# INTEGRATION OF ECOLOGICAL DIMENSIONS IN LAND USE PLANNING

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## ABSTRACT

**Integrating ecological dimension in physical and land use planning ensures the long-term sustainability of our natural resources and life-support system. This has often been neglected in the development planning of an area. The two most critical ecological factors that have to be considered in physical and land use planning are ecosystem compatibility and resource carrying capacity. A systematic approach to integrate these ecological factors in land use planning are discussed. The successful implementation of a sound land use and physical plan is vital in supporting future population increases.**

## INTRODUCTION

Physical planning, specifically land use planning, is premised on the best possible use of land resources to adequately support present and future populations. A land use plan with marginal consideration for ecological dimensions has a weak framework and futuristic orientation. Similarly, a land use plan lacking scientific basis for determining ecological phenomena has a weak predictive capability. An ecologically sound land use plan is one measure which ensures the requirements of future generations. Integration of ecological dimensions in land use planning assures the long-term viability of the plan. Ecological dimensions enhance the dynamic mode and characteristic of the land use plan. With these inputs, the future state of the environment could be fairly predicted.

The main objective of this paper[1] is to provide the necessary perspectives in the integration of ecological dimensions in land use planning. Although we fully recognize the value of ecological factors in land use planning, in actual practice, these vital elements are neglected and oftentimes obliterated or overruled by dominant economic and political motives. A systems approach to land use planning is discussed to show the strategic position and role of ecological parameters in the formulation, evaluation, and reformulation of a realistic and sound land use plan. This approach tries to blend ecological factors with socio-economic, cultural and political motives, objectives and targets in order to ensure short, medium, and long-term viability of the land use plan. Compromise and trade-offs are axiomatic in land use planning, thus the approach is guided by these realities. If the approach is found and tested to be pragmatic and implementable, it will successfully harmonize development goals and environmental enhancement.

Finally, a policy agenda for land use planning is presented for consideration. Overall, this paper hopes to provide the take-off point for land use and physical planners in seriously considering the integration of dynamic ecological dimensions in iterative land use planning.

## CONCEPTUAL FRAMEWORK: ECOLOGICAL LAND USE PLANNING

Physical planning without considering natural or ecological processes could ultimately be disastrous. On the other hand, ecological planning *per se* without considering socio-economic and related factors could be an exercise in futility. A balance must be struck between these two groups of ecological and socio-economic factors in land use or physical planning.

Since the balance is tilted in favor of socio-economic and related variables, there is a need to strengthen the operational mechanism that serves to integrate the ecological dimensions in the process of land use planning. A conceptual framework has to be formulated that will systematically integrate ecological dimensions in land use planning process. Prior to this, we must first identify these crucial ecological dimensions.

### *Ecological Dimensions Crucial to Land Use Planning*

Several ecological variables have been identified by planners pioneering in ecological land use. Foremost of these planners is Ian McHarg who developed the concept of ecological/physical determinism in land use planning (McHarg, 1971). This concept suggests that development should be compatible with the operation of natural processes. Natural/ecological processes which are vital in physical planning include natural water purification, atmospheric pollution dispersal, climatic amelioration, water storage, flood control, drought and erosion control, top soil accumulation and others. McHarg's thesis is centered on physiographic principles which indicate the types of development and densities appropriate to various landforms. Each area has an intrinsic suitability for certain land uses depending on its physiographic characteristics. Hence, surface waters, marshes, flood plains, aquifers, aquifer recharge areas, steep lands, prime agricultural lands, forest and woodlands have their permissiveness and prohibition to certain land uses.

A comprehensive classification to cover ecological variables such as those identified by McHarg and other ecological planners (Edington and Edington, 1977; Davidson and Wibberly, 1977; Lassey, 1977) has been formulated by this author. Ecological variables crucial to land use planning are grouped into:

a) variables determining ecosystems compatibility; and

b) variables determining resource carrying capacity.

Ecosystem compatibility and resource carrying capacity are actually, in this author's opinion, the two most crucial ecological dimensions in land use planning. Some of the variables employed in the determination of both ecological dimensions are similar, and the two dimensions are not mutually exclusive but rather interrelated. However, these two dimensions have different end-goals and use different approaches/methodologies.

