LATEN Dissemination Note # 14

Policy Options to Address Informal Sector Contamination in Urban Latin America:

The Case of Leather Tanneries in Bogota, Colombia

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INTRODUCTION

1. Working with the informal sector in urban Latin America is a great challenge, and dealing with the the sector's environmental aspects is even more daunting. Governments and scholars alike have been thwarted in their attempts to define the informal sector much less find data on its activities and its role in urban pollution. Yet the few studies that are available do support some broad conclusions—that the informal sector in urban Latin America is vibrant, is likely to contribute considerably to the region's economy, and therefore is also expected to add significantly to urban pollution. Even if the informal sector proves not to be a major polluter, failure to address its contamination may hamper efforts at curbing localized pollution problems and improving overall environmental conditions.

2. This paper builds on available literature about the informal sector and environmental policymaking. Its goal is to raise awareness about urban informal sector contamination and to establish an initial policy options framework to address it. The following section describes the informal sector, its significance in urban pollution, and some of the activities that warrant greatest concern for regulators. The paper then focuses on the factors that influence decisionmaking, available policy options and their effectiveness, and approaches that go beyond the usual regulatory instruments. This is followed by a case study of informal leather tanneries in the San Benito neighborhood of Bogota, Colombia, including proposals and policy options for addressing the industry's pollution problems. Finally, the last section provides conclusions and highlights the main ideas of the paper. An annex, with two mini case studies from other urban centers in Latin America, illustrates the diversity of informality and urban contamination.

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1. Messrs. Dan Biller and Juan David Quintero work as Economist and Environmental Specialist, respectively, in the Environment Unit of the Latin America and the Caribbean Region of the World Bank. Carlos Federico Basanes' assistance and helpful discussions, and John Surdyk's assistance in preparing the annex are gratefully acknowledged. The authors also wish to acknowledge the invaluable comments of Carl Bartone, John Dixon, and peer reviewers Emmanuel Jimenez and Alberto Ninio. Editorial and secretarial support from Peter Brandriss, Mercedes Aleman, and Diana Montas is also gratefully acknowledged. Special thanks are due to the Government of Colombia and the Municipality of Bogotá for their assistance in the field.

THE INFORMAL SECTOR AND URBAN CONTAMINATION IN LATIN AMERICA

What Is the Informal Sector?

3. A well-established typology to define the informal sector is absent from the literature. This lack of accepted typology produces a variety of terms and characteristics which authors use differently depending on the problems they wish to highlight. For example, some authors define the informal sector according to organization, production, and technology; therefore, a firm in the informal sector is characterized by small-scale operation, family ownership, reliance on domestic resources, and intensive use of labor as an input. Further, it participates in a market characterized by easy entry. Other authors take a regulatory approach, defining the informal sector as a group of firms that elude official regulation despite being "in a legal and social environment in which similar activities are regulated."[2]

4. Recent economic literature relies more on the second definition (the regulatory one) and focuses on labor and macroeconomics issues.[3] This is the approach used in this paper. In general, the informal sector encompasses a broad group of activities in which state regulations—such as taxes and licensing, among others—are partially or totally unenforcable. Consequently, these activities fall beyond the standard measures of economic production. Box 1 describes a typical informal sector firm in an environmental context.

5. In theory, an informal sector activity could be considered equivalent to an illegal activity, but in practice the former is usually more tolerated than the latter.[4] This greater tolerance level may be explained by institutional weakness in law enforcement, inadequate regulatory frameworks, and poverty-related factors, among other reasons. On the violator's side, we will assume a rational economizing behavior; that is, this economic agent will weigh the gains from the informal activity against the costs of keeping it concealed.

Why Is It Important to the Urban Environment?

6. As mentioned previously, having accurate information on the informal sector in general, and specifically on its pollution, is usually a complicated task. Definitions are often unclear, the normal economic statistics do not usually reflect informal activities, and data complexity existing in most environmental issues complicates the design of efficient instruments for pollution prevention.

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2. To compare how these two approaches define the informal sector, see ILO (1972) and Castells and Port (1980).

3. For example, see Fortin et. al., 1994; Braun and Loayza, August 1994; Loayza, August 1994; and, Chandra and Chhikara, May 1995.

4. For a detailed discussion of the legality aspect, refer to Tokman (1992).

Box 1. An Informal Firm in Rio de Janeiro, Brazil

Mr. X produces semi-finished and finished leather goods in Pavuna, an industrial/residential suburb of Rio de Janeiro, Brazil.[5] He purchased the company in 1986, but never registered the business with the environmental agency and with the finance secretariat. Until recently, regarding both the municipal and the state government, Mr. X's company did not exist, even though its location has housed the same type of activity since 1918. Mr. X owns a typical informal sector industrial firm.

