



**CENTRO AGRONÓMICO TROPICAL DE  
INVESTIGACIÓN Y ENSEÑANZA**

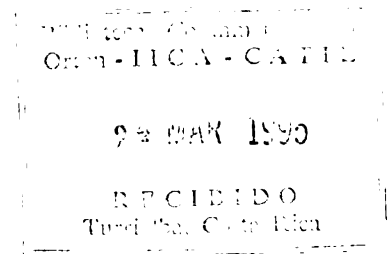
**PROGRAMA MANEJO INTEGRADO DE  
RECURSOS NATURALES**

**AREA DE MANEJO DE CUENCAS**



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**UPLAND DEVELOPMENT AND CONSERVATION PLANNING IN  
HONDURAS: A CASE OF INTEGRATING RURAL DEVELOPMENT WITH  
HYDRO-ELECTRIC POWER PROJECTS FOR SUSTAINABILITY**

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PROJECTS FOR SUSTAINABILITY**

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## 1. INTRODUCTION

The National Institute of Electrical Energy (ENEE) in Honduras has recently completed feasibility studies of four large hydroelectric power dams in April, 1992. The detailed specifications of these dams and their projected costs are given in Table 1. In 1991, ENEE realized that these costly large dams will soon lose their productive lives due to sedimentation from their hilly watersheds unless the degradation of their upland rural areas is halted by appropriate development and conservation. The major causes of this upland degradation are given in Table 2. In all cases, the sustainability of the large dams is directly dependent on the sustainability of their upland watersheds, hence in turn on the sustainability of their upland rural populations.

Table 1: Specifications of proposed hydro-electric dams and their projected costs (in million US\$) based on pre-feasibility studies (ENEE, 1983)

DAM	Water-shed areas, Km <sup>2</sup>	Type of dam	Height of dam, m	Mean monthly river discharge, cusec	Storage capacity, M m <sup>3</sup>	Installed capacity, MW	Power generation/year, (100%) GWh	Costs (rounded) M \$
Agua de la Reina	152	(To be a shall project for short term needs till other larger projects are financed.)						
Remolino	1,193	Rock	75	140.6	35	125	550	225
Sico II	4,338	Rock	120	100	605	122	701	374
Naranjito	3,651	Rock	116	76	570	72	411	179

The objective of this case study is to report on the methodological package used for integration of the upland watershed rural development and conservation plans into the feasibility studies of the hydroelectric dams in Honduras and its results. This was required to be done in a very short time with little information available. Hence, quick methods were required to integrate upland component with the dam component in the feasibility study. First year of the action plans was earmarked for detailed planning as a part of the development activities.

## 2. BRIEF DESCRIPTION OF THE UPLAND WATERSHEDS AND THEIR RURAL POPULATIONS

### 2.1 Locations of the Upland Areas

Fig.1 shows locations of the four watersheds along with their areas and the location of the four dams proposed on them. The Agua

Table 2: Major causes of upland degradation

Watershed	Causes in order of priority
Agua de la Reina & Remolino	<ol style="list-style-type: none"> <li>1. Shifting agriculture on sloping lands resulting into rural poverty</li> <li>2. Over grazing of natural pastures</li> <li>3. Fires on pasture/agricultural lands and forests</li> <li>4. Indiscriminate logging of forests for fuelwood and industrial purposes.</li> </ol>
Sico II	<ol style="list-style-type: none"> <li>1. Indiscriminate logging of forests for fuel-wood and industrial purposes</li> <li>2. Over grazing of pasture and forest lands</li> <li>3. Subsistence level hillside agriculture resulting into rural poverty</li> <li>4. Forest and pasture land fires.</li> </ol>
Naranjito	<ol style="list-style-type: none"> <li>1. Subsistence level hill side agriculture resulting into rural poverty</li> <li>2. Over grazing of pasture and agricultural lands</li> <li>3. Pasture/agriculture and forest land fires</li> <li>4. Indiscriminate logging of forests for industrial and fuel-wood purposes.</li> </ol>

de la Reina dam is proposed within one Km below the confluence of the rivers Frio and Comayagua below existing El Cajon dam. The Remolino dam is proposed 10 Km below the confluence of the rivers Cuyamapa and Camayagua. The Sico II dam is proposed to be located on the river Sico at Los Chorros. The Naranjito dam is proposed at Santiago de Posta in Santa Barbara district on the river Jicatuyo, 43.4 Km below the confluence of the rivers Mejocote and Higuito.

