LAND USE PLANNING AND PRODUCTIVE CAPACITY ASSESSMENT

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Introduction

The determination of the "productive capacity" of the land is the main component of the Food and Agriculture Organization of the United Nations' (FAO) Agroecological Zones (AEZ) approach, and it is also an element in the sequence of land evaluation and land use planning as advocated by FAO for use in developing countries. The nature of the subject lends itself to little or no privatization, which is the main theme of the present Symposium. At the international level specialized scientific institutions and development agencies such as FAO should continue to take the lead. At national and provincial level ministerial and parastatal entities on natural resources inventory, monitoring, and assessment are the logical executing bodies. Usually national soil survey and land evaluation centers take the lead. They may be performing comprehensively in their own right; often they have the broadest and most detailed geo-referenced data bases on natural resources, and are then the first institution to be contacted on the definition of scope and geographic location of envisaged development or conservation projects. However, in many cases they need to be stimulated to obtain the effective cooperation of other national centers such as meteorological departments, remote sensing imagery holding centers, vegetation and land use monitoring institutes, farming system analysis groups, and environmental conservation units. Only in a few cases the need for an integrated and holistic approach to agroecological zoning and land use planning has translated itself into interministerial, multidisciplinary institutions with undisputed responsibility and ensured long-term financial and establishment arrangements.

Some Definitions

First a number of definitions should be given (FAO 1992):

Land: An area of the earth's surface, including all elements of the physical environment that influence land use. Thus land refers not only to soil but also landforms, climate and hydrology, plant and animal population, and the physical results of human activity like terraces and drainage works.
Land characteristic (or property): An attribute of the land that can be measured or estimated, for example slope angle, soil depth, mean annual rainfall.
Land quality: A complex attribute of land that affects the suitability of the land for a specified use in a distinct way, that is, largely independent from other qualities. For example, the quality 'sufficiency

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of water' directly affects crop yields and, therefore, land suitability for that crop. Land qualities can only be assessed by modeling the interaction of a number of measurable land characteristics.
Land capability classification: A classification of the land in terms of its potential for use in specified ways and with specified management practices (United States Department of Agriculture, USDA).
Land evaluation: The assessment of the suitability of land for a specified use, in terms of sustainability, production, and the inputs needed to assure that production and economic return.
Land use: The management of land to meet human needs. This embraces rural land use such as agriculture, forestry, and aquaculture as well as all forms of urban and industrial use.
Land use (or utilization) type: A kind of land use, current or envisaged, described in enough detail to assess its land requirements and to plan the necessary inputs. Equivalent to an individual farm enterprise like irrigated rice production or dairy farming.
Sustainable land use: Use of the land that does not progressively degrade its productive capacity.
Land use planning: A coherent set of decisions about the use of land and ways to achieve the desired use. A land use plan consists of a definition of goals; an ordering of land, human, and material resources; an explicit statement of the methods, organization, responsibilities, and schedule to be used; and agreed targets.
Agroclimatic region: An area of land that is suited to a specified range of crops, defined in terms of its temperature and rainfall regime and especially its growing period.
Agroecological zoning: The process of quantifying the productive capacity of land resources for human use, in dependence of the physical and biological characteristics.

The Agroecological Zoning Approach

To assess the productive capacity of the land at regional and global level the FAO developed, as a sequel to its world inventory of soil resources (FAO, 1971-78), the concept of Agroecological Zones and its application for the determination of the potential population-supporting capacities at three different levels of input (Higgins and others 1987, see also the brochure "How Good the Earth," FAO 1991). The agroecological zones delineations are being taken up now by the international agricultural research centers of the Consultative Group on International Agricultural Research (CGIAR) system, and by the Terrestrial Ecosystem research program of the International Geosphere-Biosphere Programme (IGBP). The AEZ methodology also is to be used for an assessment of the effects on productive capacity and human carrying capacity of the surmised climatic change (the enhanced greenhouse effect) at global, regional, and country level. Country level applications at present-day climatic conditions already have been carried out, with ad-hoc financing, for Kenya, Mozambique, Bangladesh and less detailed for the Philippines, Indonesia, and Malaysia, and is currently under way for the whole of China. The requests for country level AEZ studies are increasing rapidly and it is hoped that the expertise, which presently exists in FAO's regular program, can be continued and strengthened.

Elements used in AEZ are (a) the establishment of the photosynthesis and temperature requirements of individual crops (C_3 and C_4 plants); (b) a detailed agroclimatic inventory (determining the length of growing period of the land, based on thermal regimes and moisture availability over the year); and (c) a small-scale, that is, low-resolution soil inventory (especially regarding the soil moisture storage capacities). These elements are then combined to assess the agroclimatic suitability for each crop, soil type, and level of external input (high, medium, or low).