Yet, the informality of Mr. X's firm does not preclude it from participating to a certain degree in the formal economy. In fact, Mr. X pays property tax (otherwise the company would not have electricity and water), part of the value-added tax (ICMS) to escape federal scrutiny, and has 25 out of 50 workers formalized.

Mr. X's firm also contaminates the environment in two key ways. It discharges wastes from dyeing substances in the Pavuna River and emits particulates into the air. Through this contamination, yet for personal reasons (someone did not like Mr. X in the neighborhood), the firm was discovered by the environmental agency, and a lengthy judicial process commenced. The outcome will be either the legalization or closure of the activity.

7. Most empirical studies of the informal sector adopt the labor approach, including estimations of the sector's size regarding formal versus informal employment in a given economic activity. This tendency may be partially explained by the perceived reliance of the sector on intensive use of labor as a primary input in the production process. The resulting data indicate that the informal sector in developing countries employs between 35 and 65 percent of the total labor force.

8. The few available estimates of the importance of the informal sector in the world's economies indicate that the size of the sector is significant in developing nations, and may be important in some developed nations as well. The size of Peru's informal sector, estimated to account for nearly 40 percent of the country's GDP, is typical of many other developing nations.[6] Even in countries like the United States, estimates of the informal sector from the late 1970s and early 1980s range from about 5 to 35 percent of GDP. These figures are likely to be higher in other developed nations, like Italy, where it is widely assumed that the informal sector has historically played an important role in the economy.[7]

9. Since the informal sector in urban Latin America is likely to contribute a considerable share of the region's wealth, it should be expected that the sector significantly impacts the overall contamination of the region's urban centers. This assumption, however, merits at least two caveats. First, part of the sector focuses on

5. Based on discussions with Mr. X's lawyers in Rio de Janeiro, on condition of client anonymity.

6. Chickering and Salahdine (1991) mention a range of 20 to 40 percent of GDP for most developing countries, yet the issue is far from settled. In the same publication, estimates for the Philippines range from 23 to 70 percent of the country's GDP in the 1980s, and from 12 to 24 percent in the late 1960s. For Sri Lanka, estimates indicate the size of the informal sector to be about half of the country's GDP. See also Soto (1989).

7. For analysis of informal sector activities in both developing and developed nations, see Portes et. al. (1989).

activities such as commerce that generally do not cause significant direct environmental damage. Second, since the decision to operate informally is likely to depend in part on the cost of concealing the economic activity, and smaller firms may have smaller concealment costs, in a given industry informality may be concentrated among smaller economic units. These units may produce less and thus contaminate less, yet due to capital costs they usually have higher pollution per output ratios than formal firms in the same industry.[8]

10. Given the above caveats, environmental regulators may initially focus on larger firms because they are often perceived as larger polluters. This may lead to a distorted policy, principally because (a) there is a greater degree of uncertainty when regulating industries where participation in the informal sector is likely to be high, and (b) in some cases (e.g. pollution prevention and cleanup) threshold levels have to be attained to make overall environmental quality improvement feasible. Box 2 illustrates this situation in the context of a large South American city, and suggests that a successful urban environmental policy cannot rely solely on command and control (CAC) measures.

Informal Sector Activities Relevant to Contamination

11. There are a number of urban informal sector activities that are potentially harmful to the environment, from improper dumping of waste and sewage to air pollution caused by informal transportation. This diverse range of polluting activities

Box 2. Informal Sector and Sewage Treatment Facilities in a Large South American City

Sewage treatment is often based on the utilization of biological processes and tends to be a costly enterprise. These mechanisms take advantage of sewage processing bacteria that are able to free the environment of some organic contamination. The high cost of treatment is often a function of the machinery needed, and the special conditions required to enable the bacteria to act. Yet, even with the correct structure at the treatment site, it is important to guarantee that the effluent is acceptable for treatment. For example, sewage with high content of heavy metals is likely to hamper treatment efforts, since bacteria are unable to digest the effluent.

Aware of this constraint, regulators in a large South American urban center invested in a command and control (CAC) policy to curtail the discharge of heavy metals into the city's sewer by large metalworking firms. This was done prior to constructing sewage treatment facilities. Initial results seem to indicate that the CAC policy attained its goal of controlling heavy metal discharges into the sewerage system by large firms. Yet, at the treatment site heavy metal contamination has hampered the functioning of the treatment facilities. A large metal-related informal sector made up of small firms (backyard type often with less than 20 workers) thrives in the city, discharging heavy metals into the sewerage system in sufficient quantities to disable proper treatment.[9]

8. The potential environmental threat from the sector is nonetheless well recognized in the literature. See, for example, UNEP (1987).

