Management Challenges on Small-Scale Gold Mining Activities in Brazil

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This article presents a focused study of environmental management in small-scale gold mining, called garimpo, at the Tapajós River in the Amazon basin (Brazil). Environmental management is necessary in this very important area not only for Brazil but for the general world welfare. The fact that this is a very dispersed area, with a very low economic and education level, complicates the issues. Added to these factors are legislation, administration, and control processes which are shown in their historical, technical, health, and economic aspects. Using systemic integration, the article describes how the inherent interests of each part directly or indirectly involved may be articulated to result in self-control. The same approach reveals also the potential conflicts. Some existent proposals are analyzed with regard to the extent to which they can work, given the described aspect.

Key Words: environmental management; small-scale gold mining; systemic integration; self-control; mercury pollution; garimpo.

INTRODUCTION

The economic development has been increasingly subdued and reconsidered under the recent emergence of environmental concerns. Dialectic was then created: the environment is the greatest human asset and its resources are used to promote development; on the other hand, if the environment is devastated, human survival becomes jeopardized.

The Amazonia has had to live with such environmental conflict since the 1980s, when preservation concerns became evident, after a decade of integrationist and occupational policy. There is nowadays a special need for preserving the natural resources, such as water, at risk due to the harmful effects of development and the lack of an effective control against it.

In fact, it is known that large-scale activities bring pressures against control, but sparse and multiple small-scale activities also create enormous difficulties for the implementation of control. This is the case for small-scale gold mining in the Amazonia, a local activity that does not devastate the forest, but may cause serious environmental problems if inappropriate procedures are used.

Amazonia is the region around the Amazon River, the largest river in the world in volume of water carried and 6280 km long. The complete Amazonia is 7.8 million km² in area, comprising 60% of the combined areas of Bolivia, Brazil, Colombia, Equador, Guyana, Peru, Suriname, and Venezuela. The Brazilian part of the Amazonia is called “Legal Amazonia,” and its greatest part is located in the north region of Brazil, spread in nine states: Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and Maranhão.

This area is one of the remaining repositories of planetary biodiversity and an important part of the Brazilian culture. Because of its being a huge source of natural resources, since the 1970s Amazonia has been suffering from wrongful developmental policies, based on the dictates of occupation and integration with the Brazilian center–south predominant economy. These policies allowed vile capitalism to be used many times for personal enrichment at the expense of the extraction and extinction of natural resources. New world attention to this situation in the 1980s fomented discussions on both the character and the effects of this occupation, to both the land and the local communities, evidencing the confrontation of the social forces at play.

By the end of the 20th century, the Amazon Basin was pending between the need for planned and intelligent occupation and the concerns of environmental preservation. The advancement of economic interests usually provokes environmental degradation by use of aggressive land clearing techniques for wood...
exploration and cattle breeding, in addition to the degradation to the ground cover and soil caused by activities related to ore extraction or even great projects, such as hydroelectric projects.

Gold is among the natural mineral resources that deserve special emphasis, due to its influence in the region's social organization. Mercury is used in gold mining, causing several forms of environmental impact. This impacting agent will be treated in this article, covering small-scale gold mining management and performance in addition to the contradiction between short-term gains and self-sustainable development.

The largest garimpo, or small-scale gold mining site, is found in the central area of the Tapajós River basin, an affluent of the Amazon River (Fig. 1), between the Jamanxim and Tapajós Rivers, in an area greater than 100,000 km². Since 1980, in this area, at 460 garimpo mining sites and 340 landing strips (Silva, 1997), 140,000 miners produced approximately 500 tons of gold (Veiga, 1997). The peak production, in 1989, came to 4 tons of gold per month. According to the Brazilian Geological Research Department (BGS-CPRM), there are still over 300 active sites in the Amazonia, 60 of them in the Tapajós area, where the production rate is currently 0.2 tons per month. In the 1990s, garimpo activity was responsible for the emission of up to 120 tons of mercury per year (Veiga, 1997).

SEICOM (Commerce and Industry State Secretary) estimates actual reserves of 50 tons of gold in the region, but the alluvial (secondary) superficial reserves are disappearing and gold mining is going to the deep primary deposits. The gold commercialization center is located in Itaituba city, on the left margin of the mid-Tapajós river, around 250 km from the nearest main city, Santarém, and 891 km in a straight line from the state capital city, Belém. The travel time between Itaituba and the garimpo areas varies from 30 to 120 min by plane or from 2 to 3 days by boat.

This article presents an analysis of the garimpo in the Tapajós area (Fig. 1) and the critical points for the implementation of systemic integration for environmental management. In a possible way to achieve this control, some of the different interests are considered with regard to use of a systemic conception to induce self-control, in a way that, at the same time, all the parties can achieve a political or financial advantage while environmental impacts are minimized.

DESCRIPTION OF TAPAJOS AREA AND GOLD MINING

History

Gold has been known to exist in the Tapajós area since the 18th century, but gold mining as an activity began only since the commercial decline in latex extraction from rubber trees. In 1958 an expedition of 60 people came to the Tropas River, an affluent of the Tapajós, River, and found gold. In the next decade, some other sources in the river Tapajós, Crepore, and Jamanxim were found and explored. During those years, gold mining remained essentially a manual activity.

In the 1970s, the construction of the giant roads of Transamazonica and Cuiabá–Santarém brought many more people to the region, along with the increasing prices of gold in the international market. These factors contributed to the mechanization of the gold mining activities in the region, when the alluvial gold was being exhausted and the work was being transferred to the large rivers, requiring high-pressure pumps for initial processing and transportation. The final processing, called concentration, however, remained rudimentary until the end of the decade.

A pioneering association was created by the local government (Miners Assistant Foundation) to organize, register, and provide technical orientation for the workers, in addition to providing materials for reasonable prices. This program was discontinued after 2 years due to the lack of political incentive. Starting in 1978, indeed, boats and machines began to deteriorate the riverbeds, and other predatory exploitation methods were developed, damaging both the mineral production itself and the environment as a whole (Rodrigues et al., 1994).

Methods

The secondary veins in the Tapajós area, represented by the river terraces and watercourses, have been
intensely explored since the 1970s and are becoming scarce nowadays. The methods used in these cases are hydraulic dismount, for river terraces, and dredge work, for watercourses (National Mining Production Department (DNPM), 2001).

In hydraulic dismount, the miners use water jets to remove land strips, which go by gravity to pools. In these pools, gold pulp is formed, and operators use suction pumps to put it into rudimentary sluice boxes, 12% sloped, with a wavy rough bottom to retain heavy material. Usually, mercury is used at this stage to improve gold recovering by amalgamation. The heavy material in the boxes goes to final concentration in a conic tool called “bateia,” through rhythmic rotation, water in and out, in a way that light material is removed and heavy mineral is retained. The next step is separation. Part of the mercury, around 25%, is recycled. It is removed by distortion of the mix with cloth. The residual mineral is burned in open air, and mercury evaporates (Fig. 2).