## 2.2 Upland Topography and Land Use

All the watershed areas of the 4 proposed dams are hilly. Table 3 gives the indicative figures on the slopes of these watersheds (ENEE, 1992). Over 76% of the uplands of the Agua de la Reina and Remolino watersheds, 61.6% of Sico II watershed and over 67% of Naranjito watershed are over 10% slope range. This makes agricultural use of these lands unsustainable unless they are appropriately conserved.

Recent data on actual land use of these watersheds are not available. However, it is estimated that most lands in slope classes (>20 %) III, IV and V are under conflictive land use compared to their land capability and recommended land use practices (Table 3). At the national level there has been an annual reduction of 1.9% in forested areas compared to 1980 (ENEE/BCIE, 1991a).

Table 3: Topography of the upland watershed areas (ENEE,1992)

Slope class range %	Areas (Km <sup>2</sup> ) of slope classes <sup>2</sup> in various watersheds						Reco- mended land use <sup>3</sup>	
	Agua de la Reina and Remolino		Sico II		Naranjito			
	Area	%	Area	%	Area	%		
I	0-10							
-Ia	0-2.5	157.82	12.17	523.92	12.24	206.25	5.68	All
-Ib	2.5-10	152.88	11.79	1,119.70	26.17	974.85	26.85	All,Agc
II	10-20	367.30	28.32	1,254.04	24.31	1,310.10	36.08	All,Agic
III	20-30	336.99	25.99	763.82	17.85	666.05	18.34	SP, F
IV	30-50	226.18	17.44	459.25	10.73	342.01	9.42	F
V	>50	55.63	4.29	158.27	3.70	131.74	3.62	PA/RF
Dam area		48.2		59		20		
<b>TOTAL</b>		<b>1,345</b>	<b>100</b>	<b>4,338</b>	<b>100</b>	<b>3,651</b>	<b>100</b>	

In Remolino watershed the upland shifting agricultural areas have expanded by 30% while the forested and pasture/brush/shrub areas have reduced by 15% between 1980 and 1990. Most of this expansion in agricultural area is on hillside lands above 20% slopes (CATIE/ENEE, 1992a). These lands generally have relatively poor soils. The climate of the watershed is sub-humid to semi-arid.

Sico II upland watershed had about 85% of its area under forests till 1982 (ENEE/BCIE, 1991d) with little or no organized logging activities. However, by then about 815 Km of unpaved roads have been constructed which opened the forested areas to accelerated logging, over grazing and some subsistence hillside agriculture. Due to this, conservative estimates put present forested area to be less than 50% (CATIE/ENEE, 1992b). The lower watershed (about 900 Km<sup>2</sup>) has very highly erodible soils but little population.

In Naranjito watershed, only about 15% of the area is expected to be under forests today due to large expansions in hill side subsistence agricultural areas, coffee plantations, and extensive pasture areas. This is a result of high population pressure in the rural and urban areas of the watershed. Additionally it has very fragile sandy to sandy loam soils with high erodability and semi-arid to sub-humid climate.

### 2.3 Socio-economic Conditions

The extent and number of families and the population of the rural areas summarized from the national population census of 1988 is given in Table 4 (CATIE/ENEE, 1992a,b,c) for the uplands of the 4 watersheds. This does not include places with >200 families defined here as towns/cities and most of which are in valleys. Areas which will be submerged under the proposed dams are also

excluded. Separate plans for rehabilitation of these areas have been made elsewhere (ENEE/BCIE, 1991b,e; ENEE/Bechtel, 1990).

Table 4: Extent of rural areas and their families in the four watersheds (ENEE, 1992a,b,c) based on 1988 national census

Watershed	Area, Km <sup>2</sup>	Municipalities	Villages (Aldeas)	Hamlets (Caserio)	Families	Upland rural Popula- tion
Agua de la Reina	152	2	5	44	609	1,767
Remolino	1,193	5	35	234	3,879	20,737
Sico II	4,338	3	38	448	4,818	24,751
Naranjito	3,651	18	205	1,180	19,056	95,505

Agua de la Reina and Remolino watershed population live on subsistence level shifting agriculture having <5 ha of land. Its illiteracy rates is about 29%. The population growth rate is 4.6% and >50% of the present labor force is unemployed (ENEE/BCIE, 1991c).

