TOPIC 2

ENVIRONMENTAL ASPECTS OF LAND-USE IN SEMI-ARID AND SUB-HUMID REGIONS

Scope

Extensive areas of the developing world have either limited rainfall or are subject to prolonged droughts often followed by torrential downpours. These recurrent floods and droughts make the ecosystem fragile. As anthropogenic activities reduce the natural vegetal cover, the soil is lost by erosion and environmental degradation results. Thus in these fragile areas unsuited to heavy demographic pressure, the management of land acquires a special significance. Any program of land use must be based on a survey of historical land use patterns and must consider potential productivity, the preservation of the environment, the amelioration of past damage, and, in addition, satisfy the human requirements.

Some of the IBP studies in India have shown that deciduous forests may have an annual yield per hectare of 16 tons of dry organic matter; a grassland produces 20-30 tons and a standing crop 8-15 tons. Forests and grasslands, therefore, are as efficient as standing crops in the production of organic matter and provide protection for the soil at the same time, especially on sloping ground.[1] In Africa, because of unplanned and uncontrolled grazing, the savanna and the extensive steppe area are exposed to wind and water erosion, resulting in degradation and lowered productivity.

The relative evaluation of land for various uses is an urgent problem in the semi-arid and sub-humid regions. Industrial, recreational, park, and nature preserves versus diverse agricultural and pastoral uses of the land should be evaluated. Options for meeting the problems, though limited, are based on the ecology of the specific local area or region. The decision makers must involve scientists and listen to their arguments in planning land use in different types of terrain.

Options

While the land tenure system of large land holdings offers a better opportunity for efficient management, the social and economic incentives inherent in small holdings for intensive farming are lost. Although large holdings are amenable to modern mechanized and fertilized cultivation, the practice

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[1] If agricultural practices are intensified by irrigation and fertilization, the yields can be doubled, but at high cost.

becomes wasteful if the land is open to agents of erosion. A balance between the two systems may be desirable.

The development of irrigation facilities, while boosting agriculture, has led to large-scale disturbances in the forest and the grassland ecosystems, to soil erosion in the catchment areas, and to several public health problems. Reservoirs constructed at tremendous cost are silting up, while persons displaced by the reservoirs are demanding more and better land for food production in the forested catchment area and are being subjected to new or more concentrated public health problems. Hence, the techniques of water harvesting have to be carefully evaluated from economic, ecological, social, and health viewpoints before implementation. Industrial pollutants may damage plants and animals directly or may be transmitted to them through the food chain, so siting options and pollution control technologies must be evaluated before making decisions.

Most of the people subsist on a vegetable diet, depending on pulses (legumes) and milk for their protein supply; meat production, fishing, and game hunting meet the demands of a smaller number of people. If a change from a vegetable to a meat-based diet were encouraged, the resulting increase in cattle population, already too large in some areas of the world, would further damage the forest and grasslands by overgrazing.

Many of the semi-arid and sub-humid areas of the world border on coastal zones, and in these areas the use of marine resources as a potential food supply must be evaluated. Solar energy must also be considered a resource, and its possibilities regarding food and energy conversion should be explored; for example, the potential of biosynthesis to produce protein, particularly enhanced in these areas of high solar energy insolation should be investigated. Finally, the successful utilization of controlled environment greenhouses is particularly appealing since they provide electrical energy, food, and the conversion of saline to fresh water.

Developing countries are all planning to establish industrial sectors. Such plans for industrialization require careful economic analysis, consideration for the health and welfare of society, and the advantages and disadvantages of alternative land uses. Industries, for example, should be located on land not suitable for agricultural use.

The rising expectations of growing population and the accompanying social and political stresses require proper education and a respect for traditional, cultural, and spiritual values, if the ecological management of local land resources is to be successful.

Guidelines

Land use planners in virtually every country of the world complain that their recommendations are ignored by legislators, city managers, and other decision makers. Officials often display these plans with pride, but they seldom read them, and development decisions are often contrary to the plan. It is essential, and possibly of more importance than the technical documen-

tation, that we increase the real communication between planning bodies and decision bodies. One method may be to involve the decision makers more in the details of the planning process. Another may be to submit sections of the plan as it is being formulated, facilitating the process of review and allowing for revision. The mere size of some plans is self-defeating, at least for many very busy administrators.