In the Tapajós area, around 4 liters of gold pulp are driven to one “bateia” each 9 min, representing from 0.3 to 1 m³ of mineral/h. The mean recovery of gold is 55%. The correspondent daily dismounted land amounts to 90 m³. Each week, mercury is used again to wash the sluice boxes and recover all the residual metal.

Dredge work is used to remove submerged mineral from the watercourses. Usually, a boat on buoyancy tubes carries the centrifuge pump, two hoses, and the concentration box. One of the hoses stays submerged, and a cylindrical piece is attached to select the granularity to be admitted. The material caught by the pump is placed in the concentration box. Every 40 h, the box is washed with mercury to recover the pulp. The pulp is shaken in the “bateias,” in a process similar to that described above.

As the secondary veins are becoming scarce, the primary sources are going to be the main targets of garimpo in the Tapajós area. The miners are searching for gold in areas surrounding the former secondary sources. In these cases, the environmental impacts are larger, and the law requires the miners to submit an exploitation plan to the DNPM and wait for an approval to start working. Despite that, the garimpeiros have been working illegally.

In primary sources, gold is always combined with quartz or another mineral, and the ore caught by the pump is ground into small pieces in hammer mills. After that, the process is the same as that described above for secondary veins.

With all of the methods, the discarded material goes to the river, causing turbidity and shoaling. The worse effects are caused by the dredge work, which uses scarification products to remove the sediments, and usually drops oil in the river, destroying the plankton and the aquatic fauna.

In resistance to this deterioration, the Environmental Secretary of Itaituba is trying to select and apply low-cost technology based on the acceptance by the garimpeiros. For that, they are implementing the “Model Garimpo,” for which the main techniques involve dams and decantation basins to avoid mercury transfer from the small to the large rivers. Retorting is being stimulated to avoid excessive emission of mercury. Some garimpeiros are learning to make holes in the sluice boxes to retain the heaviest mercury concentration.

The artisanal equipment used by the garimpo largely contrasts with the heavy and modern equipment used by companies such as Vale do Rio Doce (CVRD) in the Amazonia to explore ore in the primary deposits. This company usually fulfills the legal requirements to recover the degraded areas, using different methods such as direct seeding or covering with organic scrap. In some mines, CVRD removes and stores the fertile layer of the area before the excavation, so as to provide a harmonic recovery in the future.

CVRD is now exploiting the most productive Brazilian mine, Igarapé, in the south of Para state. This mine produces annually 11 tons of gold from 4 million tons of ore extracted from a 150-m-deep excavation. This company uses two different processes to obtain gold: carbon in pulp, used in Igarapé, is the most efficient method, with a 97% recovery; help leaching is another method, less expensive and much slower, with a 79% recovery. With both methods, there is a chemical dissolution of the ore

**FIG. 2.** Schematic view of the hydraulic dismount garimpo (Source: DNPM, 1992).
and gold is absorbed by activated carbon. In the carbon in pulp method, the liquid gold lays on a stainless steel plate through electrolysis, before being delivered in solid bars.

Work Structure

Garimpo activity in the Tapajós area and in Amazonia in general is a hierarchical activity involving landowners, mid-sized entrepreneurs called “garimpo entrepreneurs,” managers, workers called “peões garimpeiros,” and cooks. Garimpo requires a certain infrastructure: equipment, landing strips, drags, housing, and food (Loureiro, 1991).

When the entrepreneur is not the landowner, he pays the equivalent of 10% of the production value to the landowner. In most cases, the small entrepreneurs work beside the workers. Usually the entrepreneurs are educated and live at a reasonable economic level. They are concerned about regional issues. In Itaituba, the mid-sized entrepreneurs founded in 1991 an association called AMOT, in which small entrepreneurs are not admitted. Their main interest is to provide the best conditions for the return of their investment, such as transportation, low prices for supplies, insurance, and a local branch of the commodity market for selling gold under better conditions. These meetings are highly used to exchange knowledge about techniques, tips, and local issues.

As most of the garimpo places are not near roads, there are parallel groups of entrepreneurs working in flying services and fuel supply. In addition to good revenue, these groups also become politically influential.

There are two classes of workers: unskilled day workers are used in the heaviest tasks; specialists are paid according to the production, from 30 to 40%. The day workers are paid around US$ 4 per day, and they usually stay for a short time in each place, whereas the entrepreneurs use the percentage system to maintain selected workers hopefully in the same place even during the time when gold is not found. When a garimpo place is being installed, to attract good workers, the percentage is raised to 50%. In addition to the competitive nature of this activity, the percentage workers usually cooperate for mutual gain, in the face of all the difficulties of their jobs. They help themselves in cases of danger, harm, or hunger.

The workers operate in groups of four to six in the hydraulic dismount and in groups of three to four in the dredge work. The mean wage of a specialist worker is around US$ 3000 per year. The managers earn 10% of the production. As an example of the garimpo internal economy, the cooks salary is around 15 g of gold, the local currency.

The workers always depend on the garimpo owners or entrepreneurs for the high cost of implementing a garimpo place, with regard to equipment and infrastructure. Most of the workers come from the northeast areas, and they work in the garimpo only in the dry periods, when there is no work in the fields. Thus, they do not have enough time to create social or labor ties in the garimpo areas, and usually their education level is very low. There is also an increasing number of workers coming from the urban unemployment situation.

Although garimpos is a sparse small-scale activity, official data indicate that in 1990 the Tapajós reserve comprised around 100,000 workers in 360 garimpo sites. Nowadays, in 60 garimpo sites, Tapajós still has about a quarter of the Brazilian garimpeiros.

In the hydraulic dismount mining, the main issue is the land ownership. When gold is found in a place, the land price become high, and violent conflicts may arise when the juridical ownership is not defined, a normal situation in the Amazon region.

In the dredge work, land ownership is not the problem, but the entrepreneurs have to buy the boat and all the equipment, which cost up to US$ 20,000. Many accidents are caused by the use of untrained divers in this activity.

There is a commissary in each garimpo place, in which gold, always low rated, is the currency. The workers know that farther from the garimpo place they can sell gold at a higher rate, but sometimes they have to pay debts in the commissary or even get money quickly. The workers know the market rates by listening to local radio.

There is social mobility in the garimpo, as the day worker gains experience and becomes a percentage worker or a worker, after a good mining campaign, becomes a commissary owner or small entrepreneur, who is always a candidate to become a garimpo owner, buying the necessary equipment and infrastructure, even for dredge work. The top level is an owner who becomes a regional entrepreneur, with political influence.

Garimpo is an activity with certain rules, but internal conflicts are frequent. In workers conflicts, the verdict comes from the garimpo owner. This is a sensitive issue, because a rejection of a verdict from the group may weaken the owner’s authority.

In addition to financial risk, the garimpo causes health risks. There are no safety devices, parti-
cularly with regard to land dismount accidents. The work is hard, from sunrise to sunset, jeopardizing health and resistance against contagious diseases.