In the upland rural areas of Sico II watershed most of the population are subsistence level hill side pastoralist cum agriculturists owning <5 ha of land. Over 50% of this population does not have land titles. The population growth rate is 3.6% and over 50% of the labor force is unemployed. The illiteracy rate is over 38% (ENEE/BCIE, 1991f).

The Naranjito watershed is highly populated. Most of the families (88%), owning <5 ha, live on hill side subsistence agriculture and/or are pastoralist. The rest also grow coffee, potato and other fruits and vegetables. Most of these families have legal title to their lands but very often these lands are not suitable for agriculture. Almost all the flat and good lands of the valleys are in the hands of big (>50 ha) farmers who live in cities. The stocking rate on the upland pasture lands is also very high (7-8 animals/ha) resulting in over grazing and low production from the pasture lands (ENEE/Bechtel, 1990).

In all 4 watersheds the rural population depend on the rivers for their potable water needs. The rural areas have no latrines resulting in poor hygienic conditions. The schools also need improvements. These areas are generally connected by unpaved roads which need annual maintenance.



### 3. METHODOLOGICAL PACKAGE USED IN THE ANALYSIS OF THE RURAL AREAS

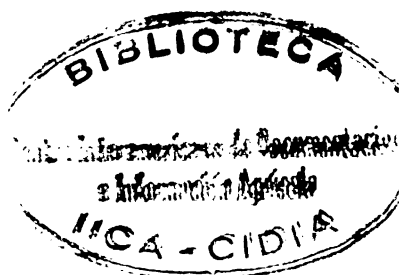
All information, as given in the references, was collected and reviewed to access available data. A sondeo, by a multi-disciplinary team of CATIE/ENEE, was made in the different zones of the watersheds to ascertain rural population needs, to integrate farmers' local technology knowledge (LTK) and points of view in the action plans (Chambers et al, 1991; Ferran, 1991) and to get a global overview of the problems of upland rural area degradation. Up to date actual land use maps which are used to determine critical areas for conservation were not available for the country. In absence of this, priority areas for development in each hamlet were determined based on an area need assessment for rural families.

#### 3.1 Minimum Area Need Assessment

Based on detailed discussions held with different organizations in Honduras, minimum area needs for a family were ascertained as given in Table 5 for sustaining the upland rural populations in the hilly areas of the 4 watersheds. Pasture lands need is higher in Sico II and Naranjito where most rural populations are pastoralist cum farmers. Thus, if on an average, about 5 ha/family are managed well, the upland areas can sustain the rural population without destruction of the resource base. For farmers having <5 ha, priority should be given to stabilization of agriculture followed by sylvo-pastoral development and home/fruit gardens. Farmers with >5 ha can devote more land to the purpose they desire.

Table 5: Agro-silvo-pastoral area development needs for a family in different watersheds

Watershed	Average area (ha) needs per family				Total
	Stabilized agricultural by agro-forestry methods	Sylvo-pastoral	Fruit Trees/home gardens/ reforestation (on-farm)	Forest natural regeneration for fuelwood (on-farm)	
Agua de la Reina	2	1.5	0.5	1.0	5
Remolino:					
-high and medium zones	2	1.5	0.5	1.0	5
-lower zone	1	1.5	0.5	1.0	4 <sup>a</sup>
Sico II	1	2.5	0.5	1.0	5
Naranjito	2	2.0	0.5	0.5	5



### **3.2 Land Capability/Land Use Analysis**

In absence of detailed soils and actual land use maps, data from slope maps given in table 3 were used as indicative land capability maps. For this reason an additional activity was added to the initial stages in the implementation of the proposed action plans (CATIE/ENEE, 1992a,b,c) to develop detailed appropriate land use plans for determining critical areas (Sharma, 1991a) once the action plans are funded.

### **3.3 Priority areas in hamlets for upland development**

Based on the 1988 population census of Honduras (CATIE/ENEE, 1992,a,b,c), the number of families and their population in each and every hamlet and village in the 4 watersheds were determined. These have been summed in Table 4. The minimum priority area needs for a family were used to derive estimated total priority area for upland development.