### Ecosystem compatibility

Ecosystem compatibility is concerned with determining whether a given or proposed land use is compatible with the ecosystem[2] and other adjacent land uses. Determination of such in land use planning will ensure a higher probability of sustained productivity of given ecosystems, and maintenance of life support systems[3] below a threshold which will likely trigger ecological disasters or catastrophes.[4] Ecosystem compatibility is, therefore, concerned with possible alterations/disruptions that may be brought about by certain pattern of land use which could significantly affect in the long-term, the integrity of ecological processes such as material and energy flow (biogeochemical processes), diversity patterns, food chains, succession, and ecological control. Eco-compatibility of land use results to a homeostatic environment which is characteristically healthy and productive.

### Resource carrying capacity

Resource carrying capacity is concerned with the natural capacity of a given resource (land, forest, energy, space, water, fisheries, minerals) to support human populations (present and future), on a sound environmental basis. The resource system's capability to sustain a given human population in a geographical area for some period or perhaps indefinitely, is a measure of its carrying capacity.[5] The determination of potential optimum production of natural resources through carrying capacity measurement is very important in physical and land use planning.

Resource carrying capacity and ecosystem compatibility more or less determine the optimum production and sustained productivity, respectively, of an area under a given land use or multiple uses. And because of their futuristic orientation, they are valued as crucial determinants in guiding medium- and long-term physical/land use planning.

A macro-framework for integrating these ecological dimensions in land use planning is depicted in the schematic diagram (pages 84-85).

### *Conceptual Framework for Integration of Ecological Dimensions*

The systems approach to land use planning (see diagram) takes into account ecological as well as socio-economic and cultural factors. This reflects the comprehensive and interdisciplinary character of the land use system. Involvement of various sectoral agencies and institutions are therefore, required in the preparation of a physical or land use plan. These bodies are responsible in providing and processing these inputs in collaboration with other concerned agencies/institutions to generate information relevant to physical/land use plan.

**Systems approach to land use planning**

The approach as presented in the graphical model operates on two basic principles:

a) the land use plan should be ecologically sound; and

b) the land use plan should be socio-economically, culturally, and politically desirable and attainable. It can be seen that the model first screens the ecological desirability and viability of a land use plan. After making the necessary adjustments for the plan to meet the established ecological criteria, the modified plan is then tested against the socio-economic/cultural considerations to isolate any incompatibilities. Alternatives are then designed to buffer or resolve these incompatibilities. In the final analysis, what evolves is a set of plans with ranked and prioritized alternatives which are ecologically sound and socio-economically acceptable.

The systems approach clearly defines the input, process, output, methodology, sources and/or processing centers of data/information involved in land use planning. Substantial data and information are actually available in the different government agencies/institutions all over the country. However, these data/information exist in different formats and level of aggregation. These data/information could serve as important inputs in land use planning.

In the systems approach, the "process" defines what should be done with the inputs and the outputs arising from the analysis. It should be noted that the outputs of one process could serve as inputs to the next or succeeding "process". The model also clearly states the available methodologies/approaches applicable in the analysis of data/information. The detailed discussion of these methodologies, however, is not within the scope of this paper. Nevertheless, an overview or brief description of some of the methodologies will be provided to clarify new concepts and procedures.

