

GIS Management of Socially Affected Areas by Constructions of Hydroelectric Power Plants

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Abstract

The implementation of an Environmental Management System - IMS in COPEL constitutes an ultimate tool that has set up the appropriate, efficient and effective environmental management to an adequate solution for socially and geographically affected areas by the construction of hydroelectric power plants. The alphanumeric registry and cartographic data were organized so as to prevent Copel's real estate from being overrun by individuals as well as by neighboring proprietors, and to establish a permanent preservation of land areas surrounding the reservoirs. To reach the project goal, an ArcGIS 8 software has been used, which has made possible a systematic management of the Company's assets, particularly in the solutions of social matters and associated aspects of environmental impacts.

1. INTRODUCTION

The EMS is at the implementation phase. It is made up of a group of policies, management programs, and operational practices aiming to benefit the health, safety, and social status of the families impaired by the constructions of dams, as well as to promote the environment protection. COPEL has been endeavoring to set the right direction to those issues, as well as to organize its activities according to ISO 14000 standards.

Several different environmental aspects permeate all activities of the Company, without exceptions, from office administrative and bureaucratic works to field undertakings, encompassing facilities constructions, power plants and reservoirs operation and maintenance, plus management of bordering land.

The environmental Management System – EMS seeks to secure commitments from all sectors, working teams, employees, suppliers and collaborators of the Company. It embraces a systemic vision of environmental, social, and assets concerns, viewing the achievement of ISO 14000 certifications for the Company's units.

For the effectiveness of these tasks, all alphanumeric and cartographic registry data have been organized through the ArcGIS 8.2 softwares, enabling COPEL to prevent from invaders in its real properties, and to legalize real estate registries of land owners in the vicinities. As a result, a definite and adequate environment preservation plan could be turned possible.

A particular matter is the one that refers to resettlements of locals that were evicted due to their properties being unavoidably inundated by the reservoir completion. Approximately 19,000 hectares of land were flooded by the construction of Salto Caxias Power Plant, involving 600 families and 466 letters of credits. COPEL's generation branch covered all costs of resettlements that included expenditures with the overall infrastructure; that is to say: building of homes, water supply, sewers, roadways, electricity grid, etc.. This project has become a worldwide referential, being so far sought after by related professionals from several countries such as China, England, Finland, Japan, Germany, Belgium, Mexico, and others.

COPEL owns 18 electric power plants, being 17 hydro and one thermal. For the transmission of its product, the Company counts on 6,800 km of transmission lines of its own at voltages of 69 kV through 500 kV: 234 substations of 34.5 kV, and 126 substations from 69kV to 500kV. The distribution branch has a total of 2,127,000 poles, all registered and geographically referenced, 298,000 transformers, 158,000 km of distribution lines at voltages from 13.8 kV to 34.5 kV, plus 4,500 km of optic fiber lines, the latter integrating the telecommunication grid for the whole State of Paraná. At present, COPEL supplies electricity for 3,000,000 consumers, being 2.3 million homes, 45 thousand industries, 250 thousand business establishments, and 307 thousand rural properties.

COPEL's generation branch takes up as its mission: commitment with electric energy generation for the energy market, and render generation engineering solutions under safety, reliability, profitability, and due respect to nature.

2. METHODOLOGY

All of COPEL's facilities are supported by an Information System Data Base – ISDB. Thus, a reliable, integrated, and shared alphanumeric, graphic, and geographic data are accessible.

One critical point has been the maintenance of the ISDB. Several alphanumeric and cartographic data have to be validated, converted, and geo-referenced at field through mobile equipment such as the Global Position System - GPS, digital cameras, notebooks, etc..

The data base technique architecture was developed with the use of an ArcGIS server through ArcSDE and Oracle, as it is shown in Figure 1. The applications, rules and interfaces with other systems were evolved through the ArcGIS. The Unix system was used as a platform of the operating system, and the ORACLE, as a receiver of the whole base of alphanumeric data for cartographic images, both for raster and vectored. OMNI is a system that integrates the maintenance and the operation information of COPEL's whole generation branch. It serves as an interface between the users and the ORACLE data base. Finally, the Electronic Management of Documents - EMD manages all existing documents, such as registrations and title deeds, correspondences, maps, and all matters related to the assets owned by COPEL.