9. Information on this case is based on the authors' personal communications with the authorities.

causes a number of impacts. Alternatively, it should also be recognized that some informal activities, such as garbage sorting by "scavengers," promote environmental conservation.[10] Although the policy options discussed here may be utilized across the board to address informal sector contamination, the paper focuses primarily on informal industry's contribution to urban contamination. The paragraphs below discuss some likely sources of informal industrial contamination in the region. The list is of course neither complete nor exclusive, since it is highly dependent on country-specific factors.

12. *The Metalworking and Electroplating Industry.* This is likely to be one of the most contaminating informal activities in the region's urban centers, and little information is available on it. Firm size varies greatly, depending on the type of goods produced, capital needed and/or services provided.[11] Many companies function in residential backyards or are associated with other economic activities. Since production is undertaken without major noise disturbances and odors, and inputs and outputs are not bulky, concealment costs are likely to be low. In addition, the industry tends to be spread over large areas. Major contamination from this industry occurs in the form of hazardous wastes like heavy metals, for which the environmental absorptive capacity is low. Major threats are likely to include health-related issues, and damage to sewerage systems and landfills.

13. *Textile Industry.* Though unlikely to be as contaminating as the metalworking and electroplating industry, the textile industry shares some of its organizational characteristics. Firm size varies greatly, and it is generally spread sparsely in the urban areas. Its output may be sold in informal markets or established stores, and depending on its size the activity may occur without major public disturbances. Concealment costs are therefore likely to be low, but depending on the process being utilized pollution impacts may or may not be negligible. Minor contamination may be caused by solid wastes from the use of textiles and other materials. Alternatively, major contamination may occur when the firm undertakes dyeing and processes that emit large quantities of particulates (as is the case in box 1). Ultimately, alkaline liquid wastes may be discharged directly into sewerage systems or natural bodies of water, and air may be significantly contaminated in local neighborhoods.

14. *Automobile Repair Shops.* A popular economic activity in many cities in Latin America, automobile repair shops may contribute significantly to inappropriate toxic waste disposal such as used oil and batteries, and other contaminants such as sludge from car and engine washing. These contaminants are either directly discharged into the environment or find their way into sewerage systems and landfills. Firm size tends to be small, and the industry is spread over large areas. Since this is primarily a

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10. For an example of this case, see Waas and Diop (1991).

11. Firm size in this section and context refers to number of employees and/or output. Any possible conflict between the two is clarified as needed.

service industry, concealment costs are not likely to be as low as in the case of the metalworking and electroplating industries.

15. *Brick Manufacturing*. Normally peri-urban, brick manufacturing in some cities may be a major contributor to air and water contamination. In particular, emissions of particulate matter and discharge of sediments in waterways are often the primary contaminants. The impact's severity is a function, among other things, of the population density of the area where the activity takes place and the final use of the waterways being contaminated. Firm size varies, and the industry tends to be concentrated in certain peri-urban areas where access to raw materials like clay is easiest. Due to the nature of the contaminants and the industry concentration, concealment costs may be higher than in the above cases.

16. *Tanneries*. Very active in some countries, tanneries are probably the most studied informal industry. Leather tanning is likely to be found in rural and peri-urban areas, yet in some cases where city growth has engulfed formerly peri-urban areas leather tanning has remained a popular informal activity. The processes are generally well known, and may be passed on through several generations. In some situations the process is broken down into subtasks, with smaller firms undertaking only a fraction of the total tanning process. The industry is generally concentrated in certain neighborhoods, since its foul odors and organic residues cause public outcry. Major effluents involve a cocktail of hazardous wastes such as heavy metals, organic compounds, and liquid detergents, which are generally discarded in sewerage systems and rivers. Given the industry concentration and type of contaminants, concealment costs tend to be higher than in the other informal activities.[12]

POLICY OPTIONS TO ADDRESS POLLUTION FROM THE URBAN INFORMAL SECTOR

Factors Influencing Policy Decisions

17. As discussed above, a major consideration in a firm's decision to operate informally is the cost of avoiding the regulation, or the concealment cost. This factor is industry and firm specific. For example, an industry with a large number of firms may exhibit a high rate of informality. Indeed, as competition increases in the industry, informality may also increase, since it becomes more difficult for the authority to control and enforce regulations. In addition, firms may compensate for the increase in the number of competitors by avoiding regulations in order to cut costs.[13] Though a regulator cannot know the concealment cost of each firm, knowledge about the industry definitely pays off in terms of regulatory efficiency.

