ANNEX B

TECHNICAL OPTIONS

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A. Purpose of Annex

The purpose of this annex is to provide the USAID/Guatemala Mission and the Project Paper design team with interim information on: 1) types of interventions; 2) implementation methods; and 3) costs and benefits of potential activities within the project's demonstration component. These interventions link directly with identified policy, institutional strengthening, and land access constraints.

Several major conclusions became apparent with regard to implementing field activities:

- Guatemala is on its way to environmental rock bottom where improved production of exports and basic cereals and pulses is directly dependent on widespread application of regenerative technologies and approaches to improve environmental and natural resources management. POD goals of broad-based, export-led economic growth will be unachievable without improved management of soil and water resources.

- While technical options abound, local success will be determined by the extent to which the implementing consortium establishes and maintains the confidence and participation of local communities. More popular replication will depend on alleviating pressure from economic policies, insecurity of tenure, and improved local organizational capacity.

- The need to be responsive to local interests and macro-level activities such as policy reform, land access, and institutional strengthening will likely result in complex activities and partnerships. This situation strongly suggests that the project focus on no more than three watersheds for field activities. Given the probable focus and geography of the Altiplano these watersheds should also be located within the same department for management efficiency.

Effective synergy between policy reforms, improved access to natural resources, and institutional strengthening will be felt at the ground level and ultimately determine project success. The level of their integration will largely depend on how well a cohesive implementation consortium is fostered. The project management structure will largely determine how collaborative these partners and components are.

B. The Watershed Context for Field Activities

One way of grouping different types of economic alternatives is to look at a land use appropriateness continuum along a watershed transect, from protected areas requiring stricter protection on the upper slopes, through pastures and traditionally cultivated middle slopes, ending in gentler, high-production areas characterized by irrigation and high-value crops. The key questions are:

- How can each type of land be best managed to ensure that maximum short-term benefits are consistent with long-term productivity?

- How can private incentive structures facing resource users be changed so that sustainable management practices will be positively reinforced, thereby minimizing resistance to adoption and the need for (usually impractical) enforcement measures?

The following are three different types of lands that tend to be managed unsustainably, including a description of ways in which economic opportunities or incentives can be provided to reinforce more sustainable uses.

1. Upper Watersheds: Lands Requiring Complete Protection or Severe Use Restrictions

Certain types of lands, such as very steep slopes and cloud forests, are extremely fragile and susceptible to degradation and productivity loss unless managed very carefully. Given their fragility and lack of productivity, they are either uninhabited (public) or are inhabited and/or managed by marginalized indigenous populations who are forced there by population pressure and lack of access to more productive resources. Some of these lands provide a niche for a large variety of plant and animal species that could be lost if not protected. There are several strategies that have been tried or proposed that could lead to protection via careful management of these lands.

- Establishment of parks and bio-reserves
- Income-generating management of natural forests via:
  - Planting and harvesting of non-timber forest products
  - Selective timber extraction
- Improved milpa systems using multi-purpose trees and berms
- Potable water acquisition systems

2. Mid-Slopes: Recoverable Fragile Lands in the Process of Degradation

There is a good amount of mid-slope land in pasture production that through inappropriate use (fire, overstocking) is in the process of becoming degraded in the sense that in time it will lose most or all of its productivity. In some cases, it may be worthwhile to maintain or restore productivity either by leaving the land fallow to regenerate naturally, or taking actions to retard degradation or speed up recuperation of productive potential. Mechanisms that have been tried or proposed include:

- Reforestation/plantations
- Periodic crop/tree - fallow rotations
- Improved soil management - berms, terraces, cover crops
- Agroforestry - contour hedgerows with nitrogen-fixing trees
- Continuous cropping with woody perennials

3. Lower Slopes: High Potential Lands Subject to Sustainable Use under Intensive Management, and Often Irrigable

There is an important potential linkage between the pattern of distribution and productivity of land appropriate for agricultural production, and the real possibilities for protecting and effectively managing the fragile steep slopes and tropical forests. With effective management and improved means of access, pressures on more fragile lands could be reduced by providing incentives for people to remain on better lands, and attracting them away from already overcrowded fragile areas. Alternative strategies that have been proposed or attempted include:

- Land redistribution
- Development of labor-using or land-saving technologies
- Irrigation
- Shift in production toward higher-value products
- Shift from livestock toward agricultural production
- Potable water distribution systems

4. Non-agricultural or Natural Resource Management Employment Opportunities

Non-farm and off-farm employment opportunities that promise higher incomes, better living standards, and food security are potential magnets to draw people away from marginal lands. The range of opportunities is almost infinite. They include:

- Labor-intensive industries (e.g., maquila)

- Employment in the tourism industry

- Handicrafts and tourist articles

- Public works for conservation - gully plugs, check dams, recreational parks, wastewater management, public water supply development, solid waste management

All of the above alternatives require changes in policy, technology, organizations, and resource distribution. The specific changes required depend upon the alternative(s) selected in a specific geographic area.

