PROJECT COMPLETION REPORT

ECUADOR

ALBARRADAS IN COASTAL ECUADOR: RESCUING TRADITIONAL KNOWLEDGE ON SUSTAINABLE USE OF BIODIVERSITY

GEF MSP GRANT No. TF023977

APRIL, 2004

Bolivia, Ecuador, Peru and Venezuela Country Managing Unit
Environmentally and Socially Sustainable Development Sector Unit
Latin America and the Caribbean Region

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ALBARRADAS IN COASTAL ECUADOR: RESCUING TRADITIONAL KNOWLEDGE ON SUSTAINABLE USE OF BIODIVERSITY

GEF MSP GRANT No. TF023977

Implementation Completion Report

I. Basic Data:

(1) Date of Completion Report: ***December 3, 2003.***

(2) Project Title: ***ALBARRADAS IN COASTAL ECUADOR: RESCUING TRADITIONAL KNOWLEDGE ON SUSTAINABLE USE OF BIODIVERSITY***

(3) GEF Allocation: ***US$725.000***

(4) Grant Recipient: ***ESCUELA SUPERIOR POLITÉCNICA DEL LITORAL ESPOL – CENTRO DE ESTUDIOS ARQUEOLÓGICOS Y ANTROPOLÓGICOS CEAA.***

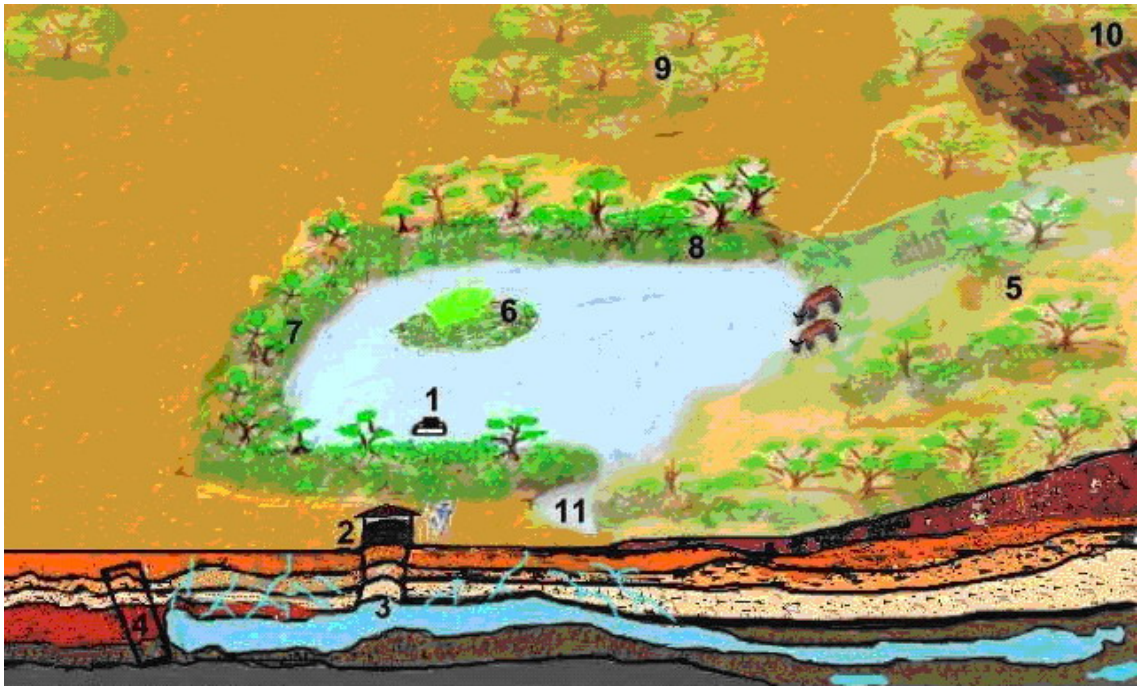
(5) World Bank Manager/Task Team: **Gabriela Arcos**

(6) Goals and Objectives:

No changes were introduced to the project goals and objectives during the implementation period.

The goal and project objectives were consistent throughout project implementation. The goal was to increase knowledge about traditional and modern systems of technologies for sustainable use of the globally-outstanding biodiversity of southwestern Ecuador, and increased local participation in the benefits of conservation. The specific project objective was: (i) to enhance understanding of the Albarradas systems as a response to a changing environment by determining ways in which newly constructed Albarradas differ from traditional ones (placement in the landscape, fluvial and surface runoff, design, and core construction) (a) Remote sensing survey of the study area to identify Albarradas and aquifers in the study area. (b)Limited test excavations at the remnant of the Muey Albarradas system (Santa Elena Peninsula, Ecuador) and of a stratified sample of other sites in the region, and analysis by social and natural scientists.; (ii)To understand the ways through which traditional common property resource management systems (Albarradas) have changed in response to changing social, economic, and political contexts (a) Socio-cultural, natural scientists and civil engineers assessments of native community knowledge of traditional and present use and significance of Albarradas; (iii)To enhance understanding of wild relatives of crop varieties in the area's ecosystems and to promote their conservation, (a) Botanical and ethno-botanical identification of cultivars and wild relatives of cultivars from the ecosystems where ancient Albarradas occur. (b) Botanical bank of wild and ancient cultivars (seeds and/or plants); (c) A set of recommendations for the proposal of future projects for on sustainable use of biodiversity in the coastal Ecuador.

Albarradas or *Jagüeyes* or Pre-Columbian Detention Ponds, are built on the drainage plain before rivers are formed. These hydraulic structures are formed by removing the topsoil (quaternary alluvium) from an area where water from the runoff remains after a heavy rain. The soil is deposited in small layers, and packed to form a horseshoe shape or semicircular embankment enclosing the borrow pit. During the rainy season or during an El Niño event (ENSO), Albarradas detain and hold water from the runoff, the water held in the Albarrada's vase infiltrates the underlying permeable sandstone deposits of the Tablazo formation, enriching the aquifer and raising the water table.