### **3.4 Land Titling**

Majority of the rural families in the rural areas of Agua de la Reina, Remolino and Naranjito watersheds have legal possession of their lands. However, in Sico II watershed, about 50% of the rural families do not have legal titles. Hence land titling for the upland rural population in Sico II watershed was seen as an essential activity. The cost was estimated on the basis of total cost/ha of making a total cadastral survey of the uplands (municipalities of Gualaco and San Esteben) for land titling. This cost was US\$ 3.44/ha for the district of Francisco Morazan as used in the Case of El Cajon (GOH/OEA/BID, 1991).

### **3.5 Approach to Upland Development and Conservation Through Incentives**

#### **3.5.1 Agro-sylvo-pastoral systems adapted to farmers LTK for stabilizing uplands**

Agro-sylvo-pastoral methods as adapted to the traditional farming systems of the region (Sharma, 1991b,c,e) are recommended for sustainable development of the upland rural areas. These include soil conservation and soil fertility maintenance by agro-forestry methods (Young, 1991; Sharma, 1990) for stabilizing shifting/hill side agriculture, appropriate sylvo-pastoral management of existing natural pasture lands to sustain the present animal load/ha (2-3 in Agua de la Reina, Remolino and Sico II, and 7-8 in Naranjito), home/fruit gardens or on-farm reforestation for cash, and (4) on-farm level natural regeneration for fuel wood-lots.

For on-farm level gully control, simple vegetative methods and regeneration of natural vegetation (Sharma, 1991d) are proposed.

About 100m/ha of these gullies are estimated in the agriculture and on-farm natural forest regeneration areas.

In case of Naranjito watershed a potential for micro-irrigation also exists. The plans include 2,000 ha of this for cash crops to be implemented through credit from a rotating fund.

### 3.5.2 Conservation incentives

Incentives to the farmers are required for all those activities which are not a part of their traditional farming practices. These can be in kind in the form of grass/tree seeds, plants, tools technical assistance, extra man power requirements etc. Based on these (Sharma, 1991c,d) and the local market conditions following value of incentives is included in the action plans:

Stabilization of shifting/hill side agriculture:	US\$ 75/ha
Silvo-pastoral management in the hill sides:	US\$ 75/ha
On-farm forest natural regeneration :	US\$ 50/ha
on-farm home/fruit gardens/reforestation:	US\$ 100/ha
On-farm gully control:	US\$ 50/Km
Rural forest nurseries/ha of plantation:	US\$ 50
Credit from rotating fund for gravity	
micro-sprinkler irrigation for cash crops:	US\$ 1,800/ha

In principle, once the upland agriculture and pasture areas are managed sustainably, the human and animal pressure from the rest of the uplands is removed. Thus, they can regenerate naturally provided they are protected from fires, irrational exploitation of their resources and natural forest reserves are protected.

### 3.6 Rural Extension Service

An efficient system of rural extension service is considered essential for successful implementation of the proposed activities. This is to be based on the necessity of giving technical assistance to each and every rural family (Ferran, 1991c) as has been designed for El Cajon watershed (GOH/OEA/BID, 1991). The families in the hamlets are joined into groups of 10 beneficiary families in a farmers' association. For every 3 groups of beneficiary families, a village level extension worker (VLW) is assigned on a full time basis. This VLW could be an innovative farmer or a natural village leader from the same or nearby hamlets. The VLW is to visit, by a prior calendar, at least 7-8 farmers in a day. Thus he will cover 30 families in 4 days of a week. The 5th day is dedicated to procuring supplies, meetings with extensionists, lectures in schools, office works or reserving time for consultations by farmers other than the beneficiary groups etc.. A group of 6 VLWs will be assisted and guided by an experienced and qualified agro-forestry extensionist.

Thus each extensionist will cover about 180 families in different hamlets along with the VLWs. In this way, each and every rural family of the watersheds will be assisted within the duration of the action plans. This duration is 5 years for Agua de la Reina and 10 years for all other watersheds.

### **3.7 Forest Protection/Management Service**

The biggest impediment to natural regeneration is forest fires which often originate from slash and burn practices in shifting agriculture or from fires used for land clearing on hill sides annually. The practice of annual burning of natural pasture for regeneration is also very prevalent which does not allow regeneration of the tree/shrub/bush component in the pastures. This is also the biggest cause of erosion from the sloping lands as presence of low ground cover (live or dead mulch) is the major factor in soil erosion control (Nair, 1987; Young, 1991; Sharma, 1991b,c). Hence, the proposed rural extension service is also to make a large campaign for controlling these causes of forest fires. In addition, a system of fire observation towers and observers are required for every 100 Km<sup>2</sup>.