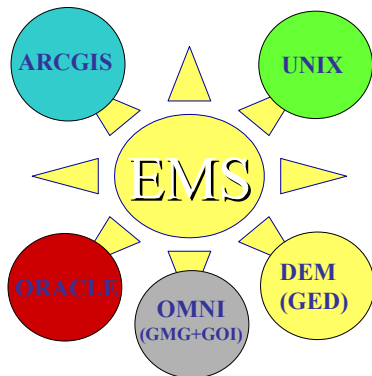


Figure 1 – Technique architecture of EMS data base.

Figure 2 shows the interrelation between several softwares and data base, where, as shown in Figure 1, is managed by the ORACLE.

Through periodical meetings the EMS Permanent Committee organized activities and an implementation strategy was planned. As a result, subdividing the EMS into several subsystems was considered to be the most appropriate and productive solution.

The EMS implementation structure was formed by the use of the ArcGIS software family, where ArcSDE actuates as an interface between the data base and other softwares.

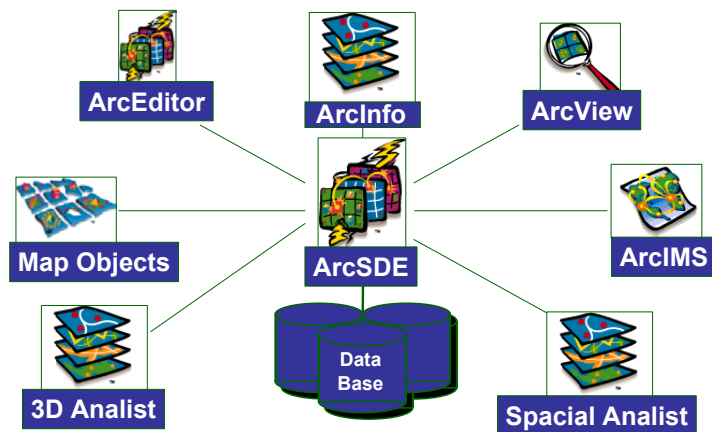


Figure 2 – ArcGIS Software utilized to structure the EMS.

3. RESULTS AND DISCUSSION

3.1 Environmental Management System – EMS

The EMS Permanent Committee was created by COPEL's high rank staff in January, 2001, to carry out the EMS implementation, in accordance with NBR ISO 14000. At that occasion, five of its Environmental Policy Principles – EPP were approved:

- 1st. COMMITMENT: We declare committed with the valorization, conservation and defense of the environment, abiding by the precepts of maintenance evolution in the exercise of our activities;
- 2nd. OBEDIENCE TO LAW: We commit to comply with the environmental legislation in force on the accomplishment of our activities;
- 3rd. COMMUNICATION: We shall maintain an open and permanent connection with authorities, communities, collaborators, customers and suppliers, so as to be constantly updated on environmental matters;
- 4th. ENVIRONMENTAL DYNAMICS: We shall be attentive to factors that define the environmental dynamics, constantly reviewing our principles, in the search for appropriate measures of continuous evolution;
- 5th. INDIVIDUAL RESPONSABILITY: We shall make our collaborators aware of their personal responsibilities and attitudes towards the environment in the accomplishment of our activities.

According to NBR ISO 14000 we are taking the following steps:

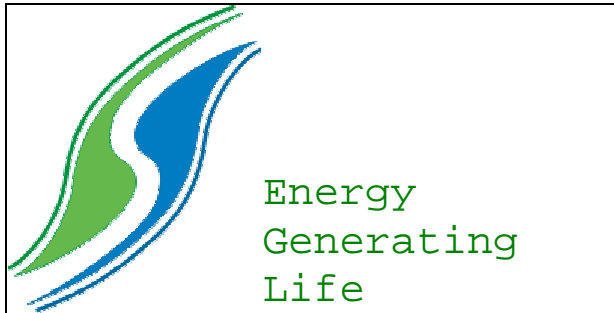


Figure 3 – Logo mark and EMS slogan.

- 1st. Commitments from all active branches and definition of an Environmental Policy;
- 2nd. Implementation Planning;
- 3rd. Implementation and operation of the EMS;
- 4th. Measurements ,evaluation and corrective actions;
- 5th. Critical analyses and suggestions from superior staff.

As a starting step for the dissemination of the EMS implementation throughout COPEL's branches, an internal contest was held for the selection of a logo and slogan, the winner being the one shown in Figure 3.

