Journal of Philippine Development
Number 47, Volume XXVI, No. 1, First Semester 1999

INTEGRATED LAND USE PLANNING AND SUSTAINABLE WATERSHED MANAGEMENT

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The main purpose of this paper is to discuss the key issues and concerns regarding sustainable watershed management in the Philippines. Emphasis will be on the various requisites of sustainable watershed management, sharply focusing on the critical roles of land use planning.

It is expected that the ensuing discussion can lead to a better understanding of the topics discussed and contribute to an improved operationalization of a truly sustainable watershed management in the country.

BASIC CONCEPTS IN WATERSHED MANAGEMENT

In order to achieve a common understanding of what watershed management is all about, it is necessary to define some key terms and discuss several relevant concepts.

What is a watershed? Why is it important?

- A watershed or catchment or basin or drainage area refers to any topographically delineated area that can collect water and is drained by a river system with an outlet (Brooks, et al., 1981). It includes all land areas extending from the ridge down to the stream for which water is collected (Figure 1).
- Watershed is not necessarily an upland or a mountainous land form. There is an upland watershed, a lowland watershed, an

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Figure 1. A typical upland watershed.

agricultural watershed, a forested watershed and an urban watershed.

- Watershed is a terrestrial ecosystem consisting of intricately interacting biotic and abiotic components (Figure 2).
- Watersheds contain, aside from land and water, many other valuable resources such as plants, animals and minerals. It is a functional and integrated system capable of producing/ providing water, timber and non-timber products including food, fiber, medicine and many intangible goods such as aesthetics and wholesome environment with solar radiation, precipitation, land, labor and capital as major inputs.
- It is a major site for residential, commercial, industrial, agricultural, educational, experimental, environmental, and forest land uses. Many of these uses are often conflicting and competing with each other for the limited watershed land resource.
- It is a major source of nutrients and pollutants, which are deposited in lakes, coastal areas and rivers.

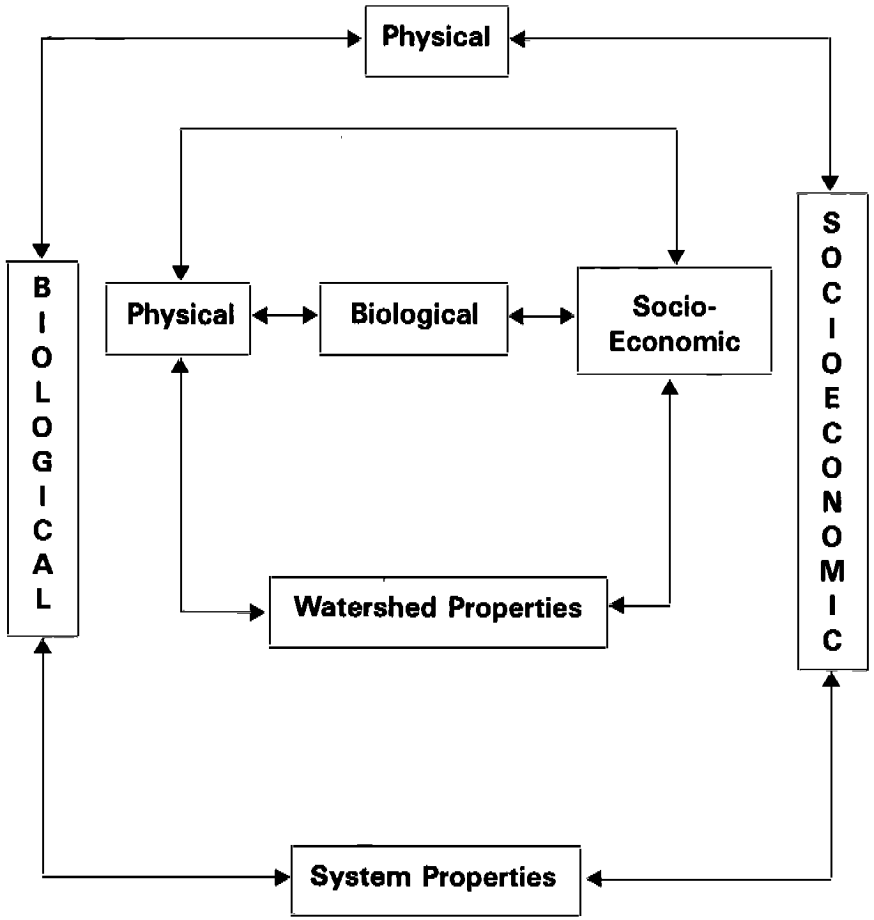

Figure 2. Schematic representation of a watershed system.

What is watershed management?

Watershed management is defined as the process of guiding and organizing land and other resource uses in a watershed to provide desired goods and services without adversely affecting soil and water resources (Brooks, et al, 1991). It is also defined as the application of business methods and technical principles to the manipulation and control of watershed resources to achieve a desired set of objectives such as maximum supply of usable water, minimization of soil erosion and siltation problems, and reduction of flood and drought occurrences (Clawson, 1970; and Satterlund, 1978).

What are the basic objectives of watershed management?