**Legal Issues**

Historically, before any reference in the law, garimpo was a clandestine activity, marked by persecution and resistance. The first Mining Code was approved in 1934 and, concerning the garimpo activity, it gave the framework for the Decree 1374 (1939), recognizing as legal the semimechanized garimpo. The National Mining Production Department was created at this time, with the role of mapping, assisting, and becoming the monopolist gold purchaser of the garimpo areas.

During the military government period (in Brazil it began in 1964), though, a new Mining Code was issued, in 1967. In the articles 107 to 113, the garimpo was redefined as an individual activity, not mechanized, leaving for the large companies the mechanized mining activities. At this time, garimpo went back to clandestinity (Cleary, 1992), and the DNPM became a contradictory entity, as a government department against the law.

It turned out to be clear in 1979, a period of the Amazonian gold rush, when the national government created the PEGB (Project for Studying the Brazilian Garimpo), aiming to stimulate the garimpo entrepreneurs to register as companies to legalize the activity. Another objective of the PEGB was to avoid conflicts between garimpo and large companies, and for that the government demarcated the garimpo legal reserves, such as Tapajós. Despite that, conflict continued, because all the garimpo outside the reserves were, in practice, inside the company reserves.

In fact, garimpo was responsible for around 90% of the Brazilian real (not only the official) production during the 1980s. The government wanted to get all that gold and made clear that the official bank would pay 10% over the market price. It had not been a steady procedure, though, like all the government projects for garimpo, because of the pressure that the government constantly receives from the large companies. There are many claims for the weak government health and technical assistance to the garimpo despite the strong interest in gold.

Concerning environmental issues, gold mining was first mentioned in Law 6938/81, which introduced the National Environment Policy, determining protection and/or recuperation of the environmental degradation caused by gold mining activities (articles 2 and 3). However, according to Decree No. 882/93, all the municipalities belonging to the Tapajós area could constitute garimpos as long as they prepared previous environmental impact studies and the miners provided the recuperation of the degraded environment. Otherwise, they are responsible (physical and juridical bodies) for any environmentally damaging activities and subject to penal and administrative sanction (1988 Constitution, chapter VI, title VII, article 225, and Law 9605/98).

Law 7805/89, article 21 concludes this matter, by the establishing of prison terms running from 3 months to 3 years and fines when gold mining activities are made without due permission.

The permission for the use of mercury in the extraction of gold is given only in areas licensed by the local environmental entity, which would fix the period for the environmental formal petition. The non-compliance of these rules would cause the immediate interdiction of the activity (Decree No. 97507/89; Law 7805/89, article 13 and Law 5887/95, article 38). Should there be damages caused to the environment, the responsibility for these will be delegated (Law 7805/89, article 19). This law also applies to obstructing research or any other beneficiation in protected territorial areas (article 39) and to the people responsible for the contamination who are obliged to monitor the environmental leftover problems (article 42).

These rigid aspect of the 1989 law for mining, so distant from reality, have forced the activity again to become mostly illegal, and, consequently, labor legislation changed from very lax and useless to very strict and ineffective. Until 1989, “garimpeiro” applied simply to persons accepted into the DNPM, a federal agency, a certification allowing free participation in such activities. In opposition, Law 7805/89 determined all the mining activities without permission from the federal mining and environmental agencies to be a crime. This permission has been given only to registered cooperatives, in a move to provide means of organization, environmental preservation, and control of the activity.

In fact, this law prompted most of the “garimpeiros” to become illegal workers, due to the lack of inspection, the slow pace of the registration procedures, and the transitory and risky aspects of the activity.

In the state of Pará, Law 5793 in 1994 created the Mining and Hydric Policy. It defines the strategies for gold exploration (article 1), including support and permanent assistance to the implementation and operation of the gold mining activity, to improve exploration and environmental conditions (parts V and VI). It also suggests that the large projects be
responsible for financing the social, educational, and sanitation infrastructure (part IX) and that the water resource planning and management be in accordance with the regional development (part XIV).

The Hydric Resources National Policy, created by Law 9433/97, includes mechanisms to impede the pollution of the water resources, through tributes and taxes imposed on the polluting agents.

There is also some legislation concerning mercury. Barreto and Marinho (1995) verified that this legislation was not being implemented due to a lack of resources, insufficient public power, and/or inadequate orientation and assistance to the miners. There is also a direct dependence of legislation on technology, in such a way that legislation is implemented only if the existent technology fits the legislation.

Gold Production and Commercialization

The State of Pará is the second state in mineral production in Brazil (16% of the total production). The estimated reserves in Pará are iron at 17.4 billion tons (35%), bauxite at 2.4 billion tons (81%), copper at 1.4 billion tons (75%), manganese at 80.1 million tons (25%), nickel at 80.1 million tons (21%), and gold at 283 tons (12.3%).

The greater mineral reserves of Pará are Carajás (iron, manganese, copper, nickel, and a reserve of 210 tons of gold), Tapajós (reserve of 50 tons of gold), Gurupi (gold), Andorinhas–Sapucaia (reserve of 13 tons of gold), and National Copper Reserve, in the North of Pará.

Pará is one of the biggest gold producers in Brazil, contributing almost 35% of the total gold production. The gold comes mainly from the Tapajós area and the counties of Cumaru, Redenção, and Tucumã. Vale do Rio Doce Co. began production in 1991 (Figs. 3 and 4). By the end of 1998, the production had increased to 11.4 tons, whereas the production from the garimpos has been declining as demonstrated below.

According to Fig. 4, Tapajós is one of the largest gold production areas in Brazil, despite a steady decline over the last few years (Fig. 5 and Table 1). In fact, gold mining for garimpos is becoming difficult due to the crescent exhaustion of riverbed extraction. On the other hand, deep deposits are now being increasingly explored industrially, mainly by CVRD.

In Fig. 6, historic gold values (US$/g) are shown. Its highest rate was in 1987, with a continuous declining to now. Therefore, extraction investment has decreased. According to Hanai (1997), the investments in gold mining had a 40% fall in the 1980s and 1990s. They fell from US$ 50.2 million (1981) to US$ 30 million (1990). DNPM says that this fall was felt in all gold mining sectors, where there was a loss of 80% in investment in prospecting and mineral research.

Gross National Production (GNP) from Pará State sources comes from Services, Commercial, Industrial and Agriculture (Fig. 7). It is important to note that the garimpos was not included in the GNP because they are mostly illegal and at the same time are not part of the Mining Financial Compensation (CFEM) contribution. CFEM is an environmental tax revenue for all mining activities that have tributary obligations to the country/state/county. From Fig. 8 it can be seen that Pará State GNP makes a very small contribution to the Brazilian GNP.

Gold is commercialized in three cities in the Tapajós area: Itaituba, Alta Floresta, and Santarém. Itaituba, the largest gold production center, has been decreasing in importance in the garimpo economy, due to the progressive distance from the garimpo places and the lack of roads nearby. Air flight costs and the precarious infrastructure of this
FIG. 5. Percentage of gold production in Tapajós in relation to Pará (Brazil) (Source: DNPM/SEICOM/BACEN).