12. Details of the informal leather tanning industry are discussed in the case study.

13. This point is explored in a forthcoming paper by Basanes and Biller.

18. Few firms are totally informal; that is, unless they operate completely outside a monetized economy, it is likely that at one level or another they participate in the formal economy. For example, a firm may purchase most of its inputs informally, yet sell its output in a relatively formalized market. It may also do the opposite. Regarding government services, the firm may choose to pay some charges (as is the case in Box 1), and avoid those that do not translate in a direct benefit to production. Aware of all these possibilities, albeit unaware of each firm's concealment costs, a regulator has to find the likely "Achilles' heel" of the industry, and then construct an effective and cost efficient environmental policy. Issues such as location of the activity and number of firms in the industry are also important factors to take into consideration when choosing the right instruments to apply the policy.

19. A very important factor for policy decision is the institutional weakness facing the policymaker. Institutional capacity determines how well regulations which may look perfect on paper are translated into effective action.[14] In the short to medium term, institutional capacity is likely to be a constraint rather than a controllable variable, therefore it is important to consider the institutional capacity of the regulating agency when choosing policy instruments.

20. Informal activities are often equated with poverty, yet as explained earlier this may not always be the case. Informality is present in both developing and developed economies, though to a different degree. The quality and quantity of regulations likely play a major role in the decision to turn informal, particularly in the case of urban informal industries. Unfortunately, the poverty argument is often overused by the informal industry lobby, and it is the regulator's responsibility to find out through research how much of a safety net is necessary to guarantee an equitable distribution of the possible burden of an environmental policy.

Policy Instruments for Correction and Prevention

21. The menu of instruments available to a regulator when addressing pollution is the same whether the contamination comes from informal or formal activities. This menu is summarized in Table 1, including some examples of these instruments being utilized.[15] The distinction between direct and indirect instruments is fundamental for addressing informal sector contamination. As discussed previously, in the case of informal sector contamination the idea of putting a charge on pollution or attempting

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14. Colombia's new environmental law may provide an interesting example of this issue. Articles 42 and 43, for instance, describe an optimal pollution charge in the theoretical sense without the presence of informality. It prescribes charging the polluter the value of the damages it causes. These damages will be assigned monetary values through valuation exercises. The effectiveness of the charges in practice, however, remains to be seen. In fact, Basanes and Biller (forthcoming) also shows that in the presence of informality, attempting to directly charge polluters for their damages may be far from optimal.

15. See Eskeland and Jimenez (1991), which is the source of Table 1.

Table 1. Some Instruments for Environmental Policymaking

Type of policy	*Variable affected*		
	Price	*Quantity*	*Technology*
Incentive			
Direct	• Effluent charges (Netherlands, China) • Stumpage fees (Canada, United States) • Deposit-refund schemes (beverage containers, northern Europe)	• Tradable emissions permits (emissions trading program, United States) • Tradable fishing permits (New Zealand)	• Technology taxes based on presumed emissions (water pollution control, Germany, France)
Indirect	• Fuel taxes (Sweden, Netherlands) • Performance bonds (hazardous wastes Thailand)	• Tradable input or production permits (lead trading program, United States)	• Subsidies for R&D and fuel efficiency (catalytic converters, United States, Japan, Western Europe)
Command and Control			
Direct		• Emissions standards (United States, China) • Logging quotas and bans (Thailand)	• Mandated technical standards (catalytic converters, United States, Japan, Western Europe)
Indirect		• Land zoning (Rondonia, Brazil) • Bans and quotas on products and inputs (high-sulfur fuel, Sao Paulo, Brazil)	• Efficiency standards for inputs or processes (fuel efficiency standards, United States)

to impose a direct control may actually lead to a suboptimal abatement level. The inadequate regulation may actually stimulate formal firms to switch into informality.

The Direct Approach

22. A direct approach to pollution reduction implies that the regulator knows a great deal about the contamination caused by the polluting firm. This may be feasible in the case of a monopoly or an oligopolistic industry, where informality is usually not a problem. Yet in cases where the informal sector dominates or is significant, it is unlikely that the regulator has enough information to establish and enforce an efficient direct instrument. The paragraphs below discuss some of the major direct instruments for pollution control and prevention, highlighting their potential flaws in addressing informal sector contamination. It should be noted that we do not discuss

the advantages of economic instruments over command and control measures (CAC) since this has already been widely discussed in the literature.[16]

23. *Pollution Charges.* A pollution charge levied on a polluter attempts to internalize the marginal external cost to society of the contamination. If the charge captures the exact amount of the damage, it is known as an "optimal Pigouvian charge," and in principle it is the first best in a menu of instruments.[17] In general, however, it is easier for the regulator to know the price effect of a charge than its pollution effect; therefore a process of trial and error may be necessary to attain the desired reduction in contamination. In an industry with a high degree of informality this type of charge has obvious limitations—how can a pollution charge requiring significant enforcement and monitoring costs be implemented when regulators cannot even ensure enforcement of more common regulations such as operating licenses and value-added taxes?