3.2 E M S - Development and Implementation

At first, the Permanent Committee established 13 subsystems: Water Management; Reservoir Water Quality; Contingency Plan for floods and dam damages; Aquaculture; Environmental Education for COPEL personnel as well as for local population; Resettlement of people evicted due to construction of reservoirs; Permanent Preservation of surrounding areas of all COPEL's reservoirs; Plant Nursery production; Environmental Licenses as: *Previous Licenses – PL* , *Installation Licenses – IL*, *Operation Licenses – OL* for all Copel's power plants; Recovery of degraded areas caused by the plant construction activities; Zeroing of Effluents and Residues from the plant maintenance process – ZERE; Master Plan – Zoning, comprising 1000 meters surrounding range at the reservoirs; and Social Management of COPEL's real properties – HARPIA. Of the above 13 subsystems, four of them were given priorities (Figure 4) .

1. Social Management of Copel's Real Properties – named HARPIA
2. Effluents and Residues – named ZERE (Zero Effluents and Residues)
3. Environmental Education – named GREEN GENERATION
4. Permanent Preservation Areas – named PPA

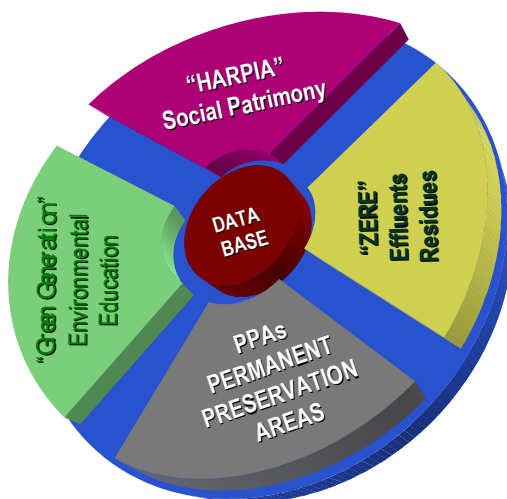


Figure 4 – Four subsystems on development.

3.2.1 Social Management of Real Property Subsystem - HARPIA

Harpia is the zoology technical name of the real hawk (*harpia harpyja*). It is the largest prey bird in Brazil and on the planet. One of its characteristics is that it lives a solitary life, except at the time of procreation, and requires a large forest area for its survival, about 50 km² for each bird. Its dwelling area ranges from the South of Central America to Paraguay. In Brazil, it can be found in the states of Amazonas, Paraná and Rio Grande do Sul, and in some places along the Atlantic Forest.

Its activities are performed at daylight and its main feature is its sharp vision, being eight times more powerful than the human vision. The mobility of its eyeballs is, however, very small, demanding the bird to turn its head constantly to get the relational notion of its position within the ambience.

These characteristics are equally essential for us to achieve a good functionality of the project, a constant watch for our

territory, and to monitor it remotely. These are the reasons for the creation of the HARPIA subsystem.

As part of the EMS, the Real Property Social Management is assisted by a software capable of providing registry mechanisms, control, monitoring and subsidies for decision makings related to the management process of the existing real estates in the Company's power plants.

The HARPIA is being developed at present in the 2.0 version, assisted by graphic resources to support the geo-referenced registry of the properties information from a common registry base of the cartographic data.

Considering that the scope defined for this subsystem embraces a wide range of functionality and potentialities, the current project was defined in versions so as to assist step by step the necessary functionality for the social management of the Company's real properties. Each new version is characterized as an independent project that will be improved in the superseding version.

For the development of the HARPIA project RISC servers were acquired and configured by a staff of COPEL Information Technology, in accordance with the configuration contained in the demand definition.

Then, there came the need to integrate the language programming, because COPEL's pattern is Borland Delphi (Object Pascal) and the components of the geo-processing platform to be used are developed in Visual Basic using COM pattern – ActiveX.

It was of fundamental importance to determine which geo-processing software to be used. Amongst the available softwares in the market, it was chosen the one that was most adaptable to the EMS development encompassing environmental subjects. Some technical and architecture characteristics showed that the ArcGIS of ESRI would be the best choice.

The HARPIA 1.0 version was characterized by the management and systemic treatment of the alphanumeric registry for COPEL's real estate social management only.

The assisted levels in the first version were: municipal districts and those districts where the real properties are localized; types of the properties; the remainder areas partially flooded by the reservoir water level elevation; properties of third parties; problems derived from land invasion and the invaders themselves.

