LIFE Certification—Experience of a Hydroelectric Power Plant in Restoring Ecosystems in the South of Brazil

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ABSTRACT. The article presents a case-study of how the efforts of a hydroelectrical power company are contributing to restore life in Paraná, in southern Brazil. The company, Itaipu, is a world leader in clean and renewable energy having produced more than 2.3 billion MWh since it started operating, in 1984. With 20 generating units and 14,000 MW of installed capacity, Itaipu provides around 15 per cent of the energy consumed in Brazil and 75 per cent of the energy consumed in Paraguay. The company is located on a basaltic line spanning the border between Argentina and Brazil. The surrounding subtropical rainforest has over 2,000 species of vascular plants and was originally home to the typical wildlife of the region: tapirs, giant anteaters, howler monkeys, ocelots, jaguars and caymans. In addition to the impacts of the installation and operation of Itaipu, prior decades of economic development in the region, mainly agricultural activities, have resulted in the loss of natural areas. To maintain and restore life in the region, the company has been contributing through a wide variety of projects such as: biodiversity corridors, reserves and sanctuaries, reforestation, seedling production, forest restoration and wildlife management, including repopulation programmes and fish farming. In recognition of all this proactive work and the resulting improved maintenance of ecosystem services, the company has been awarded the LIFE Certification.

Certification LIFE - Expérience d'une centrale hydroélectrique dans la restauration des écosystèmes du Sud du Brésil

RÉSUMÉ. L'article présente une étude de cas sur la façon dont les efforts d'une compagnie d'énergie hydroélectrique contribuent à rétablir la vie au Paraná, dans le sud du Brésil. Itaipu est un leader mondial de l'énergie propre et renouvelable qui a produit plus de 2,3 milliards de MWh depuis sa mise en service en 1984. Avec 20 unités de production et 14 000 MW de puissance installée, Itaipu fournit environ 15% de l'énergie consommée en Brésil et 75% de l'énergie consommée au Paraguay. L'entreprise est située sur une ligne basaltique traversant la frontière entre l'Argentine et le Brésil. La forêt subtropicale environnante a plus de 2000 espèces de plantes vasculaires et abritait à l'origine la faune typique de la région: tapirs, fourmiliers géants, singes hurleurs, ocelots, jaguars et caïmans. Outre l'impact de l'installation

et du fonctionnement d'Ipaitu, les dernières décennies de développement économique dans la région, principalement les activités agricoles, ont vu la perte de zones naturelles. Pour assurer la pérennité et le rétablissement de la vie dans la région, la société a participé à divers projets tels que: couloirs de biodiversité, réserves et sanctuaires, reboisement, production de semis, restauration de forêts et gestion de la faune, y compris les programmes de repeuplement et la pisciculture. En reconnaissance de toutes ces actions proactives et de leurs résultats pour le maintien des services écosystémiques, la société a reçu la certification LIFE.

Certificación LIFE - La experiencia de una central hidroeléctrica en la restauración de ecosistemas en el sur de Brasil

RESUMEN. El artículo presenta un estudio de caso de cómo los esfuerzos de una empresa hidroeléctrica están contribuyendo para restaurar la vida en el sur de Brasil, Paraná. La empresa, Itaipú, es un líder mundial en energía limpia y renovable habiendo producido más de 2,3 mil millones de MWh desde que comenzó a funcionar, en 1984. Con 20 unidades generadoras y 14.000 MW de potencia instalada, Itaipú proporciona aproximadamente el 15% de la energía consumida en Brasil y el 75% de la energía consumida en Paraguay. La empresa está ubicada sobre una formación basáltica en una región fronteriza entre Brasil, Paraguay y Argentina. El bosque subtropical que rodea las instalaciones de la empresa tiene más de 2.000 especies de plantas vasculares y ha sido originalmente el hogar de la fauna típica de la región: tapires, osos hormigueros gigantes, monos aulladores, de ocelotes, jaguares y caimanes. Además de los impactos de la instalación y del funcionamiento de la empresa, las últimas décadas de desarrollo económico también han provocado pérdidas de áreas naturales en la región, especialmente debido a las actividades agrícolas. Para mantener y restaurar la vida en la región, Itaipú está involucrada en varios proyectos: la creación de corredores ecológicos, reservas y santuarios, reforestación, producción de plántulas, la restauración forestal y manejo de la fauna, incluyendo programas de cría en cautividad y piscicultura. Dado el conjunto de acciones proactivas y sus resultados para el mantenimiento de los servicios ecosistémicos, Itaipu obtuvo el reconocimiento de la certificación LIFE.

I. INTRODUCTION

In recent decades, economic development in west Paraná, Brazil, has resulted in serious losses of natural areas.