24. *Tradable Permits.* A tradable permit scheme has the same goal as a pollution charge, but attempts to achieve it by setting "quantity" rather than "price." A regulator may choose an environmental quality level in a given area, and issue (either for free or for an initial fee) tradable pollution permits to the firms active in this area. Some of the advantages of the scheme are clear. For example, the environmental regulator does not have to fiddle with charges to attain a desired quality level. Alternatively, tradable permit schemes may suffer the ills of markets in general; that is, strategic behavior, significant search costs, and market imperfections may hamper the workings of a permit market. In some specific cases, a tradable permit scheme could in principle be used to curtail pollution from an informal sector activity. If concealment costs are high enough (as in the case of a concentrated industry), if some firms benefit from the scheme due to efficiency and information gains, and if the sources of contaminants are well known, a tradable permit scheme may drive the inefficient firms out of the industry rather than driving more of the industry into informality.

25. *Direct Command and Control.* This type of regulation usually entails a source-specific restriction on the amount of pollution. These "licenses" to pollute up to a certain limit cannot be traded, and are strictly enforced on the polluters. For this type of instrument to work, substantial information is needed and the cost of implementation may be much higher than in the case of economic instruments. Once again, this type of instrument is unlikely to be cost-effective when addressing pollution from the informal sector, since the sector normally bypasses much simpler regulations than those used in environmental management.

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16. For a summary of the advantages, see Cropper and Oates (June 1992).

17. As noted in Baumol and Oates (1988), under certainty a system of pollution charges is equivalent to a system of tradable permits. With uncertainty, however, the choice of instrument will depend on the relative steepness of the marginal benefit and cost curves (Weitzman, 1974).

The Indirect Approach

26. As discussed previously, one of the main problems in regulating informal sector pollution is regulator's general lack of knowledge about the sector coupled with inability to enforce existing regulations. This is an important constraint that can only be changed over time through information gathering, institution strengthening, and revitalization of the regulatory framework. Nonetheless, additional actions to improve environmental conditions could also be taken in the short run. In this case, indirect instruments may play an important role in curtailing pollution from the informal sector. In fact, in the presence of a contaminating informal sector, indirect instruments may even be a first-best solution. Yet, there are also shortcomings, as discussed in the examples below.[18]

27. *Input Taxes.* Probably one of the most attractive options to policymakers, input taxes attempt to change pollution levels by affecting factor prices. Like most direct economic instruments, they may be revenue generating. Yet, as in the case of pollution charges, their impact on prices is more easily understood than their impact on contamination. Though they may be a first-best solution to informal sector contamination, an environmental policymaker has to consider a number of issues related to the effectiveness of levying an input tax. For example, if the input cost is small compared to the firm's overall cost structure, a tax would have to be large to yield a meaningful impact on contamination. If the input is used other industries, the policy may have a greater impact on less polluting activities, thereby curtailing environmentally benign economic enterprises. In addition, there may be a more polluting but less costly substitute sold in informal markets, in which case firms may switch to the substitute and ultimately cause more environmental damage.

28. *Output Taxes.* Taxing output is also an indirect way of addressing pollution. As in other economic instruments, output taxes may be revenue generating, but once again their impact on prices is easier to assess than their impact on contamination. Output taxes are particularly good for formal markets where direct instruments are difficult to implement. As in the case of input taxes, variables such as demand elasticities, availability of potentially more contaminating substitutes, and the possibility of firms becoming informal play a major role in the policymaker's decision to use an output tax to address pollution.

29. *Indirect Command and Control.* Regulations on processes, equipment, inputs and outputs are the indirect version of CAC. Like its direct version counterpart, this sort of regulation may require a significant amount of information, and may be extremely difficult to enforce on informal industries. For example, if policymakers are unable to enforce legislation that requires licenses to produce, it is unlikely that they would be able to enforce requirements on which tools to use.

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18. For a more detailed review of indirect approaches, see Eskeland and Devarajan (1994).

