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ENVIRONMENTAL CONCERNS IN COFFEE PROCESSING IN BRAZIL

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Environmental Concerns in Coffee Processing in Brazil[1]

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Abstract

In Brazil, coffee hulling is accomplished primarily using the mechanical (dry) process, which generates far lesser deleterious environmental effects than those observed in the wet process. The latter generates serious residuals disposal problems. Pulp and water contaminated by the intensity of fermentation and posterior washing of beans produce significant pollutant loads - chiefly sugars and organic materials - that are transported to waterways. Despite these environmental costs, the wet process is considered to yield a higher quality product, and its adoption has been stimulated as one means to counteract the secular erosion of Brazilian competitiveness in coffee production. An "eco-label" for dry processed coffee has been proposed as a means to counter this tendency.

Particulate matter emissions and odors represent serious environmental problems associated with coffee roasting. The work environment is commonly filled with the dust released during handling of raw beans. This dust contains allergenic compounds (chiefly chlorogenic acid) that result in exposed workers developing asthma, rhinitis or dermatitis. Smoke emitted during roasting is dense, containing a large quantity of fine particles derived from the materials that cover coffee beans, so affecting neighboring communities.

However, the most serious source of externalities in coffee processing in Brazil is associated with sediments produced during manufacture of soluble coffee, constituting 65% by weight of the raw coffee beans processed. Up to two kg of sediment is produced per commercial kg of soluble coffee. Disposal of the acidic residual liquor from soluble coffee manufacture represents another serious problem for the industry. In Brazil, most such wastes are disposed of directly to watercourses or sewage systems without treatment.

Packaging materials also represent a growing problem in the industry, which has found it necessary to use vacuum packaging with materials not recyclable under current technology to conserve the aromas and impede rancification of grounds. Such materials are composed of foil backed plastics from which separation of materials is uneconomical, requiring application of acid. Final disposal of these materials represents a "cradle-to-grave" issue that should be made a subject of concern.

How can such problems be resolved? Product quality demands driven primarily by Northern markets represent a principal push factor in the adoption of environmentally harmful technologies. Product characteristics that demand energy- and chemical-intensive coffee production and use of waste generating wet processing methods appear to have created a fundamental contradiction between environmental preoccupations and import quality demands in the North. The achievement of environmentally friendly production and processing techniques requires concerted

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changes in both producer and consumer behavior. "Green" marketing trends promise to improve this situation, but still represent a very small segment of consumers. Fortification of state and local environmental monitoring and enforcement capacity in Brazil allied with market mechanisms will be the most important strategy toward improvement in environmental characteristics of the national coffee industry.

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Coffee trade, structural adjustment and socio-environmental vulnerability

Prior to the mid-1950s, coffee sales were Brazil's principal source of foreign exchange revenue, accounting for as much as 75% of total value of exports, and trade in coffee was considered a major aspect of foreign policy. Although domestic consumption has always been a large component of demand (the average household consumes over 10 kg/year of ground coffee) trade in unroasted coffee beans still accounts for 60% of national output of 1.1 million t, leaving producers vulnerable to international market volatility.

Despite Brazil's continuing prominence in international trade, the nation's relatively low degree of economic dependence on coffee today (4.3% of total 1989-91 exports) is only comparable to that of Indonesia among coffee exporting nations. This transition arose both from diversification of Brazil's export portfolio with increasing weight given to manufactures, and the relatively poor quality of Brazilian coffees in comparison to its principal competitors such as Colombia and Kenya. In contrast, Costa Rica and El Salvador relied respectively for about one-third and two-thirds of export revenues on coffee throughout the 1980s (Segura, 1993).

Brazil's historical efforts to contain coffee production in hopes of nourishing greater productivity and better global price conditions served as a stimulus for other nations to enter the market, leading to a sequential cycle of glut and prosperity. This sequential cycle of glut and scarcity exacerbates producer risk in tropical perennial tree crops, whose planting might or might not result in benefits from momentary price advantages, when they began to yield four to six years later. Furthermore, competition among nations dependent on a few export commodities for foreign exchange undermines the effectiveness of producer/consumer trade agreements.