To maintain and restore life in the region, Itaipu has been contributing with a large number of projects projects involving, for example: biodiversity corridors, reserves and sanctuaries, reforestation, seedling production, forest restoration and wildlife management, including captive breeding programmes. In recognition of all these proactive actions and their positive results for the maintenance of biodiversity and ecosystem services, the company received the LIFE (Lasting Initiative for Earth) Certification in 2015.

II. ITAIPU

The company Itaipu is a world leader in clean and renewable energy having produced more than 2.3 billion MWh since it started operating in 1984. With 20 generating units and 14,000 MW of installed power, Itaipu provides around 15% of the energy consumed in Brazil and 75% of the energy consumed in Paraguay. The company is located on a basaltic line spanning the border between Argentina and Brazil. The surrounding subtropical rainforest has over 2,000 species of vascular plants and was originally home to the typical wildlife of the region: tapirs, giant anteaters, howler monkeys, ocelots, jaguars and caymans.

III. ITAIPU CONSERVATION ACTIONS

Many of the environmental results expected from the establishment of the company were foreseen in the early phases of its planning and installation. They were consolidated in some documents as the Basic Plan for Environmental Conservation (1975) and the Master Plan for the Reservoir Area (1982). These references jointed all the information available from previous research carried out in the project area, as the ichthyofaunistic (19771981), floristic (1976) and faunistic (1979) inventories that allowed compensatory and mitigatory measures to be proposed, even though there were no legal obligations concerning environmental responsibilities at the time.

Itaipu maintains a technical team of biologists, foresters, veterinarians, zoo technicians, agronomists, educators and other specialists, a total of 38 people dedicated to actions focused in flora, fauna and ichthyofauna. The infrastructure includes a forest nursery, which can produce 350,000 seedlings from 75 species a year; an ichthyofauna laboratory; a zoo that maintains a gene bank (living and cryopreserved) of 360 animals from 61 species; a veterinary hospital; and a 10.3 km long fish transposition system.

The restoration of natural areas covering 1,007 km^2 along the river includes reserves and sanctuaries that were devastated for agriculture and livestock farming before the company was set up. Since 1979, more than 23 million forestspecies seedlings have been planted on the Brazilian side of the company, called "the left bank". It was considered the most extensive reforestation in the world carried out by a hydroelectric power company. On the Brazilian side alone, the protected area along the river is 1,395 km long and 210 m wide. The protection strip along the reservoir was the greatest effort regarding to reforestation; it accounts for 86% of the total land ecosystem under company's protection in Brazilian territory (figure 1).

Since 2002 Itaipu, together with some partners, has been operating the Santa Maria Ecological Corridor, linking the Iguaçu National Park to the company´s reserves and other significant forest remaining, as

FIGURE 1 RIPARIAN FOREST ALONG RESERVOIR MARGINS.

Ilha Grande National Park. This work used the seed of 128,000 seedlings over 73.3 ha and conserved 902 ha of forest remnants and natural areas along the river. Itaipu participation comes within a Management Network, established to develop the mapping and boundaries of the Paraná River Biodiversity Corridor. This process took in account the identification of the priority areas and their social and economic relationships.

Itaipu is also responsible for the conservation of two sanctuaries: the 1,920-hectare Bela Vista Sanctuary and the 1,482-hectare Santa Helena Sanctuary. There is also the 1,356hectare Maracaju Sanctuary, which is located in the border between Brazil and Paraguay and is comanaged by the two sides of the company.

For the maintenance of these preserved areas, Itaipu keeps and manages staff for security, environmental protection and fire control.

Beyond the direct results of maintaining the composition, structure and function of the natural ecosystems, the natural areas preserved by Itaipu contribute to biodiversity conservation through wildlife research and environmental education.

In addition to providing seedlings for all forest restoration carried out by Itaipu in its own territory, the nativeforest seedling production facility in the Itaipu nursery (figure 2) also donates seedlings to the initiatives of partners, such as municipalities, non-governmental organizations and others located in the river basin. More than 4.5 million seedlings have been distributed in the last 13 years. Some of the most wellknown species produced are the pink trumpet tree (*Tabebuia avellaneda*), the cedro (*Cedrela fissilis*), and the pau marfim (*Balfourodendron riedelianum*), intended for the restoration of the riparian forests of the Paraná basin, the Protection Strip and the Maracaju Sanctuary. According to 2016 IUCN Red List, four endangered species are grown in the forest nursery (table 1).