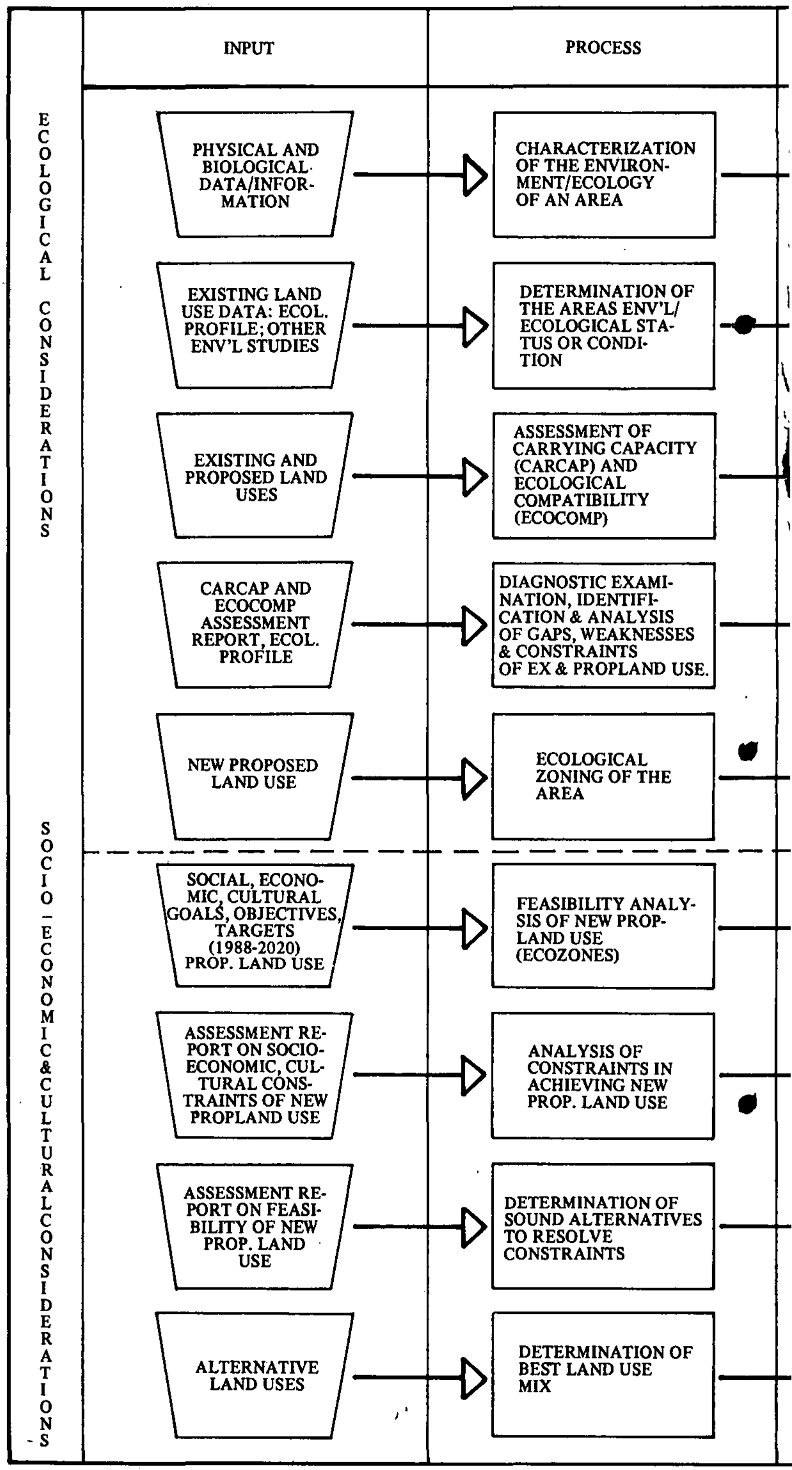
The approach, as a whole, could be made immediately operational since most of the data/information and methodologies are already available.

The model introduces two new methods useful in land use planning. They are considered new since the present land use planning process in the Philippines does not employ or in some cases, barely employs these techniques. These are the *carrying capacity* and *environmental impact assessment models.*

The carrying capacity model is used to measure or estimate the natural capacity of a given resource to support human populations indefinitely, while the environmental impact assessment (EIA) model is employed to determine the compatibility of a given land use or multiple land uses in an ecosystem.