Initial planning involving research methods and analysis, and ways to approach stakeholders and other social actors involved with Albarradas and related issues have proven most effective and successful. The use of a logical framework allowed to organize objectives and indicators – from the general to the particular – hinging the five principal fields of research (Archaeology, Geology, Botany, Paleo-ethnobotany [archaeobotanical analysis], and Sociocultural Anthropology). Each one of the components achieved their goals by working and discussing results together as planned. The project objectives were not only met, but all research teams were able to surpass initial expectations, which has traduced not only in obtaining all the expected products but to discover new products and issues that should be subject of further analysis in the future.

(7) Financial Information

Table I: Initial and Final allocations by Components

Project Component	GEF		Co-Financer ESPOL		Co-Financer OTHERS NASA, VLIR, FLORIDA (PROMSA)		Total	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
Remote sensor survey and Geological etc.	96,000.00	97,957.60	90,000.00	94,734.73	20,000.00	21,332.21	206,000.00	214,024.54
Traditional common property resource management system	267,500.00	273,833.07	130,000.00	237,179.65	9,500.00	9,516.42	407,000.00	520,529.14
Botanical/Ethno botanical Analysis etc.	361,500.00	370,763.95	80,000.00	98,518.80	28,000.00	33,883.60	469,500.00	503,166.35
SEP Development and Environmental Projects	0.00	0.00	1.300,000.00	1.862,381.58	700,000.00	823,766.08	2.000,000.00	2.686,147.66
TOTAL	**725,000.00**	**742,554.62**	**1.600,000.00**	**2.292,814.76**	**757.500,00**	**888,498,31**	**3.082,500.00**	**3.923,867.69**

The difference between the 725,000 US Dollars received from GEF and the 742,554.62 spent are 17,554.62 dollars paid in interests by the *Banco de Guayaquil* on the Project Special Account. ESPOL's and other partners contribution increased considerably more than originally planned, as the oil royalties received by ESPOL and spent (according to law) on cultural and development projects in the Santa Elena Peninsula more than doubled. A new VLIR and University of Florida projects in our study area also Increased their contribution to the area communes.

Table II: Co-financing and leveraged resources

Component	GEF		Co-Financer ESPOL and OTHERS		Total	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
1. Goods	208.860,00	204.824,11	164.500,00	178.450,00	373.360,00	383.274,11
2. Technical Assistance	230.495,00	230.828,91	40.000,00	38.785,00	270.495,00	269.613,91
3, Project Local Team	190.050,00	194.602,01	113.000,00	114.600,00	303.050,00	309.202,01
4. Workshops and Materials	15.595,00	8.614,01	10.000,00	15.640,00	25.595,00	24.254,01
5. SEP Development and Environmental Projects	0,00	0,00	2.000.000,00	2.801,313.07	2.000,000.00	2.801,313.07
6. Operational Costs	70.000,00	101.985,61	25.000,00	26.785,00	95.000,00	128.770,61
7. Contingencies	10.000,00	1.699,97	5.000,00	5.740,00	15.000,00	7.439,97
TOTAL MSP	**725.000,00**	**742,554.62**	**2.357.500,00**	**3.181,313.07**	**3.082.500,00**	**3.923,867.69**

II. Project Impact Analysis

(1) Project Impacts:

ALBARRADAS IN COASTAL ECUADOR: RESCUING TRADITIONAL KNOWLEDGE ON SUSTAINABLE USE OF BIODIVERSITY			
Project Goal	**The goal was to increase knowledge about traditional and modern systems of technologies for sustainable use of the globally-outstanding biodiversity of southwestern Ecuador, and increased local participation in the benefits of conservation.**		
Project Objectives	**Indicators in Project Brief**	**Revised Indicators**	**Results**
To enhance understanding of the Albarradas systems as a response to a changing environment by determining ways in which newly constructed Albarradas differ from traditional ones (placement in the landscape, fluvial and surface runoff, design, and core construction).	To better understand the Albarradas technology the following indicators will be considered: • Remote sensing survey of the study area to identify Albarradas and aquifers in the study area. • Limited test excavations at the remnant of the Muey Albarradas system (Santa Elena Peninsula, Ecuador) and of a stratified sample of other sites in the region, and analysis by social and natural scientists	No change	A GIS system was established, covering the study area in Guayas and Manabí provinces, based on a remote sensor survey of the area, validated by field work. The final inventories allowed to identify 369 hydraulic structures – of which 252 (68%) are traditional Albarradas – the associated aquifers were identified through hydro geological research. The GIS system created is a base line product for future research and for the implementation of a program directed to sustainable management of Albarradas and associated biodiversity. A chronology of Albarradas construction resulted from limited archaeological excavations in San Pablo (2 Albarradas), Muey (4 Albarradas) and in the regional sample (5 Albarradas in native communes and 3 Albarradas in Parochial subdivisions). This served to confirm the initial hypothesis that about the strength of this technology that is more than 3800 years old in the area.
To understand the ways through which traditional common property resource management systems (Albarradas) have changed in response to changing social, economic, and political contexts.	Assessment of changes in Albarradas through time with the involvement of social and natural scientists. • Socio-cultural, natural scientists and civil engineers assessments of native community knowledge of traditional and present use and significance of Albarradas.	No change	From an interdisciplinary viewpoint Albarradas have been characterized as *Complex Socio Historical System* in which is evident the articulation of: ecological, hydro geological, technological, and social components thoughout time. Results area included in the following reports: • Assessment of the adaptation of the Albarradas system to changes and external impacts produced on the area native communities. • Assessment of the system of Albarradas and its socio-environmental impact, based on the data recovered in 95 (recintos) settled districts in Guayas and Manabí. These results: Botanical, Archeological and Socio Cultural in character, are integrated in the System of