Parameters not included thus far are (a) the hydrological resources of the land (surface and groundwater), a clear omission but unavoidable because of the near absence of systematic inventories of these resources at regional and national level; (b) certain climatic parameters of importance at higher latitudes (day-length, permafrost) because studies in such areas were not requested from FAO thus far; and (c) the value of the natural land cover (timber, fuel, fodder nutrients of the standing biomass, biodiversity, vegetative protection against forms of land degradation). However, see the discussion of the proposed agroecological zoning of the Amazon region.

Although originally meant for regional and continental assessments, the AEZ methodology has been developed further and is proving to be a valuable tool for planning at the national and provincial levels as well. For instance, it can be used to identify areas that cannot remain self-sufficient in food production, it can indicate future food transport and storage requirements, and it can identify areas with a potential for resettlement and agricultural development. At that point the land use planning methodology takes over, at catchment area levels, in specific land and water development project areas, and in village level development and conservation schemes.

Land Use Planning

Land use planning at the local level has been a human activity since time immemorial. However, formalization of its methodological aspects for application in developing countries is rather recent. FAO has been involved in land use planning for many years, both at project and village level. Based on ad-hoc experience over the years, it has developed sets of guidelines, which became gradually more precise and quantitative. Recently, a holistic approach has been introduced, including environmental and ecological considerations. Some relevant publications are "A Framework for Land Evaluation" (FAO 1976), which was developed in consultation with an interdisciplinary working group at Wageningen, the Netherlands, and followed by guidelines for its application to rainfed agriculture (FAO 1983), to forestry (FAO 1984), to irrigated agriculture (FAO 1985) and to extensive grazing (FAO 1990). "Guidelines for Land Use Planning" (FAO 1992) was produced by an FAO Interdepartmental Working Group on land use planning. It is based in part on a number of country level land use planning manuals such as those from the United States, Australia, Canada, Bangladesh, Tanzania, Sri Lanka, Ethiopia, Zambia, and so forth.

The recommended steps in systematic land use planning are:

Step 1 - Decide what you want to achieve. Define the present situation; determine the needs of the people; agree and specify the goals to be worked for.

Step 2 - Plan to plan. Organize the work needed. Select methods.

Step 3 - Identify and structure the problems and opportunities of the planning area, including legal requirements.

Step 4 - Devise alternative solutions. Identify or design alternative land use types that might achieve the goals.

Step 5 - Evaluate land suitability. For each promising land use type, establish its land requirements and match these with what the land has to offer to establish physical suitability.

Step 6 - Appraise alternatives. For each physically suitable combination of land use and land, assess the environmental, economic, and social impact.

Step 7 - Choose the best achievable land use. Use selected methods of decisionmaking.

Step 8 - Draw up a land use plan, allocating land uses to land, and making provision for appropriate management.

Step 9 - Put the plan into action. Action by decisionmakers, lawmakers, sectoral agencies, and land users.

Step 10 - Learn from the plan. Monitor progress toward the goals; revise the plan in the light of experience and to accommodate new goals.

It may be obvious that this is a truly multidisciplinary and interdisciplinary exercise, involving many people: the land users, the planning team(s), and the decisionmakers, with involvement of the legislature, the executive and sectorial agencies (research entities, mapping institutions, extension services) at both national, province, district, and village level. The process looks straightforward and without ambiguities. The various steps are, however, full of uncertainties and pitfalls. Some examples follow:

Step 1. The terms of reference imply the existence of a national land use policy (soil policy, water services policy, commodity promotion policy, and so forth), but in many countries such a policy, or elements of it, is still nonexistent. The land use planning team may be assigned to the central office or local representatives of the ministry of agriculture or forestry or animal husbandry, the ministry of natural resources or environment, the ministry of economic planning or a ministry of local development. Worse, the team components may be scattered throughout these ministries and semiautonomous institutions, having no experience in cooperation and tending to frustrate cooperation for fear of loss of their own authority and financial resources.

Step 4. The study of relevant land use types presupposes the existence of a reliable data base on current land use, not only in the sense of statistics for each province or district but also geo-referenced, and not only in the identification of produce involved but also in its farming characteristics (labor, degree of external imput, farm size and tenure, gender issues, and so forth, in other words a farming system analysis). Mapping of current land uses in this sense has been a neglected item in many countries, in part because there is no well-defined and agreed on international system of land use typology and classification that may provide guidelines.

