A contribution to environmental justice in Brazil: valuing the impacts of production water from oil and gas offshore exploration in Restinga de Jurubatiba.

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ABSTRACT

The present work investigates the occurrence of environmental injustice in Macaé municipality, Rio de Janeiro, Brazil as an indirect effect of petroleum production chain, focusing on petroleum industry offshore exploitation activities in Campos Basin. The studied area, located in Restinga of Jurubatiba (a shoal composed by coastal lagoons, sand and dunes known in Brazil as "restinga") has been submitted to consecutive impacts related to fifty-one water production pipeline leakages and to domestic and industrial risks related to inadequate water supply and to land use patterns that characterizes vulnerable social economic populations. Discharge of all water produced by petroleum activities of Campos Basin was done into the coastal protected area nearby Comprida Lagoon, passing by Restinga de Jurubatiba National Park, an Integral Protection Conservation Unit (CU), classified as biosphere reserve. This study proposes a methodology that can be employed to estimate E&P environmental impacts in those areas. Although based on combining and adapting known valuation methods. Associating environmental valuation with CU's Advisory Council effective performance helped to minimize contamination and health risks of surrounding fragile socioeconomic populations, thus contributing to minimize environmental injustice nearby protected areas

1. Introduction

Society generally relates the negative environmental impacts generated from oil and gas production to offshore oil spills in marine environments, which mask the perception of other environmental impacts of local or even regional amplitude, related to oil and gas industry. Accelerated population growth and economic activities stimulated by the oil and gas industry in Campos Basin (RJ), whose operational units are based in Macaé/ Rio de Janeiro , since 1978, are leading to a series of pressures on natural resources and on people, which affect mostly those who live in the edge of cities in conditions of socioeconomic vulnerability, thus leading to environmental injustice conditions.

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The offshore petroleum and gas exploration activities carried out at Campos Basin, Rio de Janeiro, Brazil, corresponds to more than 80% of total country production (ANP, 2009). This activity has caused considerable socio-environmental impacts, such as intensification of regional population growth, with the consequent increase of vegetation suppression practices and occupation of protected areas (HABTEC, 2009). The whole process intensified disruption of traditional social tissues and ways of using environmental resources and services. It was also accompanied by an intensive rise in water consumption and effluent disposal, both due to domestic and industrial needs, as well as presumed increasing of atmospheric and water pollutants levels.

Facing environmental injustice conditions, usually verified all over Brazil (Pacheco, 2008), and strengthened by the planetary development model based on extensive and unsustainable exploitation of global environmental resources, whose Brazilian governmental version is called Accelerated Growth Program, Macaé, the so called "Brazilian Texas", is an example of the enclave city typology, once that enclave cities polarize low income areas of regional or even national markets, as in the case of Macaé, and low intensity income. When associated to working forces of low qualification level the occurrence of poverty islands is also characterisctic in enclaves (Pereira and Lemos, 2003) Despite of its undesirable side effects, the oil industry still represents the backbone of an energyvorous and intrinsically unsustainable way to relate with Nature - the "Hydrocarbon Society" (Yergin, 1991) - which supports the production of much of its consumption goods in non-renewable natural resources, with an industrial geography that does not coincide with the areas that hold their largest reserves (Gonçalves, 2000). In this dilemma scenario, overcoming environmental injustice situations related to petroleum production chain necessarily passes through a first unveiling step, bringing contamination and health risks of vulnerable social groups into society's lights, and a further one, finding strategies to at least minimize those risks, if changing local socioeconomic conditions is not short-term viable, despite of being aware that profound changes that would promote social and environmental equity requires an alternative model of development.

Located in the epicenter of "hydrocabon economic boom", Jurubatiba Shoal (Restinga de Jurubatiba) has suffered the impact for being in the vicinity of Cabiúnas Petroleum and Gas Terminal, which receives all Campos Basin oil and gas production and is responsible for primary treatment of production water as well as its discharge in marine environment (near the buffer zone of Comprida Lagoon coastal area). Ten kilometers of the effluent pipeline which belonged to Cabiúnas Terminal's effluent treatment unit (ETU Cabiúnas) passed through Restinga de Jurubatiba National Park, before discharging production water four kilometers from the coast. The Jurubatiba National Park's Advisory Council, composed of local social actors from Public Regulatory Agencies, regional entrepreneurs, environmental NGOs and community associations, including Lagomar Balneary's residents Association, demanded an estimate of the damages associated with the ETU pipelines installation and operation.

The urban district focused in this study, called Lagomar Balneary is located on the shoal, considered as a permanent preservation area by Brazilian Forest Code, since 1965, which by this reason should be kept untouched by human beings. The disordered and illegal occupation of the area is told by older Macaé inhabitants to have been promoted by local government, since the mid 90s, when with the intensification of migration from poorer regions of Brazil, the influx of population, consisting mainly of northeasters, in the case of Lagomar, was driven by accelerated economic patters brought with petroleum production chain.

The menace to coastal and shoal ecosystems, together with social growing pressures towards densely occupying the area led to a huge articulation between researchers and environmentalists that resulted in the creation of Jurubatiba National Park, in 1998, an Integral Protection Conservation Unit. (CU). However, since 1994, the ETU was already installed, with environmentally licensed by Rio de Janeiro State government. When the CU was created, its Federal managers faced a quite unusual situation: despite shoal suppression and/or occupation was not

allowed to common people, an effluent and various petroleum pipelines crossed the CU. Despite of no oil leakages related during those oil pipelines operations, the production water pipeline leaked 52 times in less than three years inside the CU, near interconnected coastal lagoons and groundwater sources, used in several ways by Lagomar Balneary's inhabitants (recreation in lagoons and water pits supply for poor households can be detached). Other potential contamination conditions and health risks, associated mostly to mixed land use and disordered occupation were theoretically probable to be occurring, and deserved confirmation.

Despite monitoring procedures designed to ensure that conservation and environmental protection should be considered throughout the planning and implementation stages of development (Gibbs, 2007; Filho et al., 2009), regarding CU's surroundings, and considering only direct impacts of oil onshore support facilities, expenditures with environmental monitoring tend to be bigger for higher ecologically relevant sites and can so be neglected when externalities are not adequately estimated.

