Fostering the payment for environmental services in Brazil: a fair review of the Itaipu binacional's royalties policy

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Abstract. The new Brazilian Forest Code, enacted on May 2012, will promote an intensification of the rural activities and the expansion of the agribusiness frontier. Land use change along ridge lines together with the legal possibility of suppressing forest vegetation in areas previously protected will subject hydroelectric reservoirs to a growing load of sediments, hence shortening their life. It is in this scenery that the payment for environmental services becomes a viable and attractive solution to arouse the voluntary adoption of forest preservation practices. As many other similar initiatives, such mechanism lacks a financing source which does not result in increase of the tax burden. Taking into account the amount of royalties monthly paid by the Itaipu Binacional to the states and municipalities that had their lands flooded by the reservoir, in the present work it's proposed the revision of the current criteria of sharing this financial compensation for the use of the water resources for electric power generation. To do so, the intrinsic factors to the generation of hydroelectric energy were spatialized within the Itaipu watershed. The results point out that, although there are 1.383 municipalities that really contribute for the generation of this wealth, only 342 share the financial benefits. In spite of the contribution of Paraguay to represent only 1.7% of the total of the energy generated by the Itaipu power plant, the royalties are equally divided between the two countries.

Keywords. Itaipu, royalties, financial compensation, hydroelectric power plant, social justice, payment for environmental services.

1. Introduction

The Brazilian Forest Code of 1965 had, for backbone, the key elements of a watershed. Laid on strong ecological foundations, its three main categories of permanent preservation areas – i) along the ridge lines, ii) along the watercourses and iii) the contributing area of springs – resulted in the natural formation of ecological corridors strategically distributed in different strata of any watershed. Whereas promoting biodiversity preservation, it also assured the necessary gene flow between flora and fauna for all six Brazilian biomes: Amazon rainforest, Thorny scrubland, Savanna, Atlantic forest, Wetland and Grassland [1].

The new forestry law, enacted on May 25, 2012, significantly reduced the extent and the number of permanent preservation areas categories. If, on one hand, the deleterious effects on biodiversity still will take some time to be perceived by the scientific community, on the other hand, the le-

gal feasibility of converting forest fragments or even whole forests to other land uses, clearly points out the worsening of both sediment and chemical pollution – especially eutrophication – of water reservoirs, including hydropower ones and those intended for urban supply [2]. The reduction of the lifetime of these strategically selected locations for water accumulation and the increased costs of water treatment are negative externalities that affect a population considerably larger than that located within the watershed and who benefits directly from the expansion of agricultural activities. Fostering soil conservation practices and encouraging the maintenance of vegetation cover are inseparable elements of water management policies. However, the correct quantification of their benefits is still a challenge for science, since the costs of environmental degradation are often neglected [3, 4].

Food security is closely linked to the availability of water resources, arable land, and last not least, energy. It is anticipated that global food production will reach critical levels in the close future, leading many countries to social breakdown [2, 5]. It is in this scenario, which confronts again the need for long-term environmental preservation with immediate expansion and intensification of agricultural production, that the review of the mechanism of compensation for the use of water resources for electricity generation (CFURH), a policy adopted in Brazil since 1989, emerges as an economically viable, socially just and environmentally desirable solution to establish the fair payment for environmental services within the watershed in which they are produced. The hydroelectric power plant (UHE) of Itaipu was chosen as a case study.

The royalties from Itaipu – a compensation for the use of the hydraulic potential of Sete Quedas waterfalls to generate electricity in Itaipu – are equally divided between Brazil and Paraguay, and monthly paid by the Itaipu Binacional Consortium to the treasury of these two countries since May 1985. In Brazil, the royalties are distributed as follows: 45% for states, 45% for municipalities and 10% for some federal agencies {Ministry of Environment - MMA (30%), Ministry of Mining and Energy - MME (30%) and the National Fund for Scientific and Technological Development – FNDCT (40%)}. From the total allotted to municipalities, 85% is distributed in proportion to the area flooded by the waters of the Itaipu reservoir. The remaining 15% are transferred to municipalities (½) and states (½) affected by reservoirs located upstream of the powerplant, a recognition of the benefits stemming from the regularization of the upstream water flows [6]. Throughout 2011, the Itaipu Binacional transferred R$ 370,170,615.67 to the Brazilian government and the same amount to Paraguay [7].