30. Figure 1 displays the possible paths for a regulator attempting to curtail pollution from informal industrial activities. As explained above, key variables may be the industry's concealment costs and the existence of formalized cost-significant inputs. To gather this information, surveys and sectoral studies are needed in most cases. Yet the figure also implicitly highlights the importance of a cross-sectoral approach to environmental policymaking, and an optimal combination of economic instruments and command and control measures.[19]

Some Additional Government Functions

31. Under budgetary pressure and the need to promote growth, some Latin American governments have increasingly been streamlining regulations that inhibit private sector activities. Regarding environmental issues, though, governments may keep in many instances their functions as regulators. Since environmental issues are characterized by market failures (as in the case of externalities) and the existence of public goods, market solutions may not in many cases lead to optimal social results making regulations necessary. Yet, rather than an across-the-board reduction of environmental regulations, rationalization of regulatory frameworks may be envisaged. In the section above we suggested ways of approaching this issue, particularly regarding the informal sector. In some approaches, there may even be the additional benefit of alleviating budgetary pressure. Governments may thus have additional functions such as reducing informality, disseminating information and engaging in the promotion of technological development.[20]

32. *Reducing Informality.* It is important to recognize that government can affect the firms' decision to bypass regulations by decreasing the expected profits of being in the informal sector. This can be done by increasing monitoring levels, enforcing existing regulations, designing a system of penalties for evasion and/or simplifying the regulatory framework. These measures can reduce the extent of the informality in the economy and enhance the effects of regulation. Regarding environmental issues, a policy to reduce informality may be effective if its design and implementation costs, plus those of the additional environmental instrument itself, are less than or equal to an alternative environment-specific policy. The point to emphasize is that reducing informality is not a *sine qua non* condition for improving environmental quality. Nonetheless, if a regulator can effectively achieve both, there may be additional gains to be reaped elsewhere in the planning process. Once again, the multisectorial characteristics of environmental issues and planning in general play a crucial role in deciding which path to follow.

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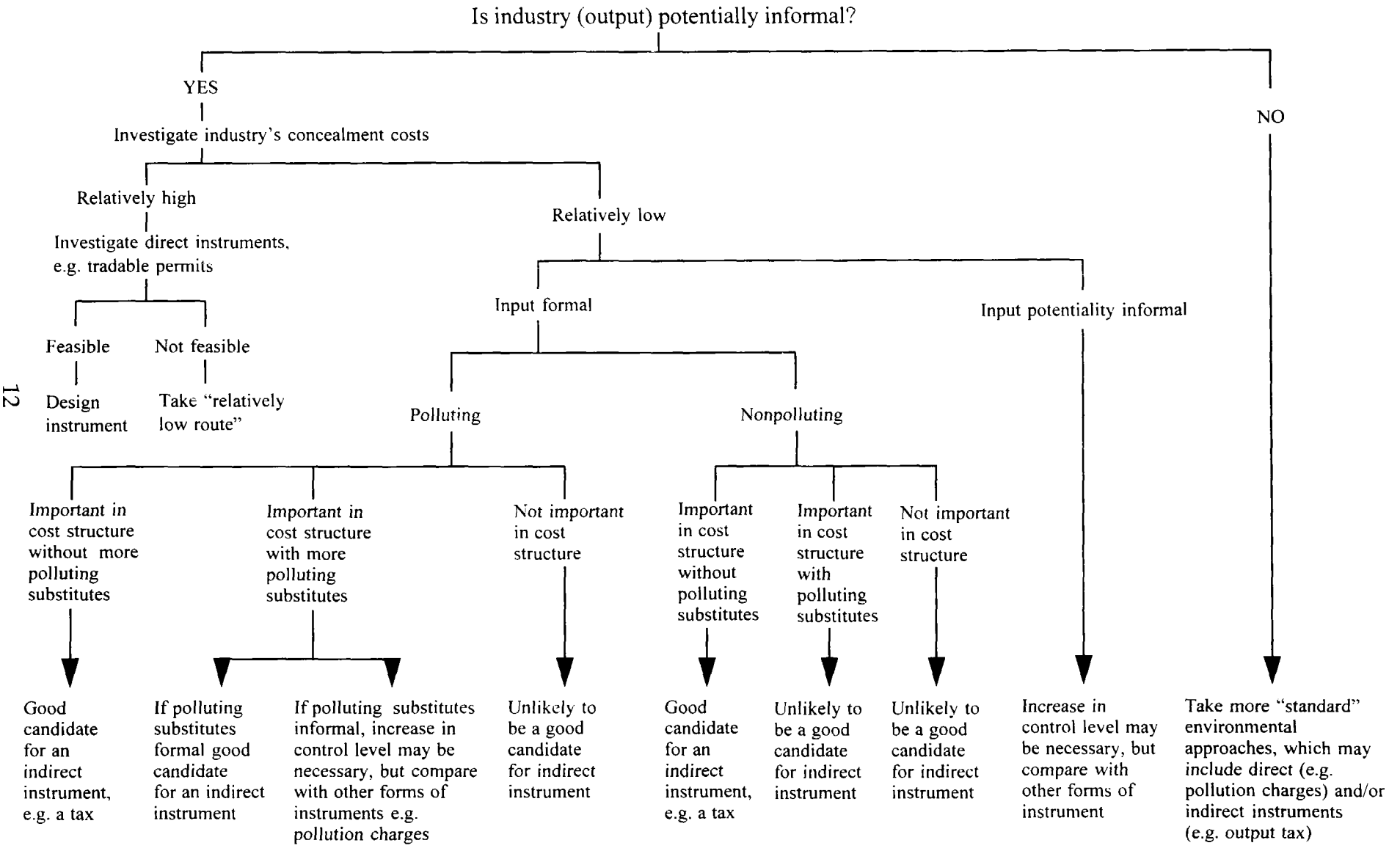
19. For discussion of a more macro approach to these aspects, see Tlaiye and Biller (December 1994), and The World Bank (March 1995).