Unfortunately for Brazilian producers, global prices were depressed at a the same time that the shrinking relative importance of production and trade in coffee to the overall economy had reduced the priority given to commodity-related sectoral policies. The overall neoliberal trend in commercial relations, leading to privatization of marketing boards, elimination of subsidies and restraints on credit left producers and processors far more vulnerable to the collapse in the economic clauses of the commodity agreements.

Increased producer vulnerability has in turn conditioned the manner and extent to which commodity production generates environmental costs.

Structure of Brazil's coffee production and processing industry

Nearly 300,000 producers form the base of the coffee agro-industry in Brazil (Figure 1), producing an average of 27 million sacks (450,000 mt) annually between 1985-90. In 1988, these farmers, together with hired labor and their households constituted nearly 10% of the rural population of Brazil. In traditional producing areas in Brazil's Southeast region, the prevailing tenure structure is made up of smallholders who mostly rely on family labor. Average productivity in unroasted beans is 480 kg/ha on nearly 3 million ha of coffee plantations throughout Brazil (IBC, 1990).

The agro-industrial structure in coffee is highly dispersed, with 3,000 processors engaged in cleaning, hulling, classifying and reprocessing coffee beans. A far smaller group of some 70 cooperatives at significantly larger scale are responsible for as much as 20% of unroasted coffee bean deliveries. Secondary processing involves a major food industry of 1,200 firms oriented toward coffee roasting and grinding, and 11 that produce soluble coffee extracts. Together, these firms transform roasted beans into conventional consumer products - ground coffee for filters and espresso machines, and instant coffee in granules and powder. Nearly half of overall production is exported in unroasted form, and most of the remainder stays in Brazil as ground coffee. Only 10% is processed, primarily by multinationals, for instant coffee, most of which is destined for export markets.

Environmental effects of coffee production in Brazil

In the realm of agricultural production, there exist two environmental problems of some significance in the coffee industry: declining fertility due to soil erosion, and the deposit of pesticide residues in the soil, water and coffee beans themselves.

Coffee expansion and soil exhaustion over the years have left behind vast expanses of degraded lands in Brazil, while policies to contain production in periods of glut have led to uprooting not only billions of trees but also hundreds of thousands of rural households. In the mid-1960s, the Brazilian government launched a major campaign for coffee eradication, resulting in uprooting 1.2 billion trees. Increased world prices led the government then to stimulate new plantings, dictating credit terms that required contour planting, restricting credit to areas considered agroecologically apt for coffee, and packaging subsidies for increased use of industrial inputs. This package stimulated coffee plantation renovation with improved species, fertilization and pesticide recommendations, prohibiting intercropping and minimizing shade. Former coffee plantations lapsed into pasture and secondary forests.

Brazilian coffee production has historically involved considerable use of chemical measures to combat pests and disease. Due to numerous applications, many intoxications were registered among workers, who lacked knowledge regarding the safeguards necessary in spraying pesticides. Large scale coffee growers have since adopted use of wide spectrum systemic pesticides applied to the soil, whose use is less risky for workers than is spraying. The search for methods to combat nematodes in coffee contributed to soil conservation, as it was discovered that the best means to control nematode attack was to increase the organic matter content in soils under coffee. This objective can only be attained through an effective soil conservation program linked with complementary measures of green manuring and composting with coffee residues.

The coffee borer, an early source of losses, was eradicated in São Paulo and Minas Gerais by the early 1980s. Biological control for the borer was later developed in Brazil, relying on the Ugandan wasp as a natural predator. With disappearance of borers from the principal coffee growing regions, biological control research was interrupted. However, by the end of the 1980s, the economic crisis that affected world coffee production and the consequent abandonment of coffee groves created conditions propitious for the borer's return.

Before government intervention, coffee growing in Brazil can be considered to have been based in up to 40% on "organic" or low-input production techniques. Growers relied on natural soil fertility to provide adequate productivity during a 7-10 year period, after which lands were abandoned. Lack of producer capitalization made it too costly to use defensive pesticides, so that the quality of coffees produced in this period was poor. These coffee groves were substantially eliminated during the eradication program. Those which remained in production adopted the government's technical recommendation package, thus boosting overall productivity and enhancing competitiveness in more discerning markets (Agostinho Guerreiro, pers. comm.). Output in coffee climbed from the mid-1970s through the late 1980s, migrating from areas in southern Brazil that had been subject to frost, to new areas of specialization in Minas Gerais, Espírito Santo and the Legal Amazon, where robusta varieties are now also grown (Daviron, 1992).