The general objective of watershed management is the sustainable production of goods and services demanded by society without adversely affecting the sustainability of soil and water resources. Specifically, most watershed management activities are directed towards the following:

1. Streamflow regulations for adequate quantity, quality and favorable flow patterns;
2. Conservation of the soil resources for long-term productivity;
3. Enhancement of infiltration capacity of the soil;
4. Soil erosion minimization;
5. Optimum production of various combinations of goods and services;
6. Eradication of the pervasive poverty in the uplands; and
7. Environmental stabilization (climate change mitigation).

What are some examples of watershed management strategies?

- Protection strategies, which include all activities geared to protect the watershed from the forces of denudation such as illegal logging, fire, encroachment, pests and diseases. These also include such programs as the (National Integrated Protected Areas System) NIPAS.
- Conservation strategies include all programs and activities designed to sustain the long-term productivity of all watershed resources (e.g., water, timber and soil). The Integrated Social Forestry Program (ISFP) and Community-Based Forest Manage-ment (CBFM) are some of the strategies for conservation.
- Development strategies, which include soil erosion control, land use planning, reforestation, infrastructure development and all other activities related to the rehabilitation and improvement of the existing condition of watershed resources.

CURRENT STATE OF WATERSHED MANAGEMENT IN THE PHILIPPINES: ISSUES AND CONCERNS

Many of our watersheds today suffer from severe soil erosion, erratic streamflow, diminishing groundwater resource, and declining land productivity. These are the immediate impacts of past and present human activities such as logging, cultivation, land conversion, grazing, and mining. To achieve sustainability, management of watersheds will

have to devise ways of minimizing, if not completely getting rid of, the adverse impacts of human activities inside and around the watersheds. In addition, it will be necessary to address the following issues and concerns:

- **Deforestation continues to threaten the remaining forest cover.**

  Between 1981–90, the rates of annual deforestation in Continental Southeast Asia (Cambodia, Laos, Myanmar, Thailand and Vietnam) and in Insular Southeast Asia (Brunei, Indonesia, Malaysia, Philippines and Singapore) were estimated at 1.314 M ha and 1.926 M ha, respectively (FAO, 1993). At these rates of deforestation, the remaining forests in Southeast Asia could be gone by the year 2055, and could stamp a big question mark on the sustainability of forest resources in the region.

  In the Philippines, only about 5.6 M ha (or 35%) of our 15.9 M ha of forestlands remain covered with forests. This represents merely 19% of the total land area of the country that is equivalent to per capita forests of less than 0.1 ha. Without appropriate interventions, extreme timber resource crisis and environmental disasters, which are beginning to be felt now, loom perilously ahead in the horizon. The more common causes of deforestation are: logging, indiscriminate conversion of forest lands to non-forest land uses and upland cultivation.

- **Increasing population in the upland can spell disaster or success.**

  Common to many countries in the region is the growing presence of population inside the forests. In the Philippines alone, at least 18.5 million people live in the uplands. This is about 1/3 of the country's population that largely depends on the forests for their daily subsistence. Undoubtedly, our ability to harness the potential of these people to become friendly and competent partners in forest management is a vital key to achieving sustainability.

- **Heightened awareness of the general public in environmental protection broadens the base of watershed stakeholders.**

  Unlike before, there is now so much interest in watershed management across the major sectors of the society. While public awareness is yet to reach the ideal level, many people now want to get involved in watershed management. Considering the mundane magnitude of watershed management, this show of interest beyond the traditional territory of forestry is a much welcome development.

- **High biodiversity conservation value of tropical forests.**

  The tropical forests of Southeast Asia account for 10% of the

global biodiversity. These diverse communities of plants and animals are eroded with deforestation and other disruptive human activities that result to the permanent loss of many species of high socio-economic and ecological values.

- **Absence of appropriate watershed resources valuation systems.**

  Improper valuation of watershed resources results to inefficient and degenerative extraction of resources. It promotes the excessive use of high value products and the low utilization of residues and low-value crops. Together with the absence of comprehensive land use plans, improper valuation tends to promote inadequate evaluation of resource use options.

- **Absence of land use and management plans.**

  Many watersheds in the country continue to be without any deliberate land use and management plans. This has caused disarray in the use of limited land and other resources in the watersheds that resulted to inefficiency and instability

- **Climate change will bring more changes.**

  Land use largely influences the direction of watershed management. However, the impacts of climate change can magnify the already disastrous effects of land use and other human activities.

- **Emerging trends to globalize forest management.**

  In recognition of the global economic and environmental values of the forests, forest management has been the subject of many international conventions and inter-governmental negotiations. As a result, several agreements have been forged that will significantly affect the forest management modes of many countries.

- **Absence of adequate database and body of scientific information.**

  There is a definite absence of a reliable database and scientific information that are essential in the preparation of management plans, in policy making process, and in technology development and application.