Step 5. The land resources surveys and the subsequent "physical" land evaluation have a number of problems too. Soil surveys in the past often were restricted to taxonomic identification of the main soils and carried out in isolation from landform, hydrological, vegetation, or land use surveys. This resulted in an unwieldy multitude of boundaries when individual mapping units on each of these land elements are integrated in a land information system. Only gradually the idea is being accepted that land form (land system and land facet) delineations should form not only the logical but also a convenient basis for the integration of the natural resources in a Geographic Information System (GIS).

Land qualities, as compound attributes of the land can be assessed only by modeling the interaction of a number of measurable single land characteristics. These models have not yet been worked out systematically as algorithms for all land qualities. The evaluation of the physical and biological land resources, through a systematic comparison of the respective land qualities in relation to the envisaged land utilization types (a "matching" or "weighting" procedure), cannot as yet be done completely automatically through the application of a well-defined and proven set of rules. A system fit for a country or group of similar countries is feasible, if indeed developed by physical geographers, soil, or environmental scientists with keen and open eyes for plant growth behavior and land surface conditions, ample experience in the study area concerned, and a willingness to listen to the wisdom of local farming communities as accumulated over the ages. In a number of cases it has already proved possible to transplant a system of land evaluation, with modification, to distant countries. However, an automated system for worldwide practical application may remain an elusive goal for the near future.

Step 7. The incorporation of environmental, economic, and social conditions and considerations to select viable land use options is at least as complicated as the activities in Step 6. For instance, the appraisal of the biotic land qualities in their own right is still in its infancy; the sustainability of the envisaged land use throughout many years to come can only be guessed ("backtracking" long-term ecological research may be helpful); the economic analysis has many built-in uncertainties as to the future marketability of the produce mix envisaged; the expected development of the social conditions may change radically in a few years' time, and so forth. Examples of such changes are regional calamitous droughts and explosions of AIDS in parts of Africa.

The involvement of the local population in the planning process is often token and short-lived. By and large the local traditional land users still are seen as part of the problem rather than as part of the solution. But even if given a real chance to participate in the planning process, the local population may wholeheartedly cooperate only if they see obvious advantages in any change, and become convinced of a long-term interest in their well-being and development from the authorities' sides. If such guarantees are absent or not apparent to them, or if some prove to be phoney, then the average small farmer will stick to his/her traditional risk minimalization, or fall back upon this once the external pressure to change has diminished.

Step 9. The plan implementation has its own pitfalls. Too often the technical recommendations of the land evaluations are shoved aside or unilaterally modified at the implementation of major project activities. This is because of the common tendency of the executors (development agencies, construction firms, local politicians) to arrive at something grandiose and showy, instead of being satisfied with such, possibly modest, grassroot level changes as may be required for sustainability. There are examples galore of disastrous "white-elephant" development projects; modesty is a rare virtue.

The Approach Exemplified

The following is an example of the combination of the agroecological zoning approach and land use planning in a region that is attracting much attention and concern worldwide right now--the Amazon region.

Thirty years ago this region was forgotten and practically unknown. The Brazilian Government requested the presence of an FAO/UNESCO multidisciplinary team to assist in development planning in the region. This resulted, among others things, in a plan for the harmonious development and protection of an area along the first Amazon highway just opened (Belèm-Brasilia). A forest reserve for sustainable production was delineated in the part with the highest commercial timber volume, with a core area to be completely protected because of its intrinsically high biological diversity value, and buffered from the advancing shifting cultivation front from the north (Belèm) by an area of carefully planned smallholders' settlements. The plan was never executed and the data gathered on forest resources and soil conditions served only to speed up massive deforestation in the area. At present the Paragominas area is largely a wasteland of abandoned ranching land, with scars in the landscape where bauxite mining was developed, because of the unintentional delineation of that geologic resource on the soil and landform map.

Again at the request of the Brazilian Government, FAO carried out a Technical Cooperation Activity in 1989-90 on the formulation of a major agroecological zoning project to arrive at rational land use planning for the Amazon region, with due regard to environmental values and the well-being of the traditional riverine and forest population. The land utilization types envisaged at such an exercise were:

- Indigenous areas (already demarcated or proposed)
- Nature conservation (national parks)
- Protection of the natural vegetative cover throughout, without any direct use (for example upper catchments)
- Conservation as biological or genebank reserves
- Extraction of non-timber resources on a sustainable basis
- Commercial exploitation of timber on a selective and sustained basis, leaving the natural forest structure intact
- Systematic production of timber, pulp or charcoal from planted forests
- Traditional shifting cultivation
- Agroforestry systems
- Cultivation of perennials
- Pasture establishment (ranching)
- Permanent production of annual crops.

The steps for such a zoning and planning for a coherent system of agroecological and socioeconomic zoning for the Brazilian Amazon Region were suggested as follows (FAO 1989):

I. Cadastration - Development and maintenance of a system of cartographic information of all data that is already available (surveys, remote sensing imagery) at regional and state levels.

