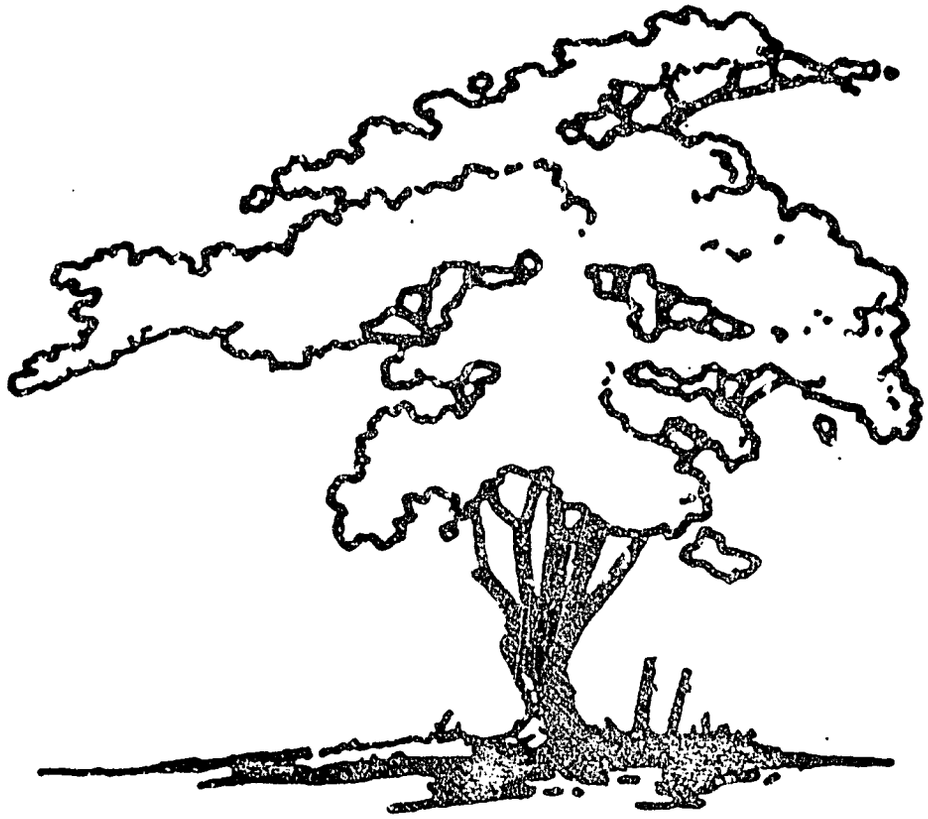
PN-ABN-631
81512

United States Agency for International Development
519-0167-0-00-1186-00

Pre-Design Technical Information Report: Options for the Project Demonstration Areas

Protection Del Medio Ambiente Salvadoreño (PROMESA) Project



Submitted by:
Tropical Research & Development, Inc.
October, 1991

TEAM MEMBERS:

David Gibson
AID-LAC Bureau, Washington, D.C.

Mark Hardin
Tropical Research and Development, Inc.
Gainesville, FL

TABLE OF CONTENTS

ACRONYMS v

LIST OF TABLES vi

EXECUTIVE SUMMARY 1

1.0 PURPOSE OF REPORT AND CONCLUSIONS 3

2.0 PROBLEM STATEMENTS 5
- 2.1 **Problem: The Wholesale Loss of Forest Cover** 5
- 2.2 **Problem: Export-led Economic Policies** 6
- 2.3 **Problem: Continental and Coastal Water Quality Degradation** . . 8
- 2.4 **Problem: Demands of a Growing Population** 9

3.0 SOLUTIONS AND OPPORTUNITIES 11
- 3.1 **Rationale for Selecting Interventions** 11
- 3.2 **Possible Interventions** 11
  - 3.2.1 **Parks and Protection Activities** 12
    - 3.2.1.1 Mitigative and Management Opportunities 12
      - 3.2.1.1.1 Infrastructure Development: 13
      - 3.2.1.1.2 Extractive Opportunities & Local Needs Assessment 13
      - 3.2.1.1.3 Biological Inventories: 13
      - 3.2.1.1.4 Improved Management Capability: 13
      - 3.2.1.1.5 Capitalizing on Ecotourism Potential 14
    - 3.1.1.2 Conservation Education Extension Approach . . 14
    - 3.1.1.3 Monitoring and Impact Evaluation 14
    - 3.1.1.4 Supporting Policy Reforms 15
- 3.2 **Upper Watershed** 15
  - 3.2.1 **Mitigative Technologies** 15
    - 3.2.1.1 Forest Plantations and Woodlots 16
    - 3.2.1.2 Tree Crops and Nurseries 17
    - 3.2.1.3 Contour Cultivation and Strip Cropping 18
    - 3.2.1.4 Trash Lines 18
    - 3.2.1.5 Biological Contours (Vegetative Strips) 18
    - 3.2.1.6 Infiltration Ditch 19
    - 3.2.1.7 Fishscale Micro-Terraces 19
    - 3.2.1.8 Bench (radical) Terraces 19
    - 3.2.1.9 Gabions and checkdams 20

3.2.2 **Technology Extension Approach** 23
3.2.3. **Monitoring and Impact Evaluation** 24
3.2.3.1 Quantitative Physical Measures 24
3.2.3.2 Qualitative Measures 24
3.2.4 **Policy Assistance Priorities** 25
3.3 **Lower Watershed** 25
3.3.1 **Mitigative technologies** 26
3.3.1.1 Primary sewage treatment 26
3.3.1.1.1 Digestion/Stabilization Ponds 26
3.3.1.1.2 Biofiltration Ponds 27
3.3.1.1.3 Constructed Wetlands 27
3.3.1.2 Sewage Treatment for Rural Areas 27
3.3.1.2.1 Septic Tank 28
3.3.1.2.2 Open Pit Latrines 28
3.3.1.2.3 Elevated Latrines 28
3.3.1.3 Integrated Pest Management 28
3.3.1.4 Forest Plantations, Woodlots and Nurseries . . . 29
3.3.1.5 Training and support for the commercial production of fuel-efficient cookstoves. 29
3.3.2 **Technology Extension Approach** 30
3.3.3 **Monitoring and Impact Evaluation** 31
3.3.4 **Supporting Policy Reforms** 32
3.4 **Mangrove Estuarine Forests** 33
3.4.1 **Mitigative Technologies** 34
3.4.1.1 Forest inventory and preparation of multiple use plans 34
3.4.1.2 Reforestation on poorly regenerated or blank areas 35
3.4.1.3 Rotational cuts within degraded areas for timber production. 36
3.4.1.4 Fuelwood plantations on upland fringes. 36
3.4.1.5 Small-scale charcoal production. 37
3.4.1.6 Small-scale, extensive shrimp mariculture. 37
3.4.1.7 Fish-Aggregating Devices (FADs) 39
3.4.1.8 Small-scale, Artesenal Long-Line Fishing Boats . 39
3.4.1.9 Ice-making, washing and cold-storage facilities for improved quality of capture fishery products. 40
3.4.2 **Technology Extension Approach** 42
3.4.3 **Monitoring and Impact Evaluation** 43
3.4.4 **Policy Assistance Priorities** 44

ANNEXES

1. Figures
2. Bibliography
3. Persons Contacted

ACRONYMS

AMAR	Amigos del Arbol
ANDA	National Water and Sewage Authority
BOD	Biological Oxygen Demand
CATIE	Centro Agronomico Tropical para Investigación y Enseñanza
CDSS	Country Development Strategy Statement
CEL	Commisión Ejecutivo Hidroelectrica del Rio Lempa
CENDEPESCA	Centro de Desarollo Pesquera
CENTA	Center for Agricultural Technology
CLUSA	Cooperative League of the USA
CPUE	Catch per Unit Effort
FAD	Fish Aggregating Devices
FAO	Food and Agricultural Organization
FIS	Fundación de Inversions
FUSADES	Fundación Salvadoreño para el Desarrollo Económico y Social
GTZ	German Fund for International Development
IDB	International Development Bank
IPM	Integrated Pest Management
IUCN	International Union for the Conservation of Nature
MAG	Ministry of Agriculture
MPT	Multi-Purpose Trees
NGO	Non-Governmental Organizations
PACD	Project Assistance Completion Date
PID	Project Identification Document
PL	Postlarvae
PRA	Participatory Rural Appraisals
PROMESA	Protection del Medio Ambiente Salvadoreño Project
PVO	Private Voluntary Organization
RENARM	Regional Natural Resource Management Project
TED	Turtle Exclusion Device
USAID	United States Agency for International Development

LIST OF TABLES

Table 1. Biophysical impacts of alternative farm soil management technologies for consideration in demonstration ares.

Table 2. Extension and adoption selection criteria for upper watershed soil conservation treatments on agricultural holding.

Table 3. Estimated Cost/Benefit of Technology Interventions in the Upper Watershed.

Table 4. Anticipated impacts of Selected technical interventions in the lower watershed.

Table 5. Estimated per-unit costs for selected technology interventions in the lower watershed.

Table 6. Summary cost/benefit presentation for one hectare extensive shrimp pond.

Table 7. Anticipated Impacts of Technical Packages in the Mangrove Portion of the Demonstration Slice.

Table 8. Extension and Adoption Criteria for Mangrove Area Income Generation Interventions.

Table 9. Estimated per-unit Capital Investment Cost for Different Technical Interventions in the Mangrove Areas.

EXECUTIVE SUMMARY

The purpose of this report is to provide the USAID/El Salvador Mission and eventually the collaborative design team with interim information on the types of interventions, implementation methods, costs and benefits of potential activities within the project's demonstration component. These interventions link directly with the Policy, Institutional Strengthening and Environmental Education components for achievement of the project's goal and purpose.

Broad problem areas that materially contribute to El Salvador's well-known environmental and natural resource management misfortunes and which are appropriate for technical solutions, are identified as: the wholesale loss of forest cover; the contributions of export-led agricultural policies to pesticide contamination; the degradation of continental and coastal water quality, and; the overwhelming burdens of high population density.

The demonstration component of PROMESA is structured around the concept of geographic "slices", which are comprised of individual watersheds from territorial limits of offshore areas to the 700 meter contour. The description of technological interventions in this report is therefore organized around the same concept - first presenting technical options for the Upper Watershed and progressing to coastal and mangrove management options.

Upper Watershed technical interventions focus on soil and water conservation technologies that should lessen the erosion and loss of crop productivity characteristic of traditional milpa cultivation. The consequent reduction in soil loss will positively affect the Lower Watershed via reduced siltation. Increased productivity will slow clearing of remaining forest cover for new agricultural land, further slowing loss of the country's remaining biological diversity. Parallel activities of plantation forestry and promotion of tree crops will likewise extend Salvador's acreage of forest cover and reduce dependency on remaining natural forest (including mangrove) for fuel and construction wood.

Lower Watershed technical interventions will focus on reducing water pollution derived from agricultural pesticides and urban/rural sewage effluent. Integrated Pest Management and appropriate primary sewage treatment are the two principal technologies considered appropriate for this area. Downstream positive impacts will include reduced health risk from fecally transmitted pathogens and contamination of estuarine food webs with persistent pesticides.

The promotion of rational management of mangrove forests and environmentally sustainable means of generating alternate income to the country's economic caste (i.e. fishermen) comprise the technical interventions proposed for the Coastal/Mangrove

areas. Thorough inventory, afforestation of blank tidal areas and rotational harvests are the principal interventions proposed for the mangrove forests; while extensive mariculture and fisheries enhancement strategies are the principal means proposed for alternate income generation.

1.0 PURPOSE OF REPORT AND CONCLUSIONS

The two person team's terms of reference called for developing a "laundry list" of promising initiatives which have had successful results in El Salvador and elsewhere. Interviews (Appendix 3), site visits and literature searches (Appendix 2) were conducted during the two week period in order to centralize and analyze available information.

Several major conclusions became apparent with regard to implementing the Demonstration Component:

1. El Salvador is the first country in Central America to have hit environmental rock bottom where improved production of either exports or basic cereals and pulses is directly dependent on widespread application of regenerative technologies and approaches to improve environment and natural resources management. CDSS goals of broad-based, export-led economic growth will not be achievable without improved management of soil and water resources;

2. While technical options abound success will be determined by the extent to which the implementing consortia establishes and maintains the confidence and participation of local communities within the Demonstration Areas throughout the project implementation cycle;

3. The need to be responsive to local interests will result in a complexity of activities and partnerships which strongly suggests the project focus on no more than two watersheds west of the Rio Lempa and consider a third to the east of the river in the event of a peace accord;

4. The lack of reliable information on production costs and market prices of traditional and non-traditional commodities, degree of water and tissue contamination, and worth of mitigative or ameliorative treatments require that the project develop improved information during the first several years to prioritize activities.

5. Neoclassical economic rationales and oversubscribed delineation of specific outputs should be dispensed with during the design. Demonstration component inputs and outputs will need to be process oriented versus being geared for fiscal and commodity measures, and emphasize the "connectivity" between upstream mitigations and downstream benefits.

Effective interaction between policy reforms, increased environmental awareness and institutional strengthening will be felt at the ground level and ultimately determine project

success. The level of integration of the efforts will largely depend on the extent to which a cohesive consortia is fostered. The project management structure will largely determine how collaborative these partners and components are.

2.0 PROBLEM STATEMENTS

The list of environmental problems facing El Salvador for which restorative/technical solution is appropriate under PROMESA constitutes a long and cheerless litany. Many issues that to varying degrees preoccupy the entire region have found their strongest expression in this country - perhaps justifying the common opinion that El Salvador has hit "environmental rock bottom". As the first to arrive at the bottom, and in the consequent absence of the large natural areas enjoyed by its neighbors, El Salvador must by default occupy a significantly more challenging niche - that of pioneer in the means by which a country can reverse the loss of its entire resource base and restore some measure of natural system function to severely degraded areas.

When faced with problems of such a generalized and acute character the decision to prioritize issues and focus USAID resources becomes an obvious one. A focus on small successes in obvious problem areas will more effectively catalyze the immense effort needed to effect similar change in the remainder of the country than would less clear-cut success spread over a number of problem and geographic areas.

Finally, the team has responded to the terms of reference and provided a menu of technology interventions that may be appropriate for the demonstration areas. However it cannot be overemphasized that the realities of the field rather than individual technology packages should drive this project. The social chaos of the past decade requires that solid fieldwork validate the appropriateness of individual technologies well before final selection is made.

Although strong links exist between all of the factors contributing to environmental degradation, the issues can be logically separated into four main technical problem areas.

2.1 Problem: The Wholesale Loss of Forest Cover

The wholesale loss of forest cover to agriculture has acted in combination with non-sustainable farming practices to produce

- accelerated soil erosion on hillsides with consequent loss of crop productivity;
- sediment pollution of lower watersheds and estuaries;
- annihilation of macro- and microbiodiversity

Driven by social upheaval and rapid population growth over the past four decades, El Salvador presently finds itself with the lowest percent forest cover (12% according to Heckadon-Moreno 1990) and highest population density of any country in the Americas (261/km2; World Bank 1990) - a condition further aggravated by a progressive invasion of higher and steeper sections of the watershed. The combination of high density, steep slopes and the total lack of soil and water conservation practices characteristic of the traditional *milpas* have produced phenomenally high rates of erosion, with values ranging from 137 t/ha/yr to 230 t/ha/yr in trials conducted by the Center for Agricultural Technology (MAG/CENTA 1985, cited in FESA 1991). This devastating loss of soil productivity and crop yields in turn accelerates the demand for newer and often steeper lands in order to survive (except in the case of Finata 207 lands, to which farmers are tied unto total loss of productivity).