- **Existing political and institutional environment is not adequately supportive of watershed management.**

SUSTAINABLE WATERSHED MANAGEMENT

Sustainable watershed management can be defined as a system of managing watershed resources that yields adequate and continuous flow of goods and services to meet the needs of the present and future generations. The elements of sustainable watershed management is

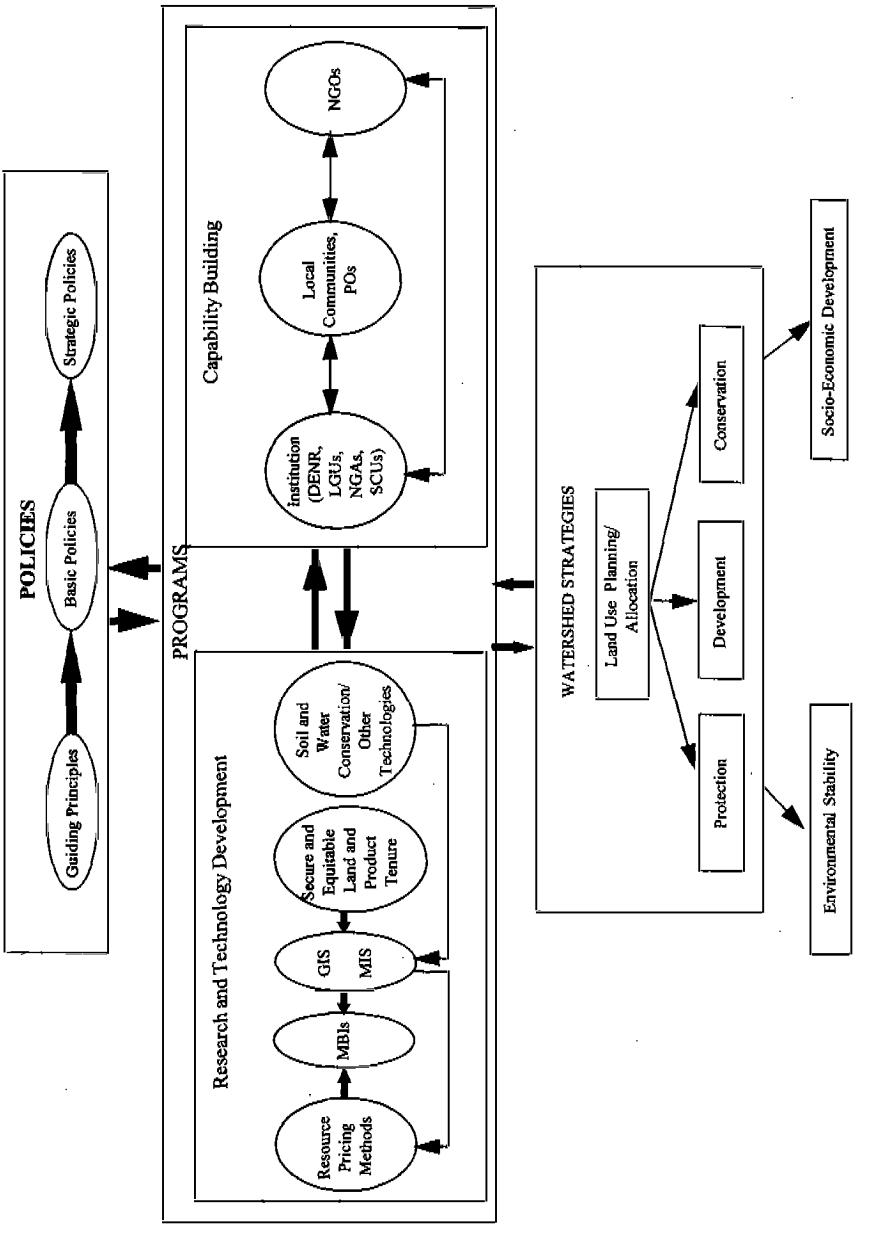

Figure 3. Elements of sustainable watershed resources management

shown in Figure 3. Generally, these include basic and strategic policies; research/technology development and capability building programs and protection, development and concentration strategies, all indispensable to sustainability of watershed resources. Specifically, some of the more critical elements in recent times are discussed below.

Guiding Principles

There are three major principles necessary for sustainable forest management. These are:

Holistic and balanced framework

Watershed is an ecosystem. It has numerous physical, biological, and social components that are intricately related to one another. Its properties and behaviors are the products of the interactions between its components as influenced by other systems and factors around it. It is largely affected by human activities and climate. In return, its properties and behaviors affect human activities and climate. It is a complex natural system, which easily responds to the alteration of any of its components. To manage it sustainably, it is, therefore, essential to treat all components with equal importance.

Watershed has many uses. It is ecologically, environmentally, and socio-economically important, being intimately attached to climate and socio-economic systems.

The watershed, specifically the forests, assumes vital roles in maintaining ecological stability. Specifically, the forests play major functions in cycling nutrients, minerals, energy and water. They affect the delicate balances of important gases and substances such as nitrogen, oxygen and carbon dioxide.

The forests, especially the tropical forests, are home to countless plant and animal species including those that are yet to be discovered. The forests also act as a protective cushion against natural calamities such as typhoons, droughts, and floods. Socio-economically, the forests are major sources and in many instances, exclusive sources of numerous raw materials for food, medicine, cosmetics, and lumber manufacturing. Millions of people depend on the forests for their livelihood. In the Philippines, more than 9 million are estimated to inhabit the forest lands, many of whom subsist through upland farming and collection of forest products.

The forest-based industry continues to generate employment opportunities for millions of people despite the declining rate of forest

harvesting. Irrigation of millions of hectares of agricultural lands also relies on the forest lands for the uninterrupted supply of water.

The sustainability of watershed resources will, therefore, heavily rely on a system of utilization that is able to seek and maintain a desirable dynamic balance between economic and environmental uses of the watershed.

