ironmental Management Guidelines, No. 11

ENVIRONMENTAL GUIDELINES FOR

Agroforestry Projects

UNITED NATIONS ENVIRONMENT PROGRAMME

AGROFORESTRY PROJECTS

Environmental Management Guidelines

1. Pesticide Use on Industrial Crops
2. Irrigation in Arid and Semi-Arid Areas
3. Watershed Development
4. Pulp and Paper Industry
5. Hides and Skins Industry
6. Coastal Tourism
7. Formulation of National Soils Policies
8. The Restoration and Rehabilitation of Land and Soils after Mining Activities
9. Afforestation Projects
10. Agricultural Mechanization
11. Agroforestry Projects
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AGROFORESTRY PROJECTS

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FOREWORD

It has been our concern, shared by other bodies and agencies within and outside the United Nations family, that development projects and programmes should take account of basic environmental parameters and constraints. It is clear that broad-based sustainable development is not feasible, especially in the long-term, without sound environmental assessment and management.

There are many pitfalls to be avoided in initiating development activities and many opportunities that can be availed of without much additional cost. Experience during the last ten years has shown that remedial measures must be incorporated, if they are to be effective, in the conceptual and design stages of projects. The same applies to planning procedures. Later attempts may prove to be only cosmetic, as ecosystems are fragile and complex and may not recover from the stresses to which they are exposed.

Prepared by UNEP, in close consultation with the United Nations specialized agencies concerned, the first six guidelines were jointly financed by UNEP and UNDP. They were adopted by UNDP and distributed to the UNDP Resident Representatives. The remaining guidelines in the series have been prepared by UNEP to cover important areas of emerging concern.

The remedial or preventive measures outlined are meant to be illustrative rather than exhaustive in nature: there is no substitute for local experience, foresight and prudence. We have only attempted to draw attention to the kind of considerations which must be kept centrally in mind in undertaking development activities.

The objectives for which we strive in these guidelines are numerous and interrelated, requiring a formidable array of diverse technologies and disciplines. Although the guidelines are essentially national in nature and scope, international cooperation and co-ordination to bring into play the different inputs required, may often be necessary.

I sincerely hope that the guidelines will be acceptable and meet practical needs, particularly in developing countries. Additional sectors will be examined and further guidelines prepared in collaboration with the UN specialized agencies, UNDP and other multilateral and bilateral development financing institutions, as appropriate, taking fully into consideration comments and advice which we expect to receive regarding this set of guidelines.

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PREFACE

At an informal meeting held in Rome in September 1978 the Designated Officials for Environmental Matters (DOEM) of the United Nations Administrative Committee of Co-ordination recommended, on the basis of a report prepared by a consultant, Mr. O.M. Ashford, that UNEP undertake, in close collaboration with the UN specialized agencies, the preparation of environmental operational guidelines to assess and minimize the possible adverse environmental impacts of development activities. The report of the meeting states "that priority should be given to the preparation of guidelines aimed at improving the consideration of environmental aspects at all stages in the planning and execution of projects". It was recognized that the level of sophistication in such guidelines would depend on the audience for which they were intended. Much of the available material was of a general nature which would mainly be of interest to universities and senior international and national officials. At the other extreme, detailed guidelines based on in-depth studies of specific projects would be very useful for specialists but difficulties were foreseen in obtaining the necessary information for such analyses, which would take a long time to complete. The meeting agreed that the primary need was for guidelines which would be useful at the operational level. For this purpose each of the major categories used in the consultant's report (e.g. agriculture) would have to be broken down into a number of subareas (e.g. crop pest control and rangeland management). A first list of subareas on which guidelines should be prepared soonest was agreed on as follows:

1. pesticide use on industrial crops
2. irrigation in arid and semi-arid areas
3. watershed development
4. pulp and paper industry
5. hides and skins industry
6. coastal tourism

At a subsequent meeting the DOEM determined that the operational guidelines should "avoid undue technicalities. They should be clear-cut statements of the environmental concerns, parameters and constraints arising in the area of interest. A distinction should be made between what would be useful for informed laymen, such as UNDP Resident Representatives or officials in the ministry of planning or ministry of economic affairs of a developing country, to reach a decision on the need for and nature of environmental considerations in a given project at a very early stage of its formulation on the one hand, and the analytical tools required by engineers, economists and other scientific consultants in the form of coefficients, etc., to implement a project on the other. The latter should not be a part of the operational guidelines but in manuals of implementation".