The rationale behind the equitable division of royalties from Itaipu is based on the fact that the lake's surface is roughly equally distributed between the two countries (56% in Brazil and 44% in Paraguay). Nevertheless, it is well known that the production of hydropower results from both the falling height (m) and the water flow (m^3/s) [8]. This fact, itself, indicates the perversity of taking just one single criterion as north to the apportionment of the royalties from Itaipu. The same mistake contaminates the shared values of CFURH paid by other Brazilian electricity companies [9], since only those municipalities that had part of their lands flooded by the reservoir of a hydroelectric plant are financially rewarded. To solve this problem, Oliveira [10] developed a methodology, based on the spatial distribution of specific water flow, to quantify the percentage of electricity generation due to the areas upstream of the dam and thus calculated how much of the financial compensation would be proportionately due to each county within the basin.

In this paper, based on the approach proposed by Oliveira [10], it was determined the proportional contributions of Brazil and Paraguay to the 92,245,539 MWh produced during the year 2011 by the Itaipu Binacional and, for Brazil, the contributions of each state whose lands are intercepted by the Itaipu watershed.

2. Methods

The Itaipu hydroelectric power plant is located in the Paraná River basin. Specifically, it lies on the border between Brazil and Paraguay, taking advantage of the topography of the Sete Quedas waterfalls region. In Brazil, the areas flooded by the reservoir of Itaipu reach a total of 16 municipalities, being fifteen in the state of Paraná and in one the state of Mato Grosso do Sul (Figure 1).