			Geo-referenced Information on Albarradas (SGIA) appended to GIS, to be used in future projects and applications.
To enhance understanding of wild relatives of crop varieties in the area's ecosystems and to promote their conservation.	A determination of wild relatives of cultivars and their dependence upon local ecosystems and the Albarrada technology: • Botanical and ethnobotanical identification of cultivars and wild relatives of cultivars from the ecosystems where ancient Albarradas occur. • Botanical bank of wild and ancient cultivars (seeds and/or plants). A set of recommendations for the proposal of future projects for on sustainable use of biodiversity in the coastal Ecuador	No change	Analysis of carbonized seeds, plant material and Phytolith, obtained from flotation of soil samples from past activity areas located on Albarradas through archaeological excavations, allowed us evidence of wild relatives of cultivars. Other ancient plant remains point out to little environmental variation, as same plants appear in the past as they do in present day botanical collection. It must be considered however that Albarradas create their own microclimate preserving quite a few plant species that have disappeared or are endangered in the Tumbésico dry forest characteristic of our study area. Phytolith analysis show cyclical wet and dry periods similar as today. Several plant species characteristic of lowland, piedmont, brushes, and savannas (natural and man induced) have been located in the Albarradas plant collection. 595 species are preserved in the project herbaria, including seeds of endangered species and endemic species. This has allowed us a taxonomic study and the characterization of the region biological diversity. Ancient plant cover of Albarradas and their environs was determined, 8 wild relatives of domestic plants were identified, 31 endemic species, and 181 species that were considered endemic to the Galapagos Islands. The wild relatives recovered in Albarradas conserve the species germoplasm preserving them from extinction. Recommendations: • Albarradas systems should be placed under "Ramsar" protection, and "Biological Diversity" agreements signed by Ecuador as artificial lens wetlands, for being one of the basic supports for the conservation of remnant biodiversity of the coastal dry tropical forest. Find the best legal mechanism to guarantee their integral protection. • A Regional Plan for Socio-environmental management should be implemented to strengthen the Albarradas system as support for the remnant biodiversity in the area. • Promote that projects directed to the use and management of vegetable species in the region (agroforestales, agro-silvo-pastoriles, silvicultura, etc.) use the genetic bank collected by the

			Albarradas Project. • Take into consideration in environmental programs the integral relationship between Albarradas systems and the communities that mange them. Considering that the majority are organized under the Commune regime with the collective management of natural resources, and to consider possible conflicts between the different social agents that act in the area. • Organize interactive environmental educational programs (formal and informal) that take into consideration the Albarradas Project results. • Implement the Integral Model for sustainable management and upkeep of Albarradas, integrating local traditional knowledge that allow sustainable management of biodiversity. • Enlarge the Real Alto Arboretum incorporating all endangered species of present importance.
Project outcomes: For <u>Objective 1:</u> Determination of Traditional Albarradas and modern horseshoe dams[1] allocation in relation to the environment and fluvial order and their characterization participating geologists, geographers, hydrologists and engineers form the Earth Science Department at ESPOL. Determination of the sites where the system could be tested and geological and geographical evaluation of the Tablazo area. Select a stratified	**Indicators** For <u>Objective 1:</u> • Maps of traditional Albarradas and modern horseshoe damns in relational to the fluvial order. • Assessment of changes in the distribution of Albarradas and ground plant cover appearing in series of aerial photographs for the area in the last forty years. • Sample 20% of relevant cases to be studied by social and natural scientists with typical biodiversity and socio-cultural variations for the area, based on remote sensing data provided by NASA and on ground verification by natural and social scientists.	No change No change	• A map showing relationship between Traditional Albarradas with the hydrographic systems in our study area has been produced. This product has confirmed the hypothesis that all traditional Albarradas are places on the interfluvial plain to catch and conserve water from the runoff, within the hydrographic network. It serves to determine the best location to build Albarradas when needed • By combining remote sensor analysis of satellite images, aerial photographs, existing large detail maps and field work, changes in vegetation covers were determined both for the last 40 years and the last decade. An animated thematic map was developed within the GIS showing the impact of deforestation. It also points out to the Albarradas function as biodiversity reservoirs of the Tumbésico dry forest species. • Stratified ethnographic research including 20 Communes, 5 thickly settled districts (recintos), 3 rural districts (parroquias), 1 county (canton) and 1 farm. Research products are 293 registered interviews, more than 100 field observation forms, a list of key informants representing the socioeconomic diversity encountered. 4 regional maps and 12 sketch maps of the Communes sampled a photographic archive (< 2000 images), 2 edited videos, copies of archival documents. It is at the System of Geo-referenced Information on Albarradas (SGIA), at the Project Data Base

[1] In order to clearly separate between traditional and recently built Albarradas, from now on we shall refer to the latter as "modern horseshoe dams"