The systems approach employs also other methods/techniques useful in land use planning, such as ecolo-

## SYSTEMS APPROACH TO LAND USE PLANNING



| OUTPUT | APPROACH/METHODOLOGY | SOURCES AND/OR PROCESSING CENTERS OF DATA/ INFORMATION |
|---|---|---|
| ENVIRONMENTAL/ ECOLOGICAL PROFILE | ENVIRONMENTAL ASSESSMENT AND PROFILING | BS, BFD, NRMC, NEPC, NPCC, BL, PAGASA NSTA, BM NWFC, PCARRD UP SYSTEM, OTHER INSTITUTIONS |
| ENVIRONMENTAL QUALITY MAP SHOWING DERELICT, DE-GRADED & CRI-TICAL ENVT. | SCANNING OF ENV'L/ECOLO-GICAL STATUS/ CONDITION | HRC, NEDA, NEPC NPCC, BM, BS NRMC, NSTA, RESEARCH INSTITUTIONS |
| CARCAP AND ECO-COMP ASSESSMENT REPORT OF EXISTING AND PROPOSED LAND USES | CARRYING CAPACITY MODELS, ENVIRON-MENTAL IMPACT ASSESSMENT MODELS | NACIAD, NEPC HSRC, BS, NEDA NRMC, MLG |
| NEW PROPOSED LAND USE BASED ON SOUND CARCAP AND ECOCOMP | CARCAP MO-DELS, EIA MODELS | NACIAD, NEPC, NEDA |
| ECOLOGICAL LAND USE MAPS (ECOZONES) | OVERLAY METHOD/ ECOZONING | NACIAD, NEDA |
| ASSESSMENT REPORT ON THE FEASIBILITY OF NEW PROP LAND USE | SOCIO ECONO-MIC, CULTURAL, COMPATIBILITY ASSESSMENT, SBCA | NEDA, BAECON, MECS, OMACM |
| ASSESSMENT RE-PORT ON CONSTRAINTS OF NEW PROP. LAND USE | CONSTRAINTS ASSESSMENT | NEDA LUC |
| ALTERNATIVES TO NEW PROP. LAND USE (ECOZONES) | FEASIBILITY ANALYSIS OF ALTERNATIVES BASED ON CARCAP AND ECOCOMP | NEDA-LUC, NEPC, NACIAD |
| FINAL LAND USE MAPS | ALTERNATIVE LAND USE MIX DETERMINATION BASED ON GIVEN SOCIO-ECONOMIC CUL. OBJECTIVES | NEDA-LUC |

gical profiling, social benefit-cost analysis, and constraints analysis. These methodologies are fully discussed in other literatures (Werner, 1984; Ramsay & Anderson, 1972; Hufschmidt, 1981; Pearce, 1978; Gramlich, 1981).

**Environmental impact assessment**

The method of environmental impact assessment (EIA) was originally designed for analyzing and measuring the possible impacts of proposed development projects or actions on the environment. It was, however, found to be highly applicable also to the assessment of land use impacts on the environment. EIA,[6] as applied in land use planning, is a method for studying the probable changes in the bio-physical characteristics of the environment which may result from an existing or proposed land use. The method, actually, is not only limited to biophysical impact measurement but also extended to socio-economic impact measurement.

The general steps involved in EIA in relation to land use are as follows:

a) description of the components of existing environment;

b) description of proposed changes in land use;

c) description of the effects of alternative land uses or proposed land uses on existing environment; and

d) presentation of the best possible land uses of the existing environment.

Several EIA models are currently being used in impacts prediction and measurement such as checklists, matrices, and networks (Jain, 1977; Canter, 1977; Ward, 1978; NEPC, 1983). The principles and techniques employed in these models could also be applied to impact assessment of particular land uses on the following critical areas:

- swamplands
- shorelands
- floodplains
- prime agricultural lands
- recharge areas of aquifers
- mangrove areas
- coral reefs
- forest areas
- surface waters.

**Carrying capacity assessment**

Models for assessing carrying capacity are currently limited to land resources (FAO, 1978; Higgins, et. al., 1981; Watt, 1973; House and Williams, 1975). An initial attempt to compute the carrying capacity of water resources, however, was done by Don Wilkin of the University of California (Boughey, 1976). Models to determine the carrying capacity of other resource systems such as energy, forest, minerals and space are still undeveloped. Full development of carrying capacity models for all vital resource systems would apparently contribute to the fields of physical/land use planning.