FIG. 6. Historic gold price (Source: London Stock Market).

city are particular disadvantages in favor of the two other cities.

Alta Floresta is the largest gold commercial center for the garimpo. This city is located in the extreme south of the mining area, in the state of Mato Grosso. The reason for that choice is the proximity with the wealthy Brazilian southeast region, mainly São Paulo, the ultimate buyer market for gold and from where the miners get their main supplies.

Santarém also has a reasonable structure, with docks, support for air flights, and some good hotels. The gold price in this city is linked with the commodities market of São Paulo.

Health and Environment

Accommodation in garimpo activities depends on the gold mining method used. In hydraulic dismount the workers live in tents inside the work field, under extremely bad sanitary conditions. Close to the garimpo place there are small houses and brothels, forming an environment called “currutela,” where the workers get partial support for their basic needs. In the dredge garimpo, the workers live on the boat. Depending on the gold production in the area, the boats form a conglomeration called “fofoca” (Cleary, 1992).

Basically, the garimpo nourishment consists of rice, beans, and manioc flour; local meat is very rare, and fish is avoided because of the mercury pollution.

Brazilian studies confirmed the contamination of the Tapajós ecosystem, in the sediments (Rodrigues et al., 1994; Pfeiffer and Malm et al., 1999), in the water (Rodrigues et al., 1994; Silva, 1997; Castilho and Bidone, 1999), and in the air (Silva, 1997;

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<th>Year</th>
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<th>Total Tons</th>
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<th>S. Pelada</th>
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<th>CVRD</th>
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Note. C/R/T, Cumaru, Redenção, and Tucumã cities; CVRD, Companhia Vale do Rio Doce; n/a, not available. Source: DNPM/SEICOM/BACEN.
Fonseca et al., 1999). The evidence that garimpo activity affects the physical environment (sediment, water, and air) is more than substantial. It also influences the biota (fauna and flora), human health, and socioeconomic and cultural environments (Conesa, 1993). In this area, the evidence is overwhelming.

According to Professor Pedro Sergio Fadini from the Catholic University of Campinas, São Paulo, despite the fact that 90% of the population of the Rio Negro Basin presented concentrations of mercury above tolerable levels, there were no signs of intoxication. There is strong evidence that this is due to the consumption of Brazilian nuts native to this area. These nuts have a high level of selenium, which inhibits the toxic action.

Itaituba is a city without a sewage system, and drinking water comes directly from the river, so the population is exposed to verminous diseases and cholera. Some other health problems are very frequent in the region, in particular malaria, due to the mosquito *Anopheles darlingi*. Deaths of 1-year-old children are numerous, due to hunger and lack of a consistent vaccination program. Instead of public hospitals, there are only private hospitals, leaving the poor unassisted. Medical assistance is given by a pharmacy clerk, experienced in clinical diagnostics and pathologic exams. People go to these local pharmacies, but usually take expired medicines.

The only preventive health campaigns are made with precarious equipment by the National Health Foundation (FUNASA), spraying insecticide to control the malaria incidence. They also make blood exams to measure the progress of this disease. FUNASA operates nine laboratories in the garimpo areas, but malaria and intoxication prevention requires an overall state of permanent alert and advice giving. The region needs material for public notices and technical training for the local health professionals to adequately deal with the diagnosis and treatment of malaria and mercury intoxication.

**THE DIFFICULTIES IN THE IMPLEMENTATION OF CONTROL IN SMALL-SCALE GOLD MINING ACTIVITIES**

Some of the difficulties in the implementation of control are derived from the conditions described above. The main obstacle in the implementation of control since the beginning was the lack of resources and political support for the DNPM to execute the government project of mapping, assisting, and becoming the monopolist gold purchaser of the garimpo areas.

Mainly after the strict law approved in 1989, the clandestinity of most garimpo activities was due to a set of interrelated reasons: lack of inspection, excessively long procedure for license, high tributes if all the requirements were fulfilled, and sparseness. The sparse locations make it difficult to register and assign the location of the estimated 450 garimpo places in an area of 100,000 km². The long procedure to get a license corresponds to the demands of three different registrations for the same activity, from three different institutions: DNPM (federal), State Secretary for Environmental Control (state owned), and Environment National Institute-IBAMA (federal). The clandestinity causes the production by place not to be registered, and so there is nobody responsible for recovering the degraded areas.

There are some difficulties caused by the socioeconomic conditions, and several aspects affect degradingly the conditions in the garimpo areas: most of the workers have a very low education, and many...
of them are less than 18 years old. Being clandestine work, garimpo attracts also all kinds of swindlers and people ejected from regular jobs. The enormous gap between the workers and the entrepreneurs with regard to work, health, and financial conditions results in social tension, frequently expressed through physical violence. There are cases in which the workers run out of money and get loans from the owner, creating a slavery condition, sometimes leading to violence.

Violence is also the result of land conflicts, which may arise when juridical ownership is not defined or from two other specific reasons: (1) Some mining companies wait for the garimpo to come out of the reserves and search for gold. When gold is found and the exploration begins, the companies get legal authorization and expel the garimpeiros in violent fights. (2) Gold mining (garimpo or mining companies) sometimes is done on Indian land, with or without official, although illegal, authorization. Violence happens when there is not an adequate financial agreement with the Indians. According to Almeida et al. (1986), the government has issued more than 500 authorizations on Indian land.

Another class of difficulty is the absence of resources and qualified employees for inspections. For the sparseness of the garimpo area, inspections would need many trained employees, boats, planes, and expensive equipment for measurements, which is fundamentally incompatible with the low political priority to control this activity.

Another problem is the high distrust of the government agencies by the garimpo workers due to their belief that they have been cheated by a federal financial institution in charge of dealing with gold. They estimate US$ 120 million in losses due to the low prices paid due to the allegation of impure gold due to the presence of palladium, a situation that should increase the price.

The work structure causes another difficulty: there are no fixed salaries and the rule is no gold, no money. Most of the workers live miserably, motivated simply by the dream of finding gold and becoming rich. The workers would not change this dream for less than a very good proposal, which would never be offered by the entrepreneurs. The only interest of the entrepreneur is profit; environmental or social conditions are not their concerns.

From the border of the rivers to the deep riverbeds, garimpo activities are evolving to require more expensive and heavier equipment that most of the entrepreneurs cannot afford. There are general losses for abandonment in this phase, in addition to the decline of the garimpo activity itself.

In fact, the strict laws about mining are only a reference, because there are no specific laws for the garimpo activities (small-scale gold mining), which are indeed not recognized as a different class of mining activity. If there were specific laws for garimpo, all the requirements should be reduced proportionally to the actual or historic production of this sector.

**SYSTEMIC INTEGRATION AS AN INSTRUMENT FOR IMPLEMENTING THE SELF CONTROL**

*The Systemic Integration Concept*

Gold mining in the Amazonian region involves a complex of different and frequently contradictory groups, interests, cultures, and organizations. These aspects are tough and too difficult to be overthrown in a conventional way. Systemic integration is a planning methodology that this article proposes to transcend the actual perspective.