Thus, taking the controversial premise that environmental valuation can be regarded as an important tool to biodiversity conservation (OECD, 2002) as a starting point, and hypothesizing that in the case of fragile economic populations in Integral Protection CUs' surroundings it might also help to promote environmental justice, this work presents an methodological proposal for valuing impacts related to offshore production water in shoal ecosystems functions and services, by combining existing models and methods and applying them for Restinga de Jurubatiba. The combined methods model developed was adapted from IBAMA's (Brazilian Federal Environmental Agency) model for calculating the economical values for impacts and damages related to pipelines located in Brazilian CUs.

2. **Facing petroleum industry and promoting environmental justice in coastal areas – the Lagoamr Balneary case**

Environmental injustice can be characterized in situations when fragile socioeconomic communities are differentially submitted to risks associated to industrial contamination, and or are preferentially affected by indirect negative impacts brought by huge economic enterprises (like oil and gas industry).

Since 1999 Macaé (Fig. 1) was consolidated in Brazilian petroleum industry scenario as one of the major producers. As the second largest receiver of royalties transfers from oil and gas production in the Campos Basin (CEPERJ, 2010), Macaé lives with abundance brought by the financial resources influx related to oil and gas, production chain, on the one hand, and urban equipments, infrastructural interventions, urban planning and environmental sanitation scarcity, on the other hand. It is worthwhile noticing that despite of having an annual GDP per capita Macaé of approximately U$ 15,000.00 (IBGE, 2010), considered high for most Brazilian municipalities, in 2007 almost 50% of Lagomar Baneary residents did not have access to public sewage disposal systems. Regarding the observed percentage of growth from 1970-2007, Macaé grew at a rate of approximately 3.6, compared to 2.0 for Brazilian average rate, to 1.7 in Rio de Janeiro State, and to 1.6 for the North of Rio de Janeiro at the same period.

As stated by Soffiati (2007), with the discovery of oil fields in the Campos Basin and the subsequent construction of the installations of PETROBRAS in Macaé, the city began to receive thousands of people from all across Brazil, attracted by employment expectations. Many of those migrants were not qualified enough to work for petroleum industry and ended up marginalized, increasing not only urban violence levels but also invasion environmentally protected areas.

Associated with environmental and social problems caused by the process of extracting oil and gas, the city's growth has generated a pressure on the estuary (Costa and Ferreira, 2010). In some places there is a dizzying process of urbanization for the poor, becoming consolidated in a few points: (i) on the right bank of the old river, (ii) within the island colony Leocadia, (iii) in the stretch end of the channel-Macaé Campos, (iv) and on the left bank of the river. Urbanization, in addition to suppressing important areas, causes another major problem:

increased release of chemicals (Lacerda et al., 2008).

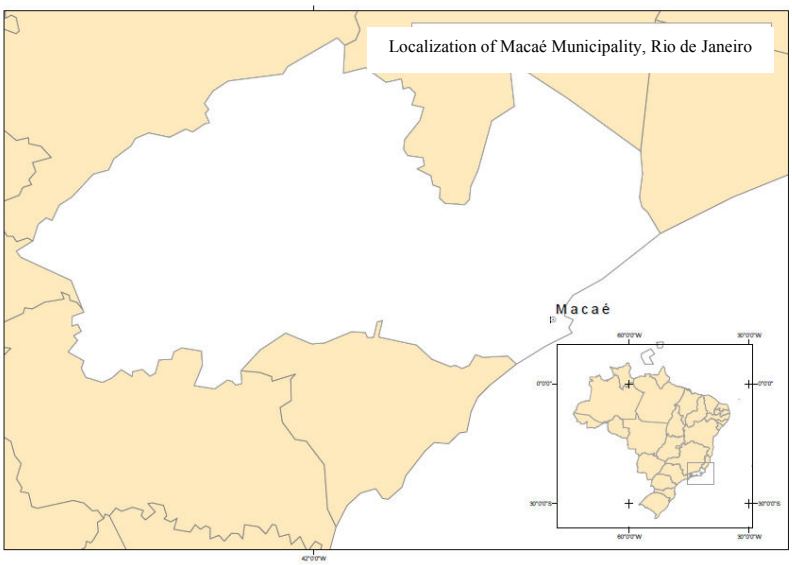

Fig. 1. Localization map of Macaé municipality, in Rio de Janeiro State, Brazil.

It should be noted, as evidenced in the Economic Vulnerability Map of Macaé's urban area (Fig. 2), that neighborhoods Lagomar Balneary (located near the terminal Cabiúnas, and therefore subject to risks of chemical contamination) exhibits very high vulnerability (more than 40% of resident population that works and responded to the interview to win a minimum wage). The crossing of industrial pollutants contamination sources associated with oil and gas production chain, promoted by disordered growth patterns which are evident in the city, together with above mentioned risks and social vulnerability confirms the hypothesis of the existence of environmental injustice in the city, to the impacts associated secondary and indirect oil industry.

Being located on the border of Jurubatiba Restinga de National Park, which is protected by the Federal System of Conservation Units' Law - SNUC (Brazil, 2000), Lagomar Balneary would theoretically also be object of special regulations in terms of land use and occupation because the SNUC Law states that human activities allowed to be developed in the region are subject to restrictions and should cause minimum negative impacts. Due to sandy and high permeable shoal soils, environmental damages caused by direct disposal of waste and effluents by or accidental contamination may be greater, because the area sits on sandy soils, or high permeability with high water table in some places. Furthermore, interconnected lagoon systems can worsen environmental risks. From field observations and in situ data collection, it can be stated that the location does not have effluent treatment systems nor safe water supply, making use of wells, often without evaluating water quality, neither making any king of water treatment. Poor or lack of effluent treatment systems at one location increases the potential for contamination of water bodies. In soils with high permeability shallow groundwater, the hypothesis that water quality may be being affected by contamination from domestic sewage seems plausible, and was verified in ten sample points in domestic wells or reservoirs. In 2007 95,1% of Lagomar Balneary households were served by dug wells, increasing potential risk of harm to public health due to water and soil contamination.