sample to include all the ecological, cultural, and historical diversity in the area.	• Map of aquifers and Albarrada-sites that may serve for future biodiversity programs in the study area. • Determine best Tablazo underlying structure to build Albarradas in the future.		Centre and supports the Model for Integral Management and Conservation of Albarradas. • At GIS: one interactive hydro-geological map for the region showing aquifers and the location of Albarradas and environs. This product serves to plan for future biodiversity conservation programs in the study area: • It shows that Albarradas are found only on permeable (Tablazo) or semi-permeable (other) geologic structures. • These results serve to plan for optimal location of future Albarradas on the appropriate geologic structures (identified in out study) wherever such conditions exist.
For <u>Objective 2</u> Assessment and interpretation of native communities views of the traditional knowledge; and of changes in construction, maintenance, management of natural vegetation and agriculture in Albarradas systems. Socio-economic interpretation of the relationships between common property resource management	For <u>Objective 2</u> • Chronology for Albarradas construction and changes in mode of construction of traditional Albarradas and modern horseshoe damns. • Assessment of changes in patterns of maintenance of Albarradas in the last fifty years. • Determination of changes in mode of construction of traditional Albarradas and modern horseshoe damns. • Socio-cultural evaluation of economic significance and use of Albarradas and its environment by the communities within the sample	No change	• A chronology for the construction and upkeep of Albarradas was based on radiocarbon absolute dating done at the ^{14}C Laboratory – University of Arizona, Tucson, financed by project partner (Ames Centre at NASA). And by relative association of known chronological indicators found in excavated activity areas on Albarradas limited excavations. The oldest Albarradas were located at San Pablo dating from late Valdivia (3800 years ago). Most of the Albarradas tested date from 2500 years ago, and they continued being built, rebuilt, and upkeep throughout the Colonial, and Republican periods. • Most Albarradas in use today are Pre-Columbian in origin. • Limited archaeological excavations showed differences between ancient and modern Albarradas structures, changes in form and retaining wall size, as well as changes in construction techniques, allowing for explanation of why Albarradas built according to traditional (ancient) construction techniques best resist the impact of heavy rains during ENSO (El Niño Events). • In the last 50 years an accelerated process of partial loss of ancestral knowledge (among the young) of Albarradas and the inappropriate use of heavy road building equipment in their rebuilding and in their upkeep shows the need for a more aggressive program of dissemination of recuperated knowledge amongst Albarradas stakeholders. • A comparative study between the Albarradas'

systems (Albarradas) and their changes in response to the changing social, economic, political context.			traditional layered construction technology and modern road building machine soil piling methods used to build modern horseshoe structures and small dams, show traditional technology more efficient with respect to retaining wall durability, not only with respect to El Niño flashfloods, but also in resisting pervasive wind and rain erosion. While 77% of Albarradas are functional, only 25.8% of small dams built with government funds resisted the El Niño events (1982 and 1997). • Information gathered form limited archeological excavations has been implemented in the Integral Model for the Management of Albarradas and will serve as a guideline for new water management constructions and investments that may be planned in the future.
	• Recovery of data from oral tradition about appropriate places and manner of construction and performance of Albarradas.		• The cultural model for management("open" and "closed") of local Albarradas systems show they function is directed to the social and economic reproduction of the native people in our study area. • Stratified (zoned) analysis permitted a listing of the principal uses that Albarradas systems have today, showing that they contribute to the sustainability of biodiversity and of fresh water resource for the population of the study area, especially for the more vulnerable sectors of local society. • Based on the ethnographic material analysis, that recuperated fragmented local knowledge, a Model for the Integral Management of Albarradas was restored. The model emphasizes the efficiency of Albarradas technology through out history, and the quality of information transferred from generation to generation about the natural environment and its ecological management. A long list of norms, values and knowledge that contribute to the conservation and management of the Albarradas system has been registered in the Project data base.
	• Identification of external factors in communities within the sample, which may have influence		• Identification and analysis of external agents (National and local governmental institutions, NGOs, business and ethnic organizations, academic institutions, news media etc.) and their impact on the study area native communities

	in the conservation, upkeep and/or destruction of the Albarradas system • Assay socio-cultural factors in the sample communities that may encourage conservation, upkeep [and/or destruction] of Albarradas.		were the basis for the V Project Workshop. • Elaboration of diagrams and power structures with the principal social actors and agencies that intervene or act on the study area. • 24 institutions (governmental and NGOs) that act in the study area, and the programs in execution under them have been identified (Infrastructure, economic development, health, education, empowerment, etc.). • Agreement with FCG (Federación de Comunas del Guayas) and PRODEPINE for the development of a Pilot Project for the Integral upkeep and management of Albarradas systems and environs to begin in two Communes selected from the sample (Tugaduaja and Manantial de Chanduy) and socialization of this experience in other Communes of the study area. • Transference of information to the Programa de Desarrollo de la Peninsula de Santa Elan de ESPOL, to improve on their intervention on the upkeep and rebuilding of Albarradas. • Political and sociocultural characterization of the Native Communes of the region, in the appropriate field for self government and in the management of existing resources in their territory. • Estimation of the collective territory governed by Communes where systems of Albarradas exist (407,132 hectares). • Assessment of sustainability of the Albarradas systems taking into account socioeconomic and ecological dimensions and the dangers and conflicts that may endanger the system. • This analysis evidences the need to generate strategic alliances among different social actors on the basis of similarly oriented objectives, to take advantage of economic efforts, time, and human resources in order to dampen risks of sustainability of the system.
For Objective 3: Identification of wild and cultivated plants through phytollith, pollen, macrofossils, charcoal and seeds	For Objective 3: • Gather wild and domestic plant seeds and animals associated with Albarradas in the	**Pollen Analysis discarded due to poor preservation of pollen in non-acidic soils.**	• A study of Phytolith and macrofossils (charred seeds and wood) identified from soil samples collected from use surfaces and activity areas identified in limited archaeological excavations were evaluated with laboratory comparative collection • For the preparation of the comparative collection a study of 498 plant species producers