Downstream effects of such immense sediment movements have been equally striking. Estuarine vegetation has been smothered, tidal regimes that sustain mangrove forests have been altered and -in the case of El Triunfo - ship access to port facilities has been hindered (Foer, 1991).

Not surprisingly, the decline of El Salvador's floral and faunal diversity has occurred in equal measure to the rate of deforestation - with the El Salvador country environmental profile classifying 128 vertebrates (excluding marine forms) in conditions ranging from threatened to extinct (EMTECSA, 1985). An additional 65 tree species and 52 orchids were listed as being "in danger of extinction" in the USAID-sponsored study. At present, a scant 6% of the national territory remains in natural forest, of which pine and mangrove comprise about one half and most of the remainder is secondary growth. The remaining balance of natural forest is so thoroughly fragmented among the country's 108 designated protected areas (parcels ranging from the 150 ha. "Volcan de San Vicente" to the 5,000 ha. "El Imposible") as to lose real utility as biodiversity reserves.

2.2 Problem: Export-led Economic Policies

Export-led economic policies emphasizing intensive cultivation of high-value commodities such as cotton, coffee and fresh vegetables have resulted in heavy, sustained use of persistent pesticides and chemical fertilizers, causing

- long-term contamination of soils and water;
- accelerated eutrophication of major lakes and lagoons;
- loss of human productivity due to acute health problems associated with pesticides;

- decreased foreign exchange earnings via compromised quality in export commodities; and,
- loss of biodiversity, particularly in higher-order predators of the coastal estuaries.

El Salvador's penchant for heavy use of pesticides is legendary. Prior to the decline of cotton in the early part of the 1980's, El Salvador ranked as the highest consumer of pesticides in Central America - reaching a high of 593.5 kg/km2 of organochlorides and Parathion in 1973 (USAID/WASH 1991).

Although the most extreme pesticide abuse and consequent contamination has diminished in proportion to cotton's decline, many of these compounds and their derivatives persist at detectable levels in beef (up to 3.42 ppb DDT & metabolites in fatty tissue - Arreaga et al, 1988, cited in USAID/WASH 1991), soil (up to 2.52 ppm DDT - MOP, 1983 cited in USAID/WASH, 1991) and clams (up to 30 ppb in Anadara spp - USAID/WASH 1991). It is also widely suspected that the reactivation of cotton fields that have lain fallow since the early 1980s will bring up pesticide-laden strata during the sub-soiling process. In any event present use of pesticides remains high - and mishandling or improper application is the rule rather than the exception.

This chemical load has exacted a toll on the country's human health, export status and biodiversity that will yet persist for some years. Although 1,176 cases of pesticide poisoning were reported annually (Arreaga et al 1988; cited in USAID/WASH 1991) this number represents only those cases sufficiently acute to warrant hospitalization. These statistics furthermore fail to account for any role the chemicals play in birth defects and chronic ill health - recognizable problems to any long-term resident of the country. Pesticide residues have also been cited as cause for seizure of agricultural exports by the FDA, most notably on oranges (Mary Ayling, FDA Import Operations Branch, Rockville Maryland, personal communication). Although not documented, persistent anecdotal accounts of pesticide residues in shrimp exports are testimony to El Salvador's reputation, and contribute to very real perceptions of poor quality in the highly competitive U.S. market.

Finally, although no data is available to correlate wildlife populations with pesticide contamination, there is a marked absence of higher-order birds that became obvious to the team during field visits. In one weekend tour that covered the foothills of El Imposible, the Barra de Santiago and the connecting distances to San Salvador; only one terrestrial raptor (a kestrel; Falco sparverius) was observed during the entire period. More striking was the virtual absence of piscivorous birds in the estuary of the Barra de Santiago, which yielded the observation of only four brown pelicans during the team's visit...and

where formal inventories of avifauna have yet to account for a single observation of cormorants in the past year (Marta de Tobar, Museo de Historia Natural de San Salvador; personal communication).

2.3 Problem: Continental and Coastal Water Quality Degradation

The degradation of continental and coastal water quality as a direct result of sewage and other point-source pollution has resulted in:

- increased human diseases and productivity losses via water-borne transmission of pathogens; and
- loss of foreign exchange earnings via quality problems in export commodities.

The discharge of raw sewage into rivers and lakes is prevalent in El Salvador. Although two coastal cities - La Libertad and Acajutla have installed primary treatment facilities, these have suffered chronic malfunction resulting from inappropriate and complex technology (Ruth Castro de Melara, ANDA, San Salvador personal communication). The city of San Salvador itself has no sewage treatment and discharges raw effluent into the Acalhuate River, although construction of centralized collection centers is imminent pending approval of financing from the IDB. As a result of this generalized condition, fecal coliform counts regularly exceed 1,000 mpn/liter in the coastal areas (Nunez et al 1990) and were recorded as high as 26,0000 mpn/L in September of 1991 (USAID/WASH 1991). It is noteworthy that in the latter survey every one of the samples from 26 sites in the coastal area west of the Lempa River was contaminated with fecal coliform bacteria - a parameter for which international drinking water standards allow zero tolerance.

These conditions exact a measurable cost on Salvadoran productivity. The Ministry of Public Health reported in its 1988 yearbook that 65% of the population sampled (25% of national) suffered illness attributable to poor environmental conditions and that diarrhea and parasites (i.e. caused by fecal contamination) accounted for over half of those cases (Nunez et al, 1990). In parallel fashion to the case of pesticides, the contamination of high-value commodities by human pathogens has affected El Salvador's export status. Shipments of fresh shrimp from El Salvador were in fact seized for salmonella contamination in April 1991, and all imports of fresh shrimp into the US from El Salvador are at present subject to automatic detention for bacterial contamination (Betsy MicMichael, FUSADES/USAID Aquaculture Program, personal communication). In the April case, the contamination was strongly suspected to have originated with contaminated pond water, since processing and packing was subject to very strict control (Bethsy MacMichael, USAID/FUSADES shrimp mariculture project, personal

communication).

Although IDB financing is pending for the construction of sewage treatment plants in 12 small (pop. 5,000 to 15,000) cities, none of these are located in the proposed PROMESA project areas. Increases in population and the advent of cholera therefore only assure further degradation from this source.

2.4 Problem: Demands of a Growing Population

Rapid population growth, combined with prolonged civil war and restructuring of social systems (i.e. land tenure) has driven

* large-scale movements of rural populations into the productive areas; and
* unsustainable pressure on natural systems as rapid occupation of increasingly fragile land drives up demand for food (e.g. fisheries) and fuel, while elevating pollution loads on the watershed.

Already possessing the highest human density in the Americas, continued rapid growth of El Salvador's population is expected by some experts to produce figures as high as 420/km2 by the turn of the century (Haggerty, 1990 - cited in Foer, 1991). The obvious and expected effect of this growth on the utilization of natural resources has been further complicated by large shifts in population as result of war and agrarian reform.

Particular concern exists over measured declines in fisheries catch-per-unit-effort (CPUE) values in recent years (CENDEPESCA, 1990). In the Barra de Santiago - one of the likely demonstration watersheds - the population has grown by over 3% p/a over the past three years (CATIE, 1991); and on a national scale the fishing population has increased from 1,500 to 20,000 families since 1975 (Francisco Guevara, Director of Statistics for CENDEPESCA; personal communication). Many of these new fishermen are recently arrived farmers from the interior who were driven to the coastal areas by the conflict.

In parallel fashion to the finfishery, commercial exploitation of conch, bivalves and crabs has produced alarming declines in wild stocks (Foer, 1991). In the case of oysters and clams (especially the popular "curil" - Anadara spp.) particular concern has been expressed that populations could be degraded beyond the ability to recuperate (Jorge Ramos, FUSADES/USAID aquaculture project, personal communication). In the case of nearshore trawl and gill-net fisheries dwindling catches are popularly attributed to excessive by-catch from commercial shrimpers - although the decline of the estuarine crustacean and mollusc harvest is clearly attributable to local, artesenal harvest.

Extraction for fuel and timber is considered the single greatest threat to the mangrove forests (Yanes et al, 1991). In light of their lonely presence as the largest remaining stands of timber in the country and the domestic dependence on firewood as the primary energy source (=64.3% of national energy consumption - Guevara Moràn et al., 1985; cited in Yanes et al, 1991) the continued extractive pressure on these forests is a given. In addition to cooking fuel, wood energy is used almost exclusively in firing bricks, the primary housing construction material.

Although recent estimates of mangrove forest cover vary from 17,000 ha (Francisco Rivas; Amigos del Arbol, personal communication) to 35,000 ha (Miranda, 1990) no formal effort has been made to inventory the actual extent of the resource.

On the management side, deficiencies in policy and institutional strength further contribute to the problem. Although cutting is nominally managed via permitting through the Servicio Forestal (MAG) in their proprietary capacity, the strength of this organization is not equal to the exercise of the most minimal control over unsanctioned cutting - even by other branches of the government. Ayana (1990, cited in Yanes et al, 1991) believes that a full 70% of mangrove cuttings are unsanctioned. The few permits that are granted have no rational basis since the location, quality and volumes of timber within each of the Forest Department holdings is completely unknown. Further compounding such man-made issues, a severe hurricane in 1983 leveled many stands of mangrove that have not fully regenerated to this day.

Continued lack of basic forest management practices - coupled with weak enforcement of (or nonexistent) management policies and a primary dependence on mangroves for fuel - assure that these mangroves will not survive into the next decade in any significant functional capacity unless the present situation is turned around.

3.0 SOLUTIONS AND OPPORTUNITIES

3.1 Rationale for Selecting Interventions

The following section attempts to identify, prioritize and develop a limited economic rationale for some of the potential interventions within the Demonstration Component. Activities are desegregated by geographical juxtaposition beginning with protected areas that occur at the top of the watersheds and at the marine/coastal area. Between these two the areas are divided into upper watershed, which includes the steeper erosion-prone terrain inhabited by non-Cooperative members (minifundistas and desplazados), and the lower watershed, characterized by softly undulating topography of which better than one - half is held by cooperatives for the large-scale production of commodity crops.

Following each geographical zone, a listing of policies upon which widespread adoption of technologies depends is provided. Interaction between policy reform and demonstration is an implicit part of the PID and should be carefully nurtured in the Collaborative Design Process.

3.2 Possible Interventions

The following solution set is intended to be illustrative and for the use of the Mission and Collaborative Design Team's consideration. Given the tremendous diversity of demographics, land forms, historical land use, institutional and extension order, and agroecology the technical solutions need to be weighed and arranged through a consultative process. Component implementers will doubtless find that this process and development of a supporting policy environment will determine adoption success. For these reasons technology selection "sieves" should be ordered first by likelihood of adoption criteria, followed by biophysical impacts, and finally through more straight forward economic/financial criteria.

It must be recognized that with the limited available information classical economic evaluation methods may not show cost effectiveness from many of the technical interventions (particularly the Upper Watershed actions). However, if extended beyond the project assistance completion date these same interventions should make a material and economically viable contribution to environmental integrity in demonstration areas. Anticipated benefit flows that will enhance the "connectivity" and well being of a given demonstration are are illustrated in Figure 8 (Appendix 1).

3.2.1 Parks and Protection Activities

Of the 60 natural areas in El Salvador that were deemed worthy of some protection (Benitez 1989, cited in Nuñez et al 1990) only six have park wardens. For the total number of 108 areas that have some classification as parks only 31 professional staff are available in the Servicio de Parques Nacional for their administration (Hasbun pers. comm.). The areas are of two principal types: remote upland forested parks on very steep slopes and marine areas located at the mouths of major drainages typified by mangroves and littoral wash accumulation. Many of these areas are probably of minimal biologically utility due to smaller than minimum critical size for maintenance of populations. Park authorities recognize this and with some assistance would like to consolidate protected areas to less than a dozen of the most valuable tracts and consider passing the other forests over to MAG's Forest Service.

Forested Parks are surrounded by dense populations of usually unorganized subsistence smallholders operating in difficult farming conditions and disenfranchisement from public services. These Parks, such as El Impossible and Los Volcanes suffer the consequences of unregulated hunting, timber harvest and full scale encroachment due to lack of regulatory capability. Since farming occurs right up to the edge of protected areas, in most the concept of a "buffer zone" is not readily applicable. All activities described within the Upland Watershed activities would be applicable around the park perimeters.

The Marine Parks, such as Barra de Santiago and Herradura, are located at the foot of flat or softly undulating land inhabited by dense populations most often practicing large scale commodity agriculture as cooperatives. These estuarine areas have been largely impacted by extractive activities (shellfish and fish harvest, mangrove cutting and hunting, agriculture expansion) and widespread contamination by agrochemicals used in adjacent cane, cotton, rice and maize culture.

3.2.1.1 Mitigative and Management Opportunities

Objective: Protect and manage the remaining biological resources within the National Parks and Special Reserves located in upper watersheds and coastal areas. This will include straightforward park management activities including biological assessments, improved regulatory capacity, enhancing awareness of protected area values, and development of long-term financial solvency. Prioritized activities are as follows:

3.2.1.1.1 Infrastructure Development:

With support from PROMESA survey and clearly demarcate the Parks' boundaries to halt encroachment and unregulated extraction activities. This activity will require temporary strengthening of the Park Service's surveying capability or support to the Cadastral Service as the surveying backlog and capability of the latter precludes timely response. Develop an adequate set of foot trails and trained park guards for surveillance purposes. Construct a small office for guards adjacent to the park interpretation facilities and study the potential for establishing a research camp. Guards should be hired from adjacent villages to the greatest extent possible.

3.2.1.1.2 Extractive Opportunities & Local Needs Assessment

The project should support consultancies by local social scientists who will implement rapid rural appraisal surveys of surrounding populations. Lists of products and activities occurring in the parks should be made and every effort to work with the development NGO to provide alternative sources of products should be undertaken. 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.

3.2.1.1.3 Biological Inventories:

Develop comprehensive floral and faunal species lists. The lack of knowledge of species in and around El Salvadors' few remaining protected areas is nearly complete. Since the project will undertake protection of at least two of the four Parks which may be biologically viable all efforts to utilize local university and NGO talent to develop systematic inventories and a supportive database system is a priority. Other areas could be judged by these inventories and the Park service can then concentrate on those protected areas meriting attention and consider options for consolidating or relinquishing less important areas. The National Park Service maintains 103 protected areas with a staff of 31. Careful attention to predatory estuarine avifauna should be used to gauge resiliency of the mangrove areas from agrochemical toxicity.