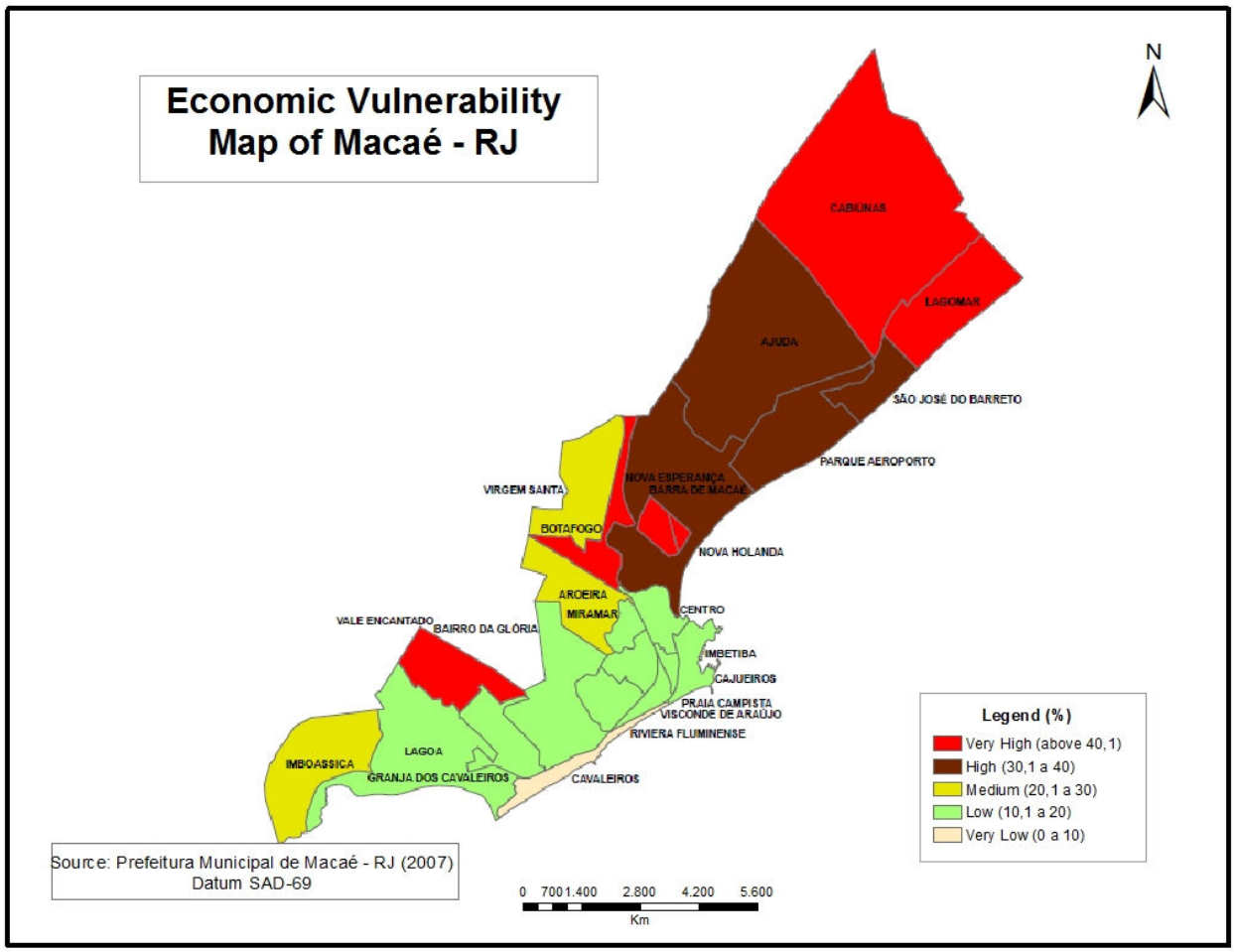

Fig 2. Economic vulnerability of Macaé urban districts.

If we consider the possibility of industrial contamination with hydrocarbon and heavy metals, present in petroleum production water, that leaked repeatedly inside Restinga de Jurubatiba National Park, close to the populated area, and think about interconnection between Jurubatiba's coastal lagoons and Lagomar's groundwater, we can paint a rather serious picture.

Between 2005 and 2006, one of the authors worked in a Safety Department of a small facility installed on Lagomar and had access to medical reports and absenteeism rates of facility's employees. It was then observed that the number of occurrences of non-occupational diseases in workers that lived in the neighborhood was often higher than that observed for non-resident workers. That fact can be linked to the inefficiency of environmental sanitation. During interviews made with residents during sample water collecting high colored water flowing from home taps was observed and told to be frequently by the 10 interviewed. Expanding the interviews from households to the doctor, the nurses, the nursing technicians and the health workers from the neighborhood Health Post we found that the most common local diseases that affect the resident population are (i) arterial hypertension, (ii) skin diseases, and (iii) respiratory diseases, and the latter two may be related to environmental contamination. One of the interviewed health workers stated that:

> *"Despite having years of experience in working with communities, I have never seen so many cases of skin diseases in the same neighborhood. When there is another and major health problem,*

skin diseases is not the motivation for going to the Health Post, but the doctor and his team also detect the skin problem, which affect either newborns, or middle aged persons and also elderly. You do not have to be a scientist to publish scientific stuff. Just go and watch in situ the problems of inefficiency sanitation in Lagomar Balneary. "

It is noteworthy that the high rate of skin diseases reported by local Health Post medical team may be related not only to waterborne diseases associated with domestic wastewater, but also to chemical contamination linked to oil and gas production chain industrial activities, which developed simultaneously with residential occupation there (Fig. 3). The land use and occupation in the neighborhood help to discern the inadequacy of the municipal urban planning in fulfilling requirements which are consistent with an Integral Protection CU buffer zone.

