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

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

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

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

[2] Indicated options can be additive so the 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 criteria having inherently high risks either due to unsure markets, unsure returns to labor investment, or physical soil loss through slumping.

Table 3. Illustrative NPV returns to different hillside technologies.
All costs and returns in Quetzals.

1. COSTS (Labor + materials, including scheduled maintenace labor)

Years	Fuelwood Woodlots	Sawntimber Woodlots	1/2 Fuel+ 1/2 Saw	Vegetat strips	Barriers+ Infil Dtc
1	884	884	884	284	2370
2	480	480	480	142	355
3	167	167	167	167	355
4	167	167	167	167	355
5	167	167	167	167	355
6	167	167	167	167	177
7	167	167	167	167	177
8	167	167	167	167	177
9	167	167	167	167	177
10	167	167	167	167	177
11	167	167	167	167	177
12	167	167	167	167	177
13	167	167	167	167	177
14	167	167	167	167	177
15	167	167	167	167	177
16	167	167	167	167	177
17	167	167	167	167	177
18	167	167	167	167	177
19	167	167	167	167	177
20	167	167	167	167	177
21	167	167	167	167	177
22	167	167	167	167	177
23	167	167	167	167	177
24	167	167	167	167	177
25	167	167	167	167	177
26	167	167	167	167	177
27	167	167	167	167	177
28	167	167	167	167	177
29	167	167	167	167	177
30	167	167	167	167	177
total	9616	9616	9616	8126	13079

2. BENEFITS: ANNUAL PRODUCTION (Commodities at farm or forest gate)

prod/ha= valu/unit	12/m3/yr 130	12/m3/yr 1147	12/m3/yr 630	4297 lbs/ha 2640	4297 lbs/ha 2640
1	981	8656	4819	1660	1660
2	981	8656	4819	1660	1660
3	981	8656	4819	1660	1660
4	981	8656	4819	1660	1660
5	981	8656	4819	1660	1660
6	981	8656	4819	1660	1660
7	981	8656	4819	1660	1660
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26	981	8656	4819	1660	1660
27	981	8656	4819	1660	1660
28	981	8656	4819	1660	1660
29	981	8656	4819	1660	1660
30	981	8656	4819	1660	1660
NPVb	7767	68530	38149	13144	13144
NPVc	2619	2619	2619	1452	4920
NPV	5148	65911	35530	11693	8224

(1) Assumes 12m3/yr/ha @ 100% fuelwood, poles and timber considerably higher
(2) Assumes 10% net increase in maize yields (10% area loss to tecnology)
(3) Assumes a 20% loss in area planted in maize but includes compensatory yields from 200 banana plants
(4) all costs and prices in Q 1991 with i @ 20%
(5) Fuelwood and timber estimates from CATIE (1990)

3. Lower Watershed (IPM, Soil Conservation, Sewage)

As previously described, this is an area of gently rolling topography characterized by high population density, commercial cultivation of commodity crops interspersed with subsistence cereals and pulses, and numerous rivers that drain the small watersheds of the adjacent mountains. While erosion is insignificant compared to the upper watershed, this is the region that suffers most from agricultural and sewage contamination.

Objective: To mitigate the significant environmental trauma visited upon this and the downstream portion of the watershed, with particular emphasis on sewage and agrochemical 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 areas where topography and farming practices have caused significant local soil loss. Extension of fuel-efficient cookstoves will also reduce demand for firewood from upland forest areas.

a. Mitigative Technologies

(1) Sewage Treatment for Population Centers, Including Drainage and Collection Structures

These primary treatment technologies are normally selected for towns of 5,000 to 15,000 people. Primary treatment makes particularly good sense in areas where the primary potable water source is slow-moving such as a lake. In selecting these technologies, emphasis should be given to minimal moving parts or energy inputs, and consequent low operating and maintenance requirements. Any structures necessarily have to have user associations and a fee structure to recuperate maintenance costs along the same lines as potable water systems.

- Digestion/stabilization ponds
- Biofiltration ponds
- Constructed wetlands

(2) Sewage Treatment For Rural Areas

These very basic benefits could be extended to the 50 percent of the rural population that does not presently enjoy any form of sewage collection.

