Abstract

Forests are expected to provide multiple products and services for current and future generations. National Forest Monitoring and Assessment (NFMA) produces information on current forest resources and their changes. Future forest resources and their potential use are more difficult to estimate because they depend both on current forest resources and their management. Correspondingly, decisions concerning forest management strategies affect future forest resources, products and services.

Scenarios are useful tools for making strategy options and their consequences more transparent for participatory and collaborative decision and policy-making processes, such as national forest programmes (NFPs). Several different approaches and tools exist for scenario modelling at national, sub-national and local levels, including trend extrapolation, matrix models, and stand-level or regional-level forest dynamics models, which are often used together with forest sector models. In the future, the compatibility of NFPs and their reference scenarios with sustainable development, international agreements and global markets will become increasingly important. FAO therefore supports harmonization through, for example, Global Forest Resource Assessment, national forest monitoring and assessment projects, the National Forest Programme Facility and the UN-REDD programme.

1. Introduction

Both developed and developing countries have encountered challenges with regard to sustainable forest management (SFM).

SFM covers a wide variety of economic, ecological, social and cultural factors. In addition to industrial round-wood and fuel-wood, non-timber forest products and the role of forests in protecting biodiversity and water resources or providing facilities for recreation and carbon dioxide storage, should also be taken into account. To compensate, protective measure payments for ecosystem services (PES) have been introduced.
Consequently, there may exist several alternative combinations of forest products and services and corresponding management strategies for a given country. Large-scale industrial plantations, small-scale community forest plantations, agroforestry, strict forest protection, forest rehabilitation and ecosystem approaches for multiple-use forest management, or any combination of these, may be optional management strategies for many developing countries. At the same time, developed countries may consider different national strategies to utilize the potential of forests in climate change mitigation, such as the amount of carbon that should be stored in harvested wood products and growing stock.

The SFM objectives, including different forest products and services together with the corresponding forest management strategies and policy measures, should be defined collaboratively with the stakeholders and decision-makers who will be involved afterwards in implementation. This kind of participatory process, which aims to promote sustainable and multipurpose forest management through collaboration, is referred to as a national forest programme (NFP).

The role of an NFP in a given country is to formulate activities and policy programmes towards the desired future in terms of sustainable use, conservation and development of forests. Because future forest resources and their potential use depends on adopted forest management strategies, the evaluation of alternative strategies and their consequences in terms of future forest products and services is an important part of participatory and collaborative decision and policy-making processes. Scenarios are useful tools to make strategy options and their consequences more transparent. They can be used, for example, to determine the impacts of different management strategies, such as shifts in land-use, establishment of plantations and investments in fertilization programmes, or to analyse the impacts of different utilization rates on future wood resources.

Intergovernmental dialogue has recognized the essential role of NFPs in addressing forest sector issues. To this end, FAO established in 2002 an NFP facility to assist countries in developing and implementing NFPs that effectively address local needs and national priorities, and reflect internationally agreed principles (e.g. country leadership, participation and integration of cross-sectoral issues). An ideal NFP is a cyclical process split into four phases: analysis, policy formulation and strategic planning, implementation, and monitoring and evaluation. National Forest Monitoring and Assessment (NFMA), also supported by FAO, plays an important role in the analysis and monitoring stages. In the policy formulation and strategic planning stage, additional future-oriented tools such as scenarios are needed.

The objective of this chapter is to introduce different scenario modelling approaches, outline a typical scenario modelling process with linkages to NFMA and NFP and, finally, discuss some future challenges of scenario modelling. The chapter focuses on the potential of scenarios for the design of national forest strategies and policies.1

2. Scenario modelling approaches

A number of different approaches and tools are used in scenario modelling. Based on the driving force of the model, scenarios can be categorized as either supply-driven or demand-driven. In supply-driven scenarios, the target of modelling is to analyse the impact of change factors on supply of forest resources. Supply change factors may include afforestation, strict forest protection or rehabilitation programmes. In demand-driven scenarios, the modelling aims to analyse the impacts of use of resources on future forest conditions. Demand change factors may

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1 For more information on spatially explicit landscape modelling or growth and yield modelling, see www.cifor.org/online-library/research-tools/flores.html and Weiskittel et al. (2011)
Supply-driven scenario modelling covers:

- Statistical trend extrapolation of forest resources
- Predictive models that forecast transition of a forest class into another class among a matrix of classes (e.g. EFISCEN)\(^2\)
- Forest dynamic simulation models applied to inventory units (stands, trees) or their aggregates (e.g. OSKAR).\(^3\)