laboratory analysis of archaeological soil-samples. Economic and Socio-cultural evaluation of the Albarrada system today as a support to biodiversity in the area of study. A survey and census of the natural plant cover in the area, and development of a registry and evaluation of the plants associated with Albarradas. The ecology and economy of the existing vegetal communities in the study area: a qualitative-quantitative inventory.	sample. • Number of relatives identified and properly stored. • Comparative study of present-day vegetation at Albarradas and plant remains recovered from soil samples. • Study of biodiversity associated with Albarradas systems in the past. • Participative assessment (through workshops) about the interest of the native communities in the conservation of the Albarradas system and associated biodiversity.	**Phytolith analysis was conducted instead according to Piperno's methodology**	of siliceous structures. A comparative seed collection of 357 species was achieved, and wood samples (trees and shrubs) for 145 species were collected in Albarradas and environs. • From the flotation and dry sifting of archaeological soil samples 18123 charred seeds were analyzed corresponding to 94 species, and 542 fragment of carbonized wood were identified as belonging to 39 species. • Contextual analysis of the data (seeds, charcoal and Phytolith) confirmed the existence of the same vegetable species (combination of arboreal, herbaceous and gamine vegetation) in Albarradas and environs since the Late Formative (3800 years ago), suggesting a climatic stability in the area. Additionally the archaeobotanical information shows a larger proportion of arboreal vegetation in the past than what it exists today, showing continuing and increasing human impingement on the dry forest. • Most of the species identified in the analysis are being appropriately conserved in the project herbarium and at the *arboretum* in Real Alto (Pechiche Commune) constituting a genetic bank useful for future reforestation plans and improvement of traditional cultivars. • This information also contributes to the history of plant domestication in the in the study area and rescues some traditional plants (food and industrial) that may be useful to the Communes and for the Pharmaceutical research and for industry in general. Consequently it emphasizes on the Albarradas systems as reservoirs of biodiversity, as well as their potential for allowing future projects in environmental sustainability. • Three workshops with representative of the regional Communes in order to socialize the Project investigative process. The first two workshops were directed primarily to the Communes governing bodies, in the third workshop convened other representative sectors of the Communes (Age and Gender). • A fourth workshop took place with members of three Communes selected to propose the Albarradas Pilot Project, sustaining the Model

	• Proposal for a program of alternative management of Albarradas and their potential benefit to their users and to the conservation of biodiversity.		for Integral Management of Albarradas, to be financed by PRODEPINE. • The fifth workshop was focalized to the 24 institutions that intervene with projects or direct programs in the area. It met with the objective to promote the Albarradas system and to transfer information about the Model for Integral Management of Albarradas. A proposal for the establishment of an "Inter-Institutional Information Network" destined to support the sustainable development of the people of the coastal region of Ecuador was socialized and an accord was reached to have the Centre for Scientific and Technological Investigation (CICYT) at ESPOL manage the network. • The workshops and meetings create an new dialog scenario between social actors who interact with the Albarradas system in the region. It permitted to recover proposals for the non-traditional use of Albarradas oriented to the development of the communities. • The interpretation of the use pattern of the Albarradas system throughout time, served to recognize the ethno-ecological knowledge marshaled by the local population which integrated well with scientific knowledge in producing the proposal for the Integral Management of the Albarradas systems to be applied in the Regional Plan for Socio-Environmental Management.
mmunity Participation	**Workshops** **Focus Groups**	No change	
Administration	Final workshops with project stakeholders on evaluation of the implementation of the project according to established output and impact indicators. Preparation of annual reports.		Mid-term and final workshops held with input from project stakeholders. Annual reports completed on a timely basis.

The Project objectives were met by multidisciplinary research, with different research teams discussed the implications of their findings in relation to the objectives and indicators, validating

them, and/or generating new hypothesis, when needed, to further refine and test variations of the initial research hypothesis and indicators. All specific research hypotheses were tested and validated by the different research teams, the results have been beyond our initial expectations.
Carbon sample assessment at the Radiocarbon Laboratory of the University of Arizona, Tucson, *generously financed* by the Ames Research Centre at NASA have shown that the *Albarradas system* is the result of a long–term process, which responds to actions taken by farming communities to manage their environment in our area of study. Beginning some 3800 years ago, most of the history of the development o f the Albarrada technology extends beyond documentary and oral history. To rescue the traditional knowledge on sustainable use of biodiversity in Coastal Ecuador, there is a need to expand our knowledge of the *Albarradas* native technology. As planned the selective study of prehistoric cases. The Albarradas at San Pablo were built during terminal Valdivia c.1800 BC; the ones at Muey during the Machalilla and Engoroy societies dating between1500 – 300 BC, continued to be built and rebuilt all the way through the Guangala period (250 BC – AD 800) and the Huancavilca state formation (AD 900 – AD 1500) have permitted to enrich the content of models of *Albarrada* development, broaden them and make them more powerful, flexible and realistic.

(2) Project Sustainability

The data, covering all ecological and historical-cultural variability in the area, has permitted us to successfully design a viable program of sustainable management of *Albarradas* and their environs. This study, based on a representative sample, initially planned to be a 20% of all *Albarradas,* was changed to 20% of Communes and other central places in our study area, once we found that the number of Albarradas was more than 300% what had been expected to find, and that there were more than three Albarradas in each population site, showing that Albarradas had been conceived as a system for managing and storing the runoff. The sampling method used was selective, but stratified by traditional communal territories dating from the Colonial Period (Indigenous people *Reducciones*) and by ecologically differentiated bands of vegetation, in this way based by the criteria defined by the multidiscipline research team and considered basic and important for the selection of investigation units, every cultural and natural environment was tested. In this way *Albarradas* and their environs broad diversity of ecological and social conditions that exist, were considered as planned, to identify particular issues pertinent to each conservation and development situation.