One of the 3-5 towers (depending on topography) also acts as a central coordinating tower. A fire fighting brigade of 7 members along with their fire fighting equipment is required for every 10 Km<sup>2</sup> under an observation tower for a period of up to 3 months/year during the dry season. This system of forest protection and the extension service are also to help in forest management on existing forest lands.

### **3.8 Forest Reserves and Parks**

Most areas declared as forest reserves and parks by the Government of Honduras in Remolino and Naranjito watersheds are invaded by shifting or hill side agriculture and extensive pastures, except those which are designated to indigenous communities who culturally know how to live in harmony with the nature. Rural people who live in them, need to be stabilized through agro-silvo-pastoral methods and the rest of the areas need to be protected from fires. Hence, all the presently designated forest reserves and parks are included in the extension service and forest protection areas.

In case of Sico II, the lower watershed of the Sico river all along the proposed dam (900 Km<sup>2</sup>) is demarcated as forest reserve area in the action plan (CATIE/ENEE, 1992b). This is because the soils of this area are very fragile and highly susceptible to erosion. It is at present in good natural forest cover and very little population (232 families) live in it. While traditional methods of forest use by local population do not endanger this area, industrial concessions are not to be allowed. Many families can also be employed as forest guards. A guard for every 10 Km<sup>2</sup> is

required. The rest of the families at present practicing hill side agriculture can also continue to live in it through stabilized agriculture and traditional forest products use.

### **3.9 Rural Road Maintenance**

The existing unpaved rural road system (183 Km in Agua de la Reina, 885 Km in Remolino, 450 Km in Sico II excluding principal roads which are also unpaved, and 550 Km in Naranjito) is thought to be sufficient for rural needs. Hence, no new road construction is proposed as in hilly areas it will only result in large scale deforestation. However, the existing road system is in need of annual maintenance. The machinery for this is locally available. The costs based on local prices are estimated to be US\$ 30/Km/year.

### **3.10 Costing of Different Activities**

The cost of different activities are estimated based on local unit costs of manpower and materials. These costs of personnel for executing unit at headquarters, international technical assistance, field extension service, forest protection service and their material and operational needs etc., are given in detail in CATIE/ ENEE (1992a,b,c). A provision for 5% annual rate of inflation and 8% overhead administrative costs is also made.

### **3.11. Sustaining Upland Rural Development after Duration of the Action Plans for Continued Sustainability of Hydro-electric Systems**

The hydro-electric system consists of four major components, namely: the dam structure, the electric distribution network, the reservoir and the area producing water i.e. the watershed. As long term maintenance of the first three components is essential for successful operation of the hydro-electric system, so is the case with the fourth component (the watershed) for maintaining the life of the system by sediment control through the various conservation activities. The beneficiaries of the upland watershed rural area development are the farmers themselves and the hydro-electricity users. Hence, the need for a negotiated cost sharing arrangement between them. This should clearly result in determination of the percentage of revenues from hydro-electric sale to be earmarked for upland watershed maintenance. These negotiations are to be completed in the last 3 years of the action plan periods.

## **4. RESULTS**

### **4.1 Priority Areas for Sustainable Management**

The priority areas for sustainable management calculated based on Table 5, are summed up in Table 6. In total 3,216 ha in Agua de la Reina, 21,581 ha in Remolino, 24,076 ha in Sico II and 95,668 ha in Naranjito are considered to be priority areas for different

activities in the respective watersheds.