II. Prezoning - Identification and characterization of natural land units, land utilization types, and socioeconomic conditions.

A. Delineation of natural land units and thematic analysis of their geology, geomorphology, climate, hydrology, relief, soils, vegetation, fauna, and present land use.

B. Determination of the physico-biological land qualities and limitations for each type of natural land unit distinguished. An example of A.+ B. is formed by the recent Superintendencia de Desenvolvimento da Amazonia (Belem)/Fundacao Instituto Brasileiro de Geografia e Estatistica (Rio de Janeiro) (SUDAM/IBGE) thematic maps on "prezoneamento," scale 1:2,500,000, for the whole region, though without climatology, hydrology, and fauna.

Simultaneously, the following need to be carried out.

C. Identification of agroecologically viable land utilization types.

D. Determination of the physical-biological requirements of each land utilization type.

E. Characterization of the socioeconomic conditions and perspectives for each subregion, hydrographic subbasins, or municipalities, and of areas already demarcated for specific use such as "areas indigenas," biological reserves, and natural production forests.

III. Zoning (sensu stricto) - Physico-biological rating of natural land units, comparison with socioeconomic conditions, and delineation of recommended land utilization types.

A. Systematic comparison, through a process of matching and weighting, of the physico-biologic qualities of each identified natural land unit, with the physico-biologic requirements of each envisaged land utilization type; resulting in a rating of the land units in classes of physico-biological potential for each land utilization type on a sustained basis. An example is the recent agroecological zoning for the whole region, at scale 1:5,000,000, by Empresa Brasileira de Pesquisas Agropecuarias (Brasilia)/Servico Nacional de Levantamento e Conservacao de Solos (Rio de Janeiro) (EMBRAPA/SNLCS), though without incorporation of biological diversity.

B. Modification of the physico-biological rating through comparison with the prevailing socioeconomic conditions; resulting in the identification of the preferred and recommended land utilization or nonutilization type per land unit or combination of land units, and its cartographic delineation. The latter is the formal end product of the zoning process. Examples are the socioeconomic-ecologic zonings carried out by the Programa de Desenvolvimento Integral de Noroeste de Brasil (POLONOROESTE) program for Rondonia and Mato Grosso, and by Projeto de Protecao ao Neio Ambiento e das Comunidades Indigenas (IBGE/PMACI) for western Acre, both at scale 1:1,000,000.

This exercise is a dynamic process; it will have to be repeated every 10 to 20 years, taking into account newly emerging technological and socioeconomic conditions.

IV. Post-zoning - The zoning work should be followed by a process of regional physical planning ("amenagement du territoire") that includes planning; preprojects for legislation; political decisions; implementation, legal, administrative, and institutional; and demarcation on the ground, inspection, and control of its adherence.

In principle this sequence is scale independent. It can be applied at any level of intensity or detail. In the Brazilian case a preliminary zoning at scale 1:5 million or 1:2.5 million was foreseen, a systematic zoning at scale 1:1 million or 1:500,000, and a semidetailed zoning at scale 1:100,000 or so. The more detailed the level, the more quantified the information has to be and the more precise the areal delineation.

The practical examples given in the sequence illustrate the acknowledgement and integration of methods and activities already developed and carried out by a number of national Brazilian institutions. Whether in practice these institutions will be prepared to harmonize methods and to cooperate effectively, a main aim of the envisaged FAO project, still remains an open question. Any FAO involvement is complicated further by the issue of the formal authority and responsibility, morally and technically, for the ecological zoning and subsequent land use planning for the Brazilian Amazon region: Does this authority lie with the national or international scientific or popular ecological community; with the cooperating countries of the whole Amazon region; with the Federal Brazilian Government; with the nine individual states of the Brazilian Amazon; with the local town and commercial communities, or with the traditional forest dwellers?

Some Postscriptum Statements

There is a strong need for geo-referenced, quantified, computer-assisted, and compatible data bases on natural resources, both at global or continental and at national level. In such data bases, hydrological and soils information should preferably be linked systematically to landform information.

There is an acute shortage of geo-referenced information on current land uses, and on their characterization in terms of produce, type of land and water management, socioeconomic conditions, and degree of change or departure from "natural" ecological conditions.

In the discussions on the value of biodiversity one should not forget the stock of human-induced "land races" (plant and animal) in traditional farming systems, especially those based on smallholder mixed farming practices.

The concept of "low-external input sustainable agriculture" (LEISA) implies the acceptance of local nutrient mining and microgeographic nutrient harvesting. In view of the ongoing rapid population growth in many developing countries, one should rather promote the concept of "balanced and adequate external input sustainable agriculture" (BADEISA).

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