3.2.1.1.4 Improved Management Capability:

Assist the Central and Demonstration Area specific offices of Parques Nacionales to improve their fiscal, personnel and material management systems. The ultimate goal should be, in direct cooperation with the Institutionally Strengthening component, development of a pay-as-you-go clientele and financial management systems which will allow individual protected areas to live beyond PACD. Acquisition of one vehicle (a boat for the marine parks) and two or three motorcycles per Demonstration Area is required.

Field equipment and development of incentive systems to reward effective guard performance should be developed as early as possible.

3.2.1.1.5 · Capitalizing on Ecotourism Potential

Develop interpretation centers 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 ultimately defray recurrent costs. The potential for foreign tourism is very limited in El Salvador so park management should focus on local opportunities with a strong conservation education accent on initiatives. Development of modest interpretation centers near park entrances provides access to an increasingly environmentally aware Salvadoran population. Foot trails and strategically placed overlooks and vistas within the parks are also recommended.

3.1.1.2 Conservation Education Extension Approach

This activity will be undertaken through the Environmental Education Component of PROMESA although it is recommended that Protected Areas within the selected Demonstration Areas receive prioritized attention. The traditional "comic book and t-shirt" approach to conservation education will need to offer more direct alternatives to present practices if a long-term management response is desired. The Institutional Strengthening Component, in that it will equip and organize NGOs, should specifically support those NGOs (like AMAR) willing or already active in Parks.

3.1.1.3 Monitoring and Impact Evaluation

The monitoring and impact of protected area activities will require several perspectives. The worth of specific interventions will be measured by the extent to which encroachment in upland parks ceases, management of extraction within marine areas improves, and people adjacent to the parks are active members of a conservation coalition.

Spatial time-series data (satellite or high altitude photography) coupled with park guard records should be used as the basis for determining encroachment success. Records depicting the ability to successfully interdict and prosecute cases of illegal activity will also provide a proxy for improved presence and guard performance.

Lastly, CEL's high interest and considerable technological sophistication would make it a worthy partner for university studies undertaking extraction and analysis of differential watershed yields. Under CEL guidance, thesis and dissertation research could be developed to provide runoff measures from undisturbed areas (e.g. El Impossible) combined with comparative assessment in inhabited areas - providing benchmark goals

for results in demonstration watersheds. Subsequent installation of instrumentation in similar topographic conditions within project watersheds would provide valuable data that could help tune the aforementioned treatments and models.

3.1.1.4 Supporting Policy Reforms

According to Nunez et al (1990) the legal framework for the Park Service is adequate. The fundamental problems lie in the Service's ability to garner fiscal and personnel support from central sources. Since macroeconomic conditions are unlikely ever to permit National Parks to have significant resources several financial management and administrative policies should be investigated under the Policy Reform Component.

Specifically changing the laws which govern control of park gate receipts will be required 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 which regulate who and how park boundaries are established need to be reviewed and probably revised. Under the present backlog and prioritization methods, surveying and titling for the Park Service would probably not happen for a very long time.

3.2 Upper Watershed

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

3.2.1 Mitigative Technologies

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

The following descriptive list begins with more strictly tree-related types of afforestation to more traditional on-farm interventions and completes with management of run-off not assimilated in either of the former two classes. The level of risk, inputs and extension

ease are located Tables 1 and 2. Illustrative economic analyses of several of the technologies are found in Table 3. Figures 1 through 7 illustrate recommended technologies (Appendix 1).

Given that individuals and cooperatives will choose the technologies they feel best respond to their needs, the process and approach of extension development (section 3.2.2) is probably more critical than any single intervention. Provision of demand-driven interventions based upon solid diagnostic work will be key.

3.2.1.1 Forest Plantations and Woodlots

Development of individual or group woodlots for fuelwood, construction poles and saw timber offer the greatest opportunities for direct economic returns commensurate with the primary environmental objective. Preliminary economic analysis (Table 3) using accepted fuelwood yields (Tschinkel 1991; Ing. Lario pers. comm.) and market prices for fuelwood and saw timber (Nagy pers. comm.) confirm that woodlots and plantations offer attractive opportunities. Thirty-year net present value estimations for fuelwood and saw timber plantations at present discount rates and 1991 prices are c/5,148 and c/65,911 respectively. A composite stand of 1/2 fuelwood (branchwood and sidecuts) and 1/2 saw timber would yield an NPV of c/35,530 under similar conditions. No information was available on pole timber yields although they normally fall between fuelwood and timber. Well organized cooperatives on better drained sites may wish to strongly consider development of export-oriented high value timber plantations such as teak (Tectonis grandis) where returns offer exceptional opportunities in a hemisphere quickly depleting remaining hardwood resources.

Regardless of economic yields in order 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- large monospecific block plantings should be discouraged in favor of mosaics based on site-species matching). Overuse of dense stands of eucalyptus or pines on steep sites where understory vegetation is out-competed should be avoided;

- Construction of harvest access roads should carefully follow standard slope limitations, drainage requirements and distance from stream beds;

- Use of agrochemicals for establishment should be discouraged but more benign types used when needed;

3.2.1.2 Tree Crops and Nurseries

Use of improved or grafted fruit tree stock such as mango, avocado, cashew, and bananas 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) which can be harvested for wood and green manure products should be considered. These are best combined with one our more of the techniques listed below. Species readily available and identified by the team during site visits include Leuceana leucocephala, Gliricidia sepium, Caliandra calothyrsus, Samana saman, and Sesbania spp.. CATIE can provide genetically verifiable and improved seed through the RENARM project's Tree Seed Improvement component.

El Salvador has an estimated 265 nurseries which are tended by some 5,300 people and produce approximately 1.1 million seedlings annually[1] (Tschinkel 1991). Survival rates are highly variable and evidently depend on seedling quality, outplanting practices, and maintenance. Not surprisingly anecdotal 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 any of the PROMESA project's tree production 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. The FAO project (Solazano per. com.) has had excellent results with credit repayment by small nursery operators. While it is tempting to provide a list of appropriate and probably desirable species the authors feel it is prudent to leave that to project implementers (the PP design team should also refrain from getting specific and concentrate on developing processes and systems which 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 Salvadoran countryside.

[1] This implies the average nursery produces some 4150 plants and employs a considerable 20 laborers. These figures are well below efficiencies found in neighboring countries.

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

3.2.1.3 Contour Cultivation and Strip Cropping

All of 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 which limits unimpeded surface flow and improves percolation, reducing erosivity. 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 more intensive efforts listed below. Finally - by way of general warning - all of the following technologies are soil depth and structure, slope and microclimate dependent: they should not be viewed as unabashed panaceas and need to be preferred only after thorough investigation.

3.2.1.4 Trash Lines

Trash lines take contour farming a step further in that crop residues and stones encountered during cultivation are collected along contour lines. 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 been proven to increase yields in relatively short periods where water availability is a limiting factor.

3.2.1.5 Biological Contours (Vegetative Strips)

Biological contours are an additional improvement over the contour strip farming and trash lines and are most often used together with these first two techniques of arresting pedon migration. This technique requires that farmers cultivate across slopes instead of up and down. 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 the lines are together. Leveling of 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 advised 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, 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% loss in surface area (due to the presence of the strips) offset by a 20% increase on remaining acreage would yield a positive return to associated investments (NPV = C 8224). Other models tested under similar agro-ecological conditions would support this conclusion and, given the apparent on-farm labor surplus, these technologies deserve closer attention during design and implementation.

3.2.1.6 Infiltration Ditchs

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. There are a wide variety of ditching 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 contouring 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 El Salvador can construct 20-25 m of ditching per day. On steeper slopes the project will need to carefully monitor for mass wasting (slumping) which been known to occur on steep and volcanic water-logged sites (Rwanda, Uganda, Philippines) under this system.

3.2.1.7 Fishscale Micro-Terraces

Fishscale or mini-terraces are used on steep slopes in order to catch and direct maximum run-off to small areas where valuable tree crops are placed on very steep slopes (60%+). Typically the semicircular, rock-faced, back-sloping design measures a variable 1-2 m long by 1-2 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 in El Salvador (Salano pers. com.) suggest an average male laborer can construct seven to 10 terraces per day. No information is available on fruit tree yields however.

3.2.1.8 Bench (radical) Terraces

Bench or radical terraces are generally accepted as the ultimate intensity in physical management of soil runoff and water retention management and are most often associated with animal or machine traction. Although it is unlikely the project will successfully introduce these on a widescale, they are worth mentioning. 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 increased growing area suggest why nearly all of China's bread basket is bench terraced.

3.2.1.9 Gabions and checkdams

Gabions and check damns are structures designed to slow water that has escaped from farm lands and has exceptional erosive force which has created gullies and can wash out important infrastructure. 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.

Table 1. **Biophysical impacts of alternative farm soil management technologies for consideration in demonstration areas.**

ACTIVITY [2]	Contour Farming	Trash Lines	Vegetative Strips	Infilitrat. Ditches	Fishscale Terraces	Radical Terraces
Biophysic. Impact						
Reduce Erosivity	+	+	+	+	+	+
Increase Recharge		+	+	+	+	+
Lengthen Cropping			+	+	+	+
Increase Runoff Period				+	+	+
Decrease Slope					+	+

(1) + deontes positive impact

Table 2. **Extension and adoption selection criteria for upper watershed soil conservation treatments on agricultural holdings.**

ACTIVITY	Contour Farming	Trash Lines	Vegetative Strips	Infiltrat. Ditches	Fishscale Terraces	Radical Terraces
Selection Criteria [3]						
Low Farmer Risk (B/C)	+	+	+	0	0	0
Low Cost & Inputs	+	+	0	0	0	-
Ease in Extension	+	+	0	+	-	-
Tradition. Produce Markets	+	+	+	+	-	-

[2] Indicated options can be additive so that net result of any two or more technologies will greatly enhance biophysical performance. (+) denotes where an impact has been quantifiably demonstrated.

[3] the subjective classification of adoption criteria is as follows: (+) is assigned to favorable factors, (0) is assigned to those nearing neutral and (-) to those criteria having inherently high risks either due to unsure markets, unsure returns to labor investment

or physical soil loss through slumping

Table 3. Estimated Cost/Benefits of Technology Interventions in the Upper Watershed
A. COSTS (Labor+materials, including scheduled maintenance labor)

YEARS	Fuelwood Woodlots	Sawntimbe Woodlots	½ Fuel+ ½ Saw	Vegetat strips	Barriers + Infil Dtc
1	1,405	1,405	1,405	452	3,769
2	763	763	763	226	565
3	266	266	266	266	565
4	266	266	266	266	565
5	266	266	266	266	565
6	266	266	266	266	282
7	266	266	266	266	282
8	266	266	266	266	282
9	266	266	266	266	282
10	266	266	266	266	282
11	266	266	266	266	282
12	266	266	266	266	282
13	266	266	266	266	282
14	266	266	266	266	282
15	266	266	266	266	282
16	266	266	266	266	282
17	266	266	266	266	282
18	266	266	266	266	282
19	266	266	266	266	282
20	266	266	266	266	282
21	266	266	266	266	282
22	266	266	266	266	282
23	266	266	266	266	282
24	266	266	266	266	282
25	266	266	266	266	282
26	266	266	266	266	282
27	266	266	266	266	282
28	266	266	266	266	282
29	266	266	266	266	282
30	266	266	266	266	282
TOTAL	9,616	9,616	9,616	8,126	13,079

B. ANNUAL PRODUCTION (Commodities at farm or forest gate)

prod/ha = value/unit	12/m3/yr 130	12/m3/yr 1147	12/m3/yr 630	4297lbs/ha 2640	4297/lbs/ha 2640
1	1,560	13,764	7,662	2,640	2,640
2	1,560	13,764	7,662	2,640	2,640
3	1,560	13,764	7,662	2,640	2,640
4	1,560	13,764	7,662	2,640	2,640
5	1,560	13,764	7,662	2,640	2,640
6	1,560	13,764	7,662	2,640	2,640
7	1,560	13,764	7,662	2,640	2,640
8	1,560	13,764	7,662	2,640	2,640
9	1,560	13,764	7,662	2,640	2,640
10	1,560	13,764	7,662	2,640	2,640
11	1,560	13,764	7,662	2,640	2,640
12	1,560	13,764	7,662	2,640	2,640
13	1,560	13,764	7,662	2,640	2,640
14	1,560	13,764	7,662	2,640	2,640
15	1,560	13,764	7,662	2,640	2,640
16	1,560	13,764	7,662	2,640	2,640
17	1,560	13,764	7,662	2,640	2,640
18	1,560	13,764	7,662	2,640	2,640
19	1,530	13,764	7,662	2,640	2,640
20	1,560	13,764	7,662	2,640	2,640
21	1,560	13,764	7,662	2,640	2,640
22	1,560	13,764	7,662	2,640	2,640
23	1,560	13,764	7,662	2,640	2,640
24	1,560	13,764	7,662	2,640	2,640
25	1,560	13,764	7,662	2,640	2,640
26	1,560	13,764	7,662	2,640	2,640
27	1,560	13,764	7,662	2,640	2,640
28	1,560	13,764	7,662	2,640	2,640
29	1,560	13,764	7,662	2,640	2,640
30	1,560	13,764	7,662	2,640	2,640
NPVb	7,767	68,530	38,149	13,144	13,144
NPVc	2,619	2,619	2,619	1,452	4,920
NPV	5,148	65,911	35,530	11,693	8,224

(1) Assumes 12m3/yr/ha@100% fuelwood, poles and timber considerably
(2) Assumes 10% net increase in maize yeilds (10% area loss to technology)

(3) Assumes a 20% loss in area planted in maize but includes compensatory yields from 200 banana plants
(4) All costs and prices in C 1990 with I@20%
(5) Fuelwood and timber estimates from CATIE (1990)

3.2.2 Technology Extension Approach

Farmers never adopt packages of technologies, only components that if extended correctly can, over time, approach the desired composite. The successful transmittal and execution of technology extension messages for activities in the Demonstration Component will depend on the harnessing of local interests through extant institutional structures.

The presence of fairly well organized cooperatives in the lower watershed areas is not paralleled in upper areas where loose municipal affiliations and religious structures may offer the best opportunities. Development of ground-truthed "Participatory Rural Appraisals" (PRAs) in each upper watershed will be necessary and time consuming and may preclude actually implementing any actions for up to a year from project inception. Typically PRA has several distinct and chronologically ordered stages (Gibson 1987; WRI 1990) including:

1. Site section and contacts with local GOES officials;
2. Preliminary familiarization site visits;
3. Date collection (a) spatial; (b) time-related; (c) social and institutional fabric; (e) labor availability and (f) technical problems
4. Data synthesis and analysis;
5. Isolation of primary technical problems and setting institutional opportunities for extension;
6. Ranking opportunities and development of a democratically-approved resource management plan;
7. Implementation of the resources management plan;
8. Follow-up and continual evaluation, and reappraisal of training and material support requirements;

Selection of enumerators should be competitive with the objective of using them ultimately as extension agents for technical interventions. Enumerators and the community must be involved during all stages of design and implementation. The extension design must incorporate continual feedback so that adoption and modification of packages by farmers can be integrated into extension materials.