Table 6: Priority areas and magnitude of various other activities for sustainable management of the uplands in the four watersheds (CATIE/ENEE, 1992a,b,c)

Activities <sup>5</sup>	Watershed			
	Agua de la Reina	Remolino	Sico II	Naranjito
1. Stabilization of shifting or hill side agriculture, ha	1,218	5,067	4,818	36,270
2. Silvo-pastoral management, ha	913	5,816	12,046	38,270
3. Farm level forest natural regeneration, ha	609	4,879	4,586	9,564
4. Farm level: fruit gardens/home gardens/reforestation for fuel-wood, ha	304	1,940	2,294	9,564
5. Micro-irrigation, ha				2,000
<b>Total priority area, ha</b>	<b>3,216</b>	<b>21,581</b>	<b>24,076</b>	<b>95,668</b>
6. Legalization of land tenancy, No. of land titles to be given (approx. 5 ha each)			2,300	
7. On-farm level gully control, Km	162	893	821	5,139
8. Rural road maintenance, Km	183	885	450	550

In addition, about 2,300 land titles need to be given in Naranjito watershed. This will need a total cadastral survey of about 1,600 Km<sup>2</sup> and shall be executed by the National Agricultural Institute (INA) on a sub-contract basis.

A total of 162 Km of on-farm gully control in Agua de la Reina, 893 Km in Remolino, 821 Km in Sico II and 5,139 Km in Naranjito are planned. Annual rural road maintenance is to be done on a sub-contract basis.

#### 4.2 Rural Extension Service

The rural extension service is designed to achieve the priority area targets for the population of all the hamlets as given in Table 4. To assist each and every family as planned, a total of 3 extensionists and 17 VLWs are required in Agua de la Reina. For the same, 11 extensionists and 66 VLWs in Remolino, 13 extensionists and 81 VLWs in Sico II, and 53 extensionists and 318 VLWs in Naranjito are needed (Table 7), covering half the no. of families (Table 4) in first 5 years and the rest in second 5 year duration of the plan.

Table 7: Field agro-forestry extension and forest protection/management system in the upland rural areas (CATIE/ ENEE, 1992a,b,c)

Watersheds	Agro-sylvo-pastoral system, No. of			Forest protection system No. of		
	exten- sionists	village level ext. workers	farmer beneficiary groups <sup>6</sup>	fire tower observers <sup>7</sup>	fire fighting brigades <sup>8</sup>	forest guards
Agua de la Reina	3	17	51	1	12	
Remolino	11	66	398	6	57	
Sico II	13	81	482	8	101	90
Naranjito	53	318	1,906	13	133	

This service is to be assisted by a minimum team of specialists at the headquarters of the executing unit. The extension system is to work in complete collaboration with the forest protection service.

Table 8: Global estimates of areas for different purposes in the four watersheds

Purpose	Estimates of areas (Km <sup>2</sup> ) in watersheds			
	Agua de la Reina	Remolino	Sico II	Naranjito
I Total watershed area	152	1,193	4,338	3,651
II Reservoirs	1	48	59	20
Reserved forest:				
- Protected area proposed	-	-	900	-
- Govt. declared parks	-	114	-	170
- Indigenous rights areas	-	100	12	-
Valleys already under intensive agricultural or pasture use	-	359	1,644	1,181
III Priority areas for agro-sylvo- pastoral development in the hamlets	32	216	240	956
IV Area for forest protection (fire control)/management and natural regeneration (I - II - III)	119	570 <sup>9</sup>	1,013 <sup>10</sup>	1,324
V Area for total cadastral survey for land titling (IV + 50% of III)	NA <sup>11</sup>	NA	1,602	NA

#### 4.3 Forest Protection/Management Service

The areas for forest protection and management for natural regeneration are calculated in Table 8 on a global basis. A total of 119 Km<sup>2</sup> in Agua de la Reina, 570 Km<sup>2</sup> in Remolino, 1,013 Km<sup>2</sup> in

Sico II and 1,324 Km<sup>2</sup> in Naranjito need a forest protection and management service for natural regeneration. This will require a total of 1 fire observation tower in Agua de la Reina (in addition to the one already existing at El Cajon), 6 in Remolino, 8 in Sico II (in addition to 2 already existing with COHDEFOR), and 13 in Naranjito. These are to be equipped with their observers, communication equipment, transport and fire fighting equipment for their respective fire brigades. The agua de la Reina will need 12 brigades, Remolino 57, Sico II 101, and Naranjito 133 brigades, respectively. These are needed for 3 months/year of dry weather.

In the lower Sico II watershed 90 forest guards along with a forester are needed to maintain this area as a protected forest reserve. Four additional foresters are also provided for Sico II for forest management working in close collaboration with the extension service.