The Objectives of the Operational Program were achieved fully, 8 wild relatives of the crop varieties and ancient cultivars plus 31 endemic species and 180 species registered as endemic for the Galapagos Islands have been identified in Albarradas and their environs, showing that the Albarradas system aids to the conservation and sustainable use of dry tropical forests. This has been confirmed by sociocultural analysis which has determined and rescued the knowledge of indigenous people, directed to improving our understanding of sustainability issues in biodiversity**.**

Through limited excavations, cultural material association and radiocarbon dating (supplied by NASA) it was confirmed that Pre-Columbian societies – as early as 3800 years ago – developed sophisticated systems to respond to ecological fluctuations and, in some places like in our study area, were able to conserve biodiversity and fine-tune benign interaction with their environment. The species identified in Albarradas and their environs, and collected in the project Herbarium at ESPOL's CEAA, plus the seeds recovered and planted at the Real Alto Arboretum constitute a germoplasm reserve that will allow the recuperation, conservation and protection of the Albarrada

system, an ancient technology that will decidedly contribute to the rational and sustainable management of the region.

(3) Replicability

Taking into account the interdisciplinary and complex character of the Albarradas Project, it is noteworthy the effectiveness and flexibility of the logical framework designed in guiding research, allowing to follow-up lines of inquiry, and, in evaluating and transferring advance results as the project progressed.

We have been able to reconstruct important aspects of traditional Albarrada construction, in what respects to site selection, which includes natural drainage, and thin deposit layers extracted from central borrow pits and sequential sediments, that assure strong wall construction. The project data base allows for the systematization of the mode of construction and maintenance of Albarradas, making replication likely. It must be added that present development of detention pond technology, and hydrological studies by several Brazilian, US and European research teams, developing aquifer recharging systems similar to traditional Albarradas, strengthens replication not only for Coastal Ecuador but for dry lands and semidry lands the world over.

Replication of this MSP will be a major vehicle for the project to contribute to the GEF Operational Programs. Specifically within Ecuador, the MSP's results and proposals for managing areas where the *Albarradas* system could be a solution for problems of water-resource management and biodiversity conservation will reach other potential users like agency officials at local and national levels, NGOs, and other formally organized groups. In addition, it is expected that this interdisciplinary form of research on traditional knowledge and technologies may be replicated in other areas around the world where similar problems of water-resource management and biodiversity conservation are found. More broadly, this traditional knowledge and technologies are critical inputs to enhance our understanding of factors affecting biodiversity sustainability and therefore can make a substantial contribution to improving GEF's methods and approaches described in its Operational Programs.

(4) Stakeholder Involvement

The project focused on the validation of results through a feedback mechanism with stakeholders and other social actors involved is sustaining biodiversity and/or development in our study area. Planned activities included the organization and implementation of workshops with stakeholders (native communities and local or national organizations) active in the study area. Products resulting from this experience were: a) strategic alliances with organizations that lead programs or projects in the area (local or national government and NGOs) and with users of the Albarradas system; and b) recording experiences (both positive and negative) by other relevant projects executed in the area.

One of the principal lessons learned was that other project failures were blamed on the lack of local interest and participation of local stakeholders (Communes). However in our experience, this is not so. A Pilot Plan now in process of implementation with PRODEPINE in the Communes of Tugaduaja and Manantial de Chanduy has been delayed not by stakeholder failure to participate, but by PRODEPINE's local officer's lack of understanding of Albarradas recovery and maintenance procedure insisting on relying on "modern" technologies, not compatible with the Albarradas system, and proven inappropriate by our research, for the maintenance of the two Albarradas selected for the Pilot Plan.

(5) Monitoring and Evaluation

The review a multiple combination of sources of information, beginning by primary sources through direct field work, as well as secondary sources from the technical literature, official legislation, and communication media archives permitted to discover that Conquistadors described Albarradas on the way down to the conquest of Peru, indicating that together with their associated wells, were the only way to obtain drinking water in the area, where, although it rains frequently, the rainwater runoff quickly goes into the sea, and that rivers run dry most of the year (see Agustin de Zarate, 1555). Interdisciplinary research drove towards triangulation of qualitative, quantitative and documented strategies. The use of multiple methods, in combination with multiple data sources, is a means to assure validity, exactitude, and credibility of information. The data resulting from each one of these sources can be contested among others before reaching conclusions. This was achieved internally, in discussion workshops with the participation of all members of the research team and enriched in workshops with various stakeholders and institutions that operate in the area.

(6) Special Project Circumstances

Some unexpected problems (like the late initial disbursement of funds) were damped thanks to the ability to adapt activities within planned research guidelines within the logical framework and to the advancement of funds by the partner institution (ESPOL).

(7) Institutional Capacity / Partner Assessments:

The Project main objective was to rescue knowledge of the traditional sustainable management of biodiversity and fresh water resources, through the Albarradas system, in a region where fresh water supply is a critical problem, especially for the extreme poor.

Although the Project research strategy was not directed to:

- Integration of the Albarradas system to water management policies, one of the resulting products is a series of recommendations, on the subject, directed to governmental agencies. These recommendations are oriented to the legal protection of the Albarradas systems and their inclusion on regional developmental projects.
- The participation of social actors in the project execution, research teams have been able to involve and share information with important stakeholders and institutions, like the principal beneficiaries, the indigenous members of the Communes of the Coast. Alliances and agreements between the project and the Second Degree Institution representing them, the Federación de Comunas del Guayas.
- Information exchange also took place with functionaries from the Ministries of Environment (Ambiente), Agriculture (Agricultura), Social Welfare (Bienestar Social) and several NGOs intervening in the region. The Fifth Workshop was organized was attended by representatives of 17 regional and national institutions, among the ESPOL.
- ESPOL as a project partner maintained its financial commitment beyond the initial agreement throughout the duration of the project. Due to the resulting products and their impact ESPOL is putting forward academic and research guide lines promoting the Project sustainability in the region.

- Besides direct support as a project partner, ESPOL continued and widened its interest in the Albarradas Project through other programs and research like:
  - The Santa Elena Peninsula Development Plan, which invests petroleum research funds in the cultural development of the people of the Santa Elena Peninsula.
  - University of Florida, Gainesville – ESPOL Joint Project for the Santa Elena Peninsula.
- Collaboration by the Ames Research Centre at NASA, provided the Project with satellite images, radiocarbon dates, and biodiversity courses for the project research teams.
- During the Project execution period (2000-2003) governmental policies and regulations did not negatively impact the project guidelines, or the project's objectives.