Equitability and participatory

Watershed is a common property with many stakeholders. The benefits derived from the watersheds should be equitably shared among all stakeholders who are willing to participate and invest in the management of watershed resources. Some of the major watershed stakeholders include the state, the forest communities, the local government units, water users and the forest-based industry sector. While equitable sharing should be commensurate to one's investments, it should also be adequate enough to encourage sustainable participation. This is particularly important for forest communities which usually do not have enough resources to invest in sustainable forestry in order to generate benefits sufficient for their needs.

Sustainable participation of major stakeholders is essential due to the complex nature of watershed ecosystem and the magnitude of tasks needed to be performed. The path to sustainability of watershed resources is replete with roadblocks that will become less formidable only with the concerted efforts of stakeholders.

Efficiency and effectiveness

Enormous financial resources are usually associated with watershed management. For so many years, money has always been a constraint. To augment inadequate internal funds, we either seek the aid of donor agencies or borrow from lending institutions. This dependency on external funds, as gauged from our experiences, does not usually produce desirable results as resources are oftentimes spent on projects that are usually donor-driven and not necessarily on what is required to address a particular need.

It is, therefore, important that needs are properly identified and prioritized within the context of a sound management plan so that whatever money is available can be spent on projects that are truly worthwhile and can most effectively address the prioritized needs.

It is also important to ensure that land, water, timber and other watershed resources are allocated and used efficiently, that is,

environmental and economic benefits derived from resource use are maximized and the associated costs minimized. Hence, it is necessary that all watershed resources are properly accounted for and appropriately priced.

Adequate and Coherent Policies

Sustainable watershed management requires that adequate policies must be set in place. The policies must embody the guiding principles discussed above and must be consistent with the overall objectives of sustainable watershed management. It should facilitate the operationalization of a holistic and balanced approach to watershed management. It should also promote equitable sharing of forest benefits and the maximum participation of major watershed stakeholders in the management of watershed. Policies should, in addition, provide for efficiency and effectiveness in watershed management.

Some of the more important basic policies in sustainable watershed management are as follows:

Integrated land use planning

Land use planning is an important key to the sustainability of our forest and other natural resources. It is essential in the optimum use of scarce land resources for various environmental protection and forest production purposes. It is instrumental in harmonizing and meeting the usually competing demands for land and other watershed resources. Through land use planning, the examination of the different alternative land uses can be made in order to screen out those alternatives which are incompatible with the sustainability of forest resources.

In effect, land use planning is a process that enables us to see the different biophysical and socioeconomic impacts of various land use options. This information is important in deciding whether to reject or choose to implement a particular land use as evaluated or modified according to prescriptions that will either enhance positive impacts or minimize the negative consequences of that option.

In the end, land use planning for watershed should be able to delineate where the two major land uses (i.e., the protection and production uses) are. It should also be able to identify what particular uses are most suitable under each major land uses. In its final form when the most suitable land use options are properly delineated on a map, the land use plan can serve as a guide in determining what can

and cannot be done in an area with little or no problem with overlaps and conflicts between two or more uses.

Figure 4 shows a conceptual framework for watershed land use planning. It consists of several phases of activities that are described below.

a. Watershed characterization

Watershed characterization is a process of describing the watershed and establishing a database that is essential to the understanding of, and control over, the various biophysical and socioeconomic processes in a watershed. Adequate knowledge on the characteristics of a watershed is immensely helpful in the prediction of behavioral responses of watersheds to diverse environmental conditions and management activities. Similarly, watershed characterization provides the information needed in the identification design, development, evaluation and selection of watershed management strategies.

Some of the activities in watershed characterization include:

- delineation of watershed boundaries from the largest to the smallest units;
- identification of key actors in the planning team;
- enumeration and measurement of plants and animals in the watersheds;
- climatic, hydrologic, edaphic, geomorphic and socio-economic characterization; and
- land capability evaluation and classification.

Land capability classification generally refers to any attempt to subdivide land areas into homogenous groups possessing distinct biophysical properties. Revilla (1979) defined it as the description of a landscape unit on the bases of its inherent capacity to sustain a desirable combination of plants and animals. It is a process crucial to the success of identifying the different uses suitable to a given area. Its usefulness extends to the maintenance of the long term productivity of land resources.

The USDA Soil Conservation Service land capability classification guide is perhaps, the most popular system in existence (Klingebiel and Montgomery, 1961; and Brakensiek et al., 1979). It is based primarily on agronomic land uses and is qualitative in nature.

In the Philippines, a land capability classification guide (LCCG) was developed by the Bureau of Soils in 1976 (PCARR, 1978). Like the USDA system, this classification guide is qualitative in nature. Except