- Septic tanks
- Dry pit latrines
- Elevated latrines

(3) Training and Support for the Commercial Production of Fuel-efficient Cookstoves

While the Lorena stove originated in Guatemala, there has been no national campaign to promote energy conservation in the kitchen and for space heating. Since it is estimated that over 60 percent of total household energy demand is wood-based, development and commercial dissemination of an improved cookstove could bring real savings and remove pressure from dwindling forest resources.

b. Technology Extension Approach

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

The presence of fairly well-organized cooperatives in the coastal areas is not paralleled in upper areas where loose informal producer associations, municipal committees, and religious structures may offer the best opportunities. Development of ground-truthed "Participatory Rural Appraisals" (RPAs) in each upper watershed, to determine organizational and material needs, will be necessary and time-consuming and may preclude implementation for up to a year from project inception. Typically RPA has several distinct and chronologically ordered stages (Gibson 1987; WRI 1990) including:

- Site selection and contacts with local officials.
- Preliminary familiarization site visits.
- Date collection: spatial; time-related; social and institutional fabric; labor availability; and technical problems.
- Data synthesis and analysis.
- Isolation of primary technical problems and setting institutional opportunities for extension.
- Ranking opportunities and development of a democratically approved resource management plan.
- Implementation of the resources management plan.
- Follow-up and continual evaluation, and reappraisal of training and material support requirements.

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

Given labor and other input costs, some of the technologies mentioned 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" (in El Salvador) has had better than an 80 percent repayment rate in similar efforts that warrant consideration.

c. Monitoring and Impact Evaluation

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 it will require physical measures of resource quality and quantitative approximation of adoption by farmers and by 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 life of project, the importance of these proxies for longer-term impact should be carefully considered in the design phase. Some suggestions are as follows:

Quantitative Physical Measures

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

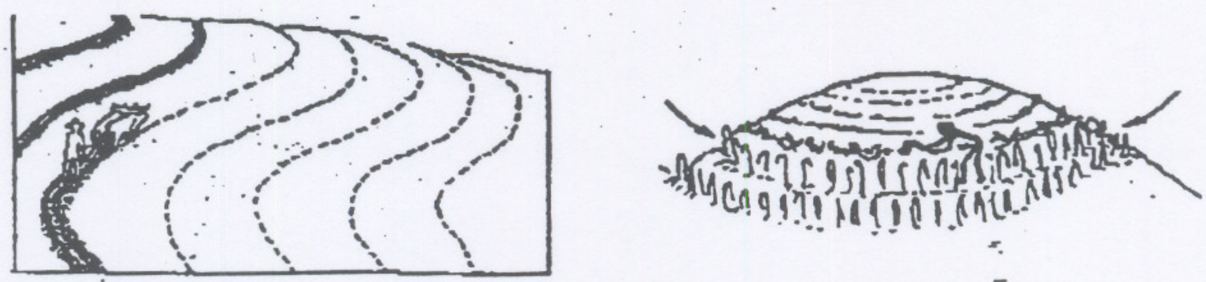
Qualitative Measures

- 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

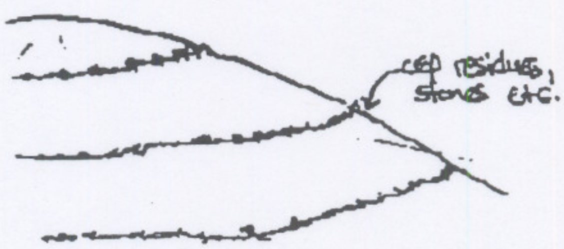
The ability to prove connectivity between upper watershed treatments and lakeside or lower watershed impacts is tenuous under the best of circumstances and is unlikely to become apparent during the life of the project. As the steeper upper watersheds flow into the undulating foothills and flatter irrigation planes, it will become increasingly difficult to isolate causal agents of water quality or quantity improvement. It is suggested that the watersheds be desegregated 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 measured at the base of upper watersheds. Turbidity and measurement of coloforms would be more appropriate at lower areas (e.g., lakeside). Weber (1990) provides treatment of appropriate measurement techniques.