Key hypotheses about the *Albarradas* native technology presented in the Operational Program were tested, and their results were as follows:

To determine the difference between traditional Albarradas and modern horseshoe dams, the following hypotheses will be tested: Modern Albarradas are located on rivers of 2nd and 3rd order, while ancient Albarradas are on the incline plane of the savanna over the Tablazo formation and/or 1st order rivers.

The main hypothesis has proven correct, however it should be modified with respect to river order, and all traditional Albarradas were built where runoff occurs before any river is formed. Modern Albarradas retention walls, built by machinery, are built moving great quantity of materials from the fill of the borrow pit, unlike ancient ones where soils were packed in thin layers to build up the retention accounting for stronger and more resistant wall construction that has proven to resist even El Niño Events heavy rains, and flash floods. This hypothesis has been validated fully.

To know about the changes of traditional common property resource management systems (Albarradas) as a response to changing social, economic and political context, the following hypotheses will be assessed:

Radiocarbon dates obtained from Albarradas activity areas, as well as datable cultural material (known ceramics styles; marked porcelain, stoneware and glass) confirm historical changes in Albarradas construction technology.

Native communal-organizations (Comunas) appear as the best device to promote programs for the conservation and upkeep of Albarradas and biodiversity in the area.

The characterization of the 63 Communes inventoried show that all Communes have a great organizational experience that facilitates the promotion of whatsoever program for the sustainable management of biodiversity. These Communes govern over 407,132 hectares by collectively taking decisions through their assemblies (*Asambleas*) and governing bodies (*Cabildos*). This social capital strengthens traditional forms of preservation and conservation of the Albarradas system, since they are the inheritors of those who started building them.

There are norms, values and cultural meanings that may help prevent, protect and damp the negative impacts on Albarradas.

The systematization of traditional knowledge of the native population has evidenced the existence of customs and collective practices that guide native society in the use and management of Albarradas systems. Such knowledge administered in the Communes (*Cabildos* and *Asambleas*) has guaranteed the sustainable management of the Albarradas technology since well into the Pre-Columbian period. Such traditional knowledge and practices have allowed to dampen some identified dangers and conflicts, that rose with socioeconomic and politica changes the last 50 years.

There may be native communities that maintain and repair Albarradas when these are of benefit to them, or are considered a means for collective survival.

All communities that are directly or indirectly beneficiaries of the Albarradas system have put into practice – along their recorded history – several mechanisms to maintain, restore and manage their Albarradas. In the twentieth century they combined modern technology (machinery) with traditional collective community-work (*minga*). Periodically (not every year-but frequently), before the rains begin, several tasks are put into practice: restoration of walls, cleaning of the overflow, weeding the vase and the lower wall, cleaning the Albarrada vase and surroundings, refurbishing the staked water wells associated to the Albarrada system, introduction of benefic water-plants and fishes that help maintain water quality; repair and construction of complementary works (laundry facility, animal drinking troughs, small quays reaching into the Albarradas vase to fill up water tanks for home use, fences, etc.)

Changes in the means of subsistence and factors that are beyond native community control Actions and development plans by CEDEGE, and other planned development programs by local parishes, municipalities etc., have placed in a risk situation the traditional use of Albarradas, as well as Communal land rights.

Regional development projects have renewed desire and expectation over native people territories presently controlled by Communes. This situation has produced a weakening of the traditional communal form of territorial possession, confronted with the advance of land-grabs, illicit land sales, pre-urban subdivisions. This situation directly affect some of the Albarradas system, since some of them are found in territories in conflict; as well as indirectly, because the weakening of the Communal system structures and patterns associated to the communal management of natural resources , limits collective capacity to manage this technology. On the other hand, development concepts and logic invoked by some external social actors are foreign to local history and culture, ignoring and undervaluing the Albarradas system as an appropriate and sustainable water resource.

Dissemination and exchange of information about the role of Albarradas may help to understand that it is feasible to recuperate and promote traditional practices in close cooperation with technologies and uses of the environment that are considered <<more>> modern.

Workshops with institutions, consulting for organizations intervening in development programs, and exchange of information with PRODEPINE have shown that the transference of information on the role of Albarradas have promoted their inclusion in sustainable development programs, involving traditional and non traditional activities. The Pilot Plan with PRODEPINE constitutes an example of complementarities between ancestral and modern knowledge and practices.

In many Communes it may be possible to maintain and develop the Albarradas system, only if adaptive uses that conform to the new mode of living and new community needs are considered.

Through out history a continuous process of adaptation of the Albarradas system responding to social, political and economic changes is manifest in our study area. Researched cases and information provided by present users of the system show that user expectations on the Albarradas system hinge on new needs and aspirations relating to the present life ways. Among the perceived present uses are directed to socio-environmental activities (ecological-parks, fish-farming, brick-fabric, small scale agriculture, etc.).

To enhance understanding of wild relatives of crop varieties in the area ecosystem and to promote their conservation, the following hypotheses will be tested:

It is possible that relicts of primitive (wild) plants may be recovered from the Albarradas environs.

Soil sample analysis, Phytolith and macrofossils (carbonized seeds and wood fragments), obtained from limited archaeological excavations, plus the ecological evaluation of the study area, has allowed the reconstruct the ancient vegetation cover of the Albarradas system and their environs, identifying 8 wild relatives of domestic plants.

Environments where Albarradas have existed for a long time appear to have helped conserve a high number of plant and animal species typical of the dry tropical forest characteristic of past conditions in the area of study.