The threat of pollution that might impact fragile resident populations also haunted Restinga de Jurubatiba National Park. And if human beings' precarious situation was not enough to move public authorities towards minimization of environmental injustice alone, biodiversity conservation and ecological significance of Restinga de Jurubatiba National Park, together with a firm actuation of its Advisory Council, that, worried about high mercury levels in production water more than with domestic disposal, demanded on Federal Fluminense Institute team (which also integrates the Council composition) the valuation study described hereinafter. Entrepreneurs repeatedly tried to convince Councilors that valuing the pipeline impact on the CU was not possible because the lack of data, and also that there was no problem in maintaining discharge point at only 4 km from coast and coastal lagoons, in a region where fish consumption and groundwater supply is expressive.

In 2007, this study confirmed contamination of groundwater supply in samples collected in all ten points we presented on Fig. 3. Color, chlorine, nitrite, nitrate, turbidity, salinity, p.H., coliform (total and fecal) were evaluated in 4 campaigns, and deviation from threshold values in nitrite, turbidity and fecal coliform were found in all campaigns, varying from sample point to point, thus confirming contamination. Fecal coliform has appeared in all samples of untreated water, even in point 04 (homely treated water), which reached a value greater than 200 *E. Coli*/ 100ml. It is noteworthy that the average of the results for this parameter has risen, from first to last campaign, and that coliform was present in 7 of 30 samples in and 60% of collection points (03, 04, 05, 06, 08, and 09) Sample analysis results showed contamination of groundwater in the region of Lagomar, which can be classified as unproper for human consumption, according to Brazilian Health Environment regulations. Heavy metals levels on groundwater were not investigated due to funding limitations.

3 Restinga de Jurubatiba environmental functions and services

Restinga de Jurubatiba is a protected ecosystem, whose ecological intrinsic value has been worldwide ratified by its choice as one of the biosphere reserves in Earth. Despite its importance in climatic regulation, carbon caption, hydrological regional equilibrium, as well as feedstock and water source of biodiversity maintenance, Restinga de Jurubatiba is located in the epicenter of Campos Basin's petroleum exploration and production activities (Tougeiro, 2010). Fig. 1 shows the schematic location of Jurubatiba Park and regional petroleum pipelines. During 2001 and 2002, Jurubatiba Park has been submitted to impacts caused by Cabiúnas Terminal, which receives all oil and gas produced in Campos Basin, and further distributed to consumers and/or refineries.

Fifty-one leakages occurred inside the CU between 2001 and 2004, from which 50 were due to a buried production water pipeline, and 1 to the Cabiúnas ETU suspended pipeline that was installed in the CU afterwards to facilitate

leakage visual detection. The over salted production water contains some dangerous contaminants used to be discharged in the coastal zone of Jurubatiba Park, which suffered with fifty-one leaks of production water into its soil, near Comprida Lagoon, a protected site include in the International Long Term Ecological Research Program (ILTER), about ten km distant from Lagomar Balneary. In order to estimate the damages associated to those successive production water leakages, it would be necessary to propose a method able to generate shoal ecosystems functions and service values, yet unpublished in academic literature.