#### 4.4 Costs of the Action Plans

The costs of various components are summed up in Table 9. The indirect costs consist of an international technical assistance component and a group of national specialists at the headquarters of the executing unit along with their support facilities. The

Table 9: Costs of sustainable management of the upland rural areas of the four watersheds (activities beginning 1993)

Watersheds	Costs (1000 US\$) for different components					Total Costs <sup>12</sup> (rounded) million US\$
	Indirect		Direct			
	Internation- al tech. assist.	National executing unit	Agro- sylvo- pasto- ral	Forest protec- tion/ manag.	Forest reserves/ protected areas	
Agua de la Reina	210	191.8	734.2	196.5		1.51
Remolino	1,092.5	615.84	4,509.47	1,827.9	* <sup>13</sup>	9.03
Sico II	1,447.5	699.96	6,099.47	3,802.2	1,492.24	15.30
Naranjito	1,447.5	1,002.22	23,295.41	5,037.4	* <sup>13</sup>	34.78

direct cost component consists of the costs of rural extension service, forest protection service, protected forest area personnel (Sico II) and the costs of executing the activities through incentives in field along with the material support needed to execute them.

The direct cost of sustainable management of the priority areas in the hamlets (agro-silvo-pastoral component) is US\$ 208.95/ha in Agua de la Reina, US\$ 228.30/ha in Remolino, US\$ 253.34/ha in Sico II and US\$ 243.45/ha in Naranjito watershed. These unit costs are higher in Sico II due to added cost of land titling and in



Naranjito due to inclusion of micro-irrigation component.

The total costs of upland development and conservation are US\$ 1.51 million for Agua de la Reina watershed, US\$ 9.03 million for Remolino, US\$ 15.30 million for Sico II and US\$ 34.78 million for Naranjito watershed. These costs represent only a minor fraction of the costs of hydro-electric dam construction and installation (Table 1).

#### 4.5 Financing of the Action Plans

These action plans have been integrated into total costs of hydro-electric systems for each dam in the feasibility studies and are being submitted to multi lateral banks for funding who authorized and paid for the dam feasibility studies. The priorities for funding will depend on various feasibility conditions to be met for the dam constructions.

### 5. CONCLUSIONS

Investment into upland rural development and watershed conservation is far more easily justified, when their sustainability also justifies the sustainability of other large national infra-structures e.g. large dams. Upland development is needed from the very inception of the construction of large dam infra-structures for assuring their designed productive lives. This case study demonstrates that quick methodological packages are already available for integrating the upland rural development plans into the large dam construction plans.

Methods of agro-silvo-pastoral systems, forest fire protection for helping in natural forest regeneration, are recommended as they are cheaper to implement, adapt easily to local technological knowledge of the farmers in the region, contribute to meet rural needs and help sustain rural production systems in addition to conservation of natural resources. An efficient extension service planned based on attending to each family (rather than top down) in a given time frame, and appropriate incentives to farmers to execute the field activities are needed to assure efficient upland rural development and conservation of their natural resources through community participation.

The upland rural development and natural resource conservation reflect only a fraction of the costs of large dam infra-structures. Cost sharing arrangements between different beneficiaries of upland rural development (farmers, electric users, tourists etc.) are recommended for continued maintenance of the upland watersheds as the benefits go to various electric and dam users in addition to the farmers.

## NOTES

1. A work jointly carried by ENEE and CATIE (RENARM/CUENCAS). The collaboration of the technical staff of the watershed management department and the manager of the Remolino/Sico II/Naranjito hydroelectric project of the ENEE, and the representative of the CATIE, Tegucigalpa, Honduras is highly acknowledged.
2. Slope analysis based on 1:100,000 scale and 100 m contour interval of topographic maps, hence these figures should be treated as indicative only rather than definitive.
3. Land use abbreviations:
  - All = any use desired by farmer but if used for agriculture then use conservation as indicated.
  - Agc = Agriculture with conservation
  - Agic = Agriculture with intensive conservation
  - SP = Silvo-pastoral
  - F = Forestry
  - PA = Protected areas
  - RF = Reserved forests
4. One ha of intensive agriculture land is available in the valleys.
5. First year of the action plans are earmarked for detailed planning
6. One farmer beneficiary group = 10 farmer families
7. Excluding existing fire observation towers
8. One fire fighting brigade = 7 persons for one quarter of a year
9. Including both government proposed forest parks and (Pico Pijol = 114 Km<sup>2</sup>) and indigenous rights forest reserve area (100 Km<sup>2</sup>).
10. Excluding middle watershed area (river Conquires = 470 Km<sup>2</sup>) which has humid climate hence no occurrence of forest fires.
11. Not applicable/not needed.
12. 8% administrative overheads and 5% inflation costs added annually.
13. Included in forest protection component.

