ECONOMIC MODELS OF LAND EVALUATION: LOCAL DECISION-MAKING

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Summary

Economic models of land evaluation inform potential users about unforeseen threats and opportunities of land use changes while giving due consideration to the needs, aspirations and attitudes of different stakeholders. The role of these models is to inform users about the effects of dynamic and spatial externalities that cannot efficiently be managed by private agents and markets, and about ways to cope with these. However, these external effects also cause special analytical difficulties that are accommodated in the economic models of land evaluation via simplifying assumptions that maintain a modular structure so as to keep the analysis tractable and amenable to empirical investigation.

Four steps in model building can be distinguished: compilation of data, specification of equations, estimation of parameters, and scenario simulation. The implementation of these phases in model building varies widely and is generally tuned to client needs and priorities. The present paper focuses on applications at local level. An accompanying paper deals with higher administrative levels, discusses the pitfalls and identifies

challenges for future research.

1. Introduction

Economic models of land evaluation differ vastly in subject matter, approaches, methodologies and degree of mathematical formalization, but all aim to support the land use planning process of private organizations and public institutions, such as a farmers association or local government. However, it appears that many of the models described in the literature were developed in relative autonomy, to address specific methodological issues but without clear reference to any user or planner. Hence, the main goal for a review of this class of models is to assess whether their structure and empirical validation are adequate for the intended purpose.
Since the client is supposed to play a key role in formulating the objective of land evaluation, user categories can be considered as the guiding principle for the discussion. Hence, four classes of users can be distinguished: a) farmer and local communities, b) watershed authorities c) regional authorities and national governments and, d) the global community.

The models are discussed in two different papers. The first discusses the general considerations of economic models in land use planning and emphasizes their role at the local or farm scale. A second paper discusses their application at watershed level, regional and global scale and identifies the pitfalls and methodological challenges for future research. The main reason for maintaining this subdivision is that at higher scales the availability and spatial resolution of the data poses problems that do not arise at local or farm level. Farmer communities commission evaluations for their area where collected data on prevailing natural conditions and households can be identified for the same geographical units. The studies apply basically biophysical models while the results consist of practical recommendations, say, with respect to the fertilizer application, the viability of the introduction of a new crop variety, or the impact of soil conservation measures.

The present paper proceeds as follows. Section 2 discusses the embedding of economic models of land evaluation within the wider field of land use planning. Section 3 reviews the main steps in model construction. In section 4 applications at local or farm levels are considered.

2. Objective of Land Use Modelling

2.1. Land is Scarce

The basic problem of land use planning is to deal with the scarcity of land. Physical space is needed to accommodate human settlements, and the infrastructure joining them, the land to produce food, fibre and fuel, and to locate the factories. Space is also needed for recreation and to maintain a certain degree of biodiversity.

World wide the pressure on land is mounting. As described by Alexandratos this is largely due to the persistent growth in population and per capita incomes and the associated rise in demand for meat and fodder products, jointly with ongoing land degradation and deforestation. For agriculture, technological change may bring some relief, through higher crop yields and improved input efficiency. However, expansion of agricultural land without initiating severe repercussions on the environment has only limited possibilities. Furthermore, the various stakeholders tend to have widely differing views on what the most desirable pattern of land occupation would be. Land use planning has to take stock of these competing uses and to provide tools and insights that help resolve the ensuing conflicts.

Within this setting, economic models for land evaluation specifically offer tools that focus on the uses for agriculture, forestry and recreation.

2.2. Land Suitability

Clearly, it is not only the physical surface that matters in land evaluation. Land appears in a great variety of forms that define its suitability for particular purposes. For instance, mountainous areas may provide attractive scenery to some and therefore satisfy recreational needs, while the steep slope angles and the shallow and stony soils make the land unsuitable for cultivation of crops.

