rapidly become more useful, available, and affordable.
- Large projects would be more readily subjected to scrutiny of the impact of minor variations in plans, allowing better fine-tuning of developments.
- The Canadian ILMM industry, already among the world leaders, would be positioned to dominate the rapidly expanding world market for ILMMs as other countries increasingly turn to ILMMs for decision making.

Further Reading

The on-line Appendix 1 to this Briefing Note (<www.policyresearch.gc.ca>) includes links to information on the models discussed here and several others.

On-line Appendix 2 lists the principle variables used in the ALCES mode.