20. For a more detailed discussion in the context of national environmental strategies, see World Bank (March 1995).

Figure 1. Policy Paths for Addressing Pollution From Informal Industrial Activities



33. *Information Gathering and Dissemination.* Many problems related to contamination from the informal sector are perpetuated by the general lack of information about the sector's activities. This works to the detriment of all potentially interested parties. For example, as discussed earlier regulators are often unaware of the extent of informality and its pollution. Surveys on the industry, and some level of pollution monitoring, are therefore needed to establish a basic data bank. Moreover, local communities may be unaware of the potential hazards of an informal activity. For example, heavy metal discharges, often odorless, may cause severe health problems without the affected parties' realization. While in the short run the existence of a polluting informal electroplating firm in a neighborhood may not cause any major discomfort, constant long-run exposure may be hazardous. Public awareness campaigns and environmental education may therefore pay off in terms of better health conditions for local communities and by uncovering and/or formalizing unregulated firms. Even the informal agents themselves may not be aware of the potential threat of their discharges, nor of novel means for optimizing production while diminishing environmental degradation. Awareness campaigns coupled with technical support may assist regulators in disseminating information while stimulating a greater degree of formalization.

34. *Technological Development.* As a complementary or last-resort measure, governments may invest in appropriate new technologies and cleanup activities when the private sector has no interest in doing so. This approach, however, may be costly, and should be weighed against other policy alternatives. If the technology also generates significant efficiency gains for firms, this would help luring them out of informality. Without the promise of efficiency gains, however, it is unlikely that such firms would voluntarily disclose themselves for environmental reasons alone.

LEATHER TANNING IN AN URBAN AREA: THE SAN BENITO CASE

35. To illustrate the above analysis and utilize some of its tools, we turn to a case study of an informal industry in one of the region's main urban centers—the San Benito leather tanning industry in Bogota, Colombia. While this is probably one of the few extensively studied informal industries of Latin America, data contradictions are prevalent in the research and solutions to pollution problems are scarce. The case study provides a brief overview of the relevant issues and proposes policy options.

Background

36. San Benito is a conglomerate of small, medium and large leather tanneries located within an urban neighborhood of Bogota's southwest sector. The industrial area dates back 40 years, when the displacement of tanneries from towns around Bogota created a core of small artisan tanneries along the Tunjuelito River. The

industry's rapid growth and the city's urban expansion created one of the largest tanning industry complexes within an urban area in Latin America.

37. San Benito is a mixed-use neighborhood, with a residential area in the northern part and a residential-industrial area towards the south. It houses over 8,000 people and 300 tanneries. The tanneries are concentrated, together with other related industries, in the southern area of the neighborhood. The great majority of the tanneries do not have the capacity or space to carry out the complete tanning process and most firms use traditional equipment and technologies.

38. Along with the electroplating industry, tanneries have been identified as having "highest environmental significance" in Colombia due to the liquid and solid wastes produced in the tanning process. San Benito houses the largest portion of the tanning sector's small industries. Tackling San Benito's pollution problems has proven to be a complex and disappointing effort, in which the tanneries' informality has played an important role.

Market Description

39. San Benito satisfies around 50 percent of the national leather demand from manufacturers of finished products (shoes, garments, and bags). Seventy percent of these finished products are sold at local markets. The remainder is exported, representing over US$45 million in export revenues in 1991.