Despite improved productivity and sustained market demand during this latter period, growers were forced to reduce use of chemical inputs during an ensuing period of depressed prices from 1987-93. This period, corresponding with a collapse in the economic clauses of the international coffee agreements, led to a new cycle of crop abandonment. Despite increasing relative participation in the international market in this period, Brazil's increased export volume was obtained at the expense of approximately $1.15 billion in export earnings annually, due to declining prices (Figure

3). This decline in revenues has had a considerable effect on coffee producers, particularly smallholders (Saes & Giordano, 1992). By 1992, a decline in crop area on the order of 800,000 ha of coffee either abandoned or eradicated, has implied a reduced labor contingent of nearly 250,000 workers, whose combined direct and indirect beneficiaries number in the realm of a staggering 4 million persons (Table 1; May et al., 1994).

The most severe environmental impact of this shift has been the substitution of coffee stands by pastures, with a consequent decline in prospects for rural employment. In the most traditional producing regions, rural exodus is dramatically evident. For those who have remained in coffee production, the reduction in household income has obliged the mobilization of women and children to work on- and off-farm as a means to survive.

Abandoned coffee groves irradiate pests to neighboring growers, making it necessary to apply heavier doses of chemicals, and became fertile ground for attack by the coffee borer, a pest thoroughly eradicated in previous decades.

While in some areas declining prices made it impossible for small coffee producers to remain in production, others were able to sustain a modest level of output and to invest in efforts toward producer organization to seek alternative market channels. Because many of these farms had applied chlorated pesticides and cupric fungicides as a standard practice prior to the drop in prices, their product cannot be considered to be certifiably "organic", until after a period of transition to eliminate residual chemical buildup in soils and tree tissues (Dickinson and Lepp, 1985). Producers have increasingly adopted intercropping, shading with leguminous trees, and mulching as means to ensure adequate nutrient availability and control weed growth (Babbar and Zak, 1994).

Besides measures to secure peasant coffee farmers on the land, to produce coffee in a manner consistent with resource conservation objectives requires investment in erosion prevention and organic matter conservation, as well as development and dissemination of cost-effective biological control and integrated pest management systems (IPM) to avert pesticide spillover effects.

Coffee agroindustries and the environment

Coffee hulling, the first stage of processing, is accomplished throughout the world using mechanical (dry) and wet processing technologies. Although nearly half of the world's coffee is wet processed, in Brazil this method is only employed in a restricted area of Bahia. Mechanical (dry) hulling and, in smaller volume, "semi-dry" processing, are far more widely disseminated, constituting the vast majority of Brazil's export product. The dry method involves washing solely for separation of impurities, and hulling itself which, although not a source of water pollution, can cause dust problems affecting plant workers' health.

The wet process has several disadvantages. It is technically more complex, requires a greater capital investment, higher energy use and greater training on the part of workers. It also generates considerable problems in disposal of pulp and water contaminated by processing; due to the intensity of fermentation and posterior washing of beans, significant pollutant loads - chiefly sugars - are transported to waterways (Bailly et al., 1992:129). Nevertheless, the wet process is considered to yield a higher quality product with broader international acceptance, and its adoption is thus being stimulated as one means to counteract the current crisis of Brazilian coffee.

In dry processing, water used to wash out impurities and facilitate the drying process ranges from 1.4 to 14 l/kg of processed coffee, depending upon the sophistication of the washing equipment. This water may be contaminated by microorganisms, which has led research agencies to recommend chlorination (Bártholo, et al., 1989).

The chief residues of dry processing are the hulls themselves, constituting as much as 50% of harvested weight (Costa, 1986; Bártholo et al., 1989; Balanço, 1991), or about 1.5 million tons in 1991 (Carvalho, 1992). Parchment, principal component of the cherry endocarp, constitutes 12% of dry harvested weight, mostly of cellulosic material. The principal potential end uses for coffee hulls and parchment include: fuel (for drying and conditioning), charcoal (including potential for gasification), organic material for fertilizer in composting and as livestock bedding material (Claude, 1979; Tango, 1971), and animal rations as a component of silage mixtures (Cruz, 1983; Adams & Dougan, 1987).