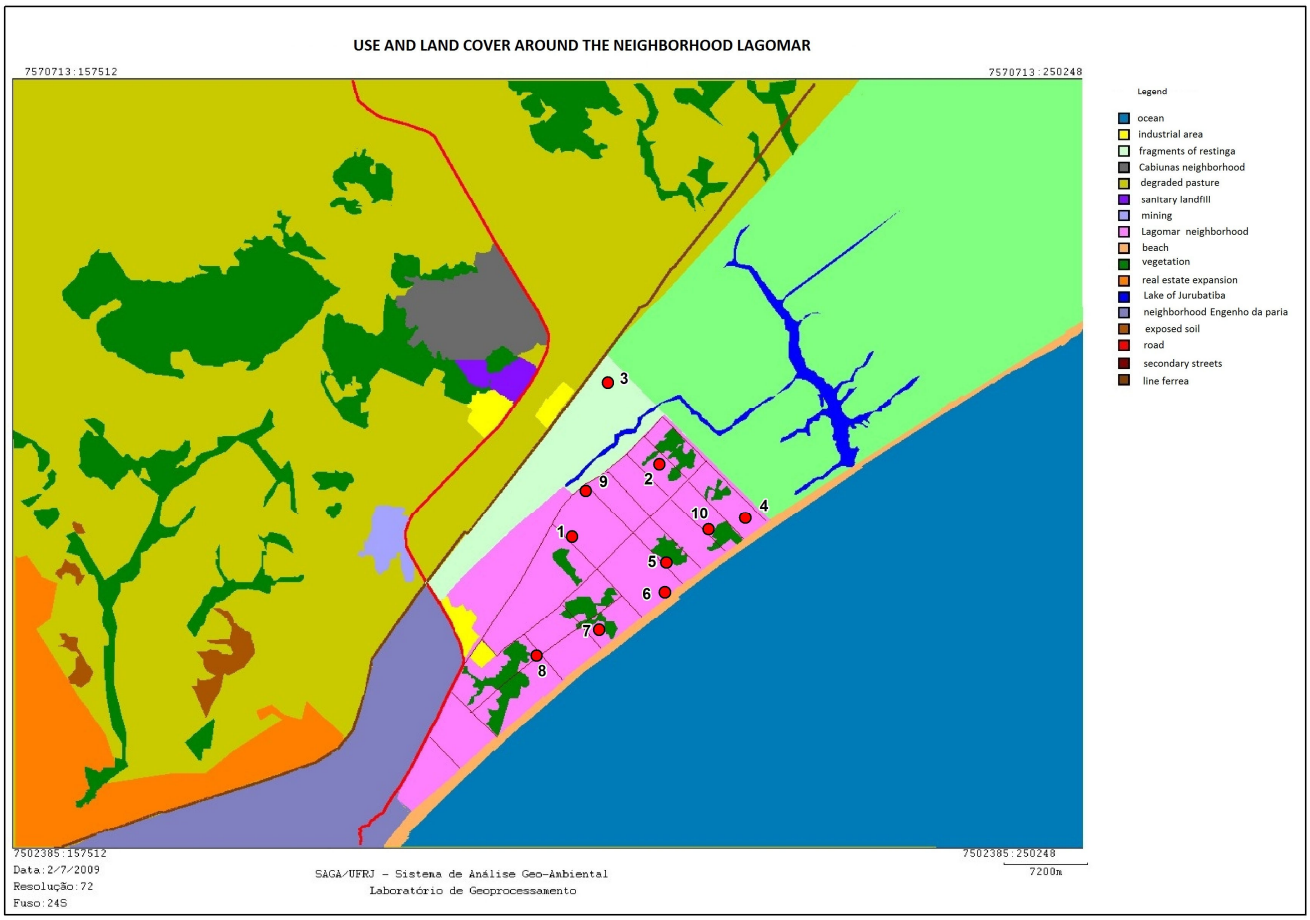

Fig. 3. Thematic map of use and land cover around the neighborhood of Lagomar Balneary, indicating points where water samples were collected.

Although the valuation of some tropical ecosystems, mainly forests, has been extensively investigated and reviewed (FAO, 1995; Costanza, et al., 1997, IBAMA, 2003), the environmental characteristics of shoals ("restingas") are very specific, despite of being considered associated with Atlantic Forest biome. Despite similar general classification of use values, it seemed appropriate to apply specific and combined valuation methods to obtain use values' parcels for Restinga de Jurubatiba, which can be related to main shoal ecosystem functions and services (Table 1).

Regarding applied valuation techniques, obtained results were based on on division of ecosystem values into five categories of use and non-use values, according to IBAMA´s model, which estimates the total value of the environmental impact/damage (*TIV*) of

pipelines and transmission towers on ecosystems, generically.

Table 1
Methodological proposal for valuing shoal protected areas through main ecosystem uses, values, goods and services found in Restinga de Jurubatiba.

Use/Value	Good/Service	Valuation Technique	Required Data
Consumptive Uses/ Option Values	Sustainable Timber Products (natural or cultivated) Sustainable Non-Timber Products (natural or cultivated)	Hedonic Pricing	Properties' market value of National Park's buffer area /market prices of timber and non-timber products
	Medicinal Plants Genetic Resources	Avoided Costs Method	Costs of specific research projects and programs costs conducted in Restinga de Jurubatiba
Direct Non-Consumptive Uses	Recreation of local communities/ Scenic beauty/ Ecotourism	Contingent Valuation Method	Visitors and local community's perception: evaluation of WTP/WVW
		Travel Cost Method	Annual mean visiting frequency and travel costs/ Costs of specific projects and programs costs conducted in Restinga de Jurubatiba
Indirect Uses (Ecosystem Goods and Services)	Environmental Education Climate regulation Gas regulation Water regulation and supply Nutrient Cycling Soil formation and erosion control Pollination Refugia and biological control	Avoided Costs Method	Costs of specific projects and programs conducted in Restinga de Jurubatiba
Existence Values	Cultural Patrimony	Contingent Valuation Method	Visitors and local community's perception: evaluation of WTP/WVW (field data and related environmental resources' intrinsic values)

Notes: WTP – willingness to pay; WVW – willingness to do voluntary work.

The *TIV* is composed by the sum of five parcels multiplied by a reduction factor (social factor, *SF*) related to local community and visitor's perceptions of facilities' environmental risks as well as ecosystem existence value (Eq. 1):

Where:

TIV = total impact value: the value of the environmental impact/damage on an specific ecosystem;
*P*1 = loss of use opportunity;
*P*2 = scenic impact value;
*P*3 = ecosystem impact;
*P*4 = loss of visitation;
*P*5 = facility's environmental risk;
SF = social factor.

$$TIV = (P1 + P2 + P3 + P4 + P5).SF$$

To adapt this generic model to Restinga de Jurubatiba, the ecosystem functions and services value were calculated by applying the same principle of summing parcels, but also estimating values for consumptive and non-consumptive real and possible uses of Restinga de Jurubatiba, as previously proposed by the authors (Ferreira et al., 2004) and illustrated in Table 1. Four parcels were used to estimate total ecosystem economic value (*TEV*):

$$TEV = OV + RV + IUV + EV$$

Where:

TEV = total ecosystem valueç
OV = option value (consumptive uses);
RU = recreation value;
IUV = indirect uses value;
EV = existence value.

Necessary data was collected in official documents, governmental agencies and other researchers direct information, and also in field research which consisted in applying 150 questionnaires to local community and visitors. Total Conservation Unit Area (*TCUA*) which was obtained by summing Restinga de Jurubatiba National Park areas located in the cities of Macaé, Carapebus and Quissamã (from LANDSAT data, scale: 1:50,000).

Normalization of all restinga's use values parcels in US$ was done by dividing them to TUCA and to the period in which data was available and/or it was collected (2001 – 2005), converting them into US$/m^2 .a values, as shown in Table 2. Differently, normalization of all production water pipeline impacts values parcels was done by dividing them to pipeline length and multiplying them by the mean of Brazilian National Treasure Reference Discount Rate in 2002- 2006 period (*TR*), to obtain US$/km.a values, as shown in Table 3. Model calculation was performed with the aid of Microsoft Office Excel 2003 plans, in which equations described in the next section were programmed. This procedure facilitates managers' dealing with the model, just by inserting necessary data, and thus obtaining calculated values of ecosystems function and services, as well as production water pipeline's impacts is this kind of protected area.

Despite of possible consumptive future uses of Restinga de Jurubatiba (some of them practiced in National Park's buffer zone but not allowed inside the CU) protected area, option value (*OV*) was calculated only by Hedonic Price Method, assuming the value obtained to be a minimum one. In terms of possible direct and non-consumptive uses and services, a global value was calculated by combining contingent valuation, travel cost and avoided cost methods. As warm-up questions it was asked to visitors if they knew the content of the pipeline, and if their willingness to pay for entering the CU would be changed if the pipeline were not installed there (once the intention of the study was not to value the ecosystem isolated from the pipeline's impact).