General systems theory was proposed in the 1940s by the biologist Ludwig von Bertalanffy, who had been searching for a way to unify the various disciplines of science after a period when science had been subdividing into many specialties. Bertalanffy was interested not only in the cells or organs of the human body, but also in how these components come together to form a whole. Bertalanffy recognized that, although a human body is composed of many parts, these parts form something greater than their sum, much like the parts of a car which do not embody everything about the finished product or its potential. The extra element not found in individual parts is known as "synergy," representing collaboration as opposed to independent individual activity (Capra, 1993).

Systemic integration deals with three basic concepts: system, network, and scale. The system is the structure, in which all the parts affect the whole organization, varying in scale. This structure is assumed to be constantly self-moving and self-organizing (Boff, 1998). The socioeconomic systems are composed of several actors, or stakeholders, in a complex web. Using systemic integration, the planner represents, using the concept of network, all the existent or possible relationships, or conflicts, among the parts, aiming to create a dynamic strategy in which a favorable synergy may produce a combination of actions toward the objective. The integration among the parts is automatically achieved when, in fact, the benefits to each part come from the combined actions of all the agents.

The systemic integration is based in human behavior, and so the proposed plan is always subject to
unpredictable reactions. The plan must be dynamically reviewed to attain its objectives.

The strategy is focused on each critical node in which a conflict has to be solved. There are eight increasing levels, proposed by Henriques et al. (1999), to obtain the involvement of all the parts in the proposed plan. The first and weakest level is geographical proximity. The second is information, followed by judgement. The fourth is action, followed by partnership, continuity, and joint responsibility. The eighth and strongest is the institutionalized participation, which will be effective as long as formal deals exist.

With this methodology, the small-scale gold mining activities in the Amazonian region were analyzed with the objective of environmental control and self-sustaining development. According to systemic integration, all the proposed actions need to be based on the motivation and involvement of all the different agents, and this synergy is achieved when a new external factor acts like a pivot to the necessary changes.

There are some eligible new ideas to this region: the jewelry pool, one of the “mineral vertical programs,” the “PPG7” (a pilot program for protecting the rain forest), and others. In this article, the jewelry pool is considered the pivot, although other initiatives are also mentioned as important to push the necessary transformations.

Searching for the Different Interests

The stakeholders involved in the systemic integration for the region include the following: federal government, state government, municipal government, landowners, managers, “Casas de Ouro” (illegal gold buyers), garimpo entrepreneurs, workers (“Péao Garimpeiro”), and great mining companies such as Vale do Rio Doce.

Federal government. The federal government and Brazilian military policies put Amazonia into the strategic agenda. Amazonia forests, rivers, and subsoils are natural reserves of oxygen, medicinal plants, wood, fish, latex, water, and metal. Threats to internationalize the region are already prompting the federal government to stimulate sustainable development.

PPG7, started in 1995, is an example of a federal government initiative, partially financed by European countries. There are 30 different PPG7 programs in Pará, with a total budget of US$ 80 million. Research, education, and environmental monitoring and preservation are the objectives of this project, which reached 10 cities including Itaituba. An important development is the founding of Environment Forums in these cities, providing massive discussions and concern about preservation.

Another example is the use of the National Environment fund to educate organized groups in the appropriate way to deal with the Amazonia resources. Small producers are also being supported by the North Region Development Fund through the Extrativism Development Support Program (PRODEX). With regard to environmental management, the Environment Ministry has been decentralizing and reformulating its structure so as to strengthen municipal environmental management and integrate actions among the Amazonian states.

The federal government also has responsibility to promote a revision in the law to consider the specific situation of the garimpo work.

Pará state government. The main interests of the Pará state government are to increase its revenue and to become more independent from the external market. The state government has been promoting some sustainable development programs, as part of a project called Mineral Vertical Program.

The heart of this project is to get local beneficiation for the natural resources. The government is supporting the creation of refineries and distribution plants near the gas and oil prospecting places, associating this to the energy supplying the aluminum companies. There are plans to implant a metallurgic belt in the region, with natural gas as iron reducer, replacing vegetal carbon.

One of these vertical programs is the jewelry pool. The state government is exploring this idea as an opportunity to, at the same time, achieve a most valuable gems market, increase employment, and provide education for the workers. There are already 25 participants in a pilot jewelry pool in Itaituba. Virtually all the state government secretaries and institutions are associated with this program.

It is important to encourage the state government to use part of the incoming taxes in the recovery of abandoned mining areas. This might be achieved by the growth of the tax receipt and a plan to establish some useful or profitable activity in these areas. A similar program by the Agriculture state secretary to cultivate land in devastated forest areas is already under way.

The Environment state secretary is responsible for mining permission, and the permissions actually go only to great mining companies that fulfill the law requirements. This same secretary is determining
an area for agricultural activities around Itaituba, to provide local food for reasonable prices and increase health conditions. A joint Canadian–Brazilian work group is measuring and analyzing the mercury contamination in this area.

New criteria are being considered to stimulate the small miners to get permission and act according to the law. For this goal, dozens of environment inspectors are being trained, but specific legislation for the garimpo, thus making garimpo workers a recognized profession, is yet to be created. This must be understood as a need of both the federal and the state governments to fulfill their interests.

**Municipal government.** Two distinct interests exist in the Itaituba municipal arena: some politicians are impassioned for the importance that the city is getting with the possibility of transforming the garimpo into a decent activity, and some other politicians are defending the status quo, supported by the owners of the “casas de ouro.”

The Secretary is responsible for a strong articulation with the federal and state governments and with nongovernment organizations in preservation, education, and recovery programs. One of the most important of these programs is the education to gold beneficiation, dedicated to the preparing of mostly the sons of the garimpeiros to work in the jewelry pool. This program is financed by the federal Labor Assistance Fund.

Additional initiatives by the municipal government could bring the Amazonia Bank to a joint project of a Primary Attention Center. One idea is to install this center, composed of a laboratory, a library, audiovisual material, and a data bank, in a boat, to serve an extensive area. The functions of this center would be to analyze the water, vaccinate against malaria, provide first aid, prescribe and distribute medicines, conduct environmental education, and archive and consult about health and environmental conditions in the communities along the river. In financing this initiative, this bank would get popular support.

Open-air events and a community radio station are also important to motivate and impel the changes among the population. However, the state and municipal governments must know that long-term support from the people will depend on effective actions, such as provision of the water supply, sewage treatment, health centers, and hospitals.

The municipal government can also invite universities to apply their research efforts to find the most appropriate and clean technologies for gold mining and beneficiation in Itaituba.

**Landowners.** The landowner has to understand that the transformations that brought the jewelry pool tend to increase gold production. In addition, if the jewelry pool work is done on his land, he will certainly get a percentage.

**Managers.** As the manager gets a percentage of the production, the possibility of production growth is beneficial to the manager.

**“Casas de Ouro.”** The strongest opposition to the transformation comes from the “casas de ouro.” Their work is mostly illegal and any kind of organization is dangerous for them. In the long term, if the transformations succeed, they may find a way to share the beneficiation work with the jewelry pool.