C. Technical Options for Field Activities

The following section attempts to identify, prioritize, and develop a limited economic rationale for some of the potential interventions in the field activities component.

The following solutions are intended to be illustrative. Given the tremendous diversity of demographics, land forms, historical land use, institutional and extension order, and agroecology, different technical options need to be carefully weighed. Technology selection criteria should be ordered first by likelihood of adoption, followed by biophysical impacts, and finally by more straightforward economic/financial data. Illustrative criteria are provided in tabular form after the discussion on the upper watershed.

1. Parks and Protected Areas

a. Mitigative and Management Opportunities

Objective: Protect and manage the remaining biological resources of the private lands, national park, and special reserves located in upper watersheds. This will include straightforward park management activities including biological assessments, improved regulatory capacity, enhanced awareness of protected area values, and development of long-term financial solvency. In addition to strict preservation activities all efforts to take advantage of extractive activities (timber and non-timber products including hunting) need to be considered. Prioritized activities are as follows:

(1) Infrastructure Development

This activity includes surveying and clearly demarcating the parks' boundaries to halt encroachment and unregulated extraction. It will require temporary strengthening of CONAP's surveying capability or support to INTA as its survey backlog and capability precludes timely response (or possibly contract surveying on municipal properties). Other activities include development of an adequate set of foot trails; trained park guards for surveillance purposes; construction of a small office for guards adjacent to the park interpretation facilities; and study of the potential for a research camp.

(2) Local Needs Assessment

The project should support consultancies by local social scientists who will implement rapid rural appraisals of surrounding populations. Lists of products and activities occurring in the protected areas should be prepared and every effort made to work with the development NGO to provide alternative sources of products. Substitution of trans-park boundary flows of goods and services will need to be the joint responsibility of both the protected area and upland watershed implementing groups.

(3) Biological Inventories

Comprehensive floral and faunal species lists should be developed. There is a nearly complete dearth and completely anecdotal knowledge of species in and around Guatemala's public and private protected areas. Since the project will undertake protection of at least two sites that may be biologically viable, all efforts to utilize local university and NGO talent to develop systematic inventories and a supportive database is a priority. Other areas could be judged by these inventories, and the Park Service can then concentrate on protected areas that merit attention and consider options for consolidating or relinquishing less important areas.

(4) Improved Management Capability

This activity includes helping the municipalities, CONAP or NGOs to improve their fiscal, personnel, and material management systems. The ultimate goal should be, in direct cooperation with the Institutional Strengthening activities, development of a pay-as-you-go clientele and financial management systems that will allow individual protected areas to live beyond PACD. Acquisition of one vehicle (a boat for the lake parks) and two or three motorcycles per watershed will be required. Field equipment and development of incentive systems to reward effective guard performance (interdiction as well as visitor interpretation) should be developed as soon as possible.

(5) Capitalizing on Ecotourism Potential

Interpretation centers should be developed within easy access to parks in the demonstration areas with the dual goal of capitalizing on increasing local interest in a mobile society while seeking to defray recurrent costs. Development of modest interpretation centers near park entrances provides access to an increasingly environmentally aware Guatemalan population. Foot trails and strategically placed mirradors within the protected areas are also recommended.