Lowland humid tropical areas are less suited for maize cultivation, because humidity is favourable for pest and disease development, unfavourable for handling of produce, and soils are often too acid for satisfactory growth, but such conditions are still well suited for the profitable production of other crops of a certain quality.

2.3. Efficiency

This suggests that given the land suitability in a particular area, there should exist something like an efficient land use configuration, to meet the various needs and aspirations of the stakeholders. In many other settings economists may expect that the market will attain a reasonably efficient allocation on the basis of the decisions by a multitude of agents, but in the context of land use planning, as Kreps clearly indicates, they mainly seek to inform potential users about unforeseen threats and opportunities that markets cannot exploit easily, largely because of inherent externalities.

2.4. Spatial Externalities

Land is not a perfectly divisible commodity like, say, gasoline. The limited indivisibility of plots in rural as well as urban areas is a major externality and cause of market failure. This is clearly illustrated by the well-known difficulties in the realization of land consolidation programs in rural areas where, like in urban development projects, the refusal of one landowner to transact may block all progress. Moreover, the vocation of one plot can have significant spill-over effects on neighbours. For instance, in a watershed the heavy use of pesticides on upstream arable lands may profoundly affect the ecosystem functioning of downstream wetlands with nature reserves.

At a higher scale, the greenhouse gas emissions of the developed world are seen as major cause of global warming, and the effects are as well felt elsewhere, also in developing countries. External effects are not always harmful. Agglomeration effects may enable neighbours to reap the gains from common amenities with high fixed costs. This is for instance the case for sugar factories that have to remain in the close proximity of sugarcane or sugar beet land, but applies more generally to most of the facilities of towns and villages the rural areas depend on, as is illustrated in the work of Schmitz and Nadvi (1999).

2.5. Dynamic Externalities

Dynamic externalities may also be important and call for public intervention. Land development programs for irrigation schemes, electrification programs, or transportation infrastructure tend to be lumpy and often require investments beyond the reach of private agents. Furthermore, as can be seen from the work of Toman et al. (1995), land degradation has irreversible consequences over a time horizon that exceeds the foresight of capital markets by far.

At local scale, soil erosion is a typical form of a dynamic externality. At global scale, the emission of greenhouse gasses changes the rainfall pattern and may significantly affect the land suitability in a way that markets cannot account for. Finally, land evaluation often considers the introduction of technologies, say, crop varieties, that are new to the farmers in the area and whose productivity can therefore not be anticipated by them.

2.6. Objectives

In land evaluation as in many other fields, economic models derive their mission from the externalities at hand, because there would be no need for planners to step in if private agents and markets could efficiently manage the situation by themselves. Designing the patterns of land use and the supporting policies that can account for these externalities, while giving due consideration to the needs, aspirations and attitudes of different stakeholders essentially is what the economist's contribution to land evaluation could be.

3. Model Construction

3.1. Simplifying Assumptions

External effects justify the construction and use of economic models, but they are also the source of complications that make it especially difficult to define efficient strategies. The basic approach in constructing economic models of land evaluation relies on a set of simplifying assumptions that keep it tractable and amenable to empirical investigation.

The first group of assumptions relates to the treatment of discrete choice. For example, the optimal assignment of given parcels to users and vocations which, as discussed by Drezner (1995), creates an extremely large number of competing configurations, the combinations of which soon become so complex that even the fastest computers cannot deal with all possibilities before selecting the efficient ones.

Also, in situations with discrete choice, the statistical estimation and validation of various combinations becomes very difficult, because most are unobserved in reality. Land use studies generally circumvent this difficulty by restricting the analysis to formulations where discrete choices are made at the level of the grid point. Consequently, the boundaries between zones may shift continuously, and land use changes become smooth at the level of the larger unit.

A second group of simplifying assumptions relates to modularity. Climatic conditions and hydrological flows typically exhibit complex spatial patterns that vary cyclically across seasons. As long as these phenomena are considered to be determined by nature, without any human interference, they can be dealt with in a hierarchical way. They only determine the parameters of economic decisions at every location, without need for the model builder to worry about the mathematical complexity of the biophysical and hydrological models such as non-convexity, discontinuity and randomness.