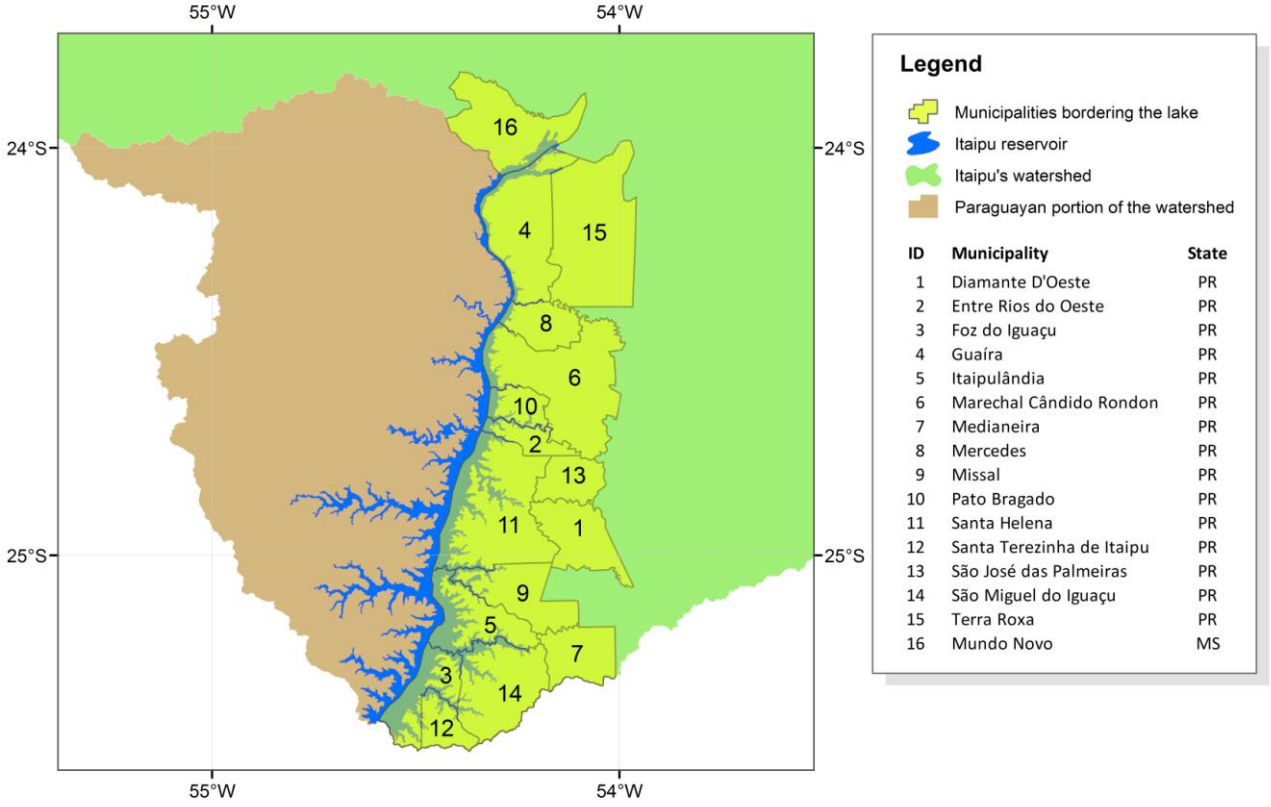

Figure 1. Brazilian municipalities intercepted by the Itaipu reservoir.

The boundary of the Itaipu lake's watershed, which is the starting point for the spatialization of the intrinsic factors of hydroelectric power generation (falling height and water flow), was derived from the Shuttle Radar Topography Mission (SRTM) dataset, which has a cell size of 90 m. All spatial analyzes were performed in ArcGIS version 10.0, adopting its native data structure called Geodatabase. Initially one selected fourteen 6^o x 6^o tiles from the SRTM 90 m Digital Elevation Database version 4.1, released in the Geotiff format by the Consortium for Spatial Information of the Consultative Group on International Agricultural Research (CGIAR-CSI), encompassing the Itaipu watershed. These data, originally produced by NASA, had been processed by CGIAR-CSI to eliminate voids and to reduce the occurrence of both spurious peaks and depressions.

The Itaipu hydroelectric power plant has a net falling height of 118.4 m and a regulated water flow of 11,680 m³/s. It has 20 generators, accounting for an installed capacity of 14,000 MW [6]. The respective percentage contributions of regularized flow (Q) and net falling height (h) to the total energy produced by Itaipu can be calculated by equations (1) and (2) [10]:

$$P_Q = \frac{100 \times h}{Q + h} \tag{1}$$

$$P_h = \frac{100 \times Q}{Q + h} \tag{2}$$

Once these values were obtained, the next step was to determine their spatial distribution within the Itaipu watershed. While the spatialization of the water flow spans the entire drainage area, the spatial distribution of the net falling height is confined to the surface of lake of the hydroelectric plant. The stipulation of the normal height of the Itaipu reservoir operation results directly on the surface flooded by the lake. Thus, the percentage contribution of each Brazilian state to the net falling height is obtained by dividing the value of the inundated area of each municipality by the total area of the lake's dam.

3. Results

The 14 SRTM tiles were mosaiced, resulting in a seamless digital elevation model (DEM) with values ranging from 165 m to 2,854 m. Next, using the Hydrology toolbox of ArcGIS Spatial Analyst extension, it was generated the flow direction grid, and then the flow accumulation one. The location of the Itaipu reservoir's spillway was obtained from Google Earth and, using the flow accumulation grid as a visual reference to guide the process, the delimitation of its drainage area was performed. The topography of this watershed presented elevations between 217 m and 2,778 m, with an average of 621 m ± 241 m. Its drainage area encompasses 822,417.22 km², being 10,391.80 km² in Paraguay and 812,023.89 km² in Brazil, as illustrated in Figure 2(a). The respective values of the areas of each Brazilian state within the watershed and the Paraguay portion are depicted in Figure 2(b).