**Garimpo entrepreneur.** There are mid-size and small entrepreneurs. The jewelry pool attracts mainly the small entrepreneurs, who are mostly illegal, in a way that regularizes their situation and induces them to work in cooperatives. The small entrepreneurs would agree to this change because of the difficulties that they have with regard to equipment for dredge work mining and primary deposits, once the superficial mining is in decline.

There are some principles to which the small entrepreneurs will have to agree, such as to improve technology to limit the use of mercury to the amalgamation phase. There is a reward for that, since use of these new and simple technologies results in a higher gold recovery rate.

The great entrepreneur will not be attracted by the jewelry pool in the short term, continuing to deal with the “casas de ouro” for better prices. The great entrepreneur will associate with the jewelry pool only when the pool structure is strong enough to pay competitive prices for gold. Of course, the condition to associate with the jewelry pool will be to work in accordance with the appropriate law and procedures, subject to inspection.

Some directives are being defined by the Environment Ministry before issuance of a mining permit: a recovery plan has to be presented along with a firm guarantee through an insurance certificate or a blocked money deposit; a responsible technician has to be registered according to the official professional associations, and an annual report including ecological measures has to be prepared, to be analyzed by the inspection; and taxes have to be paid to the government as compensation for extraction of mineral from the subsoil: in the case of gold, 1% will be applied to environmental management of the garimpo.
Garimpo worker. Many garimpo workers are educated in beneficiation concepts, but the jewelry pool may improve the life of the garimpeiros by engaging their sons in the beneficiation work. They could work through cooperatives. There is already a pilot cooperative, with 25 people working in the jewelry pool. The jewelry pool will certainly attract many more workers due to the better conditions and regular wages compared to the volatile and heavy mining work.

Great mining companies. There is actually no formal interaction between the garimpo and the mining companies. In opposition to the empiric and often illegal work of the garimpo, the exploitation by mining companies in Brazil, according to Law 7805, is always preceded by detailed research and the approval of an exploitation plan for a certain site. Their targets are 50 tons minimum of gold deposits. These companies have no interest in the Tapajós reserve, in which the gold deposits are less than 10 tons.

Historically, when the relationship occurred, it was mostly conflicting. After the law delimiting a restricted reserve in the Tapajós area for small-scale gold mining was created, in 1979, for the sake of the large-scale mining lobby, violence had been frequently used to expel the garimpeiros from outside the reserve just after they had found gold.

In recent years, though, the mining companies have moved to large primary deposits far from the Tapajós area, requiring heavy and modern equipment for the exploitation. There is no conflict now, since the garimpo and mining companies are working separately.

There have been studies and experiences (ILO, 1999) to improve the situation and create a kind of cooperation between garimpo and large-scale companies that could be applicable when they come to work again nearby. The large-scale companies could cooperate with the garimpo by providing affordable assaying services, sharing geological and other technical information with small-scale miners, providing practical training and technical advice, helping to set up or sponsor small-scale central processing plants, buying services, tools, and equipment from the local community, assisting with the procurement and storage of explosives, providing processing services, buying and treating tailings, releasing land that is suboptimal for large-scale mining, and providing emergency assistance and mine rescue.

During the time that the secondary sources are being exhausted in the Amazonia, these companies have the necessary equipment and technology to extract gold from the primary sources. So, the cooperation could include also renting equipment and defining areas to be explored by them, in exchange for a percentage of the production.

There are many of formal national and multinational mining companies acting in the Amazonia. Vale do Rio Doce Co., the privatized Brazilian mining giant company, is the overall leader in terms of production, scale, and number of employees. They have strong and modern equipment for mining gold from the primary sources. The production is either exported or sent to the headquarters in the Southeast states. These companies have official licenses, they are inspected, and the law fits the size of them. The exploitation plan submitted to DNPM includes a complete recovery after they exhaust the mineral from a place.

Management Experiences in Small-Scale Mining

Garimpo production in Brazil has always been considered a marginal activity, a result of unemployment and the unfair wealth and agrarian land balance in this country. Contrarily, garimpo should be regarded, transformed, and adjusted to represent a positive employment and development path for Amazonia, in addition to being environmentally correct. The ideas presented in the previous section should be explored by consideration of proposals and acts from other countries dealing with the technical, economic, social, and environmental aspects.

International Experiences

Bolivia, Zimbabwe, and Philippines are countries where small-scale gold mining influences both the environment and the national economy. The Brazilian natural resources and national economy are immense compared to these countries. However, the disfavored Amazonian social and economic environment is distant from the best opportunities and resources in Brazil, and many people in the region still lay their hopes on the search for gold. Tapajós has always been the most productive garimpo area in Brazil, influencing the local economy, and mercury pollution is still a problem in the region.

With regard to those differences and similarities, some international examples are useful when management of Amazonian small-scale gold mining is considered.

Bolivia. Small-scale gold mining in Bolivia is very important to the national economy, since the
times of the Incas and later the Spaniards, actually involving directly 100,000 and indirectly 500,000 of the 7 million in habitants.

San Simon highlands, a gold-rich region on the eastern side of Bolivia, is the most representative area for small-scale mining with traditional methods. In the process of open-air burning and washing, done only during the dry season (8 months per year), mercury evaporates or goes to the few and shallow watercourses that reach the Guaporé and Itenez Rivers and three protected nature reserves. San Simon was selected to be the a pilot solution for the 4-million-dollar MEDMIN technologic project (Environmental Procedures for Small-Scale Mining), conceived and financed by the Swiss Agency for Development and Cooperation (SDC) and executed in cooperation with the federal and local governments.

The total production in this region is about 400 kg of gold per year, after 40,000 tons of ore are processed with 16 tons of mercury. The mercury costs for the miners are around 10% of the gross income, and the potential savings for recycling or reducing the use of mercury and improving the gold recovery was the pivot for the active participation of the miners in this project. The project has achieved also federal and regional government support that has been important for the provision of infrastructure, education, and dissemination among miners throughout the country. The main interest of the government was to get the legalization, and so the environmental control, of the mining companies and cooperatives.

The technological improvements comprised the replacement of mills and plates by spiral concentration, which is responsible for half of the gold recovery, and sluice boxes with special carpeting, eliminating the use of mercury in this phase. The process is finalized with amalgamator drums and retorting of the amalgam. In the total process, there is a reduction of 98% in the use of mercury. In the pilot plant, even this small amount of mercury was completely recycled, and there was an increase of 10% of gold recovery. The largest investment of this plant, to be recouped in a short time, is the spiral concentrator, costing US$ 1500.

**Zimbabwe.** Zimbabwe represents the most diverse mining sector in Africa. There are 5000 small-scale mines, and a loose legislation makes it easy to get and transfer mining authorization. A typical small-scale mining site is the Button Mine. The ore treatment is done mostly in the Shamva Mining Centre (SMC), created in 1989 by the London-based Intermediate Technology Development Group (ITDG), with efficient and clean methods. SMC is partially self-financed by retaining the gold recovered from the tailings with cyanide, representing around 15% of the total recovery. SMC has a processing capacity of 20 tons of ore per day, but it has been dramatically under used.