This hypothesis was tested through an assessment of present status of biodiversity in the area. Archaeobotanical information shows conservation of relative botanical characteristics of the Albarradas system, throughout different cultural periods identified,. It has also shown that no major variations have occurred in the Albarradas environmental conditions. 31 endemic species and 180 species registered as endemic for the Galapagos Islands have been identified in Albarradas and their environs. Together, with the 8 wild relatives of cultivars they represent an important reserve of germoplasm for the area.

III. Summary of Main Lessons Learned

What are Albarradas:

- Albarradas constitute a Complex Socio Historical System, evident in the articulation of ecological, hydro geological, technological and social components.
- Albarradas system is compatible with up-to-date systems of aquifer recharge in dry and semidry lands the world over like: *jagüeyes*, detention ponds etc.

Albarradas History

- 369 hydraulic structures of which 252 (68%) are traditional Albarradas are in existence in the Study area.
- Functioning traditional Albarradas began 3800 years ago in the study area, most were built 2800 years ago, and have been maintained and rebuilt ever since.
- All communities that are directly or indirectly beneficiaries of the Albarradas system have put into practice – along their recorded history – several mechanisms to maintain, restore and manage their Albarradas.

Albarradas and Biodiversity

- 595 plant species were collected from Albarradas and their environs, preserved in the project herbaria including seeds of endangered and endemic species, showing the Albarradas constitute a reservoir of biodiversity.
- Albarradas have been responsible for proverbial biodiversity preservation in our study area, and should be replicated and/or strengthened wherever they exist, or the landscape and geological conditions are appropriate.

Albarradas and Landscape

- Not a single one of the 369 hydraulic structures, especially of the 252 traditional Albarradas, were built on impermeable soils, all are on top of permeable or semi permeable soil formations, showing that the intention of the ancient farmers of Ecuador was to recharge the aquifer.

Albarradas Construction and Maintenance

- Albarradas systems take advantage of copious rains and especially turn potentially disastrous El Niño Events into an asset, as they control floods and recharge the aquifer to maximum capacity. Their proper construction should be expanded.
- An Integral Model for sustainable management and upkeep of Albarradas has been derived. It integrates local traditional knowledge and scientific observation and ought to be implemented in the future.

Albarradas as Social Capital

- There are Open and Closed Albarradas:
    - Open Albarradas are destined for production (cattle, industry –brick manufacture– washing minerals (gypsum), and are managed by men.
    - Closed Albarradas are fenced in and directed to reproduction of society, its water is used for home consumption, drinking, cooking, and are manged by women.
    - There are other Albarradas destined for social interaction, washing, bathing and swimming, are carried out there, these are mainly used by women and the community children.

Albarradas as Productive Landscape.

- Albarradas biodiversity allows bird watching, bird shooting, deer hunting, and sustainable management of these sporting activities could bring resources to the communities.
- Well managed Albarradas can act as natural sites, which deserve protection and could serve to develop ecotourism to some communities, as ecological activities such as bird watching and native flora observation.
- Albarradas can serve to sustain traditional and new productive activities like agriculture, organic farming, apiculture, fish farming, and cattle grazing.

IV. Financial Management Status

Audit Report Covering the period August 2000-December 2001

The report was prepared in accordance with Grant Agreement requirements. However, the Financial Management Specialist (FMS) suggested that for the future audits, the Terms of Reference should be submitted to LCOAA for clearance to ensure that Bank guidelines are followed. In addition FMS recommended that a letter be addressed to the Bank by the auditors, confirming that the financial statements have been prepared in all material respects, on a cash accounting basis.

The auditors issued qualified opinions on the Statement of Sources and Uses of Funds; and on the Special Account Statement, according to the Audit Report there were ineligible expenditures by US$19,682 corresponding to payment of taxes. The auditors did not mention the implementing entity's compliance with the terms of the grant agreement and applicable laws and regulations related to the Project's financial activities. Internal controls were evaluated as satisfactory.

The FMS recommended the following actions: a) Ineligible expenditures by US$19,682 corresponding to payment of taxes should be replenished to the Special Account; ii) include the local counterpart as part of the sources of income for the whole project and iii) analyze the possibility to hire staff adequately qualified and exclusively dedicated to the project's accounting. All these recommendations were duly implemented by the Recipient.

Audit report for the period January-December 2002

The report was prepared in accordance with Grant Agreement requirements. The auditors issued qualified opinions on the Statement of Sources and Uses of Funds; and on the compliance with applicable laws and regulations. An unqualified (clean) opinion was issued on the Special Account Statement. The qualified exception opinion correspond to ineligible expenditures US$ 474.37 (tax payments) and incompliance with section 1.2 {a} of the Grant Agreement, due to the fact that the project was using the project's Special Account for both, Bank sources and counterpart funds.

The FMS recommended the following actions: I) replenishment of ineligible expenditures to the Special Account as soon as possible and ii) segregation of Bank funds and local sources, through the opening of a separate bank account for counterpart funds. All these recommendations were duly implemented by the Recipient.

Audit report for the period January-August 2003:

The FMS reviewed the financial statements' audit report of the Albarradas in Coastal Ecuador Project for the period of eight months ended on August 30, 2003. The report has been prepared in accordance with Grant Agreement requirements.

Project Financial Statements:

Audit opinions: The auditors issued unqualified (clean) opinions on the Statement of Sources and Uses of Funds; on the Special Account Statement and on the Compliance with applicable laws and regulations.

Compliance: The auditors mention the implementing entity's compliance with the terms of the Grant Agreement and applicable laws and regulations related to the Project's financial activities.

Internal Controls: Internal controls have been evaluated as satisfactory, and the auditors followed up the recommendations of the audit report FY 2002. It is essential to mention that during the project implementation, the ESPOL managed a unique Bank account for Bank sources and local sources.