TABLE 1. ENDANGERED FOREST SPECIES (IUCN) USED IN SEEDLING PRODUCTION

COMMON NAME	SCIENTIFIC NAME
Peroba rosa	*Aspidosperma polyneuron*
Pau marfim	*Balfourodendron riedelianum*
Cedro	*Cedrela fissilis*
Guabiju	*Myrcianthes pungens*

Itaipu is also responsible for captivebreeding research for some threatened species in Brazil, developing new protocols and serving as a model in the country for several researches institutions. Located in the Bela Vista Sanctuary, the wildlife captivity facility has the capacity for more than 300 animals. Since it was set up, more than 1,000 births have been recorded from a total of 48 species, mainly the Brazilian dwarf brocket/pygmy brocket (*Mazama nana*), the margay (*Leopardus wiedii*) and the lowland tapir/*anta* (*Tapirus terrestris*) (figure 3) with a success rate above 70%. One of the highlights of these endeavours was the successful breeding of the endangered species known as the royalhawk or harpy eagle (*Harpia harpyja)*, with 25 individuals being hatched in Bela Vista

FIGURE 2 SEEDLING PRODUCTION OF NATIVE SPECIES.

FIGURE 3 *TAPIRUS TERRESTRIS* IN CAPTIVITY.

Sanctuary since 2007 (figure 4). The wildlife breeding centre counts five species on the IUCN Red List, many of them breeding (table 2).

TABLE 2. ENDANGERED NATIVE FAUNA SPECIES IN THE WILDLIFE BREEDING CENTRE

COMMON NAME	SCIENTIFIC NAME	BIRTHS UP TO 2012
Northern tiger cat	*Leopardus tigrinus*	30
Lowland tapir	*Tapirus terrestres*	8
Marsh deer	*Blastocerus dichotomus*	15
White-lipped peccary	*Tayassu pecari*	64
Giant anteater	*Myrmecophaga tridactyla*	0
Vinaceous-breasted amazon	*Amazona vinacea*	0
Black-fronted pipingguan	*Pipile jacutinga*	0

Given the important relationship between the company and the river, Itaipu is developing a specific line of action to maintain the composition of the aquatic ecosystem: the Piracema channel that promotes population connectivity among migratory fishes of the region. The channel, which is 10.3 km long, promotes the flow of genes and mitigates fragmentation effects. It has been in operation since 2002 and is composed of natural segments of the Bela Vista River, concrete stretches and artificial lakes [1].

The evaluation of fishpassage structures are often limited by small sample sizes and the lack of detailed information on the movements of individual fish. Water and environmental conditions affecting the efficiency of passage can vary widely within a given experiment, which hinders the meaningful interpretation of data. Several techniques have been employed to address this problem, but prohibitive costs in terms of both time and money have limited the scope of the experiments [2].

In recent years, a technology has developed to allow the collection of detailed information on small and largescale movements of large numbers of individual fish. The passive integrated transponder (PIT) is a small, relatively inexpensive tag that can be programmed with an almost infinite number of individual codes and, with no battery, has an unlimited life expectancy. Individual PIT-tagging studies conducted in the Columbia River Basin have successfully monitored the movements of tens of thousands of juvenile

FIGURE 4 THE ROYAL-HAWK, *HARPIA HARPYJA*, IN ITAIPU, SUCCESSFULLY BRED IN CAPTIVITY

salmonids through and around the hydroelectric facilities. Comparisons with markrecapture techniques of similar sample size have demonstrated the superior level of data acquisition offered by the PIT tag [3].

In 1997, Itaipu started its own studies to determine migratory fish routes, based on the tagging and recapture protocol. Since 2009, PIT tag has also been used to determine detailed behavioural patterns of migratory species into the transposition system (figure 5). The tagging is used on migratory species as the pacu (*Piaractus mesopotamicus*), the jaw characin (dorado) (*Salminus brasiliensis*) and the grumatá (curimba) (*Prochilodus lineatus*) [4]. The information generated helps in adjusting transposition projects for neotropical fish [5].

FIGURE 5 PIT TAG INSERTION PROCEDURE. TAGS ARE IMPLANTED INTO THE ABDOMINAL CAVITY OF NATIVE CAPTURED FISH.

Since 2001, the nursery areas for fish species have been mapped systematically, in association with universities, in the main tributaries of Itaipu reservoir and Ilha Grande National Park, the largest undammed stretch of Paraná River.

Itaipu also undertakes environmental-education activities, raising the awareness of the public and social groups, thus contributing to the building of a sustainable society.

During the major water crisis in Brazil in 2015, the Itaipu "Cultivating Good Water" (CGW) programme received the United Nations Best Water Management Practices award [6]. The main activities of the CGW programme include: restoration of watersheds, with an emphasis on springs and riparian forests, soil conservation, rural road improvement, installation of community water points and water tanks for water recycling, as well as the promotion of more sustainable production and consumption systems.