FIGURES

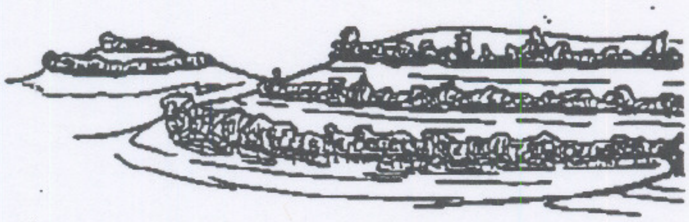
1.0 Contour Farming Techniques



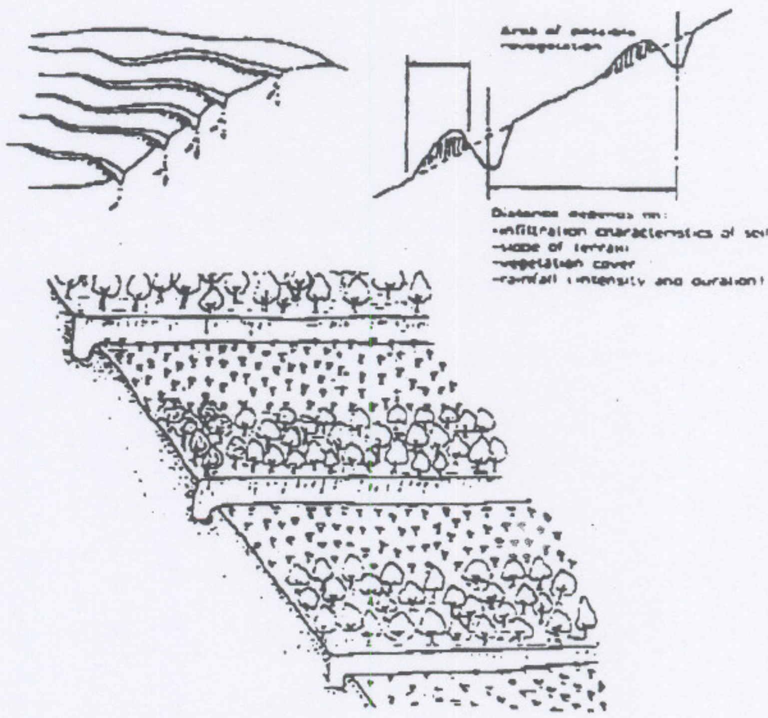
2.0 Trash Line Establishment



3.0 Vegetative Stripe

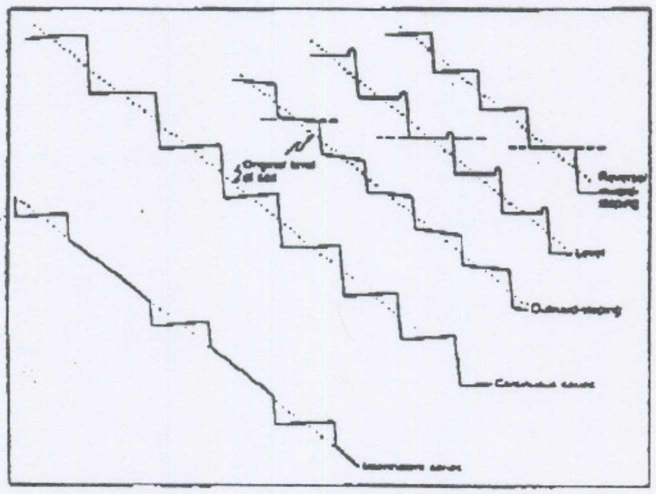


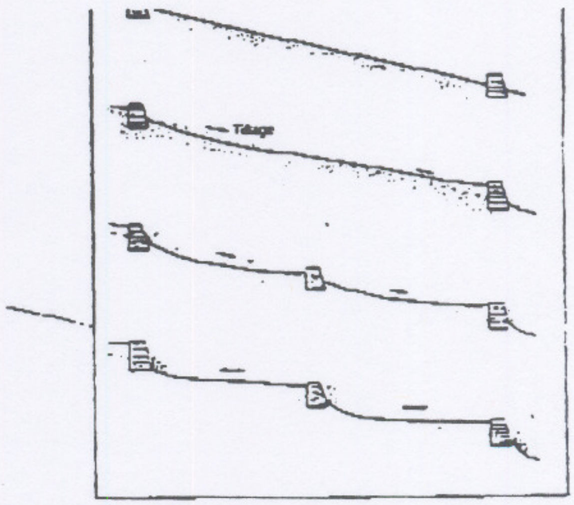
4.0 Infiltration Ditches



5.0 Fishscale Terraces

6.0 Bench or Radical Terrace Types





7.0 Gabions, Gully Plugs and Check Dams