Given the labor and other input costs some of the mentioned technologies should be credit worthy. The implementing NGOs should consider small loans for the purchase of trees, terracing materials, nursery establishment costs and any outplanting agrochemicals. The FAO "Proyecto Agroforestale" has had better than an 80% repayment rate on their

efforts which warrant a site visit by the PP design team.

3.2.3. Monitoring and Impact Evaluation

In order to determine the "best" technical options for controlling runoff and downstream impacts, and improving the connectivity between upstream interventions and improved environmental quality at the base of the watershed, PP designers will need to develop a comprehensive monitoring and impact evaluation system. In general this will require physical measures of resource quality and quantitative approximation of adoption by farmers and surface area. Weber (1990) provides a good overview of conceptual and technical means to measure impacts and Gibson and Muller (1987) provide one model to access and use changing qualitative parameters. Since direct crop yield improvements are likely to take longer than the LOP the importance of these proxies for longer-term impact be carefully considered in the design phase. Some suggestions are as follows:

3.2.3.1 Quantitative Physical Measures

- river sediment loads
- peak flow rates after event rainfalls
- longitudinal stream perenniality measures
- measure gully enlargement rates
- sediment accumulation rates behind gabions
- Wischmier plots or Gerlach trap collection of erosion rates under various treatments

3.2.3.2 Qualitative Measures

- differential farmer technology adoption rates
- change in tree species preferences
- survival rates of seedlings
- employment of appropriate maintenance practices
- participation in extension courses
- seedlings produced in private/group nurseries

The ability to prove connectivity between upper watershed treatments and estuarine impacts will be tenuous under the best of circumstances and are unlikely to become apparent during the LOP. As the steeper upper watersheds flow into the undulating foothills and flatter irrigation planes it will become increasingly difficult to isolate causal agents of water quality or quantity improvement. It is suggested that the watersheds be separated into specific units that permit quarantine of results and that different techniques be used accordingly. Peak flow rates, periodicity and physical sediment loads should be

measurod at the base of upper watersheds. Turbidity and measurement of coliforms would be more appropriate lower down. Other parameters that establish connectivity from Upper Watershed to Coastal Areas are presented in succeeding sections.

3.2.4 Policy Assistance Priorities

Several policies are likely to encourage or discourage extension and adoption of upland watershed activities. The Agrarian reform Law (phase III) will need substantial revision to encourage capital investment on non-Cooperative holdings. Small-holders are yet to be convinced that the time and trouble of investing in described technologies is worth their while. Anything that the project can do in support of accelerated surveying and titling land will encourage adoption of all the above technologies and their components. Consideration of direct support to creating mobile survey and titling teams in each slice should be seriously considered. Options for further incentives could be examined for the Finata 207 landholders through easing of long term debt.

Unlike most other countries in Central America El Salvador has an inadequate level of legislated forest management codes. Compliance capability aside, the agrarian reform failed (even in Phase III) to recognize forestry as a valid vocation of land and no credit is available to individuals for investment in forest activities with the exception of a successful FAO agroforestry project. Even more fundamentaly present tenure insecurity in many areas undercuts any motivation to plant long-term tree crops. Recognition of tree-based culture as valid and lendable land-use is critical and policy reforms and wide spread publicity about the reforms is equally vital.

Lack of quality standards for all forest products and inadequate regulatory control of illicit cutting activities act as further dis-incentives. Present fuelwood prices are comparable to those of neighboring countries with much more significant forest endowments implying that forest activities are still assigned little opportunity value other than conversion and transport costs. A absence of energy efficient stoves would also suggest the real value of household energy is still subsidized by uncontrolled fuelwood flows.

3.3 Lower Watershed

As previously described, this is an area of gently rolling topography characterized by high population density, large-scale cultivation of commodity crops and numerous rivers that drain the small watersheds of the adjacent mountains. While erosion is much less severe compared to the upper watershed, this is the region that bestows the vast majority of agricultural and sewage contamination on the adjacent coastal estuary. However, by virtue of the considerable degree of structure required for cooperative agriculture, the population of this region will also lend the greatest preexisting organizational structure to

the extension efforts initiated under PROMESA.

Objective: To mitigate the significant environmental trauma visited upon this and the downstream portion of the watershed, with particular emphasis on sewage and agricultural pollution. Control of sewage contamination, integrated pest management schemes and pesticide-use training will comprise the majority of the technical interventions - though erosion control techniques described for the upper watershed will be applied on those areas where topography and farming practices have caused significant local soil loss. Extension of fuel-efficient cookstoves will also reduce demand for firewood from adjacent coastal mangrove forests.

3.3.1 Mitigative technologies

3.3.1.1 Primary sewage treatment for population centers and point sources of organic pollution such as feedlots.

The following primary treatment technologies have been selected for the aforementioned ANDA/IDB program targeting towns of 5,000 to 15,000 population. In the selection of these technologies by the technical consultants for the ANDA/IDB project (Frederic R. Harris, Inc. 1990) the following criteria were used:

- no electrical energy requirements or moving parts;
- minimal operation and maintenance;
- utilization of natural biological processes that take advantage of Salvador's high ambient temperatures;
- utilization of nationally available materials;
- land requirements should not exceed three hectares.

Based on these criteria, the following three systems were selected.

3.3.1.1.1 Digestion/Stabilization Ponds

Stabilization ponds represent the simplest available technology and are consequently quite common in developing countries. The impermeable outdoor ponds that comprise the basic system operate on either of two principals - aerobic or anaerobic bacterial conversion of liquid wastes. The selection of process is determined by depth and flow rate; with shallow (less than 1.5 m) ponds providing greater oxygen transfer capability and

hence permitting aerobic activity, and deeper (2-4 m) ponds creating anaerobic action. The two systems are often used in tandem, depending on the volume and organic load on the incoming wastewater (i.e. water with such high BOD that no oxygen can remain in solution must rely on the anaerobic system to remove some initial portion of the organic load).

The relative advantages of this system are simplicity of construction and operation plus efficient removal of pathogenic microorganisms. The disadvantages of the system include the relatively large requirement for land and the possibility of contributing to local water-borne insect problems.

3.3.1.1.2 Biofiltration Ponds

This system relies on an enclosed, stationary media such as gravel on which a thin layer of nitrogen-fixing bacteria develops. Incoming wastewater is dispersed via diffusers, and gravity-trickles through the media for collection at the bottom of the filtration tank.

The relative advantage of this system is conservation of land area. The principal disadvantage is the need for greater removal of solids prior to treatment with consequent increase in the cost of pre-treatment structures.

3.3.1.1.3 Constructed Wetlands

This relatively new technology is comprised of a long, shallow, impermeable trench filled with permeable media (gravel). Selected vegetation is planted in a shallow layer of earth covering the media bed and the wastewater is gravity-flowed the length of the trench, allowing the vegetation to take up the organic load.

The relative advantage of this system is the isolation of wastewater beneath the vegetative/earth layer - greatly reducing odor and access by mosquitos while providing a more attractive appearance than typical sewage treatment plants. Disadvantages are that this system is the most reliant of all three on the effective pre-settlement of solids.

It should be mentioned that all of the above technologies require initial pre-treatment of the raw sewage in settling ponds to remove large solids. These components are low-tech items of simple construction and easy operation. Use of all systems further presupposes the construction of sewer lines and collection points if none already exist.

3.3.1.2 Sewage Treatment for Rural Areas

Very basic primary sewage treatment should be extended to the rural population of the project watersheds that do not presently enjoy any form of sewage collection or treatment. Primary beneficiaries would be those households adjacent to rivers and

streams that depend on decent water quality for drinking and bathing.

3.3.1.2.1 Septic Tank

Septic tanks are the most expensive individual household sewage treatment option but provide the best solution for disposal of household wastewater. The standard design recommended by ANDA calls for a brick primary tank of approximately 0.5 m3 per household resident, combined with an underground drainage "tile" line for absorption of the treated effluents.

The relative advantage of this process is effective, odorless disposal of wastewater. The major disadvantage is the relatively high expense (Table 5).

3.3.1.2.2 Open Pit Latrines

These are the standard, open pit latrines of rural areas worldwide, and which are absent from over half of the households of El Salvador. Individual homes in areas where groundwater tables are at least three meters down are the best candidates for these latrines,

The major disadvantage of this system is odor and the possibility of creating problems with insects. The major advantage is low cost and ease of construction.

3.3.1.2.3 Elevated Latrines

In areas with near-surface water tables the construction of elevated latrines is recommended by ANDA to avoid contaminating groundwater supplies. Elevated latrines typically consist of a brick tank partitioned so as to serve two separate toilets. While one of these toilets is in use, the other is sealed for a period of several months to permit anaerobic digestion of solids. When the process is complete, the full tank is emptied and used as fertilizer on pastureland, while the other tank is sealed to in turn begin the digestion process.

The relative advantage of this system is the prevention of groundwater contamination. The major disadvantage is the need for careful extension work assure that the process is carried out correctly and does not itself become a source of local contamination.

3.3.1.3 Integrated Pest Management

Since pesticide contamination is one of the primary environmental impacts originating from this portion of the watershed, the introduction of IPM is an obvious technical intervention. Even a small reductions in the use of agricultural chemicals would likely bring measurable improvements in the quality of human health and that of the

downstream fauna.

However in light of IPM's highly technical nature and the historical severity of the pesticide problem in El Salvador, it is recommended that a specialist in this field visit the country under separate terms of reference to prepare a list of technical options. This specialist should be aware that the Center for Agricultural Technology (CENTA) is performing research on IPM with support from the German government (GTZ).

3.3.1.4 Forest Plantations, Woodlots and Nurseries

Large tracts of former cotton land in Salvador's lower regions that are presently given over to pasture could be converted to plantation forestry for fuelwood, poles and timber - with the expected high economic yields described in section 3.2.1.1. The relatively well developed state of cooperative organization in this region should furthermore allow export oriented development of high-value hardwood plantations such as teak (Tectonis grandis). Following methodologies described for the Upper Watershed, the development of private nurseries should be promoted under the PROMESA project to support the forestry initiatives. Since this land is suitable for a variety of agricultural production schemes, subsequent examination of cost-benefit should reflect opportunity cost of these alternate crops. Such analysis should be expanded to reflect environmental costs associated with intensive production of the traditional crops such as cotton.

In addition to providing income, lumber, fuel and soil stabilization, the advent of plantation forestry in this region would further the PROMESA goal of enhancing biological "connectivity" within the target watersheds. Wildlife movements between the highly fragmented natural areas of the coast would be facilitated by the presence of such plantations, particularly in the treeless expanses of the lower watershed.

3.3.1.5 Training and support for the commercial production of fuel-efficient cookstoves.

El Salvador has no national campaign to promote energy conservation in the kitchen and for space heating. Since it estimated that 63% of the total household energy demand is wood-based and that 80% of households cook over wood fires - development and dissemination of an improved cookstove could meet with real savings at the household and remove pressure from dwindling forest resources.

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. Household energy conservation measures (cooking techniques, wood drying procedures and meal planning) are equally effective in reducing energy consumption by 60% and

should be included in the Environmental Education Component.

3.3.2 Technology Extension Approach

The installation of primary sewage treatment facilities in the townships of the lower watershed is the obvious responsibility of individual municipal governments and the National Water and Sewer Authority (ANDA). Candidate communities should be identified and approached promptly after PROMESA implementation to assure that the lengthy planning and design process does not create undue delay. The protocol established during the ANDA/IDB project that tailors appropriate treatment technology for individual communities is commendable and worthy of continued support under PROMESA. Consulting engineers with similar philosophical and technical approach should be retained to work closely with the PROMESA management, ANDA and community governments to identify the best treatment options within individual site constraints of land availability and configuration, population and finances.

The installation of individual latrines and septic tanks will provide no immediately visible economic return to beneficiaries. Extension should therefore be supported with small direct grants to subsidize materials and perhaps some labor. Where ongoing assistance and demonstration on maintenance is required (e.g. elevated latrines) the project must contemplate continued extension assistance beyond the construction stage.

As previously stated, the readiness with which new technologies are adopted will depend on the effective utilization of existing, successful institutional structures. In this regard ag-related extension efforts should be somewhat eased in the lower watershed by the presence of relatively-well organized agricultural cooperatives to which at least 50% of this population belongs. Lessons learned from ongoing local extension programs to the cooperative sector such as the USAID/CLUSA non-traditional export project should be utilized in the selection of target beneficiary groups. With sufficient training and preparation, in-place extension agendas, materials and personnel can be utilized whenever possible for the trial introduction of new technology packages such as the forest plantations or integrated pest management.

The selection of effective institutional structures for technology extension will be more time consuming within the one half of the Lower Watershed population that is not affiliated with cooperative agriculture. The "Organizaciones Pro-Mejormiento de la Communidad" associated with municipalities such as Cara Sucia will provide some possibilities for interventions destined for the urban periphery, but the remainder must be reached through the Participatory Rural Appraisal process described in 3.3.2.. Implications of this are that some localized rural populations (i.e. co-ops) may be eligible for new technologies from the outset of project implementation - while other groups will be

delayed for a year or more as the PRA process identifies the best institutional vehicle for the extension effort. Religion-based rural development NGOs, GOES extension programs such as the Ministry of Health, and small conservation-oriented PVOs with local interests would be good candidates from which to start this exercise.

Based on donor-organization experience in east Africa, there is ample reason to believe that retail sales are the most effective means of extending fuel-efficient cookstove technology to the general population. Under this scenario candidate retail entrepreneurs (e.g. owners of hardware stores) are selected for training in cookstove assembly, and operating capital is provided until enterprise self-sufficiency is achieved. By combining standardized mass production with private sector incentives, a considerable burden is removed that has hampered previous efforts to extend this technology - i.e. the necessity of tailoring every stove to individual kitchen-specific conditions. Error in this process has often created problems ranging from impaired efficiency to housefires and has impaired the credibility of a technically sound idea.

3.3.3 Monitoring and Impact Evaluation

The project paper team should design a monitoring program for the lower watershed that provides routine baseline and follow-on measurement of critical water quality parameters; and which further establishes causal relationship between pollution sources and project-related effort for their control.

In preparation for PROMESA, the USAID/WASH project has established sampling sites within the proposed project areas and selected parameters for measurement that are appropriate for continued support after project implementation (USAID/WASH Project, 1991). Data collected during the pre-project assessment included:

- "routine" physical and chemical water quality analyses such as nitrates/nitrites/ammonia, phosphates, BOD/COD, suspended solids, conductivity and selected metals;
- bacteriological surface/wellwater analyses including total and fecal coliform counts;
- organochloride and organophosphate (i.e. pesticide) measurements of soil, sediments, surface/well water and tissue from selected aquatic organisms.

Although the WASH effort provides useful background information on the pre-project status of the watershed, standard methods for field assessments of water quality call for repeat sampling that was simply not possible under Mission budget and end- of-fiscal-year limitations. Follow up baseline studies should therefore incorporate multiple analyses

(min. = two per site) and bracket the rainy season plus major agricultural crop cycles that heavily influence local pesticide use.