Despite this potential, coffee hulls are rarely used as fertilizer in Brazil, due to their low nutrient value and the difficulties inherent in installing hulling equipment at the farm level. Transport of hulls from local processors to farms is considered uneconomical, thus limiting their use in fertilization. Parchment is often disposed of directly into rivers (Claude, 1979). Residues used a constituent of bedding for livestock have provoked instances of caffeine intoxication in animals that habitually consume their bedding (Nazário et al., 1984:192). Utilization as a fuel has considerable unrealized potential, and may enable processing industries to become energy self-sufficient (Claude, 1979).

In coffee dry processing industries, the work environment is commonly filled with the dust that is released during handling of raw beans. This dust contains allergenic compounds (chiefly chlorogenic acid) that result in exposed workers developing asthma, rhinitis or dermatitis (Ajax & Lee Jr., 1979; Zuskin et al., 1979). The presence of these compounds is apparently reduced after roasting.

Particulate matter emissions and odors represent the most serious environmental effects of coffee roasting. Smoke emitted during roasting is dense, containing a large quantity of fine particles derived from the materials that cover coffee beans. The quantity of fine coffee residues produced during roasting can vary from 0.5- 1.0% of raw bean dryweight (Pfluger, 1975), and is seldom completely burned off, unless an incineration stage is added. Particulate emissions vary in accordance with the heat process employed, and reach 3.5 kg/100 kg of raw coffee processed (Ajax & Lee Jr., 1979).

In the processing of soluble coffee, up to 34 kg/hr of fine coffee dust is generated from pulverizing-drying equipment operating at volumes of between 450 and 910 kg/hr. The simple addition of a cyclone reduces dust levels to around 6.8 kg/hr, the powder recovered being sufficiently remunerative to cover the expense. However, when such firms are located near residential areas, complete dust removal is often necessary, requiring considerable investment in gas scrubber equipment, whose use, despite having low operating costs, is inviable for some types of roasting facilities (Pfluger, 1975).

Odors that emanate from coffee roasting processes arise from the emission of organic compounds including alcohols and organic acids, sulfur and nitrogen oxides, which can be almost completely removed through proper incineration (USEPA, 1985). Incinerators functioning at 650° C. and catalytic combustion units at 371 C., are efficient in elimination of odors (Ajax & Lee Jr., 1979). The lower fuel cost of the latter is offset by the high cost of replacement of catalyzer elements (Pfluger, 1975).

Coffee sediments produced during manufacture of soluble coffee are of considerable magnitude, constituting 65% by weight of raw coffee beans processed (Claude, 1979). Up to two kg of sediment is produced per commercial kg of soluble coffee (Purdom, 1980; Adams & Dougan, 1987; Pfluger, 1975). The insoluble residues, having 75-80% moisture content, must be compressed to reduce moisture to at most 50%, after which they may be used for animal ration, fertilizer, as a landfill or, most favorably, as a fuel (Tango, 1971; Claude, 1979; Adams & Dougan, 1987; Pfluger, 1975).

Disposal of residual liquor from soluble coffee manufacture, acidic (pH = 4.0) and containing about 1% solids in suspension, represents another serious problem for the industry. In Brazil, most such wastes are disposed of directly to watercourses or sewage systems without treatment.

Coffee is a perishable product, whose shelf life once ground is only 20 days. To conserve the aromas and impede rancification of grounds, it has been found necessary to use vacuum packaging with materials not recyclable under current technology. These are composed of foil backed plastics from which separation of materials is uneconomical, requiring application of acid. Innovative efforts by package manufacturers are required to overcome this problem, which may become more serious in future, as vacuum packed ground coffee using such packaging represents the segment of the Brazilian industry which is experiencing greatest growth.

Another packaging-related area which has received recent emphasis is that of growing insistence by exporters that jute sacking be recycled, combating importing countries' policies which prohibit this practice on sanitary grounds. Exporters contend that sacks are sold for use in transporting other grains and would have their sacking returned for recycling, thus reducing coffee export costs.

Commodity policies toward sustainable trade

Coffee prices have shown a substantial recovery from the crisis years of the early 90s, nearly tripling in value since the low of 1993. Long-term supply projections suggest that the crisis is far from over, however. The question becomes one of finding ways in which short-term improvement may be converted into a long-term basis for sustainable trade in these commodities.