All these experiences have been transformed into social technology to help local governments affected by water crisis. This programme is already being replicated in other Latin American countries and has inspired many other countries.

IV. LIFE CERTIFICATION

As the problems of environmental change become more evident, we increasingly realize how much we depend upon wildlife for a wide range of so-called ecosystem services. We all depend for our survival upon processes such as biological productivity, nutrient cycling, and water cycling which provide clean air and water, maintain the fertility of the soil, and help to regulate the climate. In recent years, economists have made important progress in defining the kinds of benefits that biological diversity provides, and in developing methods for assessing their value. The sustainable use of any natural resource implies that nothing should be done in the short term that reduces the ability of the resource to provide services in the future [7]. But, because most ecosystem services are public goods, markets are not available to provide clear units of account [8].

Certification programmes—organized and coordinated by non-State actors—exemplify efforts to encourage and control information flows to resolve environmental and social challenges within and beyond State boundaries. Such initiatives have been developed in numerous sectors to address the problems of labour exploitation, environmental degradation, and social injustice. The hope is that certification can be a tool for nongovernmental organizations, investors, governments, and consumers to identify and support high performers [9].

The need to conserve biodiversity by strengthening the engagement of the private sector has set the scene for the creation of the LIFE Methodology and Certification, a technical approach related to an international non-State market-driven instrument that can be applied in any country or sector [10]. The LIFE Methodology is applied to those businesses concerned with the increasing risks of global environmental thresholds and that, in response, aim to implement robust and measurable biodiversity action plans to compensate for the organization's impacts.

Besides the application of the LIFE Methodology, companies may have a third-party evaluation of its biodiversity performance taking into account its impact and size. The third-party evaluation can result in the granting of the Certification for the company.

Taking into account the LIFE Methodology, an organization´s biodiversity impact index (BII) is quantified by measuring its annual waste generation, greenhousegas emissions, energy consumption, ecoregional location, and water usage. These data are ranked in terms of their severity through information on the destination and degree of hazard of wastes, gaswarming potential, impacts of the energy source, ecoregional remnants and fragility and water availability in the region. Once the BII is obtained, a minimum biodiversity-conservation performance standard is calculated [11].

Finally, the organization is obliged to demonstrate quantitatively its voluntary biodiversity conservation results each year. The scoring quantification of performance is done by evaluating the company's biodiversity action plan (BAP), the score being higher when the BAP is well aligned and focused on concrete actions and results. The biodiversityactions scoring takes into account the company's technical methodology and efficiency and efficacy for the maintenance of the composition, structure and function of local biodiversity [12]. In this sense, the LIFE initiative promotes a change of mindset to mainstream natural

capital conservation in all business practices, taking into account a technical and scientific approach for the company's biodiversity action plan.

The LIFE Methodology makes it possible to assess the effectiveness of an environmental management system (EMS), highlighting potential areas of improvements for management, including the minimization of expenses and optimization of investments and reforms. This is very important, especially when the EMS also values the efficiency of processes, which does not always lead to the truly effective management of resources [13].

LIFE is considered an innovative and robust tool and it is a unique quantitative and universal calculation methodology that is able to measure; evaluate; monitor and compare numerically the environmental impact of different organizations and sectors. It is also innovative in that its methodology establishes a minimum biodiversity conservation performance that shall be calculated in proportion to the impact of each organization. Finally, the organization shall quantitatively prove its voluntary biodiversity conservation results each year. In this sense, the LIFE initiative promotes a change in mindset to mainstream natural capital conservation in all business practices.

V. LIFE CERTIFICATION OF ITAIPU

Itaipu Binacional organized a ceremony in Foz do Iguaçu on 7 April 2015 for the company to officially receive LIFE Certification. The ceremony took place in the Itaipu Auditorium during the event "Sustainable Dialogues" in the presence of Jorge Samek, Brazilian General Director of Itaipu, Nelton Friedrich, Director of Coordination and Environment, and Clovis Borges, VicePresident of the LIFE Institute Board of Directors.

For Itaipu, LIFE Certification provides a means to guide the wide range of environmental measures taken by the company, according to a robust technical protocol that provides scientific information to determine the real effectiveness of the chosen course of action.

In addition to the environmental aspects of the methodology, a huge improvement was noticed when Itaipu performed complete year-by-year monitoring of its impact. This meant an improvement in the documentation and record-keeping at all stages of the project. Statistical information has supported all the decisions taken for company´s future planning.

From now on, the main challenge is to maintain this structured system, in an attempt to achieve the best sustainability practices in its sector, a goal to be reached by 2020.

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