Although all the miners are registered and technology is available, Button Mine is not a successful case, producing only 1 kg of gold for 240 tons of ore, and the population directly and indirectly involved hardly get benefits from this activity, from which a worker receives US$ 50 per month. The mines have remained at near-surface digging, despite the potential for deeper mining, and there have been no attempts at exploiting this opportunity. From the 220 users of SMC, only 2 have indicated an intent to expand their mines. In fact, the main constraint is the high investment needed, requiring 15 years to be recouped and requiring government incentives to local and foreign entrepreneurs and businessmen to exploit these opportunities.

**Philippines.** Philippines’ annual gold production is reported to be 15 tons, half of that coming from small-scale mining. Historically treated as illegal, small-scale mining was first distinguished in 1984 by the Presidential Decree 1899, establishing renewable 2-year permits for a maximum of 50,000 tons of ore per year mining with artisanal means. The massive legalization was achieved by a clause exempting small-scale mining from any taxes except income tax and by not modifying the labor and working conditions. Therefore, the legalization under this law was unable to address all the social, economic, technical, environmental, and land-related problems connected with small-scale mining activities.

Later in 1991, the Republican Act (RA) 7076, regulated by National Environmental Department Administrative Order 34, improved the legal structure, including rights to technical and financial support, defining small-scale mining reserves, requiring, on the other side, a series of new labor and environmental procedures, and enhancing the collection of government revenues. In a transition period, this law did not extinguish automatically any existent permit and license.

Instead of permits, though, according to RA 7076 all miners must be registered and, for acquiring rights to explore an area, they have to initiate, individually or by forming a cooperative, a nontransferable contract with the local branch of the Federal Environment and Natural Resources Department. This contract, taking around 90 days to be approved,
comprises the enterprise conditions (coproduction, joint-venture, etc.), the survey plan, the mining plan, and an environmental agreement. The initial amount paid for the contract is based on the size of the mining area, and a contractor is allowed only one contract. The government receives also royalties, representing 1% of the production. The maximum size to be contracted is 20 hectares, and the limits to fit small-scale conditions are defined for each case upon consideration of the specific circumstances of the area.

During the contract approving time, the government agency gets all the information about the declared area, with regard to land conflicts and technical and commercial feasibility. The priority to sign contracts is given to requirements related to inside the small-scale mining reserve and to miners living near or in the area.

The entrepreneur has responsibility for the safety and health of the workers, including the obligation to provide a minimum sanitary infrastructure. Any accident must be communicated to the authorities within 5 days. The environmental agreement must include keeping the area clean during the mining horizon and recovering the area before abandoning.

There is motivation to legalize, in addition to fines and rescission terms for noncompliance: A fund composed of 15% of the national share is available to bring technical assistance, training, and environmental education. The law indicates that infrastructure facilities such as roads, communications, and processing plants are stimulated or provided by the government near the contracted areas. According to the law, there are special licenses to be issued to operate processing plants, which are subject to pollution control and safety standards.

This recently approved legal structure apparently addresses, in a systemic integration, all the environmental and socioeconomic aspects of small-scale mining. In contrast with the former conditions, it is comprehensible to have initial claims for such formalization, but the benefits, if put into effect, may turn Philippines into an outstanding reference for small-scale mining regulation.

Brazilian Case toward International Experiences

Bolivia, Zimbabwe, and Philippines are all developing countries, respectively, in South America, Africa, and Asia. In these countries, small-scale gold mining has been historically treated loosely as illegal, with all the predatory consequences. Nowadays, it is gradually being considered a worthwhile activity. There are few examples in which labor, environment, and health are being improved, and at the same time technological enhancements contribute for a higher productivity, favoring the government as the royalties and taxes collector or the ultimate buyer of most of the produced gold.

In these examples, the transformations are always based on proper legislation, governmental priorities, international collaboration, environmental education, and technical support. In the successful cases, though, the decisive factor in the achievement of the necessary resources and the provision of dissemination is an effective articulation. In addition, according to the systemic integration, the articulation, to be effective, has to take into account the impelling interests of all the parties. In this way, the management aspects of each of these analyzed countries could be analyzed with regard to the Brazilian case.

The Philippine legislation emphasizes the concept of the contract, in which the benefits are explicitly related to obligations, making effective the self-control. The major role in the Philippine law goes to the government, to provide the two sides of the contract, benefits and control. This concept could be considered in the Brazilian legal structure for the Amazonia. Such an approach would need special finance programs for the starting up of new contractors, under the assumption that many of them could arise from local communities.

The important contribution from the Bolivian experience comes from the way that the technology enhancements were managed. A pilot solution was implemented, in which the financial benefits are linked with environmental protection. Dissemination is necessary to put into effect the transformations from such experience. In Brazil, based on the Bolivian experience, the European Community, in cooperation with many governmental entities and miners associations, financed in the Tapajós region the pilot solution, the Mercury Project. In addition to use of the same methods as those in Bolivia for dramatically reducing the use of mercury and increasing the gold recovery, the Mercury Project undertook also the prospecting phase, in which fine-analysis methods were used to prevent vain devastation. The problem is that dissemination is problematic in the Amazonia. It would require massive articulation among local and regional entities, which is still far from being achieved.

In Zimbabwe, there are no legal conflicts, and state of the art processing is available for the miners. Small-scale mining is decreasing in Zimbabwe, however, because investment is needed to turn small-scale mining into a profitable activity. The solution could come from articulation to stimulate joint-vn-
ture initiatives. Apart from the economic differences between Zimbabwe and Brazil, the transition from secondary to primary sources in the Tapajos area somehow resembles this need. In this case, articulation is needed to provide the necessary resources, through access to credit, joint ventures, or associations.

International assistance is seen in each case as an important part in the articulation. There are several nongovernmental entities motivated by the interest of environmental preservation and United Nation agencies, such as UNDP, UNEP, and UNIDO, dedicated both to environment preservation and to developing programs. These entities are contemplating researching, financing, and assisting small-scale mining. The UNDP program includes drafting environmental regulations and pursuing activities that enhance the contribution of small-scale mining to economic and social development at the community level, while making it a more formal activity, promoting closer links with international financing institutions and multinational mining companies. The International Labor Organization supports studies aiming to improve the miners health, safety, and working conditions.

Management Issues in Different Spheres

In addition to determining the interests to be considered in the articulation, it is a role of the systemic integration to assess the right sphere for each activity, whether local, regional, federal, or international. In the case of small-scale mining, the main activities are overall management, technological enhancement, dissemination, environmental education, infrastructure, legislation, and commercialization.

Overall management. The most adequate entity to plan the articulations and get the overall management is the federal government. This political sphere usually holds influence, resources, information, and a thoughtful vision of the entire problem. As this sphere is limited by the distance to the field of action, it must be assisted by local departments or agencies and act jointly with the state and local spheres that, more than knowing, feel the problems and the benefits. In case of political quarrels between local and federal governments, though, this articulation is a sensitive issue. In this case, negotiation and hierarchical attitudes may be used to overpass opposite interests in the local government.