Solid information gathered during the initial project year will provide effective testimony to the project's success in reversing the serious environmental deterioration originating in this portion of the watershed - and further prove the connectivity with the estuarine portion of the demonstration area. Additional measurement of physical sediment load and peak flow rates in the higher reaches of this region would provide insight on the success achieved by project interventions in the Upper Watershed.

3.3.4 Supporting Policy Reforms

Wide recognition has been given to the fact that despite the existence of many laws governing the use and management of water, legislation is fragmented and does not take advantage of natural unifying themes such as watersheds and coastal zones (Nunez et al (1990). Multiple agencies such as ANDA, CEL and MAG utilize a single watershed in total independence of one another - and are in consequent frequent conflict with their individual policies. Integrated watershed and coastal zone management must be developed and promoted that will rationalize the many demands on Salvador's water resources - and which provide the legal structure that is counterpart to bio-physical watershed connectivity.

With regard to specific issues identified in the Lower Watershed, Executive Decree 50 of October 16, 1987 has established laws governing the disposal of waste water and which will provide direct policy support for reduction of sewage contamination. However no counterpart legislation exists governing the effects of agricultural practices on water quality. Special attention is needed in the area of pesticide and sediment contamination in the development of national irrigation policy.

Table 4. Anticipated impacts of selected technical interventions in the lower watershed.

Technical Options/ Expected Impact	Sewage treat.	IPM	Forest Plantat.	Fuel Eff. Cookstoves
Improved health	+	+		
Reduced pesticide use		+	+	
Reduced deforest.			+	+
Reduced soil loss			+	+

Table 5. Estimated per-unit costs for selected technology interventions in the lower watershed

Technology Intervention	Estimated per-unit costs
Digestion/Stab. Ponds	c/245 per inhabitant (1)
Biofiltration Ponds	c/450 per inhabitant
Constructed Wetlands	c/375 per inhabitant
Septic Tanks	c/2,000 per household (2)
Pit latrines	c/500 per household
Elevated latrines	c/1,000 per household
IPM	pending separate report
Plantation forestry	(ref. Table 3)

(1) All urban sewage treatment costs were extrapolated from engineering studies prepared for the town of San Francisco Gotera and Chinameca (ANDA/Frederic R. Harris, 1990). Pre-existing infrastructure such as sewage collection lines are highly variable and may greatly influence final cost for any given site.

(2) Estimates provided by ANDA.

3.4 Mangrove Estuarine Forests

As amply described in project documents, mangroves form the largest category of forest/natural area remaining in El Salvador and receive the aggregate impact from previously described upstream environmental abuse. Occupying the fringe between inland cooperative agriculture and the sea, the rapidly growing human population of this zone has little existing social structure on which to rely, and (frequently) a history of organizational attempts gone awry. Typical of fishermen the world over, their rhythm of existence is not synchronous with the remainder of the national economy. Long periods of bare survival broken by pulses of high income from fishing, windfall harvest of hurricane timber or other such natural phenomena have prevented any element of stability from entering their lives - and will hinder the development of forward-thinking, cooperative conservation initiatives.

3.4.1 Mitigative Technologies

Objective: To protect and rationalize the management of the mangrove forests and associated marine resources at the terminus of the demonstration watershed. Proposed actions will seek to directly protect existing stands of mangrove, as well as initiate management on areas degraded by storm damage, environmental deterioration and unmanaged harvest. In recognition of the contribution made by chronic, acute unemployment in the non-renewable harvest of the mangroves, additional proposed activities will improve economic conditions by enhancement of returns on traditional occupations and the introduction of new schemes for income generation.

3.4.1.1 Forest inventory and preparation of multiple use plans

The paucity of good data describing the extent and quality of mangroves in El Salvador is evidenced by the wide variation in estimates of total forest cover (17,000 to 35,000 hectares). Therefore the development of any rational management plan for mangroves within the demonstration areas should be preceded by inventory - utilizing low-altitude aerial photography - followed by ground truthing and preparation of maps indicating species composition and density (volume). This information should be utilized to delineate areas appropriate for use as indicated below.

- Core reserve areas will serve as floral/faunal genetic reserves, seedling sources and research laboratories for mangrove ecology.

- Extractive areas will allow rotational cutting for fuel and timber. These could be regenerated via natural propagation or reforested using propagules gathered from adjacent areas.

- Blank areas that have not regenerated naturally following cyclones or illegal harvest, but for which the tidal regime is adequate will be reforested.

- Tidal mudflats that are too infrequently inundated to support mangrove growth may be deemed suitable for aquaculture.

If the mangroves are within boundaries of existing parks (e.g. Barra de Santiago) the maps will also facilitate delineation of park boundaries as described in section 3.1.1.1.

3.4.1.2 Reforestation on poorly regenerated or blank areas

Reforestation of mangroves in general is facilitated by the tree's characteristic of viviparous ("live birth") reproduction, although few techniques exist that enjoy the benefit of long practice. Germinated seedlings (propagules) remain on the parent tree for sufficient time to develop considerable physical structure and food reserves, then drop to the ground to either root in adjacent mud or be tidally transported to new areas.

Reforestation of Rhizophora spp. (mangle, harrisoni and racemosa) has been taking place in El Salvador for some time. Individual members of the conservation NGO "Amigos del Arbol" (AMAR) have been organizing weekend trips to the Barra de Santiago to replant Rhizophora propagules on blank portions of the national park, and the Fundación de Inversions Sociales (FIS) has financed plantations of 60 and 80 hectares in the Barra de Santiago and Estero de Jaltepeque (La Herradura) respectively. Techniques employed in these plantations have varied widely: with the FIS plantation in Jaltepeque sowing propagules at 1m intervals (10,000 per ha) on surfaces cleared of slash; while the AMAR group plants at densities up to three propagules per linear meter (90,000 per ha). Plantations observed by the team in Barra de Santiago were apparently surviving very well and growing in uniform manner, although only small parcels were visited.

Project supported reforestation activities within the demonstration area will include activities described below.

- The collection and storage of propagules, which could take place over a period of several weeks prior to the organization of planting operations.

- Organization of large-scale plantings to enhance growth on poorly regenerating areas.

- Practical field research into optimal seedling density for a variety of production schemes (e.g. pole production versus fuelwood).

- Research into reforestation techniques appropriate for other important mangrove species such as "Cincahuite" (Laguncularia racemosa) and "Istaten" (Avicennia spp.). Reported (rumoured) research into vegetative propagation techniques under development for dwarf mangrove "botoncillo" (Conocarpus erectus) at the University of El Salvador should be verified by the design team and incorporated into the project implementation.

3.4.1.3 Rotational cuts within degraded areas for timber production.

A variety of yield projections and rotation periods can be found by perusing literature describing proposed mangrove forestry management practices - although actual data is virtually nonexistent. Using planting densities of 6,000 per hectare, thinnings in years 6, 11, 16 and a final cut in year 21, forest managers in the Indian Sundarbans have projected total yields of 40 mt timber and 174 tons fuelwood (aggregate annual production = 10 tons/ha/yr) from plantations of Excoecaria agallocha, Ceriops decandra, and Avicennia marina (TR&D, 1991). On the other hand project documents from the FIS sponsored plantings at Barra de Santiago provide assumptions of 10,000 seedlings/ha of Rhizophora spp, thinnings in years 5, 10, 12 and 20 with a final cut in year 30 - yielding an aggregate of only 113 mt or approximately 4 tons/ha/year.

Since the productivity of two mangrove estuaries cannot be so radically different despite geographic and species differences (especially in light of the significantly higher initial planting density and longer production cycle of the Salvadoran model) the need for field research becomes obvious. In the absence of better information one risks significant error in any calculation of rotation period - and hence allowable percent harvest of total forest cover. Perhaps the best available method would be to perform destructive sampling on the plantations at Barra de Santiago, completely removing and weighing material from measured portions of the plantations of known age. The team was shown six, three and one year old plantations during the visit to Barra de Santiago for which this technique should allow development of a reasonably accurate production curve that would serve management decisions better than reliance on published guesswork.

Further work is also needed on natural regeneration - which will in turn influence harvest techniques. Some forest department work has taken place in the Jaltepeque area from 1972-1974 regarding natural regeneration. In this study, 300m by 50m blocks of mangrove were clearcut, leaving 50 mature trees per hectare for regeneration. While Rhizorphora spp came back to a certain degree, the white and black mangrove (Laguncularia and Avicennia) failed entirely to regenerate (Aguilar, 1991). The initial cuts of mangrove from the managed portions of the forest should leave seed trees in a variety of densities and species compositions to generate information leading to effective cutting practices.

3.4.1.4 Fuelwood plantations on upland fringes.

To alleviate direct demand on mangroves for fuelwood, the fringing portion of the estuary should be surveyed for locations adequate for upland forest plantations. These locations should be further screened for proximity, tenure and present utility to local non-estuarine human communities - to whom appropriate plantation strategies could be extended.

Although soil conservation technologies described for the Upper Watershed are not critical for this zone, other criteria in the selection of species mix and production methods presented in section 3.2.1.1 are applicable to the estuarine fringe.

3.4.1.5 Small-scale charcoal production.

Low national production and the presence of niche "recreational" markets in San Salvador are factors contributing to a relatively high price for charcoal. Provision of small-scale production capacity to selected families in the estuarine areas would provide opportunity to add value to fuelwood exports from the demonstration area.

One brick oven with a construction cost of c/9,000 and capacity for 12m3 wood valued at c/1,400 can produce approximately 1 mt charcoal with a value of c/2.000 (data from CATIE, 1991; and Modesto Suarez, CATIE San Salvador, personal communication). Although source of wood, cycle time on the production process and oven design will significantly affect return on such an enterprise, the apparent profitability warrants closer examination during project pre-design phase. Under separate terms of reference a national fuelwood assessment is currently underway for the pre-design phase of PROMESA. This assessment should examine the economic feasibility of charcoal production in the mangrove areas with greater detail.

3.4.1.6 Small-scale, extensive shrimp mariculture.

Despite the fact that small-scale family operations comprise the backbone of the Southeast Asian shrimp mariculture industry, the Latin American version has been characterized by large-capital absentee management enterprises. In Ecuador, Panama and Honduras, shrimp farms average well over 100 hectares in size and typically require $5,000 to $10,000 per hectare in capital investment.

El Salvador however is forced onto an atypical track by virtue of land availability. Of the 8,000 hectares of land deemed suitable for shrimp farming in the country, the majority is in parcels of 10 hectares or less (TR&D 1989) - well below the breakeven size for commercial, capital-intensive production of shrimp. As a result approximately 8-10 very small shrimp farms (1-5 hectares) have developed in the country that have been constructed in the total absence of outside assistance - some of which have performed moderately well to date (Jorge Ramos, FUSADES/AID mariculture program, personal communication).

With support under PROMESA, parcels of land in the one to five hectare size range should be sought and screened for suitability as pond-construction sites. Technology would be very extensive so as to avoid the necessity of large infrastructure investment,

expensive inputs such as feeds, or skilled management that are typical of intensive operations. High availability of wild seedstock (often a limiting factor in shrimp farming) has been verified in El Salvador by the FUSADES/USAID aquaculture program and would serve as the production process primary material. The Barra de Santiago estuary in fact has been found to have year-round availability of desirable species in numbers that have allowed stocking of nearby commercial farms with a remarkably low effort (one family fishing for one afternoon can reliably catch one million P. vannamei; Remy Dugue, FUSADES/USAID aquaculture project, personal communication).

Technical production assumptions are summarized as follows:

- Seedstock are wild-caught postlarval (PL) Penaeus vannamei and P. stylirostris.
- Stocking rate of 20,000 PLs per ha/crop
- Survival to adult of 60%
- Final individual shrimp weight of 30 gms.
- pond carrying capacity (i.e. production) of 360 kg/ha/yr
- Enrichment of pond water with inorganic fertilizers as needed
- Production cycle of 200 days + 30 to prepare pond = 1.5 crops/yr

Based on these conservative construction and input cost estimates a one-hectare pond under extensive production shows a payback period of 3-4 years, which should make the operation a credit worthy investment (Table 6). As an integral part of the mangrove survey and inventory, small parcels of barren land should be sought that are appropriate for shrimp farm development.

Table 6. Summary cost/benefit presentation for one-hectare extensive shrimp pond (expressed in colones)

	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5
Construction (1)	hectare	56,000	56,000				
Management labor	man-day	40	-	2,080	2,080	2,080	2,080
Production materials:							
Seedstock	1,000 animals	15		450	450	450	450
Misc. (2)				4,000	4,000	4,000	4,000
Outputs (shrimp tails)	Kg	110		41,580	41,580	41,580	41,580
Net			(56,000)	35,050	35,050	35,050	35,050
Cumulative (3)			(56,000)	(32,150)	(3,050)	31,390	35,050

(1) Inclusive of drainage structures, diesel powered pump, equipment shed, design and construction supervision.
(2) Replacement screen for drains, fertilizers, ice, diesel
(3) Assumes 20% cost of financing on balance of unpaid debt

3.4.1.7 Fish-Aggregating Devices (FADs)

This simple technology is based on the concept that a lack of shelter is often a limiting factor to the expansion of demersal fish stocks. Under such conditions the creation of artificial structure on the sea floor therefore significantly augments the local population of fish and enhances capture fisheries as a result. Materials used in the creation of artificial habitat have varied considerably - from decommissioned ships to brush piles. In general, selection of materials is based on simple factors of cost, availability, stability in water and ease of transportation and placement.

The PROMESA project should research the availability of local materials appropriate for FAD construction - as well as appropriate locales for their placement. Nearshore areas in 30-120 feet of water within ready reach of the artesenal fishing fleet should be identified by the design team and an appropriate construction/placement methodology developed. Illustrative FAD designs are presented in Figures 10-13 (Anon., 1988).

3.4.1.8 Small-scale, Artesenal Long-Line Fishing Boats

In recent years, the chronic excess of cargo space on the return leg of USA-bound airline flights has allowed development of fresh-fish exporting businesses in many countries of Latin America. Increased consumer sophistication has further led to high-value niche markets for certain fish common to El Salvador such as the dorado (Coryphaena hippurus also known as "Mahi-mahi" to those willing to pay extra) and bigeye tuna

(Thunnus obesus). The value realized by the fishermen for these top species is often in the range of $4.00-$10.00 per pound.

The high quality required by this market has further led to a popularization of small scale long-line fisheries in many of these same countries. Long-lines are composed of a single main line that is connected on one end to a buoy and played out from the fishing vessel from the other end. Vertical drop lines are spaced every 50 to 100 feet along the main line (more closely spaced on artesenal setups) which are baited with inexpensive "trash" fish as the line is deployed (Figure 9). The rig is allowed a "soak" period of several hours and then taken up while removing fish. The advantage given by long-line over other forms of capture enters at this point, since single fish can be cleaned and iced as removed while other fish remain alive in the ocean. The difference in quality resulting from this process can be important in the hot tropics. Although success rates vary, commercial long-line fisheries enjoy capture rates of targeted species between 1-3% of baited hooks per set. These may be exported as gutted/gilled carcasses or fresh filets. By-catch species that are of no value for export (e.g. shark and marlin) are delivered to the domestic market.