To obtain environmentally desirable alterations in production systems, sectoral interests have generally concluded that it is first necessary to remunerate producers adequately, or provide compensatory transfers to ease the transition to sustainable systems. Such remuneration must be targeted, however, toward utilization of environmentally sustainable production practices. Subsidized credit or minimum price guarantees may only reinforce the tendency to exhaust soils and apply excessive industrial inputs.

The effect of price improvement in traditional markets has typically been to motivate farmers to return immediately and forcefully to the same high input techniques they had adopted prior to the crisis (May et al., 1994). Improved world prices that have brought increased financial viability has had the perverse side-effect of strongly increasing demand for industrial inputs such as pesticides, thus exacerbating health and natural environmental risks. Product quality is the principal push factor in this response, affected by the demands of Northern consumers, which stimulates cooperatives and processing industries to offer premium prices for quality beans. Product characteristics that demand energy- and chemical-intensive production methods appear to have created a fundamental contradiction between environmental preoccupations and import quality demands in the North. This suggests that internalization of environmental concerns in commodity markets requires measures that target those producers who not only adopt but stick with environmentally friendly production techniques, making necessary a broader adhesion to certification procedures where segmented markets can be built.

One mechanism to reinforce sustainable practices is that of market segmentation of organic or cooperatively grown coffees. The principal objective of market segmentation in small farmer coffee production has been to qualify for registry and export by roasters who participate in the Max Havelaar Foundation network in Western Europe. Such registry is limited to organized groups of farmers that produce good quality coffee on areas typically from 2-4 ha, on which they depend for a principal share of their income. Those who qualify are able to market their coffee with the Max Havelaar seal, widely recognized in European supermarket chains, and so secure a price premium that enables producers to as much as double net income. The organic characteristic is not a principle objective of this registry, although many such producers are moving toward such technologies. In this sense, the environmental characteristic of alternative coffee is more closely meshed with a social equity objective than with purely physical environmental concerns.

In Brazil, a few isolated groups of coffee growers in Rondônia, Espirito Santo and Minas Gerais have sought or obtained Max Havelaar registry. The technical assistance organizations that have been officially recognized to orient growers in this sense have typically adopted "alternative technologies" (low-input, labor intensive and resource protective techniques that can be used by small farmers on marginal lands) as a starting point (APTA-CERIS-IDACO-PROTER, 1993).

The prospects for expansion in Brazilian producers' involvement in this market segment remain dubious, however, due to concern among those seeking to strengthen small farmers' organizations. This concern stems from two arguments regarding Brazilian coffee growing. First, the majority of smallholders in Brazil operate coffee plantations that are larger by far than those managed by small farmers in other countries where alternative market channels are sought (according to Zylberstajn et al. (1993), "mini" and small coffee farms in Brazil are defined as those under 50 ha). Secondly, Brazil's massive production, even if only a small proportion were to be directed toward the alternative market in Europe (still only between 2-4% of total consumption in the Low Countries, France and Germany) could result in the bottom dropping out of the market. There could thus be a negative effect of competition in the "solidarity" market that has been constructed (Agostinho Guerreiro, pers. comm.).

Internalization of environmental costs in coffee and cocoa processing industries requires a mix of economic incentives and regulatory measures. To date, the threat of enforcement and public pressure have been sufficient in some states to enlist efforts by coffee roaster/grinders to seek technical solutions for particulate and odor emissions. Incentives to equipment manufacturers that encourage the containment and recycling of byproduct materials have already been assured in secondary processing, due to Brazil's conquest of EEC markets for such equipment, subject to rigid environmental standards. Processing equipment manufacturers - in seeking remunerative international markets - have also found it beneficial to standardize environmental safeguards in their machinery produced for the domestic market.

In conclusion, it is evident that consumer insistence on product quality can be a two-edged sword for environmental sustainability. An informed consumer community aware of environmental consequences of product demand can help to motivate adoption of less aggressive technologies. For example, having enough flexibility to accept slightly discolored coffee beans produced with low pesticide inputs could make a significant difference in the direction of producer expenditures. Thus, both producers and consumers have important contributions to make toward more sustainable commodity trade.