At this point of calculation, application of *WTP* could also have been done. However, it is known that environmental valuation based on *WTP* often leads to conservative results, due to the impossibility of calculating intrinsic ecosystem's values (NOAA, 2007), as well as to the lack of ecosystems and/or market data which would allow to consider other expenditures related to conservation and sustainable uses of restingas' benefits. Underestimation can also be associated to contingent valuation methods application in developing countries, due to the low income levels visitors. Considering this, the authors decided to use *WTP* only for estimating loss of visitation due to the pipeline's facilities. Regarding Travel Cost Method, it is worth mentioning that actual annual visitors' expenditures for entering into the CU could be directed calculated by Governmental fees, if visiting the area were legally permitted. This is still not happening in Restinga de Jurubatiba National Park, because visiting procedures are yet to be regulated. Environmental Education related services were not considered among these direct non-consumptive use values, neither among indirect use values, and were incorporated into existence value parcel.

In applying avoided cost method to estimate indirect uses, ecosystem goods and services, the authors proposed to consider Brazilian officially available data of Jurubatiba related scholarships and research projects, once that intense research in the CU is closely related to them. The data considered research awards for undergraduate students, master and doctorate degrees scholarships, and other types of research scholarships. It was also composed by expenditures related to the Long Term Ecological Research Program, impact assessment environmental monitoring and other Research and Management Projects and Programs that received governmental support during 2002 to 2006 (duration time of data gathering and availability considered for this environmental valuation study). If the creation of the CU was considered as initial time, estimated IUV_{ECO} would be higher. Avoided cost method and contingent valuation were

combined to estimate Restinga de Jurubatiba existence value (*EV*).

The final TEV values thus obtained (total and normalized) are shown in Table 2, and recognized by the authors to be minimum, due to all uncertainties and lack of data present in calculations and presented here.

Table 2. Minimum values for Restinga de Jurubatiba Ecosystem enviromnetal functions and services estimated by parcels.

Use Value	Model Result 1 (US$/ha)	Model Result 2 (US$/m^2.a)
Option Value	99.233,74	0,0198
Recreation Value	333.003,67	0,0666
Ecosystem Value	15.988,63	0,0032
Existence Value	707.978,87	0,1416
Total Restinga Value	1.156.204,91	0,2312

As shown in Table 2, calculation of the four parcels of Restinga de Jurubatiba ecosystem values led to very low results in terms of option, recreational and ecosystem values, mainly due to the fact that most of the specific goods which belongs to the protected area can not be transacted in market, and therefore were not included in cost valuation procedures. Furthermore, visiting activities in Restinga de Jurubatiba National Park are not yet fully regulated, and limited number of visitors and tourism programs are allowed. It is also worth noting that existence value parcel was the most effective contribution to restinga ecosystem total value, once that the data on monitoring, research and environmental education programs, as well as on environmental compensation is easily obtained in brazilian governmental agencies. Although preliminar, this study led to ecosystem value of US$ 0,23/m^2.a, in the same order of magnitude of tropical forest total value estimated by Costanza et al. (1997) (US$ 0,20/m^2.a).

4. Valuing production water pipeline impacts in Restinga de Jurubatiba

The extensive pipeline installations presently operating in Campos Basin, Brazil, crosses important protected areas and ecosystems, such as Atlantic Tropical Forest, mangrove areas, restingas, lagoons and rivers, some inside and others outside Jurubatiba region. The case of the abnormally frequent production water leakages inside Restinga de Jurubatiba National Park demanded further studies, regarding its importance as biosphere reserve and international research site. Valuing Restinga de Jurubatiba ecosystem environmental functions and services with the methodology described in section 3 was therefore the first step to the subsequent calculations of minimum impact and damage pipeline values.

Field researches made during 2001-2004 period, revealed the occurrence contaminants, mainly sulfides and mercury, whose levels where high above allowed legal parameters. Mercury levels were particularly alarming: almost twenty times higher than those allowed by Brazilian regulations. Furthermore, the temporary disappearance of three lizard species – *Cnemidophorus litoralis*, *Ameiva ameiva* and *Mabuia sp.* during apparent pipeline installation procedures was reported (Ferreira et al., 2004). Lack of water production and other enterprise related activities impact data on Jurubatiba's fauna and flora (which brings more uncertainty to valuation results) led, at least, to a minimum environmental compensation value that could be established and presented to entrepreneurs (Table 3), composed by five impact parcels.

hus facilitating its implementation by CU's managers, in non developed countries, they often have a small thechnical team and few financial support. The values seem also adequate to be applied as a first approximation for restinga's TEV and production water pipeline facilities' TIV in cases when

environmental impact assessment and/or monitoring data is not available.

The parcel of loss of opportunity in using the area (*P*1), is closely related to the area directly affected by the facility's use restrictions (pipeline exclusion installation area), and was thus associated with an easily available data: buffer zone land market values. Differently from *P*1, the calculation of scenic impact parcel (*P*2) involved indirect methods associated with visitors and local community's perception of aesthetic impact of the apparent pipeline (which replaced the original buried carbon steel pipe, decommissioned, but still located inside the CU. *P3* parcel can be mainly connected to the loss of ecosystem functions and services due to water and/or soil contamination, as well as to vegetation suppression, and associated boarder effects and other biota changes. The proposed model calculated *P3*, US$ km.a, summing three other values obtained by combining avoided and replacement costs methods, while loss of visitation due to the pipeline's facilities (*P4*) was calculated by Contingent Valuation, applying the willingness-to-pay for entering the CU without the pipeline.

Instead of employing pipeline failing, as originally suggested in IBAMA's model, the calculation of facility's environmental risk value relied on projected expenditures for monitoring pipeline impacts on fauna/flora and on soil/water quality, once that the abnormal leakage frequencies observed in that specific facility would result in excessively high impact values, which could not be generalized to similar enterprises. In that specific case, pipeline observed failing frequency was 100 to 10,000 higher than those reported in literature of gas and oil pipeline failures (CONCAWE, 2001; EGIG, 1999). The calculation is still valid once that monitoring programs are not yet fully established, reaffirming the importance of alternative valuation procedures for not developed countries, where ecosystem importance is generally surpassed by economical growth public policies.