(6) Natural Forest Management

Prior to undertaking the planting of areas, efforts should be made to ascertain the feasibility of managing natural forest stands for fuelwood, timber, and non-timber products. Site visits, interviews, and literature suggest there is significant potential to manage the mixed hardwood and softwood forests along upper watersheds for sustained yields. Timber stand improvement through controlled fuelwood harvest and selective thinning could improve the value and performance of residual trees while generating capital. Cutting intensity and intervals and the impact on regeneration are, however, unclear and will require an adaptive research component in most cases. Other products including honey, gums, resins, and housing materials can also be extracted on a sustainable basis if municipalities are willing and able to assume some regulatory function.

b. Conservation Education Extension Approach

This activity should be undertaken through NGOs with possible assistance from other AID health and population projects. The traditional "comic book and t-shirt" approach to conservation education will need to offer more direct alternatives if a long-term management response is desired. Institutional strengthening, in that it may equip and organize NGOs, should support NGOs like Amigos de Lago Atitlan that are committed to or already active in protected area development.

c. Monitoring and Impact Evaluation

Monitoring and impact evaluation of protected area activities will require several perspectives. The value of specific interventions will be measured by the extent to which encroachment ceases in upland protected areas and people adjacent to the parks become active members of a conservation coalition. Municipal receipts for fuelwood extraction will offer additional evidence. Careful regard for Regulation 216 standards will likely require that a substantial portion of project resources be devoted to assessment of site-specific activities. Rather than a one-shot EA procedure, it is strongly recommended that the PP design team consider using a program EA and set aside finances for a barrage of EAs for municipal activities.

Spatial time-series data (satellite or high-altitude photography) coupled with park guard or municipal records should be used as the basis for determining encroachment. Records describing the successful interdiction and prosecution of cases of illegal activity will also provide a proxy for improved presence and guard performance.

Lastly CONAMA's high interest and Military Mapping Agency's considerable technological sophistication would make them worthy partners for university studies of the extraction and analysis of differential watershed yields; development of runoff measures from undisturbed areas; and comparisons with inhabited areas. Installation of real time peak flow and total flow gauges in similar topographic conditions would provide valuable dissertation data that could help fine-tune treatments and models.

d. Supporting Policy Reforms

The fundamental problems lie in the public service's (DIGEBOS and DIGESA) ability to garner fiscal and personnel support from central sources. Since macroeconomic conditions are unlikely to permit CONAP and MAG to have adequate resources, financial, management, and administrative policies geared toward empowering the municipalities should be investigated within the Policy Reform activities.

Specifically, it will be necessary to change the laws governing control of park gate receipts to introduce financial responsibility and eventual autonomy to individual parks. Personnel management policies and incentive structures would probably function better under a more business-oriented approach. Cadastral policies that regulate who and how park boundaries are established need to be reviewed and probably revised. If CONAP or municipalities have to stand at the end of the titling line there will be nothing left to survey in a few years.

2. Upper Watersheds (Outside Protected Areas)

a. Description

The upper watershed areas are similar to adjacent protected areas: steep slopes (often greater than 100 percent) on highly variable soil pedons inhabited by poorly organized subsistence farmers with some coffee interspersed at higher elevations in the Altiplano. These are areas ideally managed under forest vocations to maintain watershed function and deliver timber and non-timber forest products. While the technical options are well documented for mitigating downstream siltation, unbalanced run-off, and decline in soil productivity, leading to further encroachment, organizing participants will be the most difficult task.

b. Mitigative Technologies

Objective: Reduce soil loss and fertility decline in upper watersheds by reducing erosivity and improving soil structure. Major actions include maintaining vegetative cover, increasing organic matter in soil, and reducing hillside slopes. All of these activities require local people to reorganize hillside landscapes and activities along contours.

The following descriptive list begins with more strictly tree-related types of afforestation to more traditional on-farm interventions and concludes with management of run-off not assimilated in either of the former two classes. The level of risk, inputs, and extension ease are found in Tables 1 and 2. Figures 1 and 2 illustrate recommended technologies.

(1) Forest Plantations and Woodlots

Development of individual or group woodlots for construction poles and saw timber offer the greatest opportunities for direct economic returns commensurate with the primary environmental objective. There is still inadequate information on fuelwood yields, production costs, and markets to justify plantations exclusively geared to energy production. Preliminary economic analysis using accepted fuelwood yields and prices suggests that investments do not justify the costs. While prices are evidently rising in urban areas, the unrestricted mining of fuelwood from unmanaged natural stands is subsidizing prices, and there are indications that scarcity signals may soon justify added management expenses associated with improved management of natural forest and establishment of plantations. In neighboring El Salvador, where land pressure and deforestation have heralded fair market prices for wood energy, smallholder plantations have quickly developed (Gibson and Hardin, 1991). There is good reason to believe these market signals will soon occur in Guatemala.