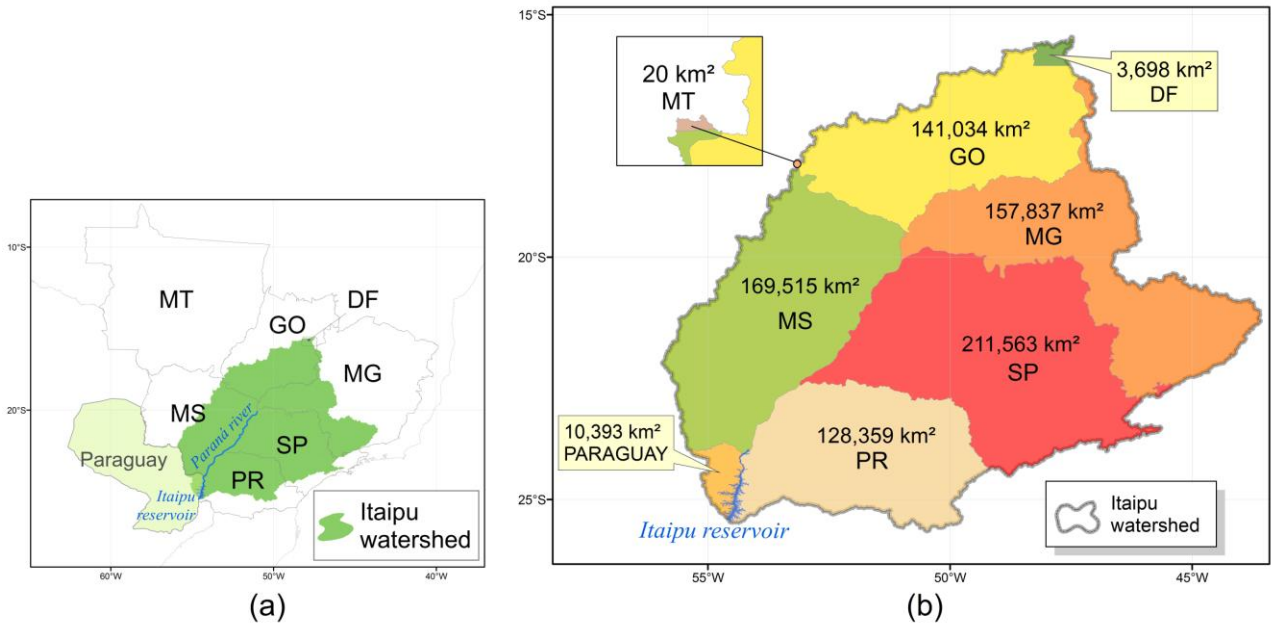

Figure 2. (a) Brazilian states intercepted by the Itaipu watershed and (b) areal apportionment of the Itaipu watershed.

The identification of the surface of the Itaipu reservoir was done by selecting all cells with elevation equal to or less than 220m. This resulted in an area of 1,294.37 km², from which 728.31 km² lie in Brazil and the other 566.06 km² in Paraguay. A regulated water flow of 11,680 m³/s contributes to approximately 99% of the total energy generated in Itaipu, and the net falling height of 118.4m with only 1%. The results of the spatialization of these two electric power generation factors, by adopting the watershed and the lake's surface of Itaipu as references, are presented in Table 1.

Table 1. Relative contribution of each state/country to the flow (Q) and head (h) of the Itaipu hydroelectric plant.

State	Area (km²)	% Q	% h
DF	3,697.74	0.45%	
GO	141,033.56	17.15%	
MT	19.80	0.0024%	
MS	169,515.13	20.61%	2.30%
MG	157,836.67	19.19%	
PR	128,358.89	15.61%	53.97%
SP	211,562.52	25.73%	
Brazil	812,024.31	98.74%	56.27%
Paraguay	10,392.91	1.26%	43.73%
Total	**822,417.22**	**100%**	**100%**

The distribution of the royalties from Itaipu Binacional during 2011, by the ongoing criteria, and the relative shares of the Brazilian states and Paraguay, are summarized in Table 2.

Table 2. Allotment of the Itaipu's royalties paid during 2011 to Brazil and to Paraguay.

State	Number of municipalities	Share	R$ 1,000
DF	1	0.0034%	25
GO	38	1.24%	9,188
MT	0	0%	0
MS	6	0.69%	5,087
MG	91	3.43%	25,390
PR	47	38.07%	281,828
SP	159	1.57%	11,637
MMA/MME/FNDCT		5.00%	37,017
Brazil	342	50.00%	370,171
Paraguay		50.00%	370,171
Total		**100%**	**740,341**

These results lay down a model of benefits sharing that, far from contributing to the rectification of historic regional imbalances among the cities of Paraná river basin and to strengthen the Brazilian federal pact, clearly leads to wealth concentration. The actual contribution of each Brazilian state for the total electric power generated in Itaipu is therefore the correct basis for initiating the fair apportionment of royalties paid by Itaipu Binacional, as detailed in Table 3.

Table 3. Fair allotment of the Itaipu's royalties based on the effective contribution of each state/country.