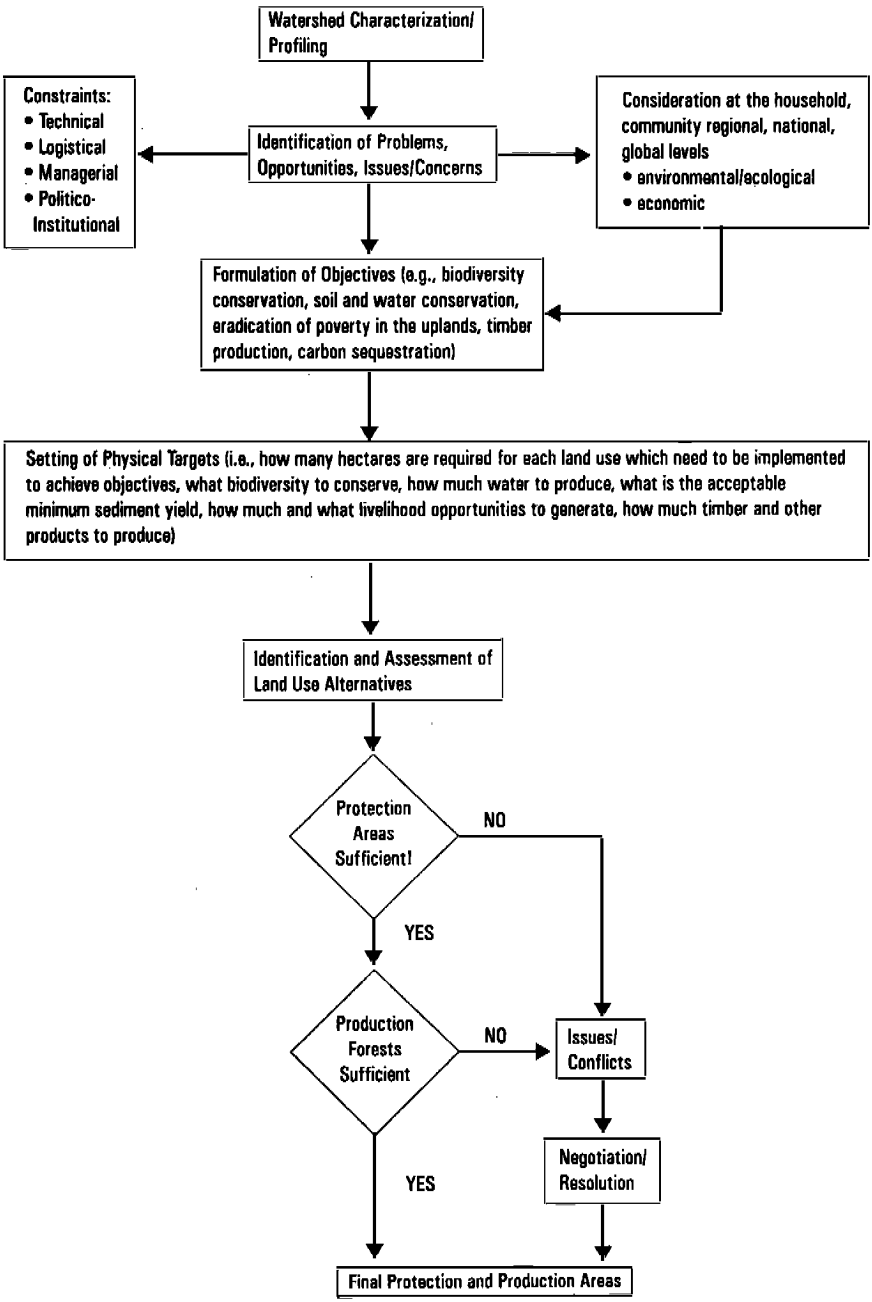

Figure 4. Conceptual framework for watershed-based forest land use planning (Cruz, 1996)

for slope and soil depth, all the other bases for land classification are qualitative descriptions of the physical and biological attributes of a landscape unit.

In spite of the availability of such guide, forest lands in the Philippines continue to be set apart from non-forest lands on the basis of slope alone. By law, lands with slope greater than 18% are classified as forest lands, and those with slope below 18% are considered alienable and disposable.

The main drawback of this slope-based system is the inadequate representation of the important biophysical features determining the productivity and sustainability of an area. The ever-growing problems of soil erosion and flooding, even on non-forest lands, and the continued stability of some agricultural systems on sloping lands like the rice terraces in the rugged mountains of northern Philippines, indicate that slope alone does not explain sustainability.

In the U.S., recently developed methods to classify forest lands were presented by Smalley (1979 and 1984). He described a system based on a combination of landforms and topography, factors considered to be important in rugged terrain. According to this system, landscape is stratified on hierarchical significance of physiography, geology, soils, topography, and vegetation.

Larson, *et al.* (1988) developed a land classification system for marginal agricultural lands of Minnesota. The system is based on soil productivity (PI) and erosion resistivity (RI) indices. These indices are used to categorize land parcels into one of four classes: nonresistant to erosion with productive soil, resistant to erosion with productive soil, nonresistant to erosion with nonproductive soil, and resistant to erosion with nonproductive soil. The PI is evaluated on the bases of available water capacity, bulk density, and pH in the uppermost 100 cm of the soil. The RI is defined as the soil loss that can occur in a short time unless some measures are taken to minimize soil erosion.

Warren, *et al.* (1989) developed an erosion-based land classification system for military installations. In this procedure, the USLE was linked to a GIS known as GRASS (Geographical Resources Analysis Support System) to generate a classification of lands based on erosion status and erosion index. Erosion status is estimated as the ratio of USLE to soil loss tolerance. Soil loss tolerance represents the amount of annual soil erosion that can be sustained by an area without reducing its long term productivity. Generally, soil tolerance values range from 2.2 to 11.2 t/ha, depending upon the locally intrinsic soil formation rates and soil depth.