Given the relatively modest success of the Lorena stove programs in Central America and the remarkable success of the commercially disseminated models developed in Asia and East Africa the latter type is recommended. Research, development, and commercial sales of the steel-jacketed ceramic lined "Jiko" should be investigated as an alternative. Energy conservation (cooking techniques, wood drying procedures, and meal planning) has been effective in reducing energy consumption by 60 percent and should be included in the Environmental Education Component.

Regardless of economic yields, to maintain the project's environmental services orientation, all woodlots and plantations should be established with concern for maximizing biomass productivity as well as water retention, as follows:

- All trees should be planted along contours, and uphill spacing between contours should be based on slope.

- Reverse slope micro-terraces/fishscales should be used whenever possible to maximize moisture to subject trees and reduce unimpeded downhill flows.

- Species planted should conform to maximum product value (i.e., better sites should support more valuable species with respect to end products, and large monospecific block plantings should be discouraged in favor of mosaics based on site-species matching). Overuse of dense stands of eucalyptus or pines should be avoided on steep sites where understory vegetation is out-competed.

- Construction of harvest access roads should carefully follow standard slope limitations, drainage requirements, and distance from riparian areas.

- Use of agrochemicals for establishment should be discouraged but more benign varieties (burnt lime, slow dispersal completes) used when needed.

(2) Tree Crops and Nurseries

The HADs and other projects have proved that the use of improved or grafted fruit tree stock, particularly avocado and deciduous fruit trees, should be encouraged. Mulching must be promoted as an integral part of these activities, and planting densities and water retention structures as listed above should be encouraged. Use of multi-purpose, nitrogen-fixing trees (MPTs) that can be harvested for wood and green manure products should be considered. These are best combined with one or more of the techniques listed below. Species readily available and identified by the team during site visits include *Leuceana diversifolia, Erythrina spp., Caliandra calothyrsus, Samana saman*, and *Sesbania spp*. CATIE can provide genetically verifiable and improved seed through the Tree Seed Improvement Component of the RENARM project.

Tree survival rates are highly variable and evidently depend on seedling quality, outplanting practices, and maintenance. Not surprisingly, anecdotal[1] information suggests post-outplanting survival is much higher for seedlings produced by private or small commercial nurseries and planted on private holdings. Statistics indicate that "communal" nurseries (generally not-for-profit ventures) are much less efficient and produce an inferior product of perhaps less desirable species.

The above would support the notion that trees should be produced in as commercial and private a manner as possible. Truly responsive nurseries will provide good quality stock and, to the extent they can be well connected during the diagnostic phase, can provide the needed species and quantities. While it is tempting to provide a litany of appropriate and probably desirable species, the authors feel it is prudent to leave that to the project implementers. (The PP design team should also refrain from being too specific and concentrate on developing processes and systems that are demand-driven and income-oriented). The range of fruit tree, multipurpose nitrogen-fixing, and timber tree species is vast and well documented in the literature and the Guatemalan countryside.

More importantly many of the soil conservation technologies described below support direct seeding and can dispense with nurseries altogether with strong extension support. Direct sowing of MPTs on berms and terrace faces has been successful in many neighboring countries with similar environments, greatly enhancing tree component uptake.

(3) Contour Cultivation and Strip Cropping

Technologies 3 through 9 below essentially reorient farming activities to mitigate uncontrolled downstream run-off. Contour cultivation and farming alternate strips perpendicular to fall lines are the first step in providing a rough surface to limit unimpeded surface flow and improve percolation, reducing erosivity. (See figure 1.0, page B-19.) The major benefit of this system is that it requires minimal labor and provides an easy first step in the process of establishing a contour framework for the more intensive efforts listed below. The Guatemalan highland farmers already appear well acquainted with slope modification, so many of these technologies and components should be readily extendable if land and policy constraints are relaxed.

All of the following technologies are soil depth and structure, slope, and microclimate dependent: they should not be viewed as panaceas and need to be thoroughly investigated. The concept paper team visited several sites where terraces were constructed and never put into service either for technical reasons (poor production rates due to inadequate concern for soil during construction) or organizational shortcomings.

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[1]The team was unable to locate a good study on nursery production costs, outplanting success, and product market information.