State	Number of municipalities	Share	R$ 1,000
DF	1	0.40%	2,966
GO	139	15.28%	113,116
MT	1	0.0021%	16
MS	58	18.39%	136,113
MG	288	17.10%	126,593
PR	297	14.39%	106,559
SP	599	22.92%	169,684
MMA/MME/FNDCT		9.83%	72,783
Brazil	1,383	98.31%	727,830
Paraguay		1.69%	12,511
Total		**100%**	**740,341**

Confronting the results of the proposed model with those from the current one, it is observed that the total amount of royalties paid by the Itaipu Binacional remains unchanged, since the tax ba-

sis, i.e., the total energy produced, does not change. What does change significantly is the fair amount due to each state or country. The values of the differences between the two approaches are summarized in Table 4.

Table 4. Comparison between the two approaches for sharing the royalties of Itaipu for 2011.

State	Current (R$ 1,000)	Fair (R$ 1,000)	Losses / Earnings (R$ 1,000)
DF	25	2,966	2,941
GO	9,188	113,116	103,928
MT	0	16	16
MS	5,087	136,113	131,026
MG	25,390	126,593	101,203
PR	281,828	106,559	175,269
SP	11,637	169,684	158,047
MMA/MME/FNDCT	37,017	72,783	35,766
Brazil	370,171	727,830	357,659
Paraguay	370,171	12,512	357,659
Total	**740,341**	**740,341**	

Finally, this information will allow one to determine how much, on average, municipalities belonging to the Itaipu watershed – *and currently excluded from receiving any royalties* – lost in 2011. These values are presented in Table 5.

Table 5. Number of Brazilian municipalities within the Itaipu watershed and their average losses in 2011.

State	Number of municipalities in the watershed	Number of municipalities receiving royalties	Number of municipalities without royalties	Average losses for municipalities without royalties (R$ 1,000)
DF	1	1	0	0
GO	139	38	101	814
MT	1	0	1	16
MS	58	6	52	2,347
MG	288	91	197	440
PR	297	47	250	359
SP	599	159	440	283

4. Conclusions

A detailed analysis of the recently enacted Forest Code – the Federal Law 12.651 of May 25, 2012 – shows that, although the riparian protection *(notwithstanding the substantial reduction in the width of the protected buffer zones, resulting from the adoption of the new guiding rules)* has survived the new legal text, the protections along the watersheds divides and the contributing areas of springs were totally suppressed. Riparian buffer zones now constitute the only articulated category of permanent preservation areas. By its intrinsic spatial characteristics, such articulation is confined to the interior of each watershed. This results in complete isolation of the safety net along the waterways of a given basin, depriving them of any connection with the permanent preservation areas of adjacent basins. Thus, the voluntary actions taken by landowners to preserve forest formations along the divides should necessarily receive special treatment, characterizing them as highly relevant environmental services. It must be recognized that much more than mere wildlife corridors, these areas play a crucial, effective role in water resources protection.

Water is an irreplaceable input in all agricultural production systems. Its commitment to generating electricity at Itaipu power plant (steady energy) severely restricts the expansion and intensification of agroforestry activities in a region encompassing 2 countries, 7 Brazilian states and 1,383 municipalities. Most Brazilian municipalities (1,041) currently affected by restrictions on the granting of water use in the Paraná river basin, which actually harms their economies, does not participate of the apportionment of the royalties paid by the Itaipu Binacional. Clear evidence of this distortion is Paraná to be the only Brazilian state benefited by the current policy of royalties sharing. However, the number of municipalities of Paraná within the Itaipu watershed which are excluded from earning royalties is more than 5 times the number of municipalities of Paraná state currently granted. Each of these 250 municipalities lost, on average, R$ 359,000 in 2011.

Considering the effective contribution to the energy generated at Itaipu, Paraguay should receive exactly R$ 12,510,938.01. By the current criterion, as the R$ 740 million of royalties paid by the Itaipu Binacional are equally distributed between the two countries, Paraguay has just received an additional R$ 358 million. Because of this, the Brazilian Ministries of Environment (MMA), Mining and Energy (MME) as well as the National Fund for the Scientific and Technological Development (FNDCT) lost a total of R$ 35.8 million during 2011.

The proposed new apportionment, based on the tacit recognition of the geographical distribution of the intrinsic factors related to hydroelectric power generation, allows to repair this historical mistake, making available the financial resources necessary to implement a policy of payment for the environmental services provided by farms located upstream of the Itaipu dam.

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