The design and components of watershed characterization may vary and are determined largely by the objectives of watershed management (i.e. objectives of the end users), available funds, expertise, and the characteristics of watershed. Whatever the characterization design and components are, there are several basic phases in watershed characterization, namely:

1. data need identification and prioritization;
2. data acquisition;
3. mapping of geographic data; and
4. data organization, analysis or processing and storage.

b. Identification of problems, opportunities, constraints and considerations

The database generated in the watershed characterization phase can yield, in its raw or processed format, vital information which will set the direction of the rest of the planning process. It is at this stage that identification of problems and opportunities, constraints and other important considerations are made.

The problems may range from biological to physical to socioeconomic in nature. It may be severe soil erosion, floods, droughts, forest destruction, or water supply shortage. On the positive side, opportunities for development such as good forest cover, good soil, organized forest communities and adequate social services should also be identified to serve as foci of development.

Constraints relevant to land use planning may include technical, financial, political, institutional, social and economic limitations. Proper identification of constraints will minimize setting goals that are unrealistic and unattainable.

At this phase, it is also important to identify key considerations at the household, community, municipal, provincial, regional, national and global levels. For example in a watershed that is a major source of timber, it will be useful for planners to know how much timber is demanded and supplied at the household up to the highest stratum of timber product consumers.

c. Formulation of objectives

All the information from the previous stages can be utilized in the formulation of objectives for the management of a particular watershed. These objectives may include:

- watershed rehabilitation,

- soil and water conservation,
- biodiversity conservation,
- carbon sequestration,
- eradication of poverty among forest communities,
- timber production, and· improvement of water supply.

d. Setting of physical targets

Once the objectives are firmed up and validated, it will have to be translated into number of hectares that must be dedicated to each particular land use option so that the objectives can be realized. These serve as the physical targets for determining how much land can actually be identified as suitable and available for a specific use.

To be able to do this, several other physical targets will need to be set. These are:

- what biodiversity to conserve,
- how much water to produce,
- what is the acceptable maximum soil erosion rate,
- how much and what livelihood opportunities to generate,
- how much timber to produce, and
- how much non-timber products to produce.

e. Identification and assessment of potential land uses

This phase will attempt to establish the suitability of each land use option by matching the site requirements of land use alternatives with the site quality, putting emphasis on the capability of the land to support such uses. The projection and assessment of the positive and negative impacts of the various options are also performed in this phase. The options that are able to achieve the most physical targets within the limits imposed by the existing constraints are deemed most suitable.

f. Selection of land uses

The final combination of forest land uses will depend on the negotiations and resolution of potential conflicts that may arise when one or more particular targets or sectoral interests are not satisfactorily addressed in the planning process. This is where the participatory nature of land use planning process becomes critical so that no legitimate stakeholder can claim that he/she was not adequately considered in the planning exercise.

In the negotiation process, land use options can still undergo modifications until these options are transformed into more sustainable

uses that can pass through the selection process. It is also possible that a number of iterations of the various phases discussed above can be made before the final land uses are selected. This suggests that forest land use planning process is also iterative in nature. Before the land uses are chosen, one or more phases of the planning process can be repeated a number of times until the desired results are generated within the context of prevailing and projected planning environment. This further implies that the final land uses yielded by the planning process are really never final. It should be anticipated that these land uses will have to continue to change through time as the biophysical and socio-economic environment change. In this respect, monitoring and evaluation will be indispensable.

Promotion of equity in forest management through community-based approach

Over the last few years, community-based approach has been revolutionizing forest management all over the Philippines like it has never done before. It is slowly displacing the traditional corporate approach to forest management. The corporate approach was responsible for raking in revenues in billions of dollars that enriched only a few but failed to uplift a large majority of forest communities from poverty.

Community-based forest management (CBFM) is a strategy to make forest-dependent communities more self-reliant, self-sufficient, progressive and effective managers rather than spoilers of forest resources. It is based on the premise that if they receive adequate forest benefits to meet their needs for a decent lifestyle, these communities will sustainably manage the forest resources because of their secure stake on it.

Currently in the Philippines, around 2.9 M ha of forest lands are under various forms of CBFM. It is the ultimate goal of the government to place about 9.0 M ha of our forest lands under CBFM by year 2008. To get there, the following issues and concerns need to be addressed:

- Appropriate tenurial instruments for land and resources use,
- Development of guidelines for resource utilization within CBFM areas,
- Provision of adequate financial and technical assistance to communities,
- Provision of adequate incentives for planting more permanent tree crops,

- Provision of more opportunities for viable non-forest based alternative livelihoods,
- Reorganizing existing forest management structure and institutions to become compatible with CBFM thrusts,
- Provide opportunities for continued participation of the private sector in forest management such as through joint and cooperative ventures with communities, and
- Recognition and enhancement of the capability of local government units in providing technical, managerial and financial assistance to CBFM communities and in implementing other similar projects on their own or in cooperation with forest communities, private sectors and other interested parties.