In the event, the guidelines that have been prepared vary in the nature of the material assembled and the technical details analysed. This has been done deliberately.

In order to afford an opportunity to assess the practical utility of different approaches to the preparation of guidelines, it was considered necessary to establish models which could be compared and evaluated in terms of practical utility. UNEP would gratefully receive views on the analytical frameworks and approaches adopted in the different guidelines as well as suggestions for their improvement or amendment.

The environmental guidelines in this series are not intended to be prescriptions for corrective action or constraints on the methods, nature and scope of development activities. They are presented in the belief that dynamics and change induced by development aims are not without environmental hazards and risks. It is necessary to identify such hazards and risks where they arise and take early steps, in so far as circumstances permit, to contain or reduce them. It is necessary to take early steps, because later attempts at remedial action may be illusory, more costly than preventive action taken at the outset, and in some cases, may be so costly as to bring into question the overall economic viability of the project.

We acknowledge with gratitude the contributions received from the UN specialized agencies, particularly the Food and Agriculture Organization (FAO), for preparing the guidelines. Without financial assistance from UNDP, the operational guidelines could not have been completed effectively within the time available. We are also dependent upon the assessment of the Resident Representatives and the Headquarters staff of UNDP on whether the guidelines meet specific needs in the field.

Within UNEP, a number of colleagues have assisted in the preparation and editing of the operational guidelines. I wish to thank in particular Mr. Nay Htun (for the guidelines on the pulp and paper industry and on the hides and skins industry) and Mr. Mohamed Tangi (for the guidelines on coastal tourism). Ms. Merran Van der Tak, Ms. Shahida Chaudhary and Mr. Mark Aeron-Thomas assisted in the research and editing of the first six guidelines in the series; the latest guidelines have benefited from the sustained efforts of Ms. Sophie Schlingemann and Ms. Gill Mayers.

UNEP's decision, to produce further guidelines, on issues currently on the international agenda for environmental action, has resulted in subsequent guidelines in the series. The first six have been complemented by the following:

1. formulation of national soil policies
2. the restoration and rehabilitation of land and soils after mining activities
3. afforestation projects
4. agricultural mechanization

The three latest ones are on:

1. agroforestry
2. farming systems research
3. environmental considerations in rural roads projects

On the basis of reports received additional guidelines are under editorial consideration.

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INTRODUCTION

There is no doubt that Agroforestry can be an environmentally sound and economically feasible means of developing and protecting marginal and ecologically fragile lands. Agroforestry, however, is a highly complex and multi-disciplinary approach to land use and should not be undertaken unless there is an adequate understanding of the cultural, economic and environmental interactions common to mixed farming systems. Half-baked or haphazard land management can lead to serious environmental and economic repercussions. It is therefore critical to embark on Agroforestry projects in a well thought manner keeping all the various inter-relationships in mind during planning, implementation and management phases.

The broad scope of Agroforestry practices and their highly site specific nature make comprehensive guidelines for their implementation impossible. The following is intended to enhance awareness of the potentials and constraints involved.

DEFINITION OF AGROFORESTRY

Agroforestry is a broad term for any land use system that combines trees, crops and/or animals in an interactive manner either simultaneously or sequentially on the same unit of land. Although there is no universally accepted definition of agroforestry, most definitions encompass the following characteristics:

- Agroforestry systems involve at least one species of woody perennial with at least one species of plant or animal.
- Agroforestry systems produce at least two outputs.
- Agroforestry systems have a cycle of at least one year.

The various forms of Agroforesstry can be divided into:

1. Agrisilviculture—agricultural crops are mixed with woody perennials.
2. Sylvopastoralism—livestock is integrated into forests or tree crop plantations.
3. Agrosylvopastoralism—agricultural crops, woody perennials and livestock are integrated.

Agroforestry systems have evolved from practices where either forestry or agriculture were the major land use. These systems are especially important in areas where the ecosystem is fragile or where it is vital for capital poor, low-input farmers to produce as many of their basic needs as possible.

ECOLOGICAL POTENTIAL OF AGROFORESTRY

The basic objective of Agroforestry should be to increase, diversify and sustain farming output in a manner that is both ecologically and socio-economically feasible. The potentially positive interactions between the environment and the various Agroforestry components should be realized to maximize land productivity and sustainability.

Agroforestry can serve to reduce the degradation of natural forests by providing alternative sources of wood and by making forests an integral part of the local socio-economic context.