## REFERENCES

- CATIE/ENEE. 1992a. Plan de accion para el manejo sostenible de las cuencas de Remolino y Agua de la Reina, Honduras. April, p72.
- \_\_\_\_\_ 1992b. Plan de accion para el manejo sostenible de la cuenca del embalse Sico II. April, p 72.
- \_\_\_\_\_ 1992c. Plan de accion para el manejo sostenible de la cuenca Naranjito, Honduras. April, p 98.
- Chambers, R. et al. 1991. Farmer first-farmer innovation and agricultural research. Intermediate Technology Publications, U.K.
- ENEE. 1983. Datos significativos de proyectos hidro-electrico en Honduras. Mimeographed communication in 1992.
- \_\_\_\_\_ 1992. Topographic, drainage and slope maps of Remolino, Sico II and Naranjito. Dept. of watershed, Tegucigalpa. (Manuscripts).
- ENEE/Bechtel. 1990. Estudio de factibilidad proyecto Naranjito, appendix D-Ecology. Jan., p 110.
- ENEE/BCIE. 1991a. Proyecto hidro-electrico Remolino, informe de recursos forestales, memoria tecnica no. 34. Sept., p 29.
- \_\_\_\_\_ 1991b. \_\_\_\_\_ informe de socio economia, memoria tecnico no. 40. Sept., p 63.
- \_\_\_\_\_ 1991c. \_\_\_\_\_ informe de manejo de cuenca, memoria tecnico no. 42. Sept., p 69.
- \_\_\_\_\_ 1991d. Proyecto hidro-electrico Sico II, informe de recursos forestales, memoria tecnica no. 33. Sept., p 33.
- \_\_\_\_\_ 1991e. \_\_\_\_\_ informe de socio economia, memoria tecnica no. 39. Sept., p 44.
- \_\_\_\_\_ 1991f. \_\_\_\_\_ informe de manejo de cuenca, memoria tecnica no. 41. Sept., p 75.
- Ferran, F. 1991a. Metodologia de intervencion rapida: ideas basicas para la implementacion de reconocimientos rapidos a nivel de campo. A paper presented at the Watershed management workshop held at San Marcos de Ocotepeque, Nov. 25-29, p 20.
- \_\_\_\_\_ 1991b. De hombres y de recursos: parámetros de la problematica sociocultural en el contexto de cuencas hidrograficas de la region centro americana. p 48.
- \_\_\_\_\_ 1991c. Tecnicas de la extension agrosilvopastoril. . p 18.
- GOH(Gobierno de Honduras)/OEA/BID. 1991. Proyecto de manejo de los recursos renovable de la cuenca del embalse El Cajon- estudio de factibilidad. p 332.
- Nair, P.K.R. 1987. Agro-forestry- a decade of development, ICRAF, Nairobi.
- Sharma, P.N. 1990. Manual on soil conservation by agro-forestry methods for Nicaragua, GCP/NIC/019/NET, FAO, Rome.
- \_\_\_\_\_ 1991a. Appropriate land use for sustained production according to land capability in tropical Honduras. (English/ Spanish). a paper presented at PRODERE(UN)/CATIE watershed management workshop held at San Marcos of Ocotepeque from Nov. 25-29, 1991.

- . 1991b. Land Use management by agronomic and cultural practices for upland agriculture and coffee plantations in tropical Honduras.
- \_\_\_\_\_ 1991c. Agro-forestry systems for upland watershed rehabilitation in tropical honduras.
- \_\_\_\_\_ 1991d. On farm gully prevention and control by vegetative and temporary structural methods in tropical Honduras.
- \_\_\_\_\_ 1991e. Natural resources management in Nicaragua:  
Part II- Conservation technology adaptation to farmers needs and traditional farming practices. A paper presented at the Watershed management workshop held at Managua, June, p 31.
- Young, Anthony. 1991. Agro-forestry for soil conservation. ICRAF/C.A.B. International, UK.