Rehabilitation of denuded forest lands

To achieve sustainability of watershed resources, the millions of hectares of forests waylaid by past activities need to be rehabilitated. This will augment the current stock of timber resources and, at the same time, help mitigate the adverse impacts of deforestation. It will help control floods and droughts and minimize soil erosion, improve hydrology and mitigate climate change due to global warming. The task however is not easy. To succeed in this gigantic task of reforesting millions of hectares of denuded lands, a seriously calculated reforestation program should consider the following issues and concerns:

- ***There should be a good species-site mix.*** This requires adequate site characterization to assess site quality that can be used to determine the most suitable species to plant. A systematic regional site characterization scheme has to be developed that is consistent with the watershed management plan. This will serve to guide a more site-specific assessment that is essential in having a wider variety of species for planting.
- ***Minimal use of exotics in favor of indigenous species.*** The potentials of indigenous species need to be explored and exploited to the maximum owing to their intrinsic resistance to pests and diseases and high biodiversity conservation value.
- ***Quality planting materials should be made available to improve chances for successful reforestation.*** Many past reforestation projects in the Philippines failed due largely to the poor quality of seeds and seedlings used for planting. There is a need to develop

sources of genetically superior seeds that can be used to grow genotypically superior seedlings essential to successful plantation establishment. In the Philippines, several seed production areas (SPA) have been established to produce quality seeds. Over the long term, seed orchards of identified priority reforestation species should be established with bias on indigenous species.

Planting stock quality assessment procedures should also be set in place in order to insure that only seedlings that meet the minimum quality standards are planted.

- ***Adequate funds must be allocated for seed production, and maintenance and protection of plantation.*** Successful reforest-ation should always be gauged in terms of plantation successfully established and not merely by the hectarage planted. Hence, maintenance and protection should be given emphasis until the plants are big enough to withstand adverse environmental conditions with minimum care.

LOW IMPACT BUT EFFICIENT WATERSHED RESOURCES HARVESTING AND UTILIZATION

This will entail not only the use of environmentally benign harvesting systems but also the maximization of the use of harvesting residues previously considered as waste materials. It will also involve maximum utilization of lesser-used resources so as to alleviate the excessive pressure on commonly exploited timber and non-timber resources. To facilitate the above measures, the following are essential:

- Market development and marketing studies to make the utilization of waste materials and other lesser-used resources attractive and economically viable.
- Harvesting, utilization and product development studies that will explore all possible uses and the associated technologies to make the above measures technically viable.
- Continuing research and human resources development

To cope with the demands of sustainable forest management, it is important for the research sector to promptly generate the required empirical data, technologies and tools.

The following are some of the more important areas of research, which must be given enough focus:

- Community-based resource utilization and marketing,

- Genetic conservation and tree improvement, forest ecophysio-logy *vis-à-vis* changing climate and CO_2 concentrations in the atmosphere,
- Watershed hydrology and land use/vegetation interactions,
- Watershed resources pricing, and
- Biodiversity and forest management.

It is also necessary to continue on producing properly trained manpower that is not only technically competent but also morally responsible for achieving the goals of sustainable forest management.

Formal and informal forestry and environmental education must continue to adapt to the emerging local and global issues to be relevant and supportive to sustainable forest management.

REFERENCES

ASEAN-US Watershed Project. 1988. Abstracts of Watershed Management Research and related Studies in the ASEAN Region. Vol. 1 & 2, S. R. Saplaco and E.M. Baltazar (eds). ASEAN-US Watershed Project. College, Laguna, Philippines.

Brakensiek, D.L.; H.B. Osborn and W.J. Rawls. 1979. Field Manual for Research in Agricultural Hydrology. Science and Education Administration, USDA. Washington D.C.

Brooks, K.N.; P.F. Ffolliott; H.M. Gregersen and K.W. Easter. 1994. Policies for Sustainable Development: The Role of Watershed Management. RPAT/MUCIA Policy Brief. No. 6 August 1994.

Brooks, K.N.; P.F. Ffolliott; H.M. Gregersen and J.L. Thames. 1991. Hydrology and the Management of Watersheds. Iowa State University Press, Ames, Iowa.

Brown S.; J. Sathaye; M.G.R. Cannell and P. Kauppi. 1996. Management of Forests for Mitigation of Greenhouse Gas Emissions. (In: Climate Change. 1995. Prepared by Working Group II for the Second Assessment Report of the Intergovernmental Panel on Climate Change. R. T. Watson; M.C. Zinyowera and R.H. Moss, [eds.]). Cambridge University Press, New York.

Carandang, W.M. and R.D. Lasco. 1997. Successful Reforestation in the Philippines: Technical Considerations. Unpublished policy paper presented at the Seminar on Mega Issues in Forestry: Key Policies and Programs. Forestry Development Center, UPLB College of Forestry and National Academy of Science and Technology, PCED, University of the Philippines, Diliman, Quezon City. February 27, 1997.

Cruz, R.V.O. 1995. Watershed Approach to Sustainable Forest Management. Second Guillermo Ponce Professorial Chair Lecture in Forestry. Delivered on February 27, 1995, Forestry Development Center, College of Forestry, University of the Philippines Los Baños.

_____ . 1991. Biophysical Characterization of Critical Watersheds. In: Proceedings of the First National Symposium and Workshop on the Management of Critical Watersheds in the Philippines. April 1991. HARRDEC. Baguio City, Philippines.

_____ . 1990. Landuse Suitability Assessment and Land Capability Classification in Ibulao Watershed, Philippines, Ph.D. Dissertation

in Watershed Management. University of Arizona, Tucson, Arizona, U.S.A.

_____ . 1984. Watershed Characterization: Modeling and Other Computer-oriented Approaches. Proc. Workshop on Standardization of Guidelines for Watershed Management Approaches and Researches in the ASEAN Region. Nov. 21–30, 1984, Chiang Mai, Thailand. ASEAN US Watershed Project. College, Laguna, Philippines.