The major ecological potential of Agroforestry exists in marginal, low-input farming areas where woody perennials can contribute to soil fertility and protection.

The introduction of woody perennials can:

- fixate atmospheric nitrogen and carbon
- aerate the soil through tree root action
- prevent soil erosion and subsequent fertility loss by providing vegetative cover, and modifying soil porosity and infiltration rates
- increase organic matter on soil surface by litter fall and root decay
- enhance nutrient cycling and economy
- stabilize soil temperature, resulting in a more balanced micro-climate
- increase permeability and water holding capacity
- trap, with deep roots, nutrients otherwise lost by leaching.

Trees, in addition to improving the micro-site, also positively affect the broader environment:

- alimentation of the water table and natural overflow channels by internal drainage of excess waters
- reduction in rate of siltation to dams and reservoirs

The introduction of woody perennials onto farmland might also have beneficial effects on air quality, radiation levels, temperature, humidity and rainfall. If practiced on a large scale, it is possible that Agroforestry could affect the atmosphere in a way similar to that of a natural forest.

CHOICE OF SPECIES FOR AGROFORESTRY

It is important to recognize that the choice of species for Agroforestry depends to a large extent on the ecological conditions of the site in question. Planting species unsuited to the local ecology is not economically cost-effective and can lead to serious environmental degradation. It is also important to consider the mutual compatibility and non-competitiveness of the various agricultural and tree species to be introduced. The different components of an Agroforestry system should be complementary over all stages of growth and maturity.

In cases where forestry is the dominant land use, the choice of agricultural crops is decided by which species can grow under the prevailing conditions without posing a threat to the woody perennials. In cases where farming is the dominant land use, the agricultural component of Agroforestry is largely dictated by local socio-economic factors; the question of species choice rests mainly with the woody component. Special regard should be given to avoiding species that pose problems of competition for water, nutrients and solar energy. In addition to commercial usefulness, the ideal agroforestry tree species should have the following important characteristics (King, 1979):

- "they should be amenable to early wide espacement "
- they should possess self-pruning properties
- if not self-pruning, they should be able to tolerate relatively high incidences of pruning, i.e. their photo-synthetic efficiency should not significantly decrease with heavy pruning
- they should have a low crown diameter-to-bole diameter ratio,

i.e. the width of their crowns should be small relative to bole diameter
- they should be light-branching in habit
- they should be tolerant of side-shade, if indeed not of full overhead in the early stages of growth
- their phyllotaxis should permit the penetration of light to the ground
- their phenology, particularly with respect to leaf flushing and leaf-fall, should be advantageous to the growth of the annual crop in conjunction with which they are being raised
- their rate of litter fall and litter decomposition should have positive effects upon the soil
- their "above ground" changes *over time* in structure and morphology should be such that they retain or improve those characteristics that reduce competition for solar energy, nutrients and water
- their root systems and root growth characteristics ideally should result in the exploration of soil layers that are different from those being tapped by the agricultural species
- they should be efficient nutrient pumps."

SOME DESIGN CONSIDERATIONS IN AGROFORESTRY

Agroforestry projects can be designed to improve or transform existing land use practices. Agroforestry is also useful as an interim land use in, for instance, the early stages of forest plantation establishment (e.g. Taungya system in S.E. Asia).

Whatever the rationale of Agroforestry projects, the decision of how to arrange plants over time and space is crucial to success. The three basic types of plant arrangement are mixed cropping, zonal cropping and rotational cropping. Zonal agroforestry describes a situation where plants are arranged in zones (strips, bands, or other geometric shapes) so that there is some but not excessive interaction between species.

The decision to use any of these methods depends primarily on the degree of compatibility of species in terms of resource use and the ecological setting. Where species are highly complementary, mixed cropping is viable. If the biological interaction is not as favourable (competition for resources occurs) some form of zoning should be considered. The exact configuration of zones depends on the degree of posi-

tive interaction. When the nature of the interaction is not known a zonal system allows for a less committed approach. In instances where species exhibit a somewhat negative biological interaction, appropriate management techniques such as time-of-planting, time-of-harvesting, training and pruning, can be implemented.

In deciding on spatial and temporal arrangements, it must be noted that tree species often require more maintenance (especially in the early stages of life) and land preparation than do agricultural crops. Special consideration should be given to arranging trees in a manner suited for soil and water conservation. Planting the wrong tree in the wrong place can lead to disastrous ecological effects.