The models also assume that outside the hydrological component – which remains tractable because it operates recursively in space and time – spatial interactions do not play a central role.

This makes it possible to follow a static, geographic approach that assesses the conditions at every land unit, and essentially only needs to link the natural conditions on that unit to the decisions of the individuals living there. Spatial interactions are then seen as resulting, say, from the supply and demand after summation over a large number of land units at regional level but not from non-recursive interactions in groundwater flows between adjacent farms.

However, once dynamic feedback effects or spatial interactions are being allowed for, say, to reflect environmental degradation, all the externalities have to be represented explicitly within the decision models if the economic agents in the model are to anticipate the effect of their actions on the properties of the land, and an efficient solution is to be obtained.

This means that these biophysical and hydrological models have to appear as constraints of economic decisions rather than being kept in separate sub-modules, but this is problematic because of their mathematical structure.

To avoid these difficulties, modellers of land use proceed in two ways. Either they maintain the anticipation of effects and only represent dynamic feedbacks and spatial interactions through variations in the given natural conditions under different scenarios, or they drop anticipation and assume that the agents fail to anticipate the effects of their actions on the environment.

One reason for dropping the anticipation may be that individual agents choose to free ride on the environment, because the effect of their own actions is negligible compared to that of others. Yet, while these approaches may help understanding of the mechanisms at play in human-ecological interactions, they will not lead to any recommendations on the efficient use of natural resources.

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Biographical Sketches

Michiel A. Keyzer is a professor of mathematical economics and Director of the Centre for World Food Studies of the Vrije Universiteit (SOW-VU), Amsterdam, The Netherlands. Professor Keyzer's main activities are in research and research co-ordination in the areas of mathematical economics and economic model building. He has led studies on development planning in Bangladesh, Indonesia, Nigeria, West Africa and The Lebanon, on reform of the Common Agricultural Policy, and on farm restructuring and land tenure in reforming socialist economies for IFAD and the World Bank.

Publications are in the field of general equilibrium modelling (with Ginsburgh, 1997; MIT press), applied mathematical and statistical techniques and the environment. Mr. Keyzer also contributed to several scientific reports of the Land-Use and Land-Cover Change Project in collaboration with IIASA.

Ben G.J.S. Sonneveld is an agronomist/soil scientist and a senior researcher at the Centre for World Food Studies of the Vrije Universiteit (SOW-VU), Amsterdam, The Netherlands. Mr. Sonneveld's major publications are on land degradation assessment with limited data combining statistical techniques with process knowledge and expert judgements. Before joining the SOW-VU he worked six years in field projects of the FAO and the ILRI. Current project activities concern agricultural productivity assessments of natural resources at nation-wide level for Nigeria, The Lebanon, Caucasus countries and Ethiopia.

His Ph.D. thesis “Land under pressure” (2002) accommodates water erosion models in a recursive dynamic optimisation model for a spatially explicit evaluation of food security in Ethiopia under alternative scenarios of migration, soil conservation and technology.

Roelf L. Voortman is a senior research fellow and land resource ecologist at the Centre for World Food Studies of the Vrije Universiteit (SOW-VU), Amsterdam, The Netherlands. Landscape ecologist by education, his main research interest is agro-ecological characterization and assessment for agricultural development planning with emphasis on climate-vegetation-soil chemistry relationships. He joined the Centre after 15 years of work in developing countries, first in the field of land evaluation and land use planning for FAO, and later as project manager for the Netherlands Government.

Publications include an overview of African land ecology and the opportunities and constraints for agricultural development for that continent and a countrywide spatially explicit assessment of the impact of global change on agricultural production in Nigeria. Recent local level studies deal with spatial variability of soils in Niger and its implications for agronomic research and external input technologies used in precision agriculture.