Experience in other countries (particularly Ecuador) shows that artesenal fishermen will readily adapt this technology if trained and equipped with the necessary gear. Further training in post-harvest handling is required to assure that the country realizes top price for the its exports.

The PROMESA project should therefore seek candidate fishermen from among the local artesenal nearshore fishing fleet based in the mangroves of project areas (e.g. Barra de Santiago). Required basic equipment consists of heavy-weight mainline (300# test), drop lines (80# test), snods, weights, hooks, buoys and an insulated compartment for transporting ice and fish. Typical artesenal boats will carry 500 to 1000m of mainline - fishing 50 to 100 hooks per 12 hour set.

3.4.1.9 Ice-making, washing and cold-storage facilities for improved quality of capture fishery products.

Even without the quality demands of a fresh-fish market the artesenal fleet could realize significant benefits from more attention to post harvest handling. Fish are commonly thrown onto the floor of an open boat, where they may remain for hours without benefit of any processing or ice to counteract the tropical sun. When landed, fish are often poorly iced in open trucks for the trip to markets, where they may arrive up to 24 hours after capture. Spoilage created by this treatment leads to lower product price and may contribute to chronic gastroenteritis among the consuming public.

The PROMESA project should therefore help develop fish handling and storage infrastructure in fishing ports that are within project areas. Basic components would be:

- concrete block storehouse;
- compressor for walk-in cold storage;
- flake-ice machine (appr. 1 ton/day);
- roofed, concrete slab for loading/unloading;
- freshwater pump/cistern for washing;
- dry storage for supplies;
- commercial beam-type scales.

Training would be the central ingredient of this package. Fishermen must be sufficiently convinced of the reward from good quality control before they will forgo the habits of a lifetime and append additional new routines to their workdays.

Table 7. Anticipated Impacts of Technical Packages in the Mangrove Portion of the Demonstration Slice

Action/ Impact	Refrst. Blank Areas	Mngd Rotat. cuttings	Fuel-wood plantn.	char-coal prod.	shrimp culture	FADs	long-lines	Fish Handling
Reduce loss of forest	+	+	+					
Increase forest area	+	+	+					
Increase timber/fuel availability	+	+	+	+				
Increase biodiversity	+		+					
Increase local income	+	+	+	+	+	+	+	+

Table 8. Extension and Adoption Criteria for Mangrove Area Income Generating Interventions

Technical option/ Selection Criteria [1]	Fuelwood Plantations	Charcoal Production	Extensive Mariculture	FADs	Longline
Low individual risk	+	+	-	+	+
Low cost inputs	-	-	-	+	0
Ease in Extension	+	+	+	+	+
Extant markets of produce	+	+	+	+	+

[1] the subjective classification of adoption criteria is as follows: (+) is assigned to favorable factors, (0) is assigned to those nearing neutral and (-) to those criteria having inherently high risks either due to unsure markets, unsure returns to labor investment or unsure site-specific technical assumptions

Table 9. Estimated per-unit Capital Investment Cost (colones) for Different Technical Interventions in the Mangrove Areas

Cost/Activity	Unit	Cost
Reforestation of Mangroves	Hectare	2,610 (1)
Plantation Forestry	Hectare	1,405
Charcoal Production	Brick oven of 12 m^3 capacity	9,000 (2)
Shrimp Aquaculture	Hectare	56,000 (3)
Artesenal Longline Equipment	Equipment for one boat (4)	8,000
Shore-based storage facilities	One station (5)	180,000 (6)

(1) Figures provided by FIS for the 60 hectare Barra de Santiago Project
(2) Figure used in CATIE/IUCN proposal - excluding costs of supply equipment such as chainsaws and vehicles
(3) Inclusive of drainage structures, diesel powered pump, equipment shed, design and construction supervision.
(4) 1,000 m main line with 100 drop lines
(5) Based on 96,000 lb annual harvest from 250 boats
(6) CATIE/IUCN figures, plus cost of ice machine and three years operating capital

Note: Costs for fish aggregating devices are highly materials and size dependent. Data should be gathered on available materials and sizes of structures during project design.

3.4.2 Technology Extension Approach

Management of mangrove areas logically falls under the purview of the Forestry Department. In the case of protected areas such as Barra de Santiago, the National Park Service is the logical extension agency for the forest management schemes described in this section. Both the National Park Service and the Forest and Wildlife Service are at present without the most basic levels of manpower (31 personnel in the former, and only three college-level staff in the latter; Nuñez et al, 1990) or material support that would allow them to comply with their existing functions - much less take on the added tasks described above. These institutions must be strengthened under the appropriate component of PROMESA to enable assumption of the inventory, monitoring, planning, and supervision of forest management activities that are necessary to protect this portion of the demonstration slice. Salvadoran NGOs that are already engaged in mangrove conservation are also logical candidates for strengthening and utilization on local conservation work. The AMAR group's reforestation of the Barra de Santiago is an excellent example of a grass roots initiative worthy of long term support.

The inhabitants of the estuarine fringe of the project "slice" have minimal existing organizational structure to facilitate technology extension efforts. Few successful cooperative organizations exist in this zone - and fishing, woodcutting or other activities

exist as individual enterprises or loosely defined partnerships. However most coastal communities do have some form of municipal government, the "Organizaciones para el Mejormiento de la Communidad" are becoming more prevalent, and (as amply described) the NGO community is increasingly active in the estuarine areas. Opportunities must be examined on an individual basis to determine the optimal structure for the extension of charcoal making, aquaculture and fisheries activities proposed for this area. The USAID-sponsored feasibility assessments of shrimp mariculture on lands held by reform-sector cooperatives (Hawaiian Aquaculture Associates, 1990) should be re-examined for ongoing utility by the design team. The original technical strategy for these assessments was the promotion of intensive aquaculture on small parcels held by coastal cooperatives but the lack of investor interest in taking cooperatives as partners has prevented further action. Nonetheless the identification of suitable land and cooperative organizations could serve as a highly useful departure point for promotion of extensive operations under PROMESA.

The FUSADES/USAID shrimp aquaculture program has indicated institutional willingness to assist small scale shrimp farming to the same extent as the larger enterprises it currently serves. Technical assistance with site selection, construction and production operations are available through TA contracts held by FUSADES - as is assistance with the preparation of credit applications.

Although 22 CENDEPESCA extension agents are posted in coastal El Salvador they are concentrated in the extensive estuaries east of the Lempa river. This force should be augmented under the institutional strengthening component of PROMESA to assist with fisheries project implementation in the demonstration areas of the western coast.

Finally El Salvador's First Lady, Margarita de Cristiani is reportedly interested in the promotion of small scale aquaculture as a means of generating village employment, particularly for women. The design team should verify the actual degree of interest for whatever good utility such powerful sponsorship could bring to the project.

3.4.3 Monitoring and Impact Evaluation

Comprehensive baseline and recurring inventory of the mangrove resources described earlier will provide direct quantitative measure of deforestation and project-related success at its control. Strengthening of the Forestry Department's control agents should provide information on annual harvest volumes from the demonstration areas, in turn allowing quantitative measure of extraction rates - while reforestation success can be directly evaluated in terms of hectares and survival rates. Percent cover can be measured on harvested areas to evaluate success at developing natural regeneration techniques.

Success in alternate income generation and the indirect effect of reduced pressure on natural resources will be more difficult to evaluate. In addition to allowing effective extension, pre-project Participatory Rural Appraisal (section 3.2.2) will be required to assess baseline economic status plus quality and degree of reliance on local natural resources. Follow-on evaluation will provide insight into qualitative and quantitative utilization of these resources, although irrefutable change may not become apparent until well beyond the project's seven-year life.

In view of the mangrove's terminal position in the watershed the question of connectivity within the target slice will be evaluated in terms of virtually all parameters of interest previously described in the document.

- Water quality entering the estuarine system will be analyzed in terms of basic parameters (i.e. nitrogen, phosphates etc.) with special attention on sediment loads, bacterial counts and pesticide levels originating upstream.

- Sediment and animal tissue pesticide residues will be measured over time to evaluate declines in persistent derivatives from the Lower Watershed.

- Diversity of estuarine animal life will be evaluated via ongoing census efforts, with particular emphasis given to higher predators such as pelicans, cormorants and raptors.

- Indices of public health will be monitored for reductions in illness directly correlated with sewage contamination.

3.4.4 Policy Assistance Priorities

Policy deficiencies are perhaps the most acute in the area of coastal zone and fisheries management. Although the General Law of Fishery Activities, Decree 799 was approved in 1981 no regulations have as yet been derived and approved - leading to conflicting interpretation and jurisdictional problems (Nunez, 1991). The Forestry Law does protect the cutting of mangrove except by permit from the Forest Department, although previously described institutional weakness and a lack of resource information preclude effective application. Certainly the stumpage fee of 2.50 colones should be reviewed in light of El Salvador's low level of forest resources.

CENDEPESCA is operating on an institutional policy to reduce the size of the national shrimp fleet. A maximum of approximately 47 boats has been estimated as the number that would extract the annual maximum sustainable yield of shrimp from national waters (FAO, 1962, cited in Foer, 1991), although the current number of operating boats is 82.

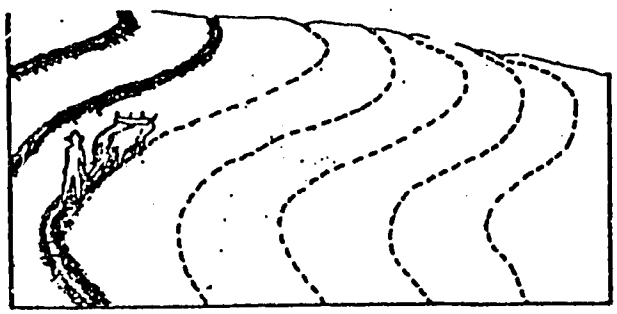
CENDEPESCA is slowly altering this situation by retiring the licenses of boats as they are lost or phased out of service. The development of alternative fishing strategies such as long-lines or even aquaculture are promoted as alternatives that will reduce the unsustainable demand on shrimp stocks and by-catch organisms. The implementation of new capture technologies should be preceded by stock assessments of targeted species to assure that the resource is capable of sustaining the additional pressure. The promotion and impact of turtle exclusion devices (TEDs) on trawlers should be monitored as well - both from the viewpoint of conservation as well as protecting El Salvador's status as a legal exporter of shrimp to the United States.

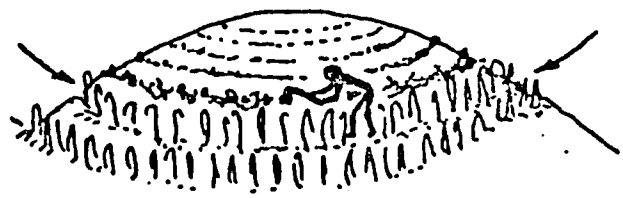
Typical to most developing countries the ability to implement is the most critically limiting policy weakness. Commercial trawlers routinely and overtly enter the three-mile exclusion zone that is established for the artesenal fleet - and the small fishermen in turn frequently rely on destructive harvest methods such as dynamiting or poisoning with complete impunity. Institutional support planned for PROMESA should closely examine the need for strengthening the 20 person enforcement arm of CENDEPESCA.