In the Philippines, an assessment of the carrying capacity of land resources to support human populations was undertaken by Cabrido and Limcaoco (1984) using three models, namely: Watt's model, agro-ecological zones (AEZ) and the food balance models. The three models employed yielded three different but related scenarios of the Philippines' future, namely:

a) using Watt's model, the *theoretical maximum* population the country could support in terms of maximum cultivable land areas (i.e., 15 million hectares) for crops and supported by food production from livestock and aquatic resources, is around 500 million. However, there is no assurance that this conjectured high level of food carrying capacity will be able to support and sustain a population of about 500 million. This is simply because other resource systems, particularly energy, water, space, and forest may become limiting or depleted at this population level, thereby significantly impairing the land resource capacity to produce food.

b) using the AEZ model, the population that could be supported by the country's food production capacity at the intermediate and high levels of inputs are 177 million and 262 million, respectively. At low level of inputs, the country will not be able to support its year 2002 projected population of 83 million.

c) using the food balance model, food production at the 1981 level, if maintained, would suffice to meet the demands of the projected population until the year 1991. If, however, our net food supply will remain constant or go below the 1981 level, we would no longer be able to support the population beyond year 1991.

Assessment of the food and population carrying capacity of land resources is an important tool in physical and land use planning for the following reasons:

a) areas where land pressure is already a problem or where it is likely to occur in the future could easily be mapped;

b) shortages and surpluses of staple commodities in every region or province could be projected for better flow/exchange of commodities;

c) planning of infrastructure and other input requirements (such as irrigation system, storage facilities, milling facilities, farm to market roads) of every production area to reach higher potentials could be facilitated; and

d) the best productive use of agricultural lands according to crop mix and input levels could be determined and zoned properly.

The population supporting capacity of land resources actually depends on the productivity of land. The potential productivity of land resources on a sustainable basis in turn depends on several interacting factors, namely:

a) climatic conditions such as temperature, sunshine, rainfall, etc:

b) characteristics of land and soil such as slope, soil type, etc ;

c) kinds of crops grown; and

d) farming practices (input levels and conservation efforts).

There are two basic approaches in assessing the carrying capacity of land. The first approach involves the assessment of crop yield which is a function of the following variables: soil, climate, crop phenology, ecological constraints, and economic inputs. The second approach is the estimation of the carrying capacity of an area which is a function of protein and calorie content of total crop yield, and population consumption/dietary requirements.

## POLICY AGENDA FOR LAND USE PLANNING

Within the context of ecologically-sound land use planning, the following procedures should be made an integral part of the land use planning process:

- determination of the carrying capacity of resources and/or ecosystems in order to calculate their limits or thresholds;
- determination of the compatibility of proposed multiple land uses among themselves and their ecological milieu to avoid incompatible and conflicting land uses;
- determination of the long-term best uses of derelict and potentially derelict areas/sites to usefully recycle these abandoned/idle spaces;
- determination of alternative land uses of declared environmentally critical areas to ensure their long-term sustainability;
- determination of the regional optimum population density in terms of area/volume and resource densities to zone accordingly overpopulated and underpopulated areas;
- determination of the population absorption capacity of upland and hilly areas to plot potential and critical areas.
- determination of best possible land uses of sub-marginal and marginal lands (grassland and brushland) to direct them into more productive uses.

These procedures strategically incorporate into the physical/land use plan the indicative relationships of population, resources and environment.

Let me cite relevant cases stressing the importance of ecological dimensions in land use/physical planning.

*Resource Carrying Capacity.* Energy accounting undertaken by this author revealed that the yield per cropping of one hectare of yellow corn can adequately meet the energy requirements (i.e., based on nutrition standards) of around 2-3 Filipinos for twelve months.[7] When corn is fed to chickens or pigs (i.e., converted to poultry and pork), the equivalent food energy that is produced by the grain feed could sustain one person for approximately four to five months. If otherwise fed to cattle, the beef produced by the grain feed provides only enough equivalent food energy for one person for about two to three months.[8]

These results simply indicate that if corn is consumed directly, it will feed more human populations rather than when it is fed to livestock and subsequently converted to meat. This case exemplifies the fact that the energy carrying capacity of land depends on the particular use of its produce.