As seen in Table 3, the modeling procedures now proposed and used for estimating Restinga de Jurubatiba total economical value (*TEV*) and for obtaining total production water pipeline impact value (*TIV*) resulted in rather low values. That underestimation is related to the limited data available in Federal Environmental Agency and the difficulties in gathering information on scholarships and on expenditures research monitoring and tourism projects conducted in Jurubatiba area. Although knowing about how conservative those results, IBAMA has applied it as a first calculus basis for environmental compensation for that specific pipeline case. The proposed method has the advantage of being simple and having relative low costs, thus facilitating its implementation by CU's managers, in non developed countries, they often have a small thechnical team and few financial support. The values seem also adequate to be applied as a first approximation for restinga's *TEV* and production water pipeline facilities' *TIV* in cases when environmental impact assessment and/or monitoring data is not available.

Disregarding the magnitude of calculated *TIV*, IBAMA´s model recommends the estimation of a parameter so called social factor (*SF*), that permits to reduce the calculated impact value according to the perception that ecosystems' users have about the social importance of an specific enterprise. This procedure is particularly recommended for depicting social acceptance of pipelines and telecommunication towers and similar facilities localization inside protected areas, more specifically inside Brazilian National Parks. In this work, *SF* evaluation involved 180 responded questionnaires, applied among local community visitors and fishermen (from poor and low-middle classes); students, teachers, researchers and environmentalists; petroleum industry workers and other middle and high local working classes (who do not belong to students, teachers and researches group), distributed as shown in Fig. 4. Used to go to Jurubatiba at least yearly, the interviewed visitors revealed a high rejection level for pipeline installation inside the CU (Figures 4 and 5), suggesting that *SF* calculation would not be relevant for the already low *TIV* obtained results.

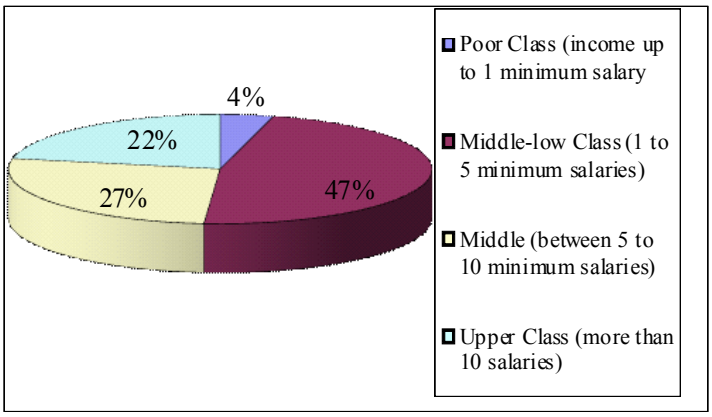

Fig. 4. Visitors' profile involved in the interviews for SF determination of production water pipeline impacts in Restinga de Jurubatiba.

Table 3
Impact values for water production pipeline installed in Restinga de Jurubatiba National Park (10 km onshore and 4km offshore).

IMPACT PARCEL	Net Value (US$. 10^{-6})	Annualized Value (US$/km.a)
Loss of Opportunity in Using the Area	0.066	187.52
Scenic Impact Value	0.274	555.04
Ecosystem Impact	2.143	4,340.57
Loss of Visitation	0.016	46.05
Facility's Environmental Risk	1.537	3,112.78
Total Production Water Pipeline Impact Value (TIV_{FS})	3.913	7,988.29

Despite of high rejections observed among visitors regarding to the presence of the production water pipeline inside Restinga de Jurubatiba (Figs. 5 and 6), impact values results shown on Table 3 were corrected by the social factor (*SF*), which can reduce *TIV* values initially estimated:

$TIV_{FS} = TIV \cdot SF$, where $TIV_{SF} \leq TIV$

Figs. 5 and 6 evidence not only an specific rejection for production water pipeline in Restinga de Jurubatiba National Park, but also for all kind of such facilities inside Brazilian National Parks, including effluent, crude oil, natural gas, vehicular gas, gasoline, diesel, and other fuels. This result was considered very expressive by the Federal Public Minister who arbitrated Jurubatiba National Park's Consultant Council against the entrepreneur which operated the offshore terminal facility.

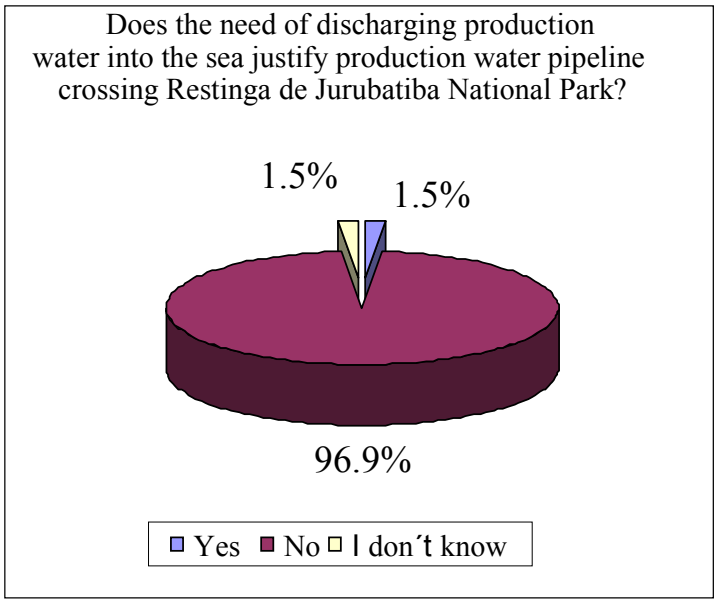

Fig. 5. Jurubatiba visitors' acceptance of locating water production pipelines inside Restinga de Jurubatiba National Park.