APPENDIX 1
Figures

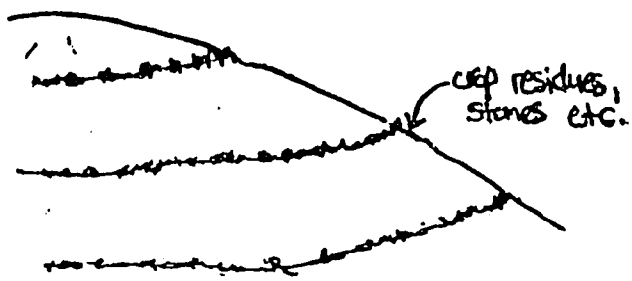
FIGURES

1.0 Contour Farming Techniques

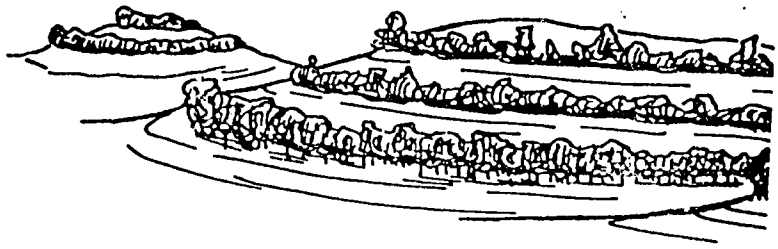




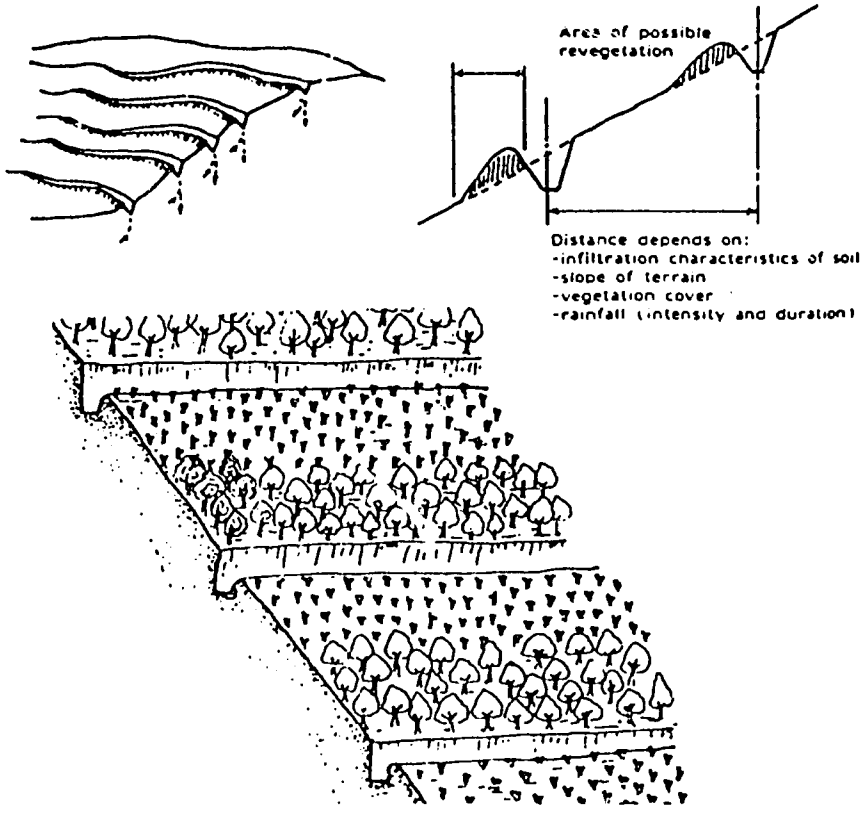
2.0 Trash Line Establishment



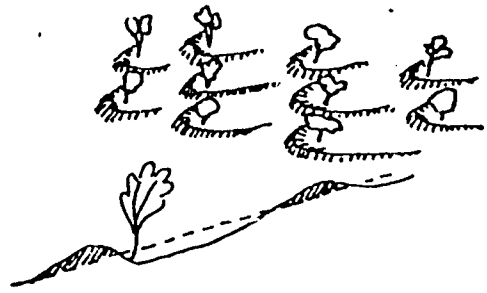
3.0 Vegetative Strips



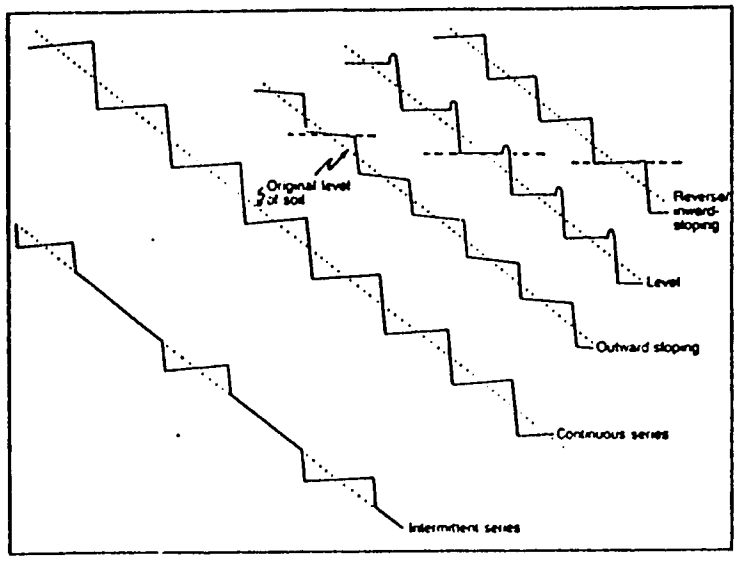
4.0 Infiltration Ditches

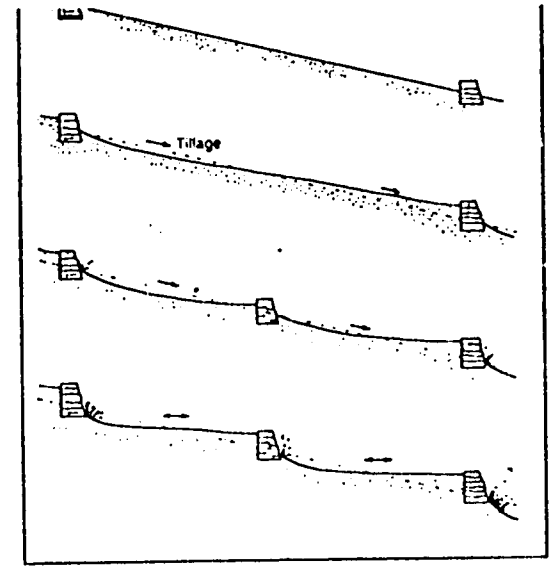


5.0 Fishscale Terraces

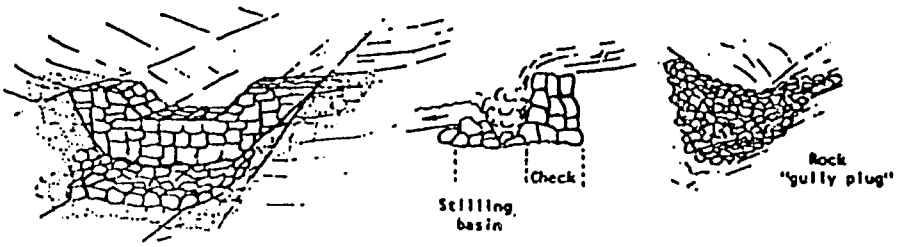


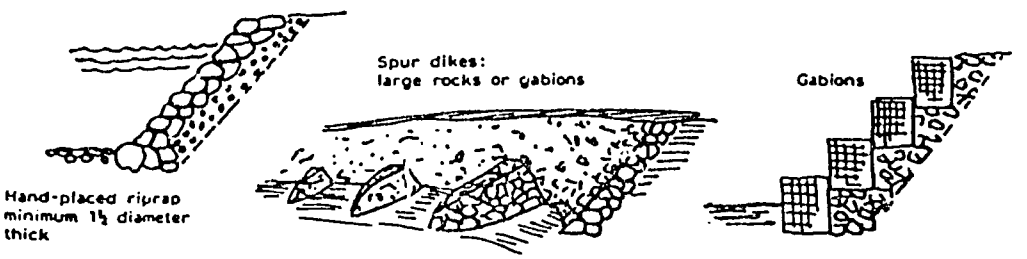
6.0 Bench or Radical Terrace Types

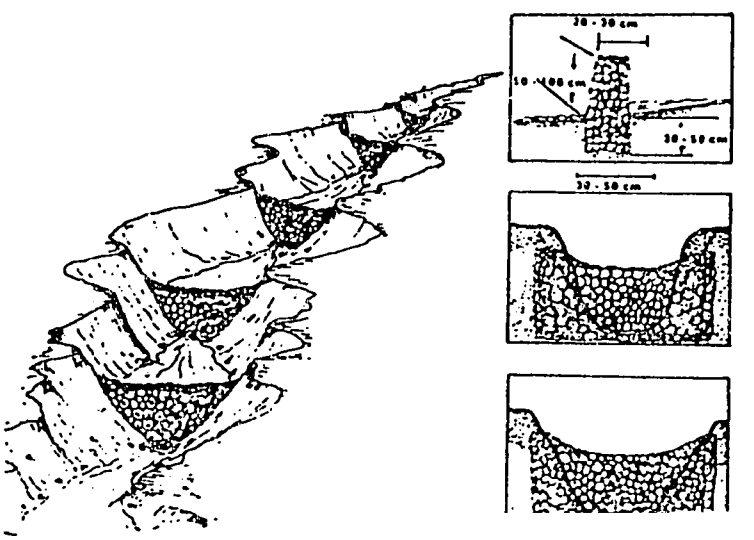




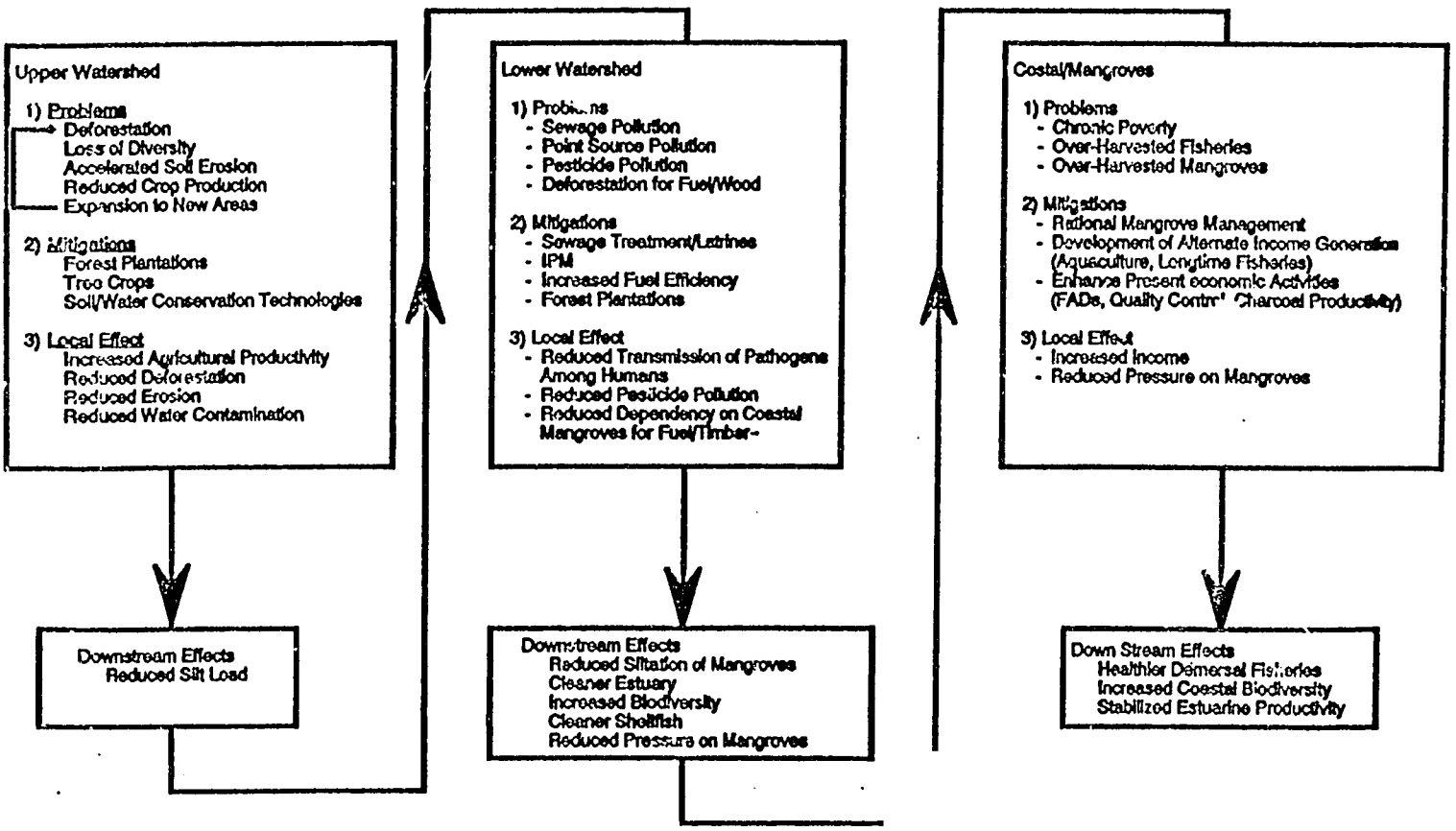
7.0 Gabions, Gully Plugs and Check Dams



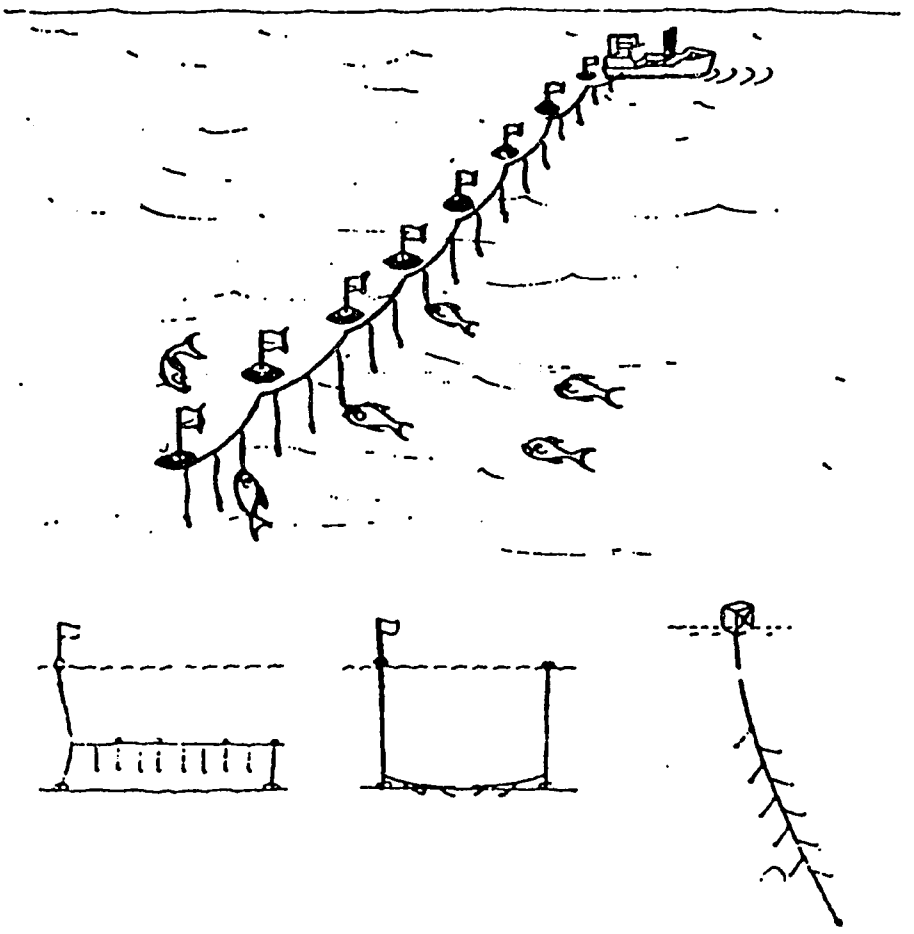




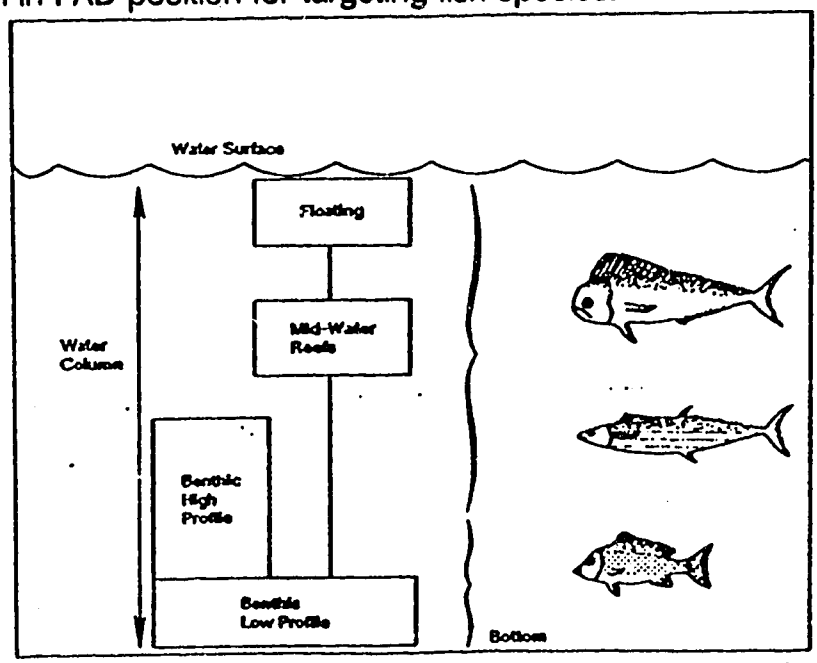
8.0 Benefit Streams of Project Activities within Demonstration Areas