*Ecosystem compatibility.* Examples of ecosystem incompatibility are geological formations with poor load-bearing properties vs. heavy industrial installations; active river flood plains vs. housing; and aquifers vs. industrial establishments. Incompatibility between two or more adjacent land uses are exemplified by the following cases: siting of a residential area alongside a major airport or steel works increases exposure to noise levels and air pollution; power stations sited near harbors are likely to increase timber damage and fouling problems; refuse tips or dump sites need to be sited in the region of 30 kilometers away from airports to minimize hazards of bird flight; siting of mine tailings ponds near streams and rivers will result to water pollution downstream.

If incompatible land uses are unavoidable, the existing condition may be ameliorated by the establishment of green belts to serve as buffer zones.

*Uses of Derelict Areas.* Derelict areas such as mine and smelter sites; and mine tailings ponds could possibly be revegetated in the long-term by grasses which have developed a natural tolerance to heavy metals. Thus, these derelict areas may serve as greenbelts and resolve the problem of sediment transport in the lowlands.

Another use for surface mined-out areas is housing subdivision development, that is, if the area is substantially large; or as recreation areas in case of smaller areas. Land uses of other derelict areas such as power plants, dump sites, fuel depots, etc. should be planned accordingly.

*Environmentally Critical Areas.* The President of the Philippines signed Proclamation No. 2146 "Proclaiming Certain Areas and Types of Projects as Environmentally Critical and Within the Scope of the Environmental Impact Statement System Established under Presidential Decree No. 1586." These environmentally critical areas are as follows: all areas declared by law as national parks, watershed reserves, wildlife preserves and sanctuaries; areas set aside as aesthetic potential tourist spots; areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna); areas of unique, historic, archeological, or scientific interests; areas which are traditionally occupied by cultural communities or tribes; areas frequently visited and/or hard hit by natural calamities; areas with critical slopes; areas classified as prime agricultural lands; recharged areas of aquifers; water bodies; mangrove areas; and coral reefs.

The alternative land uses of these environmentally critical areas could be soundly established through the conduct of environmental impact assessments (EIA). Improper use of these areas could result to their long-term despoilation. For example, erosion of fertile top soil in a critical slope caused by improper land use could take place within a year, and yet one inch of such soil is normally formed in 200-300 years. Destruction of the coral reef or mangrove areas due to unsuitable land uses will significantly diminish the yield of fisheries in the area for some period of time. Recolonization of damaged coral reefs to a fair condition may take at least 30 years.

*Regional Optimum Population Density.* It is inadequate to use population density as the sole basis for determining optimum population. The distribution, size and growth rates of population relative to resources should also be taken into account. Overpopulation or underpopulation should be gauged by population density vis-a-vis resource density indices, including rates of exploitation vs. rates of regeneration. For example, resource-rich regions could support a larger population as compared to less endowed regions. Similarly, certain types of ecosystems such as the lowlands (croplands) could adequately support more population rather than the submarginal hilly lands. Thus, the distribution patterns of population should be properly planned. Areas should be zoned according to the optimum population that could be sustained by its resources.

Ehrlich and Ehrlich (1970) theorized that an area must be considered overpopulated if its non-renewable resources are rapidly being consumed, and the activities of the population are leading to a steady deterioration of the environment. There is some logic to this statement, but one does not entirely agree to it. In many cases, depletion of non-renewable resources and environmental deterioration are caused not by the existing population but rather by activities undertaken by entities commissioned by foreign firms whose land use extends to our soil.

It is more safe to assume that although optimum population determination depends on the resource capacity of an area, it is shaped by socio-economic, technological and institutional factors.

*Long-term development of upland areas.* Population pressure in the lowlands has driven many poor and landless families to the hilly and upland areas. These families occupying mostly forest lands resorted to shifting cultivation as their source of livelihood, food, or survival in general. As the population of shifting cultivators or kaingineros grew,[9] land pressure also grew. From the ten-year fallow period practiced before, it was now shortened to as little as three to four years (Conway and Romm, 1973). Because of this, the succession pattern of plant vegetation was greatly disrupted.[10] Instead of allowing secondary forest to naturally evolve and grow during the fallow period, grass vegetation (Imperata) took over because of poor environmental conditions.[11]

With the government's plan "to open more lands for production by reclassifying all lands for their most economic use, including lands classified by existing law as forest; and to extend priority in granting leases and similar dispositions to those lands whose gradients exceed 18 percent and which, as indicated in the Forestry Code and related laws, could be occupied and developed for a reasonable number of years," the absorption capacity of upland areas should be carefully studied for long-term land use/physical planning purposes. This will lead to the identification and zoning of critical and potential areas.