- genetic heritage; it is important not to destroy ecological niches and biotypes when transforming one ecosystem into another
- ground preparation; care must be exercised to avoid destroying the soil structure. Haphazard movement of machinery should be avoided
- the construction of roads and firebreaks should be planned to minimize surface water flow erosion and other damage
- the project should be tailored to the needs of the local population to ensure their participation
- pest management; an integrated approach using a combination of biological mechanical and chemical means to combat pests is advisable. Species should be pest resistant
- fertilizers should be used with care. Minimum dosages should be used and never during rainy seasons.

Finally, with regard to the special care and knowledge required in growing and supporting trees, farmers will have to be convinced of the benefits of Agroforestry. Projects will fail without the support of those for whom they are intended.

AGROFORESTRY BY ECOSYSTEM

The design and choice of Agroforestry system are strongly influenced by soil, climate and topography.

Dry savanna and semi-arid regions

The most important aspects of these areas is the scarcity of water. Trees can be introduced to increase water use efficiency and to provide a multiplicity of outputs. Agroforestry practices in semi-arid regions should aim to improve soil structure and fertility while providing harvestable cash crops and fodder for livestock. Recommended Agroforestry practices include:

Agro-silviculture:

- introduce multi-purpose widely spaced trees on farmlands
- plant trees as live fences/windbreaks
- zonal planting of trees, shrub, and crops with emphasis on interface. This can be useful for minimum tillage cut and carry mulch poduction.

Sylvopastoral:

- introduce grazing in forest plantations
- introduce multi-purpose widely spaced fodder trees on pasture lands, which do not compete with pasture grasses.

Agro-sylvo-pastoral:

- introduce multi-purpose widely spaced trees with crops/animals
- crop/tree/livestock mix around homesteads.

Multi-purpose trees and shrubs suited for semi-arid regions should be identified; especially those useful for sylvopastoralism. Fast growing tree species requiring large amounts of water should be avoided. Certain species such as Acacia Albida and Prosopis Cineraria are recommended for sandy, low rainfall areas, but the choice of tree species must be determined locally. Minimum tillage systems should be investigated.

Humid lowlands

These areas experience high, sometimes excessive rainfall and are subjected to intense farming and other human pressures. Agroforestry can alleviate some of the problems associated with the inefficient and haphazard land uses common to these areas. Agroforestry practices and technologies suitable to humid lowlands, include:

Agrosylviculture:

- hedgerow planting with fast-growing woody perennials
- plantations for fuelwood production with agricultural component
- home gardens (planting trees and other plants around homesteads).

Sylvopastoral:

- multipurpose trees on pasture lands to provide shade/fruit/or commercial outputs.

Agrosylvopastoral:

- crops and trees/shrubs for grazing/browsing in plantations
- home gardens with mix of crops, trees and livestock.

Non-competitive commercial tree species suitable for planting in combination with crops should be identified. Leacaena leucophala and Acacia auriculiformis are examples of tree species suited for a wide range of soils. Sesbania grandiflora has a tolerance for flooding and requires little maintenance. The choice of species should be determined by local ecological conditions.

Tropical mountain and uplana ecosystems

Farming in these areas is constrained by problems of soil erosion and uneven topography. Agroforestry has great potential for soil protection and rehabilitation. Practices should focus on controlling water-erosion by including multi-purpose (food, fuel, fodder) trees with soil binding capacity. Some recommended practices:

Agrosilviculture:

- hedgerow planting; planting multi-purpose trees along contour lines with agricultural species planted between rows of trees
- planting soil binding grasses between the trees along contours

Sylvopastoralism:

- planting multi-purpose trees which do not compete with pasture grasses on pasture lands
- introducing grazing in natural forests or plantations.

Agrosylvopastoralism:

- establishing home gardens with a combination of agricultural crops, trees and livestock.

Examples of high altitude tree species include Ailanthus altissima, which grows in a variety of acid and alkaline soils and can tolerate both flooding and drought, and Prosopis chilensis, which grows in sandy, low nutrient and shallow soils. Obviously, once again choice of species should be site specific.

AGROFORESTRY OPPORTUNITIES FOR EXISTING AGRICULTURAL SYSTEMS

The choice of species and design of planned Agroforestry systems is determined to a large degree by the existing form of land use. Woody perennials can be introduced into farming areas, crops and livestock into tree crop plantations and forest plantations, and woody perennials into pasture lands.