DENR. 1997. Guidebook on Sustainable Forest Land Use Planning and Management. IEMSD-DENR, Quezon City, Philippines.

_____ . 1992. Philippine Forestry Statistics. Department of Environment and Natural Resources. Diliman, Quezon City.

_____ . 1990. Master Plan for Forestry Development. Department of Environment and Natural Resources, Asian Development Bank. Philippines.

Driscoll, R.S.; V.F. Basa and M.C. Caisip. 1987. Forestland Evaluation for Integrated Land Use Planning. A Procedural Manual for the Philippine Dept. of Natural Resources and UN FAO, Philippines.

Dixon, R.K. ; S. Brown; R.A. Houghton; A.M. Solomon; M.C. Trexler and J. Wisniewski. 1994. Carbon Pools and Flux of Global Forest Ecosystems. Science, 263:185–190.

Eren, T. 1977. The Integrated Watershed Approach for Development Project Formulation. Guidelines for watershed management. FAO Conservation Guide No. ___ p. 9-14.

FAO. 1993. Forest Resources Assessment 1990: Global Synthesis. FAO 124. Food and Agriculture Organization. Rome.

_____ . 1990. Forest Resources Assessment: Tropical Countries. Food and Agriculture Organization. Rome.

Fellizar, F. P., Jr. 1989. Watershed as a Unit for Integrated Resource Management. Paper presented during the FDC Policy Seminar. UPLB College of Forestry, College, Laguna.

FMB-DENR. 1996. 1995 Philippine Forestry Statistics. Department of Environment and Natural Resources-Forest Management Bureau. Philippines.

Fernando, E.S. 1997. Vegetation in the Philippine Islands. Unpublished paper/personal communication. 20 pp.

Gash, J.H.C. and W.J. Shuttleworth. 1991. Tropical Deforestation: Albedo and the Surface-energy Balance. Climate Change, 19:123-133.

Klingebiel, A.A. and P.H. Montgomery. 1961. Land Capability Classification. USDA Agricultural Handbook 210.

Kirschbaum, M. U. F.; A. Fischlin; M.G.R. Cannell; R.V.O. Cruz; W. Galinski and W.P. Cramer. 1996. Climate Change Impacts on Forests. (In Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis. R. T. Watson; M.C. Zinyowera and R.H. Moss, eds.). Inter-governmental Panel on Climate Change, WMO-UNEP. Cambridge University Press. New York.

Larson, G.A., G. Roloff and W.E. Larson. 1988. A New Approach to Marginal Agricultural Land Classification. Jo. of Soil and Water Conservation. 43:103–106.

NACIAD. 1983. Integrated Environmental Program: Final Report. Vol. 1: The Environmental Plan. Palawan Integrated Area Development Project, NACIAD.

_____ . 1990. Appraisal of the 2nd Palawan Integrated Area Development Project.

NWRC. 1983. Framework Plan: Northern Mindanao (Agusan Basins). Report No. 24–10A. National Water Resource Council.

_____ . 1983. Framework Plan: Western Mindanao (Pulangi River Basins). Report No. 24–12A. National Water Resource Council.

PAWB-DENR. 1992. NIPAS ACT and Implementing Rules and Regulations. National Integrated Protected Area System. Parks and Wildlife Bureau, Department of Environment and Natural Resources, Quezon City, Philippines.

PCARR. 1978. Proceedings of the National Seminar-Workshop on Soil Conservation. Philippine Council for Agriculture and Resources Research, Los Baños, Laguna, Philippines.

PCSD. 1996. Philippine Agenda 21: A National Agenda for Sustainable Development. Philippine Council for Sustainable Development. Philippines.

Revilla, J.A.V. 1997. Necessary Framework, Strategies and Programs for Sustainable Forestry in the Philippines. Unpublished policy paper presented at the Seminar on Mega Issues in Forestry: Key Policies and Programs. Forestry Development Center, UPLB College of Forestry and National Academy of Science and Technology, PCED, University of the Philippines, Diliman, Quezon City. February 27, 1997.

Revilla, A.V. Jr. 1983. Land Assessment and Allocation in Relation to Agroforestry. In: Proc. Agroforestry Symposium-Workshop. Dec. 1979. Philippine Council for Agriculture and Resources Research and Development, Los Baños, Laguna, Philippines. 21–28.

Saplaco, S. R. 1979. Problems, Issues and Strategies on Watershed Management in the Philippines. Likas Yaman, Journal of the Natural Resources Management Forum. MNR-NRMC 1(7): 1–40.

Smalley, G.W. 1984. Landforms: A Practical Basis for Classifying Forest Sites in the Interior Uplands. Proc. Twelfth Annual Hardwood Symposium. Hardwood Research Council, N.C.

_____ . 1979. Classification and Evaluation of Forest Sites for Timber Production: Introduction of a New System for Classifying Forest Sites Based on the Physical Features of the Landscape. Paper presented at the Forest Soils and Site Quality Workshop, Auburn University, Alabama.

Warren, S.D., V.E. Diersing, P.J. Thompson and W.D. Goran. 1989. An Erosion-based Land Classification System for Military Installations. Environmental Management. 13(2):251-257.

Watt, K.E. 1973. Principles of Environmental Science. Mc-Graw Hill Book. Co. N.Y.

Woolhiser, D.A. 1975. The Watershed Approach to Understanding Our Environment. J. Environmental Quality 4(1): 17–21.