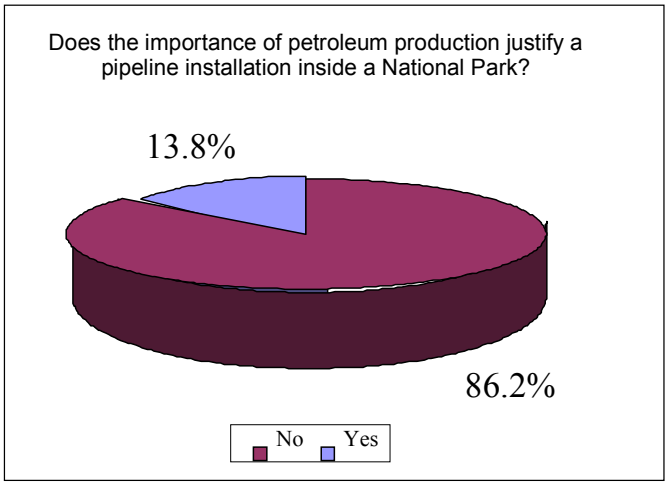

Fig. 6. Jurubatibas visitors' acceptance for petroleum related pipelines crossing Brazilian National Parks.

SF estimating procedure consisted of relating the percentage of visitors who think that the importance of petroleum production justifies a pipeline installation inside a National Park and the score ranking values for visitors' individual preferences for allowing seven different kinds of fluids to be hypothetically transported by pipelines inside Brazilian National Parks: crude oil, natural gas, gasoline, vehicular natural gas, other fuels effluents (including production water), and potable water. *SCORE* parameter was calculated by frequency distribution curves transformed into visitors' distribution of preferences.

$$FS = \left[1 - \left(\frac{\%JUST}{100}.SCORE\right)\right]$$

$$TIV_{FS} = TIV \cdot SF$$

SF values close to unity (Fig. 7) confirms a previously supposed low reduction in *TIV*, despite of the social importance petroleum production. However it is worth remembering that multiplying production water pipeline facilities' *TIV* by 0.9692 (*SF* for production

water) could cause significant reduction in environmental compensation owed to the CU in absolute terms. The present study helped to convince Brazilian authorities to suspend pipeline operation inside the CU temporarily, as well as effluent release in Jurubatiba coastal zone permanently, since 2007, and the pipeline was finally removed from Restinga de Jurubatiba National Park and Lagomar surroundings.

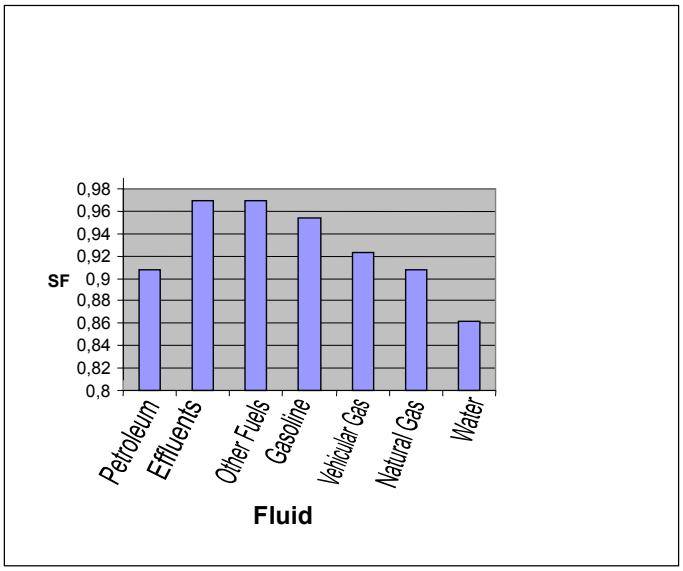

Fig. 7 different fluids pipelines' social factor (SF)

5. Conclusion

Ecosystem functions and services of restinga could be estimated by combined valuation methods, applying easily gathering protected area data, with low cost procedures especially recommended for non developed countries, in which environmental assessment and monitoring practices are not fully implemented. The proposed methodology gives as result a minimum value for Restinga de Jurubatiba (US$ 0.2312 /m^2.a), an ecosystem associated to Atlantic Forest biome, which was close to tropical forest values previously reported elsewhere. Although the present study, based on adapting known valuation methods and Brazilian Environmental Regulation Agencies' General Guidelines generated underestimated values of production water pipelines operating in tropical coastal zones, it can be used as a first approximation procedure when detailed environmental data is lacking and when governmental agencies have to give otherwise impossible technical answers on compensation values to be charged for such damages. Valuation can help to overcome very specific situations when biodiversity conservation together with social participation and mobilization (such as in Jurubatiba National Park's Advisory Council) can move Brazilian public authorities towards adopting environmentally just and correct measures.

Considering the disruption traditional modes of use and appropriation of natural resources practiced in Jurubatiba region less than one century ago, and all the profound changes in life and economy of North of Rio de Janeiro State`s coastal regions propelled by petroleum industry which came together with migration of unskilled workers, seduced by broken promises of prosperity and dreams of finding very well-paid jobs, propagated by the media. The dangerous luster of the economical heating promoted by oil and gas production chain, also promoted the occupation of less dense municipality's peripheral sites, mainly in protected areas (such as mangroves, riparian forest and restingas), which are characterized by having restrictions on use and human occupation and classified by the Brazilian Forest Code as Permanent Preservation Areas. In the case of Lagomar Balneary, illegal and

disordered occupation rules, and a social vulnerable population lives without basic sanitation in low residential appreciation conditions, coexisting with small industrial activities and very close to an oil and gas terminal, using groundwater taken from shallow wells which are excavated very close to off-specification home-made septic tanks. Environmental degradation arising from the inadequate management of household waste and/or from industrial emissions and leakages vicinal to economic vulnerable population confirmed initial hypothesis that as an indirect impact of petroleum production chain one can cite environmental injustice. Despite the Brazilian society is used to realize just the bonuses arising from the economic boom of the oil and gas industry, there is a heavy burden being carried by poor people and traditional populations, who have little benefit from the illusory prosperity brought by the current development model.

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