Some models can be used for both supply-driven and demand-driven analysis, such as MELA in Finland\(^4\) and Heureka in Sweden.\(^5\) MELA and Heureka have two main components: a stand-level simulator and a region-level optimizer. The simulator generates multiple development paths for stands. The optimizer can be used to search for combinations of paths that fulfill the demand in terms of future forest resources, products and services. The approach and tools have been designed for boreal conditions where forests are managed as stands. In temperate forests with uneven aged and multiple species stands, stand simulators or diameter-volume state transition models are required for the simulation of dynamics and selective cutting (Macpherson \textit{et al.}, 2010). It is also possible to integrate supply-driven forest resource scenario models with demand-driven forest sector models. Examples include the integration of:

- EFISCEN and EFI-GTM, used for the European Forest Sector Outlook Study (EFSOS)\(^6\)
- OSKAR and FASOM, used by IIASA\(^7\)
- Atlas and Tamm, used by USDA Forest Service for RPA until 2000\(^8\)
- MELA and SF-GTM, used by Metla to support the National Forest Programme.\(^9\)

Scenario modelling can be \textit{research-initiated} or \textit{policy-targeted}. Research-initiated scenario modelling can be divided further into ad hoc analysis addressing specific questions (e.g. Alig \textit{et al.}, 2001; Eid, Hoen and Økseter, 2002; Eriksson, Salnass and Stahl, 2007) or systematic work carried out at regular intervals (e.g. Adams and Haynes, 2007).

The most common model to capture trends at regular intervals is wood resource balance (WRB) comparing felling (removal or drain) against increment of growing stock. The utilization of wood resources has been considered sustainable as long as felling remains smaller than increment (see e.g. Forest Europe, 2007, Indicator 3.1). A static measure such as WRB works best for so-called normal forests, where a forest is composed of even-aged fully stocked stands representing a balance of age classes.

In conditions where age-class distribution is skewed, other measures are recommended. For example in Finland, three different measures are calculated regularly\(^10\) for the 10-year period, starting from the most recent national forest inventory year and comparing with the recorded removals of the preceding 10-year period: (i) potential cut, (ii) removals maximizing net present value and (iii) maximum sustainable yield. Potential cut defines the maximum removals from the forest and scrubland when forestry guidelines are followed and all restrictions for forest management due to protection and multiple use of forests are taken into account. Removals maximizing net present value also take into consideration the profitability of felling. Some forests are set-aside as non-profitable and

\(^2\) See www.efi.int/portal/virtual_library/databases/efiscen/
\(^3\) See www.iiasa.ac.at/Research/GGI/docs/oskar.pdf
\(^4\) See http://fp0804.emu.ee/wiki/index.php/MELA
\(^5\) See http://fp0804.emu.ee/wiki/index.php/Heureka
\(^6\) See http://timber.unece.org/index.php?id=55
\(^7\) See www.iiasa.ac.at/Research/GGI/docs/index.html?sb=8
\(^8\) See www.fs.fed.us/research/rpa/what.shtml#2010RPA
\(^9\) See www.metla.fi/julkaisut/workingpapers/2008/mwp075.pdf
some felling operations are postponed for later periods because of their value increment. The maximum sustainable yield defines the maximum removal that can be cut without decreasing future potentials.

The role of policy-targeted scenario modelling as a part of NFP is to forecast future forest resources, assess resource use potentials, and evaluate optional strategies and policies. Model-based scenarios that predict what will happen as a consequence of different policies or strategies are used, for example, in Nordic countries (e.g. the Finnish National Forest Programme\textsuperscript{11} and the Swedish Forest Impact Analyses)\textsuperscript{12} and in the United States (Resources Planning Act Assessment).\textsuperscript{13} In Finland, policy-targeted scenario modelling has been carried out at national (e.g. Kärkkäinen \textit{et al.}, 2008), sub-national (e.g. Nuutinen \textit{et al.}, 2009), and local (e.g. Nuutinen \textit{et al.}, 2011) level.

3. Scenario modelling process

Scenario modelling can be used to address both slow and abrupt changes. Slow changes include, for example, the natural development of forest resources, and can be predicted using simple forest dynamics simulation models. Abrupt changes, such as decisions on policy measures, usually have complex impacts on forest resources as well as socio-economic effects. Therefore, the modelling requires explicit definition of the interrelationships between the different processes and actors, and quantification of system parameters other than just those concerning forests.