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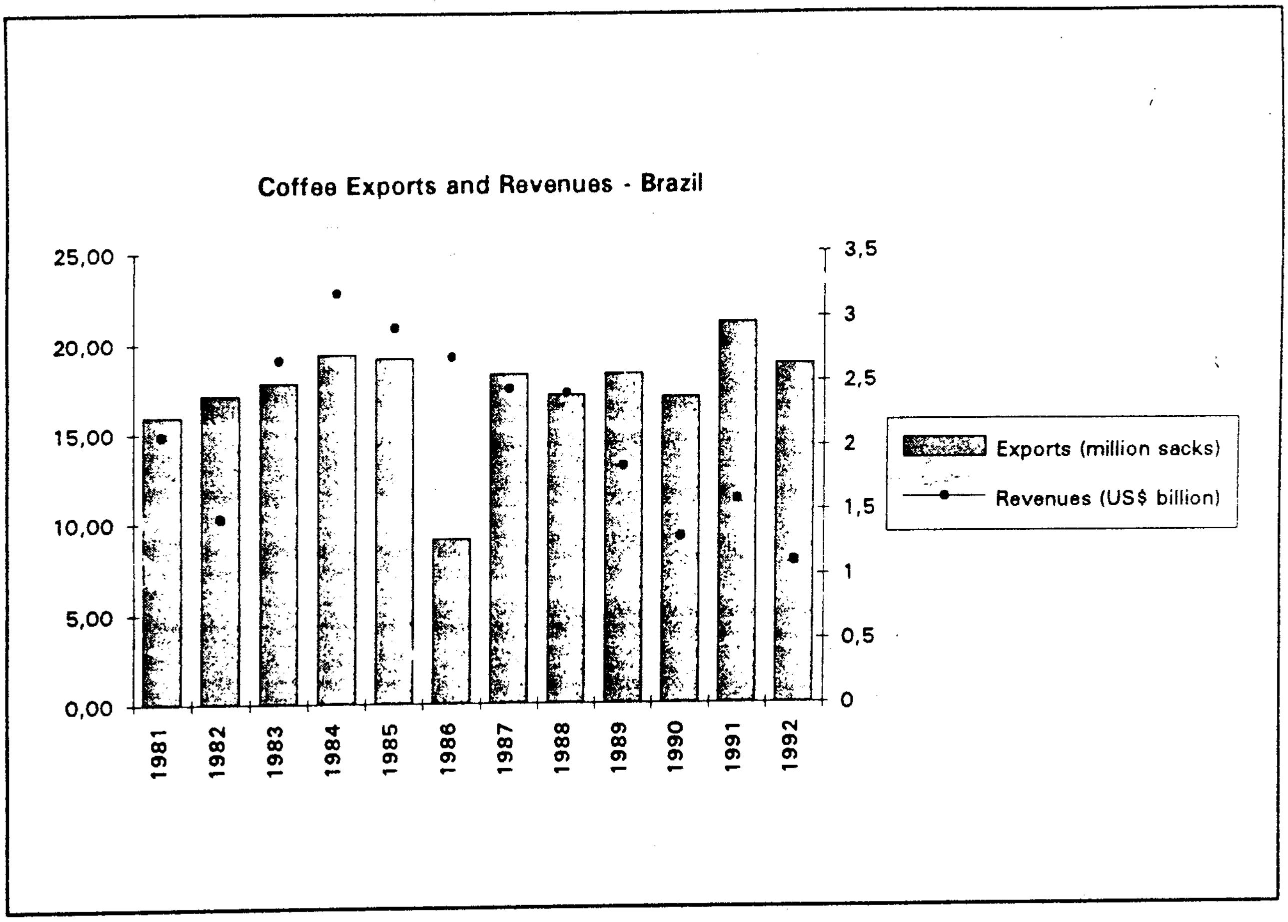
Figure 1. Exports of Coffee Beans - Brazil: 1981-92



Quotas in effect: 1981-1984 and 1987-1988
Accord broken: 1985-86 and 1989-92
Source: CACEX.

Table 1. Employment in Coffee Production in Brazil: 1988 and 1992

YEAR	PLANTED AREA	DAILY WORKFORCE	DIRECT BENEFICIARIES	INDIRECT BENEFICIARIES
1988	2.720.000	870.400	3.481.600	10.444.800
1992	1.940.000	620.800	2.483.200	7.449.600
DIFFERENCE	780.000	249.600	998.400	2.995.200

SOURCE: Cooparaíso, Technical Dept. Preliminary data.