Already in operation the HARPIA 2.0 version allows the integration of the alphanumeric and geographical data contemplating a geo-processing ambience. The development stages and the implantation of HARPIA 2.0 version considered at first the installation and management of the database through the ArcSDE. Subsequently, an entire ArcGIS customization interface was developed, being created the main menus and the corresponding submenus.

For the conversion of 1.0 to 2.0 version the alphanumeric registry data of invasions, invaders, localities, districts, acquirers, properties, and respective consultations.

For the composition of the EMS database, the loading of all power plants cartographic images was accomplished, as well as of the additional data that contemplated: maximum reservoir operation quota, geographical boundaries of municipal districts, main rivers, data conversion of streets, roads, and transmission lines in the State of Paraná.

The availability of Consultation Function of documents in the database named Electronic Management of Documents – EMD played a fundamental role in the database composition. At the end, a geo-referenced cartographic registry of all properties and the invaded areas, as well as their cartographic consultation feature were inserted.

For safety a subsystem was created so as to allow only trained and authorized personnel to feed the database, to prevent the downgrading of the system reliability. The project has been organized taking into consideration: the organizational structure of each team; the interfaces for each influential group; the contact identification; documentation, and finally the responsibilities to be taken by the members of teams and groups.

The external contribution to COPEL, essential for the success of the project, counted on the participation of GEMPI – which supplied the geo-processing software, technical support and development partnership; on the Environmental Affairs Secretary of Paraná State which provided the cartographic data; on the Hydric Resources Superintendency of Paraná State – SUDHERSA; and on Paraná Informatics Company – CELEPAR, with technical collaboration.

The flowchart in Figure 5 illustrates the stages of the whole development of the HARPIA subsystem.

Each new version of HARPIA will be considered as concluded when:

- The products are accepted by the end-users;
- Systematically evaluations of all sub-processes are accomplished (scope, time, cost, etc.) pointing out the successful items as well as the ones that diverted from the schedule.
- A closing report is foreseen to be sent to managers of the involved parts.
- The final report will group the following contents:
 - Compliance with the scope and diversions;
 - Accomplishment of scheduled terms and diversions;
 - Budget accomplishment and diversion.

- A seminar for related professionals is foreseen aiming at disclosing the results and at exchanging experiences.
- The continuity of HARPIA project depends on the feed-back that the operational team sends regularly to the information technology team, with suggestions for modifications both in the program and the interface screens, rendering subsides for the 3.0 version.

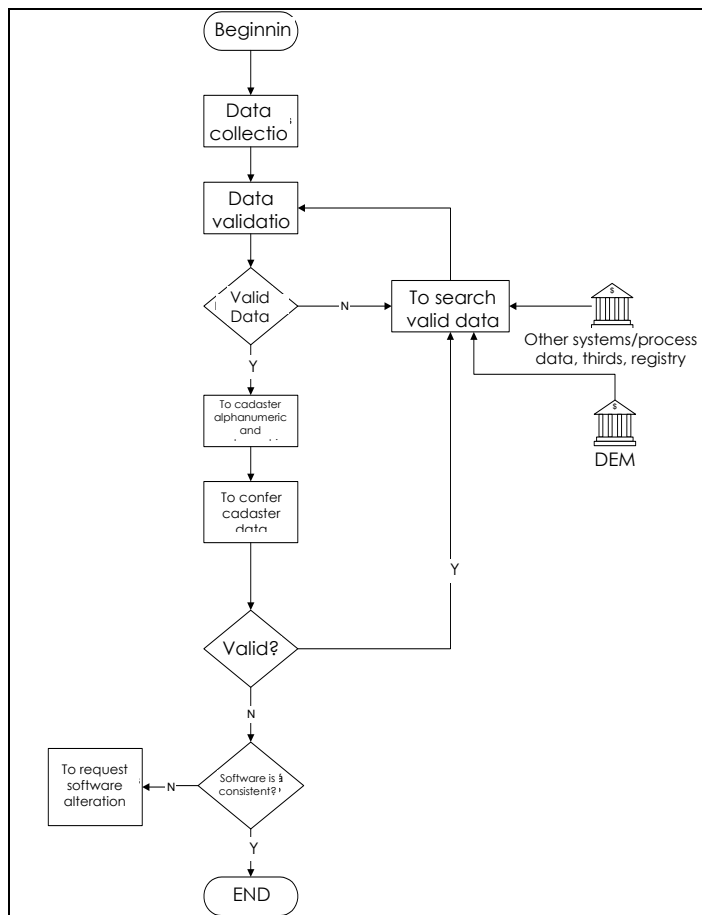


Figure 5 – Development flowchart of HARPIA EMS subsystem.