In farming areas where land is managed intensively for agricultural production existing land use systems draw heavily on available resources and create fragile and unstable ecosystems. Many of the crops grown in these areas require lots of sunlight and farmers are, therefore, reluctant to plant trees. Furthermore, the harvesting of these crops often requires mono-specific fields. Although the possibilities for introducing woody perennials into these areas is limited because of the emphasis on crop production (and the problems associated with tree

competition for resources) there exist methods by which trees and shrubs can provide soil protection and enhancement without any pronounced reduction in agricultural yield. Even in cases where agricultural yield does decline, the trade-off between the productivity and sustainability of a system must be examined.

Agroforestry techniques which do not significantly alter the existing land use procedures include:

- planting multi-purpose trees on unused sections of farm plots and using cut and carry mulch for fertilization of agricultural fields
- planting multi-purpose trees along farm boundaries, canals, roads, etc. These serve as windbreaks and live fences
- planting lightly foliaged non-resource competitive trees across farm plots.

Plantations of tree crops

Tree crop plantations consisting of, for example, coconut palms or rubber trees, offer many opportunities for Agroforestry. Generally, these tree crops can withstand the growing of compatible crops between or underneath them and, in some cases, can tolerate livestock integration. Some examples of suitable Agroforestry practices are:

- intercropping the tree species with compatible shade resistant annual agricultural crops
- integrating livestock with tree crops by introducing suitable shade tolerant pasture species (fodder, browsing) and grasses or natural vegetation
- introducing leguminous cover crops to protect against erosion.

Forest plantations and forests

Forest plantations, designed either for commercial or ecological reasons, can benefit from the introduction of other species. Agroforestry and sylvopastoralism can be integrated quite easily into both forests and forest plantations by:

- introducing shade tolerant crops (coffee, papaya, etc.) between trees
- training, pruning and lopping of densely foliaged trees to allow the planting of shade resistant agricultural crops

- clearing strips of forest to plant shade tolerant agricultural crops
- introducing shade tolerant pasture species (e.g. Jacaranda copaia in lowland humid tropics) or grasses for livestock integration.

In the case of tree crop plantations and forest plantations the aim should be to create a multi-storeyed canopy resembling as closely as possible a natural forest. The result will be a more buffered and stabilized microclimate. Furthermore, the composite litter of a mixed plantation decomposes more readily than that of a monospecific plantation, resulting in increased soil fertility.

Pastoralism

Areas where pastoralism is the chief land use can benefit from the introduction of trees and shrubs. The woody perennials introduced can provide a productive and/or service role: fuel; timber; fodder; fruit; shelter; shade; nutrient recycling; soil protection; and drought and fodder reserves. It is necessary to adapt any pastoral improvement systems to the socio-economic and ecological conditions of the region. In general, trees are considered more useful than shrubs in this context.

In cases where pastoral lands are converted to sylvopastoral forest or tree crop plantations, certain guidelines pertain:

- pasture duration should be limited to avoid excessive use and destruction of vegetation
- grazing should take place within specific boundaries with successive rotations
- necessary fallow periods should be determined
- grazing and browsing should be limited during rainy seasons to avoid soil compaction

INFORMATION ON AGROFORESTRY

Agroforestry is a complex science which draws from a wide range of disciplines. Agroforestry projects should be carefully planned to avoid creating ecologically unstable systems. To ensure a successful design it is important to have accesss to state-of-the-art technologies and data. Some requirements for necessary preliminary data:

- climatic, soil and biological aspects of proposed site
- species of agricultural crops and woody perennials suited to the ecology of proposed site
- species of agricultural crops and woody perennials which are complementary, given the ecological context of proposed site
- practices and technology feasible for socio-economic and ecological context of proposed site

Specific information concerning species, geographical zones and broader Agroforestry subject areas can best be gathered by contacting appropriate international information services. The following are indispensable sources of Agroforestry information:

- International Council for Research in Agroforestry (ICRAF)—P.O. Box 30677, Nairobi, Kenya.
- INFOTERRA (UNEP), P.O. Box 30552, Nairobi, Kenya.
- AGRIS (FAO), Via Delle Terme Di Caracalla, Rome, Italy.
- CARIS (FAO), Via Delle Terme Di Caracalla, Rome, Italy.

CONCLUSIONS

Agroforestry is an attractive means of combatting the ecological and socio-economic problems of the tropics. Properly planned and executed projects can improve land productivity, protect soils, and provide wood, food and cash crops in a manner acceptable to farmers. The end result is a self-sustaining, and, therefore, stable ecosystem.

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