Typical steps in the scenario modelling process relating to NFP and supported by NFMA include (see Figure 1):

- Collection of background information about the current situation, state and trends of:
  - forest resources covering round-wood, fuelwood, non-timber forest products, biodiversity, water, recreation, carbon dioxide storage, etc.
  - land use (including competing land-uses and their future pressure on forest land)
  - forest use
  - removal, consumption and markets of forest products
  - legislation and policies
  - stakeholders and their responses to policy measures
  - reference scenarios (e.g. global market scenarios)

- Collection of information about national objectives
- Design of alternative strategies or policies and related actions or measures
- Prediction (simulation, model-based scenarios) of what will happen to forest conditions and the potential use of forest resources under different alternatives; estimation of parameter values for current and future forest resources, products and services
- Evaluation of the consequences of alternatives
- Consensus-building, sometimes an iterative process, with the design of alternatives and consequent steps
- Implementation, and
- Monitoring of implementation to obtain feedback for the next scenario round (e.g. collecting information about stakeholder response to policy measures).

For model-based scenarios, NFMA is the essential source for data on forest resources (usually aggregated data on age-volume classes or diameter distribution) and growth estimates. Furthermore, NFMA data can be used for modelling forest parameters such as biomass or carbon content. Statistics on felling or afforestation activities can be utilized if business-as-usual scenarios are modelled.
4. Discussion

Scenario modelling has been applied in national forest strategies or policy processes mainly for boreal and temperate forests. However, the emergence of international mechanisms such as REDD+ (see UN-REDD Programme) has increased interest in scenario modelling for tropical forests. For example, the strategic decisions concerning management options such as large-scale industrial plantations, small-scale community forest plantations, agroforestry, strict forest protection, forest rehabilitation and ecosystem approaches for multiple-use forest management, or any combination of these, would benefit from analytic and quantitative assessment of different strategies in terms of carbon storage.

A major challenge for scenario modelling is to support national strategies and policies in the context of international agreements and global markets. In this context, the compatibility of national scenarios with regional or global reference scenarios becomes of increasing importance. A partnership programme based on country reports, such as Forest Europe or FAO’s Global Forest Resource Assessment.

Figure 1. Typical steps in scenario modelling process relating to a national forest programme (NFP) and supported by National Forest Monitoring and Assessment (NFMA).
(FRA), offers motivation and a potential framework to harmonize national forest scenario modelling. In Europe, the bottom-up approach based on national forest scenario modelling would complement the top-down process applied in EFOS 2011, similar to the way in which the North American Forest Sector Outlook Study (NAFSOS) is integrated with the USDA Forest Service RPA. FAO supports such processes through National Forest Monitoring and Assessment projects and the National Forest Programme Facility.

**Self-study exercises**

1. What is the role of scenario modelling in the preparation process of a national forest programme (NFP)?
2. What is the role of National Forest Monitoring and Assessment in the NFP preparation process, in particular in relation to scenario modelling?
3. List trends and other potential change factors affecting the demand for wood and other forest resources in your country.
4. List trends and other potential change factors affecting the supply of wood and other forest resources in your country.
5. What types of scenarios, approaches for scenario modelling and actual scenario models (software tools) would be applicable for your country?

**References**


**Annotated bibliography**


Examples of scenario modelling as part of policy and strategy processes:

Finnish National Forest Programme:  
www.mmm.fi/attachments/metsat/kmo/5Ad5R83tH/KMO2015engl.pdf

Swedish Forest Impact Analyses:  
www.skogsstyrelsen.se/Myndigheten/Skog-och-miljo/Tillstandet-i-skogen/Tillgangen-pa-skog/

United States Resources Planning Act Assessment:  
www.fs.fed.us/research/rpa/what.shtml#2010RPA

European Forest Sector Outlook Study (EFSOS):  
http://timber.unece.org/index.php?id=55

Examples of scenario models:

EFISCEN: www.efi.int/portal/virtual_library/databases/efiscen/

OSKAR: www.iiasa.ac.at/Research/GGI/docs/oskar.pdf

MELA: http://fp0804.emu.ee/wiki/index.php/MELA


FAO and Forest Europe linkages


NFMA: www.fao.org/forestry/nfma/en

NFP Facility: www.nfp-facility.org/en/


State of Europe's Forests: www.foresteurope.org/?module=files&action=file.getfile;id=485