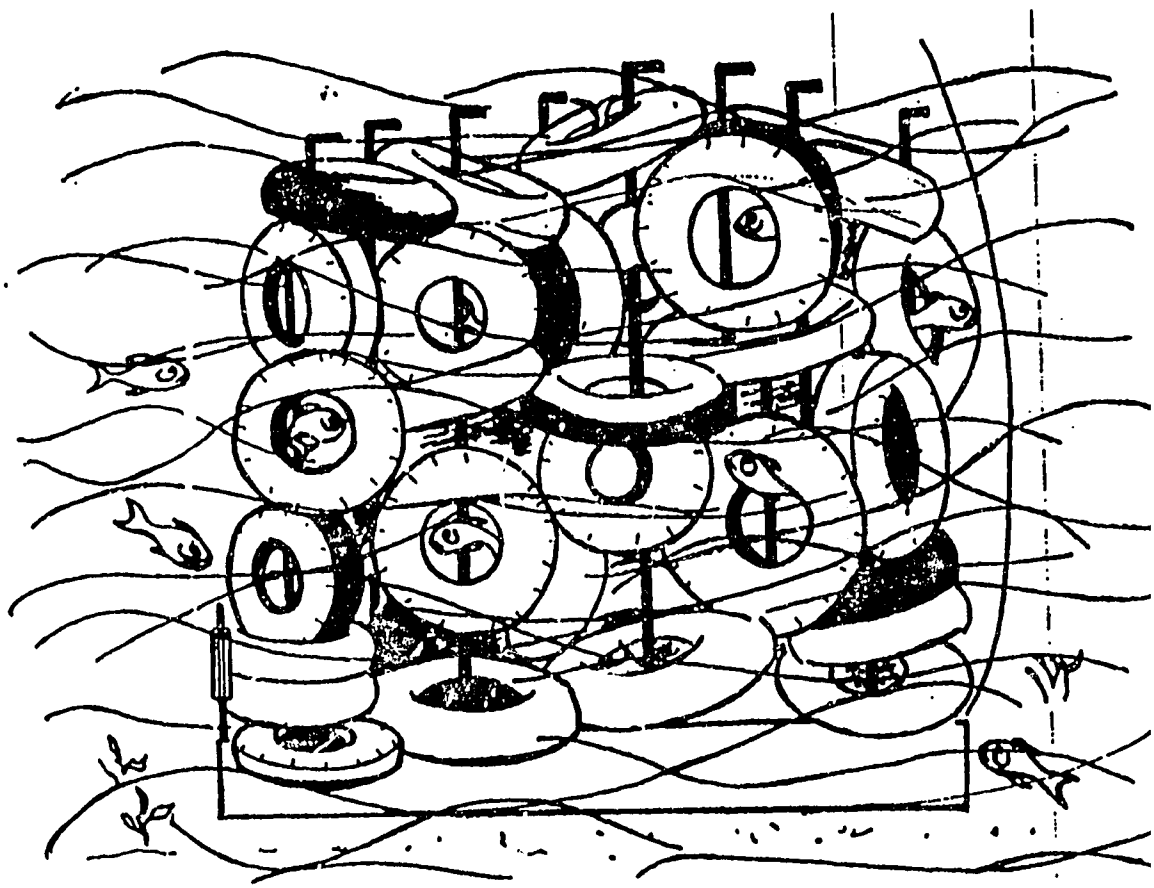
9.0 Artesenal Long-line Fishing gear.



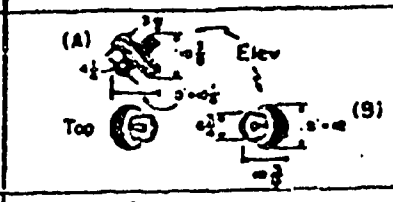
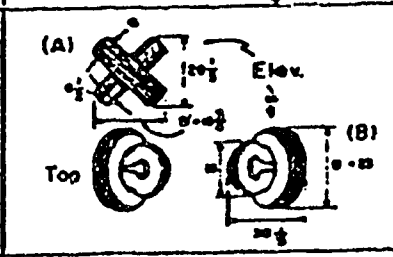
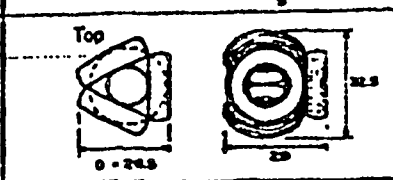
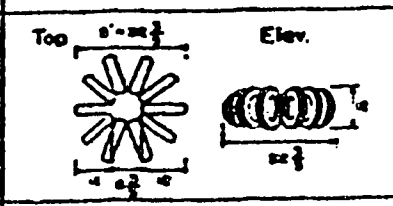
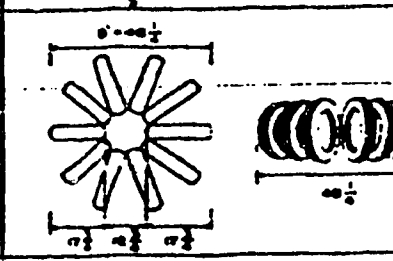
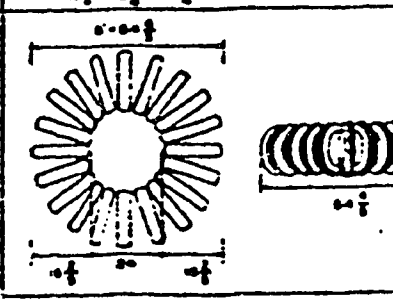
10. Variation in FAD position for targeting fish species.



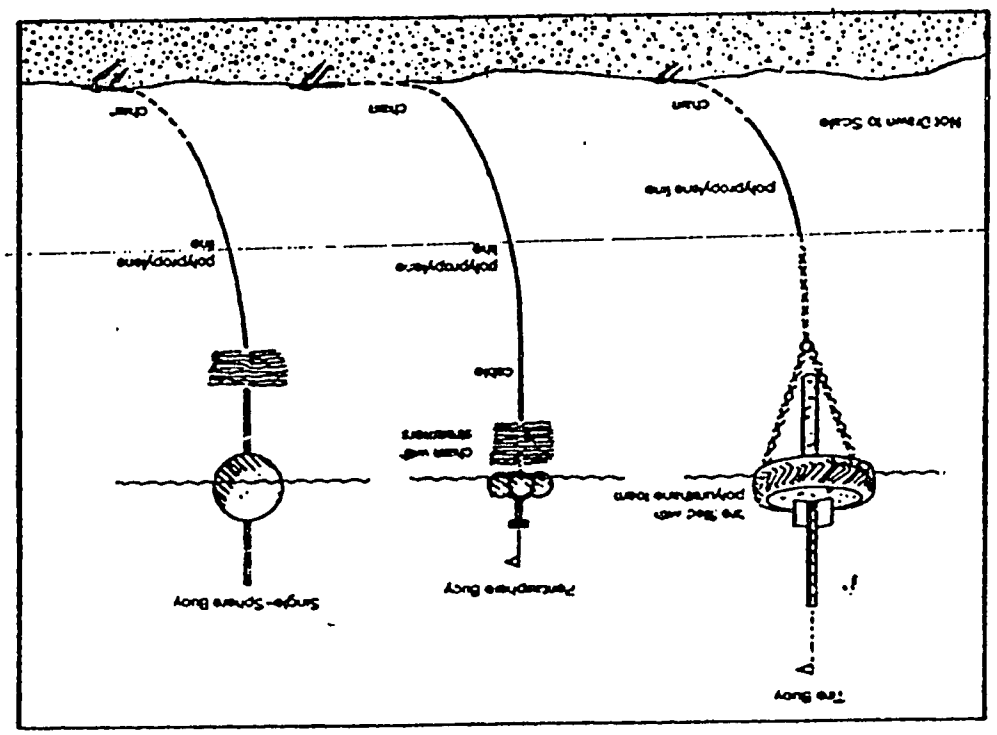
11. In Isreal, steel rods fixed in a concrete base serve as a matrix for used tires in an artificial reef.



12. Scrap tires can be combined in many ways for various-sized reefs.

Configuration	Dimensions (inch)	A (ft^2)	V (ft^3)
2 Tires stuffed (D=1.0')		(A) .55 (B) .68	1.5 x .34
2 Tires stuffed (D=1.9')		(A) 1.68 (B) 2.53	1.5 x 2.22
4 Tires triangle (D=1.9')		4.91 .75 x	5.78 .80 x
10 Tires rosette (D=1.0')		2.72	2.29 10 x
10 Tires rosette (D=1.5')		5.95	7.16 10 x
20 Tires rosette (D=1.3')		5.86	8.89 20 x

13. In Hawaii, several different designs for FADs have been tested. The most successful is the single sphere buoy.



APPENDIX 2
Bibliography

BIBLIOGRAPHY

Aguilar, Emiliano. 1991. Reforestacion de Mangle en la Barra de SAntiago, Jujutla, Ahuachapan, El Salvador. Presentado a el Fondo de Inversion Social (FIS). MAG/CENREN.

Anonymous. 1988. Fisheries Technology for Developing Countries. National Academy Press, Washington, D.C.

CATIE, 1991. Propuesta de Manejo de los Recursos Asociados a los Manglares de la Barra de Santiago. (Funding proposal to IUCN). International Union for the Conservation of Nature, San Salvador, El Salvador.

CENDEPESCA, 1990. Informe de Resultado del Censo de Pescadores Artesanales de El Salvador. Centro de Desarrollo Pesquero/OLDEPESCA/NORAD/FAO.

Consultdores Asociados. 1989. Fomento forestal. FUSADES Project. San Salvador. 45 pp. + append.

Emtecsa de CV. 1985. El Salvador, Perfil Ambiental, Estudio de Campo. USAID Report. 266 pp.

Federación Ecologica Salvadorena Activo 20-30. 1991. Estrategia Nacional para la Conservacion y Manejo de los Recursos Ambientales de El Salvador (Borrador).

Foer, Gordon. 1991. Profile of the Coastal Resources of El Salvador. Coastal Resource Center, The Univerisy of Rhode Island. 23 pp.

Haggerty. R., 1990. El Salvdor: A Country Study. Area Handbook Series, De[partment of the Army , November 1988. US Government Printing Office, Washington, D.C.

Heckadon-Moreno, S. 1990. Madera y lena de las milpas. CATIE. San Jose. 87 pp.

_____. 1989. Los viveros communal in El Salvador. J. El Chasqui. CATIE. San Jose. pp.3-24.

Gibson, D. and E. Muller. 1987. Diagnostic surveys and management information systems in agroforestry project implementation. ICRAF. Nairobi. 80 pp.

Frederic R. Harris, Inc. 1990. Estudio de Factibilidad Tecnica y Economica del Proyecto "Sistemas para la Depuracion de Aguas Residuales de Origen Domestico en Doce Localidades del Pais. Administracion Nacional de Acueductos y Alcantarillados.

Hawaiian Aquaculture Associates. 1990. Feasibility of Shrimp Aquaculture on Reform Sector Sites in El Salvador.

Juarez, M and R.E. Fuentes. 1990. Identification de productos de AUM en la region II El Salvador. CATIE. San Jose. 35 pp.

Min. Agricultura y Ganaderia Salvadoreno. 1990. Annuario de estadisticas agropecuarias. San Salvador. 90 pp.

Min. Agriculture Peruano. 1985. Manual tecnico de conservacion de suelos. Lima. 58 pp. + append.

Miranda, Ezekial. 1988. Ecosistems de Manglares. Proceedings from the FUSADES conference on Aquaculture and Coastal Resources. 55 pp.

Nunez, R.D. et al. 1990. El Salvador natural resources policy inventory. U.S. Agency International Development. San Salvador. 3 Vols.

Reiche, C. et al. 1990. Resumen regional anual de rendimientos y costos en faenas de produccion de arboles de uso multiple 1988. CATIE. San Jose. 38 pp.

Shaxson, T. F. et al. 1989. Land husbandry: a framework for soil and water conservation. Soil & Water Cons. Soc. Iowa. 64 pp.

Tropical Research and Development. 1989. El Salvador Shrimp Farm Investors Handbook. FUSADES/DIVAGRO. 101 pp.

Tropical Research and Development. 1991. Pilot Mangrove Management Component of the Integrated Forestry Management Project for West Bengal. The World Bank. 48pp.

Tschinkel, H. and A. Guillen. 1991. Trip report 131; El Salvador. U.S. Agency International Development. Guatemala City. 5 pp. + append.

USAID 1991. Proposal to Assess Water Quality in El Salvador. Water and Sanitation for Health (WASH) Project. Arlington Va.

Vega, A. 1991. Proteccion del medio ambiente Salvadoreno (PROMESA): Special agroecology report. Tropical Research & Development. Gainesville. 20 pp. + append.

Weber, F. and M. Hoskins. 1983. Soil conservation technical sheets. Univ. Idaho. Moscow. 92 pp.

APPENDIX 3
Persons Contacted

PERSONS CONTACTED

Aguilar, Emiliano
Servicio de Parque Nacional y Vida Silvestre - CENREN/MAG
Cton. Matazano, Soyapango
El Salvador, C.A.
tel 770622

Benitez, Manuel
UICN - El Salvador
Calle Nueva No.2, Casa 9; Col. Escalon
San Salvador, El Salvador
tel 235585

Calderon, Ruth
Centro de Investigaciones Agricola
Apartado Postal 885
San Salvador
tel 282066

Carpeño, Aristides
Alcaldia de la Municipalidad de la Herradura
tel 37 y 50

Castro, Zoylo
Administracion Nacional de Acueductos y Alcantarillados
El Salvador
712709

Dugue, Remy
FUSADES/USAID Aquaculture Project
14-134 Calle Victor Mejia Lara, y Av. Masferrer Sur
tel 235711

Guevara, Francisco
Director de Estadisticas
CENDEPESCA
Santa Tecla, El Salvador
tel 280034

Hasbun, Carlos Roberto

Servicio de Parque Nacional y Vida Silvestre - CENREN/MAG
Cton. Matazano, Soyapango
El Salvador, C.A.
tel 770622

Hernandez, Ricardo
CENDEPESCA - MAG
Santa Tecia, El Salvador
tel 280034

Juarez, Modesto
CATIE, Dept Economia
1a Calle P. y 61 Ave. Nte. Edificio Bukele, 1a Planta
tel 238224

Kuehn, Stanley
CLUSA
Calle las Acacias #130
tel 237043

Larios, Joaquin
CATIE
1a Calle P. y 61 Ave. Nte. Edificio Bukele, 1a Planta
tel 238224

MacMichael, Bethsy
FUSADES/USAID Aquaculture Program
14-134 Calle Victor Mejia Lara, y Av. Masferrer Sur
tel 235711

Martinez, Ana Carolina
FESA 20-30
79 Avenida Norte No 509
San Salvador
tel 238947

de Melara, Ruth Castro
Administracion Nacional de Acueductos y Alcantarillados (ANDA)
6a 10a Calle Poniente 1521
San Salvador, El Salvador
tel 712709

Myton, Becky

Water and Sanitation for Health (WASH) Project
1611 N. Kent St., Rm 1001
Arlington, VA 22209
tel (703) 243-8200

Nagy, Tibhor
USAID, San Salvador

Palacios, Eugenio
Director de Investigaciones
CENDEPESCA
Santa Tecla, El Salvador
tel 281006

Ponce, Manuel
Proyecto Agroforestal de FAO
CENREN/MAG
Col. Matazano
tel 272594

Puig, Jose Antonio
Universidad Catolica de Occidente
Laboratorio de Analisis de Suelos, Aguas, Aliminetos y Leche
1e Calle Poniente, No 32
Santa Ana, El Salvador
tel 413217

Ramos, Jorge
Colonia Santa Elena
FUSADES
tel 783366

Rivas, Francisco
Amigos del Arbol (AMAR)
Colonia Mercedes, Calle 10 #9
San Salvador
tel 231841

de Tobar, Marta
Museo de la Historia Nacional
Universidad de San Salvador
tel 227680

Vasquez, Mauricio
Museo de la Historia Nacional
Universidad de San Salvador
tel 227680