Remote sensing is a tool which has been used for many years in the preparation of maps of many types. The use of satellite data, spectral data, and computer storage have opened new uses for remote sensing. One of the new uses of remote sensing is to create composite computer maps (overlaying one map on top of another, as is customarily done with transparencies). The computer has the capability of overlaying many factors (factor maps), each one given a relative importance or weight. Thus, one could overlay, for a given region, soil maps, geological maps, transportation networks, recreational areas, industrial sites, land slopes, water resources — as many as are available. These data can be manipulated with different weighting factors, and different composite maps can be prepared, indicating to the decision maker what the optimum use would be for any given set of local conditions (the weight assignments).

In certain areas it may be determined that the most economical, social, and ecologically sound land use would be that of nomadic grazing. However, in some nomadic areas, overgrazing causes a loss of valuable soil; such losses are frequently irreversible. Further, in semi-humid areas droughts cause tremendous losses in terms of livestock and human life, as well as the loss of the soil resource. It is indeed most difficult to set guidelines for countries which are attempting to resolve specific problems associated with nomadic grazing. From a scientific standpoint, we do not understand enough about the carrying capacity of land, particularly that in low rainfall areas, to be able to draw correct scientific conclusions. Even the meteorological data for such areas are often so meager as to defy analysis. All one can say is that the land is overgrazed, but no one has the infromation necessary to state unequivocally what the appropriate livestock level should be. Even if the carrying capacity for a given piece of land could be set, by what socio-political means could such a decision be implemented? Of course, this limit (to meet the ecological balance) must be imposed not only on the herd size, but on when and where the herd is allowed to graze.

Research

The major problems for research are listed below. Priorities will differ from country to country and according to the nature of the terrain and social requirements. But long-term development of the land shall remain the focus of study in each case.

(1) Land capability and classification: soil survey from the viewpoint of agricultural and silvicultural development.

(2) Hydrological aspects and plant moisture balances of soil: movement of moisture in and along the soil mass; suppression of evaporation losses.
(3) Wind and water erosion of the soil and its control.
(4) Development of irrigation and its effect on the land.
(5) Climate and microclimate studies to correlate and predict changes in plant cover, animal population, and land use.
(6) Primary, secondary, and crop productivity; efficiency studies in relation to land use.
(7) Carrying capacity of the land based on the average rainfall of a region for man and for domestic and wild animals at different levels of subsistence; availability of water and other inputs. In certain regions, the goat population deserves special study.
(8) Plant introduction and regeneration studies in relation to intensity of grazing.
(9) Integrated agro-sylvo-pastoral management of land.
(10) Demographic stresses on marginal lands.
(11) Land use patterns in different regions at micro and macro levels.
(12) Industrial development in relation to land.
(13) Development of accurate forecasts (3 to 6 months in advance).
(14) Development of standardized methods of monitoring the present state and future trends of the agricultural environment, e.g., degree of salinization, deforestation, etc.
(15) Agricultural obsolescence with a view to reducing pressure on land:
    (a) Microbiological and genetic approaches to improving the protein content of crop plants in order to do away with nitrogen fertilizers;
    (b) Biosynthesis of food;
    (c) Development of technology to manufacture proteins from non-conventional sources such as leaves, oil seed residues, algae, and natural gas.
(16) Effects of land tenure systems on the degradation of the land.
(17) Dependency of development on the availability of a tranportation network and the ecological consequence of network development.
(18) Use of underground and partially underground space for housing and other service functions in order to relieve fertile land for agriculture and/or other purposes.
(19) How to utilize the spare time of seasonal farmers:
    (a) Dry season cultivation using ground water;
    (b) Agriculture; cottage industry; fishing in reservoirs, rivers, canals, etc.; trading; external employment.
(20) Breeding new varieties of plants, crops, grasses, and livestock compatible with poor soil quality; evaluating the capacity of the ecosystem to tolerate such stresses.
(21) Examination and evaluation of techniques to be adopted in any set of conditions.
(22) Evaluation of proper age of growth for meat harvesting.

(23) Evaluation of interrelationships between farmers and herdsmen for integrated rotational land use.

Education and training

The following should receive special emphasis in the education and training of personnel for land use and its management:

(1) Demonstration of effects of land use practices on the environment.
(2) Information on erosion, pollution, and degradation of land.
(3) The role of the land in the regulation of the function of the ecosystem.
(4) Long-term effects of overgrazing, fire, shifting cultivation, and pastoralism on the land.
(5) Training in the use of remote sensing and other new techniques through "extension service" programs.
(6) Training in the transfer of technology of a multidisciplinary nature.