3.2.2 Zero Effluents and Residues – ZERE

This subsystem named ZERE means that zero of effluents and residues will not contaminate the environment under COPEL's responsibility. It involves the handling and disposal of all effluents and residues derived from the plant maintenance and cleaning processes.

3.2.3 Environmental Education – GREEN GENERATION

The so called Green Generation subsystem deals with the environmental education for COPEL's personnel and the local population. The whole process is centered in the Iguaçu Regional Museum at Gov. Ney Braga Power Plant. Approximately 15,000 people a year visit the museum which plays an important role in the cultural history of the regional inhabitants.

3.2.4 Permanent Preservation Areas – PPA

This subsystem establishes and monitors the permanent preservation areas which comprehend a green belt of 100 meters wide surrounding the reservoirs to prevent the contamination of the hydric body and assure the water quality. This responsibility was assumed by COPEL with the environmental agency at the issuing of the environmental operation licenses.

3.3 Socially affected areas

A great deal of land was socially affected by the construction of hydroelectric power plants. Several are the types of terrain – we will point out some of them here, that are under the EMS management.

3.3.1 Resettlement

In view of the environ radical change, 600 families impaired by the construction of Salto Caxias Hydroelectric 1,240 MW Power Plant, built by COPEL, were resettled in the nearby municipality of Capitão Leônidas Marques. Those families were relocated within 10 farmlands, which constitute 19 associations of croppers. Besides the relocation, a comprehensive infrastructure was built comprising 600 homes and barns, 322 km of water piping, 415 km of roads, electrical and telephone grids, 11,690 hectares of soil cultivation , as well as educational and health assistance. This achievement has been internationally considered as a standard model (Figure 6).

The People Resettlement Program – PRP includes the preservation of existing forest, reforestry, soil cultivation, and road-works around the micro-basins.

The project had as one of its main concerns the utilization of natural resources, particularly the water. The human resources were equally considered where the production by local families could bring them benefits in the form of life quality and economical growth, under a self-sustained panorama.

The resettlement project was elaborated in joint venture mode, that is, the party to be relocated was always taken as a partner, with whom all agreements were consolidated in October, 1993. The agreements established that COPEL should comply with the following assignments:

- The resettlement project should be conducted so as to promote social justice and to prevent rural exodus;
- Attain the just solution in the resettlement process to minor proprietors and lessees, half proprietors, proprietors without title deeds, other workers, and croppers that were directly impaired by the reservoir;
- COPEL should only acquire resettlement lands with the approval of the people to be evicted;
- Family and relative groups will be taken into consideration, as well as neighbors relationships.
- The land to be acquired for resettlement should be of at least 17 hectares per family;



Figure 6 – Cascavel resettlement area where live part of peoples socially affected by construction of Salto Caxias Hydroelectric Power Plant.

the soil quality, not being in any case, less than 17 hectares;

- Elaboration of a soil cultivation and agricultural exploitation plan.

A great concern of COPEL was in the sense of executing the project with the best techniques and practices of basic sanitation and environmental conservation. For such, it carried out a survey on the acquired land as to its climate, soil type, terrain and fertility. Plotting and amount evaluation of superficial and underground water were performed. One constant concern was of preserving the land natural characteristic.

Being the owner of the database, it was possible to establish parameters of soil fertility, restriction degrees of soil mechanization, erosion susceptibility, handling and exploitation types, vegetation, and pollution levels. The main concern of the project was that of assuring that at least 80% of each area of land was productive both for crops and cattle raising.

One other concern was the conservation of the remainder vegetation which had to be carefully observed so as to be kept in compliance with the environmental legislation, which requires that 20% of the forest reservation condominium be preserved as forest partially explored.

In the degraded areas of former proprietors of the acquired land, a vegetation recovery was carried out by the plantation of 300,000 of native species supplied from a plant nursery owned by COPEL at Gov. Bento Munhoz Power Plant.

Relative to the soil cultivation, where updated soil conservation techniques were applied, 375 km of level curves and 450 km of roads were built adequate to the micro-basins for the prevention of erosion and pollution of spring-heads, nascent brooks and existing rivers.