*Uses of marginal lands.* A large portion of the upland areas are considered in the marginal state. Marginal lands are areas once covered with tropical moist forest but now converted to grassland and brushland (Haribon Society, 1983). These lands are characteristically low in fertility and unable to support extensive lowland type of agriculture.

Research on the natural ecological processes of regeneration of marginal areas could serve as an important input in the plan to direct these lands into more productive uses. The appropriate cropping systems and resource-conserving technologies should likewise be identified in the planning for the rehabilitation of marginal lands and their future uses.

## CONCLUSION

The systems approach to land use planning has shown the key points and methods of integrating and melding ecological dimensions with socio-economic and cultural considerations. The two most important ecological dimensions in land use/physical planning, namely: resource carrying capacity and ecosystem compatibility, were discussed. These ecological determinants help in firming up the long-term viability of the land use plan by projecting its potentials and limitations as well as in identifying the proper mix of alternatives. It is, therefore, suggested that these ecological dimensions should be integrated and made standard part of the regular land use planning system.

The major challenge now confronting the National Land Use Committee is the institutionalization of the inter-agency collaborative mechanism to implement a systematic land use/physical planning process. Furthermore, validation of existing land use plans and evaluation of proposed plans require immediate attention to avoid perpetuation and compounding of minor or gross errors. There is a great danger that these errors could be magnified in the preparation of a long-term physical/land use plan.

Meanwhile, the most important and urgent task for the concerned government authorities to perform is the proper enforcement of land use and related legislations. The most pressing problem confronting us now in relation to land use is urban encroachment into prime agricultural lands. This process of urban sprawl is ecologically irretrievable or irreversible and may eventually become more debilitating in the future.

Lastly, physical and land use planning should be done periodically, perhaps every eight to 10 years. This iterative exercise is imperative for the plan to cope with the dynamic changes in the ecological, social, economic, cultural and political environments.

## NOTES

[1]Paper presented at the "Colloquium on Perspectives for National Physical Planning" sponsored by the Population/Development Planning and Research Project of NEDA-Economic Planning and Research Staff and the NEDA-Regional Development Staff held at Tagaytay City on May 30 June 1, 1985.

[2]Ecosystem as defined by Odum (1971) is any unit that includes all of the organisms (i.e., the community) in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles within the system. Examples of ecosystems are forest, grassland, beach, freshwater, marine, cropland, etc.

[3]Life-support systems include the ecological processes such as biogeochemical cycles, energy circuits, diversity patterns, food chains, and ecological control.

[4]Ecological disasters or catastrophes include drought, flooding, landslides/mudslides, accelerated erosion of topsoil, pests and diseases.

[5]Carrying capacity may be defined as the asymptote at which logistic growth of a population stabilizes (Boughey, 1976; Odum, 1971; Meadows, 1972).

[6]EIA includes identification, interpretation,

prediction, and mitigation of impacts caused by a proposed action or project including changes in land use.

[7]Assuming that corn yield per hectare is 920 kgs and one person requires a food energy of 2,036 kilocalories per day.

[8]When corn is fed to livestock, there are energy losses in such forms as material wasted or not digested by the livestock, respiration by the animals, and processing waste in the slaughter house and home kitchen.

[9]An estimated number of around five million Filipinos live in uplands (Saplaco, 1982). Some 9.4 million hectares representing about 31 percent of the country's total land area may be considered as uplands.

[10]It takes about 10 years to restore the fertility of the land to its pre-cultivation level (Conway and Romm, 1973).

[11]Cultivation of sloping lands in short intervals (i.e., less than three years) causes soil fertility exhaustion and eventually, soil erosion.

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