(4) Trash Lines (Physical Contours)

Trash lines take contour farming a step further in that crop residues and stones encountered during cultivation are collected along contour lines. (See figure 2.0, page B-19.) This small barrier picks up mobile soil and eventually begins development of small "passive terraces." This technique is easy, uses available (and oftentimes troublesome) materials, requires little farming surface area, and has proved to increase yields in relatively short periods where water availability is a limiting factor.

(5) Biological Contours (Vegetative Strips)

Biological contours are an additional improvement over contour strip farming and trash lines and are most often used together with these first two techniques of arresting pedon migration. (See figure 3.0. page B-20.) This technique requires that farmers cultivate across slopes instead of up and down. Some 25-50 cm. strips of grass (*Panisetum purpureum, Panicum maximum, Vetiveria, Digitarium spp.*) of leguminous cover crops (*Desmodium intorum, Pueraria phaseoloide*) are recommended for the project site at slope-dependent intervals: the steeper the slope, the closer together the lines are. Leveling of the slope between lines is accomplished as cultural practices and soil movement begin to accumulate behind the strips, forming gentle terraces. Once soil begins to accumulate at the strip and slow leveling occurs, it is often advisable to incorporate nitrogen-fixing trees behind the strips to strengthen the structure and begin production of green manure as well as other off-farm commodities (stable feed, fuelwood, and poles).

Table 3 indicates probable returns to labor investment on biological contours assuming a 10-meter spacing. This estimate, based on available information, suggests that a liberal 10 percent loss in surface area (due to the presence of the strips) offset by a 20 percent increase on the remaining acreage would yield a positive return to associated investments (NPV = C 8224). Models of similar agroecological conditions would support this conclusion, and given the apparent on-farm labor surplus, these technologies deserve closer attention during design and implementation.

(6) Infiltration Ditches

In areas receiving over 1000 mm. of rainfall, infiltration ditches are often recommended to slow soil loss, improve shallow aquifer recharge, and extend growing seasons. (See figure 4.0, page B-20.) There are a wide variety of ditching techniques but most follow the contour at slope-dependent intervals, can be either continuous or discontinuous, and are nearly always combined with one or more of the previous methods. In several places the sites, which catch soil runoff as well as water, are preferred places to plant high-value fruit trees. It is estimated that farmers in Guatemala can construct 20-25 m. of ditching per day. On steeper slopes the project will need to monitor carefully for mass wasting (slumping), which has been known to occur on steep and volcanic water-logged sites (Rwanda, Uganda, and the Philippines) under this system.

(7) Fishscale Micro-Terraces

Fishscale or mini-terraces are used to catch and direct maximum run-off to small areas where valuable tree crops are placed on very steep slopes (60%+). (See figure 5.0, page B-21.) Typically the semicircular, rock-faced, backslopping design measures a variable 1-2 m. long by 1-2 m. deep depending on the desired crop and soil depth. Oftentimes excavation enters into rocky, well-drained and less fertile subsoil pedons so that terraces may require fertilizing or fallowing for several months prior to use. Statistics available from neighboring El Salvador suggest an average male can construct 7 to 10 terraces per day. No information is available on fruit tree yields, however.

(8) Bench (Radical) Terraces

Bench or radical terraces are generally accepted as the ultimate intensity in physical management of soil runoff and water retention management. Bench terraces have been successfully introduced to many places in the Guatemalan highlands, most often in association with irrigation and high-value NTAEs. (See figure 6.0, page B-21.) Bench terraces require deep and fertile soils to justify the amount of time required for construction. Crops may respond poorly for one or more growing seasons on sites where subsoil is excavated during construction, and fertilizers and hybrid seed are often justified by yield increases.

Bench terraces may begin under more passive methods such as strip vegetation and trash lines. Usually as the face or "riser" gets higher the farmer is required to reinforce it to reduce slump risk. These terraces are generally graded backwards or "reverse slope" so that rainfall flows back toward the foot. Rooting depth and available soil moisture is increased, and when properly constructed, there is no net loss in planting surface area. Increased yields and growing area suggest why nearly all of China's bread basket is bench terraced.

(9) Gabions and Check Dams

Gabions and check dams are structures designed to slow down water that has escaped from farm lands and has exceptional erosive force, creating gullies and washing out important infrastructure. (See figure 7.0, page B-22.) Gullies often occur on public land, and therefore building gabions and check dams will frequently enter into the "public works" realm of project activities. There are a wide variety of water containment structures, and the costs and methods of construction will be site-specific.