COPEL has focused its efforts to reach a high standard system of organic production. Besides the assignment of educating and enlightening local families on the matter, several experiences brought results beyond expectations. Among them it is worth mentioning the plantation of organic soybean in 17 areas, the application of homeopathic medicine in milk cow raising, and production of 8,000 chickens in an open-air system.

- The land to be acquired should be of higher fertility than those reached by the reservoir water.
- The size of each area of land should be determined in function of the family work force,

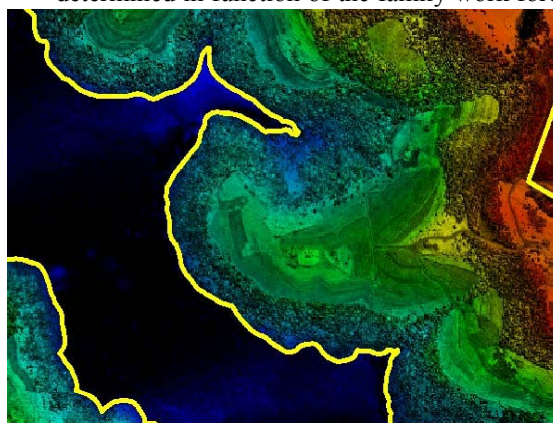


Figure 7 – Laser profile of reservoir border of Nova Prata do Iguaçu resettlement area where live part of peoples affected by construction of Salto Caxias Hydroelectric Power Plant.

The total cost of the Resettlement Project was US\$ 56.4 million. The works were accomplished in the period from 1996 to 1998. For the project completion it demanded staffs of civil engineers, geologists, agriculture technicians, social workers, economists, and lawyers.

The project has reached a consolidated status. Some following figures represent its current situation. Conventional soybean production in the year 2001 was 143,500 sacks, and organic soybean was 9,000 sacks. As to corn, 508,500 sacks of conventional production, and 9,000 sacks organic.

Our purpose is not merely disseminating knowledge on production new techniques, but to arouse in each farmer the ethics of virtual production in which the respect to Nature and Human Resources is fundamental.

Complementing the project, a Rural Development Plan was elaborated comprising several programs to diversify the agricultural activities including a study for an overall conversion of the current conventional system to the organic one, since the latter does not make use of noxious chemical product which is harmful to health.

3.3.2 Master Plan - Zoning

The objective of zoning is to characterize the form of use of COPEL'S real estates natural resources within a stretch of 1000 m wide of range bordering the reservoirs. Following, we will present some classification of zones, which were handed over to the environmental agency of Paraná State.

The main zones defined in the managing plans are:

- Consolidated Urban Zone - CUZ

This zone main characteristic is to prevent new plots of land from being less than 360 m², and that they keep a distance of 30 m from the reservoirs borders.

- Urban Expansion Zone - UEZ

This zone main characteristic is to assure that areas be of 1000 m², at least, also keeping a minimum distance of 30 m from the reservoirs borders. These zones should be situated on technically feasible terrain with compatible slopes, having the roads and streets as the pressure axes.

- Agriculture and Cattle Zones - ACZ

This zone is destined for crop and cattle activities. In Salto Caxias it is made up of 78% of the land surrounding the reservoir. These zones should keep a minimum distance of 100 meters from the reservoir borders denominated range of permanent preservation. These zones should occupy terrain with suitable slopes for crops and cattle raisings.

- Public Recreation Zones - PRZ

PRZs are directed to leisurely activities, including sports. COPEL has built these zones as one of the environmental programs in the environmental studies. These zones should be within 2000 m² – 3000 m² and be conveniently located so as to avoid population density and to allow easy and safe access to the water.

- Special Use Zones - SUZ

These zones are delimited parts to facilitate reservoir crossings, ferry operations, and circulation of local dwellers.

4. CONCLUSION

Contemporary concerns have been focusing on Nature and Human Resources. Under this view, COPEL has taken up as one of its assignments the recovery and preservation of its real properties environment as well as the upgrading of life standard of local populations, through the implementation of the GIS Management. As described above, COPEL has been successful in accomplishing every step of its planing, development and execution of the referred implementation. The elaboration of subsystems through ArcGIS tools enabled the Company to achieve consistent management results, which have been witnessed and approved by related professionals from several foreign countries. It is a certification that COPEL has given a small but very meaningful contribution to Nature and Mankind.

Acknowledgments

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