When not from the federal government, the leadership could be held by the state government, also has resources and information about the problem, but in a limited range. There is an additional motivation when the state government shares local interests.

The regional entities, mainly in the case of Amazonia, have cultural and environmental interests, but their influence and the distance from the local issues is an obstacle to function as overall guidance. The international agencies are very important to bring sensitivity, financial resources, and technology. They are not susceptible to regional political pressure, as their interest is usually the environmental preservation in a Amazonia. Otherwise, their action cannot be put into effect without local permission and federal guidance, for sovereignty reasons. After all, management requires interaction among the several spheres, for mobilizing and articulating all the parts adequately.

Technological enhancement. Technology innovations may come from international agencies or research centers in the federal or state spheres. The accomplishment of these ideas will depend on how they were conceived and how they will be applied, meaning that, although local governments are generally unable to develop technological enhancements, local issues have to be considered, such as the actual technology, culture, soil, available material, and the main problems to be solved. Local entities will be, after all, the ultimate users of new technologies. The regional sphere may influence the technological policies to meet regional directives for the Amazonia.

Dissemination. When a pilot solution becomes successful, dissemination is necessary to spread the benefits to other areas. The regional sphere is the most effective, covering in the Brazilian case all the garimpo areas in the Amazonia, but this activity is succeeded by local interests. Therefore, regional entities should coordinate this work involving state and local governments, counting on the support and initiative of international organizations, when available.

Environmental education. Environmental concern usually comes from international or federal entities, but environmental education begins only when the local entities are involved, requiring continuous practice and adherence to be effective. Therefore, this activity should be delegated to local structures, through resources and training conveyed from federal and state government departments.

Infrastructure. Small-scale mining needs some urban infrastructure such as habitation, transport, water, sewage, and health services. There is specific
delegation for each of these activities. In Brazil, by law, water, sewage, and health services have to be assumed by the local governments. In the Amazonia, for the lack of resources at the local level, water, sewage, and health services are scarcely supplied to small-scale mining areas. The state government, in addition to being responsible for habitation and transport, should work as an active source or as an intermediary with federal and international entities to assure the necessary resources to the local-level infrastructure.

**Legislation.** The federal level is constitutionally responsible for the mining legislation. This has been a problem for the small-scale mining in the Amazonia, where issues specific to the garimpo have never been considered adequately in the law. Attention to international experiences, along with intense consultation with local committees, should precede a legal reform, in which garimpo is contemplated by specific legislation.

**Commercialization.** When the gold produced in small-scale mining is sold to illegal dealers only some individuals benefit, damaging federal interests and restraining local investments that could bring collective benefits. In this case, the different spheres have specific roles.

First, the federal and state governments should adjust the amount of taxes paid by legal commercialization to a sustainable level. Actually, the Brazilian federal government is negotiating with the state governments a simultaneous reduction in the federal and state taxes for small-scale mining commercialization. This will not be enough to beat the illegal dealers until the state government implements the commercial structure for the miners jewelry pool described in this article.

**CONCLUSIONS**

This controversy about economic development and environment preservation includes small-scale gold mining, or garimpo, that as a local activity should indeed not devastate the forest or damage the environment. Despite this important concern, garimpo presents favorable features: flexibility, accessibility, adaptable technology, low cost, local tradition, and opportunity for social mobility. Historically, though, garimpo in Brazil has been regulated by successive governments, as the law in the beginning defined garimpo as a rustic, artisanal, and individual activity, followed by delimiting restricted areas and more recently assigning for small-scale mining many of the legal large-scale mining obligations, causing garimpo to be a mostly illegal and marginal activity. By this time, in the 1980s, Amazonian garimpo was receiving thousands of uneducated, landless, and unemployed people dreaming about fleeing from poverty.

In the last decade, however, investments in gold mining have decreased due to the continuous decline in gold prices. Additionally, in the Tapajós area and other parts of the Amazonia, the alluvium gold sources are gradually being exhausted, and the deeper primary deposits require different and heavier equipment. According to the DNPM (1997), to reverse this tendency, new targets must be defined, with investments both in research and in production. In the specific case of gold, to comply with the precious metal demand it will be necessary to reach in Brazil a production of 100 tons/year by 2010, requiring investment of more than US$ 1 billion in prospecting and research, US$ 2 billion in mining work, and about US$ 100 thousand a year in environmental monitoring and inventory, which will be necessary in the Tapajós Region.

Despite the gold price decline, the jewelry price has remained intact, and according to the Brazilian Gems and Precious Metal Institute, the annual jewelry market represents more than US$ 15 billion. However, Brazilian profits from the jewelry market are modest compared to the considerable gold and gem production. Apparently, this is due to the burdensome Brazilian tax of 51%, 17 times higher than that in Japan and 3 times higher than that in Italy. Recently, the federal and state governments have been negotiating a joint reduction in the tax levels for jewelry, planning to lessen it to 12%. With the opportunities to increase the Brazilian share in the international jewelry market, the state of Pará, where most of the Brazilian gold comes from, is proposing the formation of jewelry pools, so that miners can get more than the gold price for their production and the state and federal governments can profit adequately from the production.

This is only part of the solution, which also needs legal reform, technological enhancement, resources in infrastructure, and control. This is a problematic aspect due to the strong difficulty of conventional control in such areas. The only feasible solution in this case is self-control. In this article, self-control has been described to be achievable through systemic integration, a methodology applied to identify and articulate the interests of the several parties involved in gold mining, in a way such that they are induced to work to reverse the actual economic, social, and environmental situation. The articulation involves the federal government to the smallest local
entities, through specific committees. The jewelry pool was used as a pivot to the planned changes. Legislation, dissemination, commercialization, and other aspects were considered, so that a lower tax level, enhanced technology, massive legalization, and other changes can bring about a virtuous circle of higher productivity, investment, revenue, safety, environmental standards, and social conditions.

There are some difficulties to be overcome. Opposing interests may come from political quarrels, illegal dealers, and large-scale companies. This article shows a win–win scheme for cooperation between large-scale and small-scale mining and addresses the political quarrels in the hierarchic sphere. Obviously, the illegal dealers are not expected to cooperate with the changes in the beginning, but later they are expected to join the legal trading and benefitization work for the jewelry pool.

In terms of legislation, the federal government should promote legal reform for small-scale mining, in which benefits and obligations must be clear and adequate for this activity, as shown in the new Philippine law. The environmental and control agencies should be enforced to reach the garimpo areas, providing training and resources for infrastructure, environmental education, and health services. Technological enhancements taking into account the local needs and characteristics should be developed and implemented through pilot solutions and dissemination.

In this article, an environmentally, economically, and socially complex situation such as small-scale mining management in the Amazonia was studied, focusing on the conflicts and identifying the genuine interests of all the parties. The idea is that new solutions may come from a particular conjunction of all the interests, even the apparently conflicting ones.

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