40. During the last few years, surveys of the tanning industry in San Benito have produced conflicting results. This stems both from the variability and adaptability of the informal entrepreneur and from the different methodological approaches of the surveys. The most recent estimates of the number of tanneries in San Benito are shown in Table 2.

Table 2. Estimates of Number of Tanneries in San Benito

	Surveyor [a]					
Type of Producer	*EAAB*	*CAR*	*UNIDO*	*PROPEL*	*Environment committee*	*Industry survey*
Total tanneries	239	194	313	234	232	242
Chrome base	199	–	–	185	211	202
Tannings	28	–	–	25	13	28
Chrome and tannings	12	–	–	24	8	12
Leather board	9	–	–	6	5	3
Chemical distributors	–	–	–	14	15	–

a. Surveyors and year: Bogota Water Company (EAAB), December 1990; Bogota River Regional Authority (CAR), 1992; United Nations Industrial Development Organization (UNIDO), June 1993; Promoción de la Pequeña Empresa Ecoeficiente Latino Americano (PROPEL), January 1994; San Benito Environment Committee, June 1994; Colombia Small and Medium Industry and Environment, 1994.

Note: Columns may not add to totals since some tanneries are counted in more than one category.

41. Most tanneries process cattle hides, but a few also work with sheep and goats, as seen in Table 3. Estimates of total installed capacity range from 6,000 to 7,000 hides per day, but actual production is estimated at about 3,000 hides per day, or 50 percent of installed capacity. Production estimates are shown in Table 4.

Table 3. Tanning Industry by Leather Type

Type of leather	*Percent of tanneries*
Cattle (chromium base)	62
Cattle (tannings)	16
Goat	7
Becerro	6
Fresh splits	5
Sheep	4

Note: Some tanneries produce more than one type of leather.
Source: UNIDO, 1993.

Table 4. Estimates of Leather Production in San Benito

Surveyor	*Installed capacity (hides/month)*	*Real production (hides/month)*
Carnacol	168,000	84,000
Servicueros	168,000	72,000
Asocueros	144,500	86,500
PROPEL	152,000	85,000

Sources: Pellter Association of Colombia, Leather Services Association, Colombian Association of Leather Manufacturers, Promoción de la Pequeña Empresa Ecoeficiente Latino Americana.

42. Most of the raw hides are not preserved because they come from the local market and are distributed to the tanneries shortly after slaughter in Bogota's three large slaughterhouses. However, smaller tanneries also buy hides from the slaughterhouses of small towns in the Bogota Savannah and from illegal slaughterhouses in the city. A very small amount of raw hides are imported from Brazil and Argentina, and some tanneries are actually importing "wet blue."[21]

43. The raw hides acquired in the local market are of low quality, showing cuts, marks and holes. The average weight of a local hide is 25 kilograms, while an imported hide averages 35 kilograms. Both small and large firms compete in the raw hide market, and supply contracts are most often based on kinship or friendship ties rather than strict price competition. Figure 2 presents the distribution of the raw hide market in San Benito by industry size.

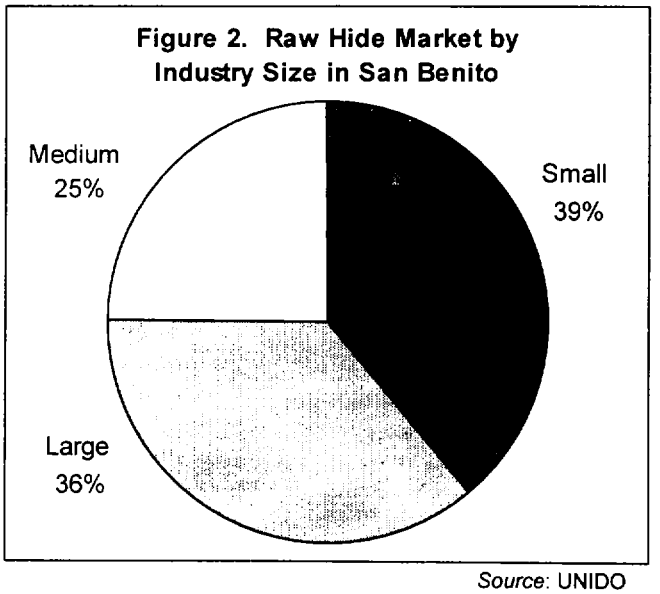


Figure 2. Raw Hide Market by Industry Size in San Benito

Source: UNIDO

44. The size of individual tanneries in San Benito is difficult to determine due to the type of processing technologies used (e.g., artisan tanning drums) and the contradictory production information supplied by the

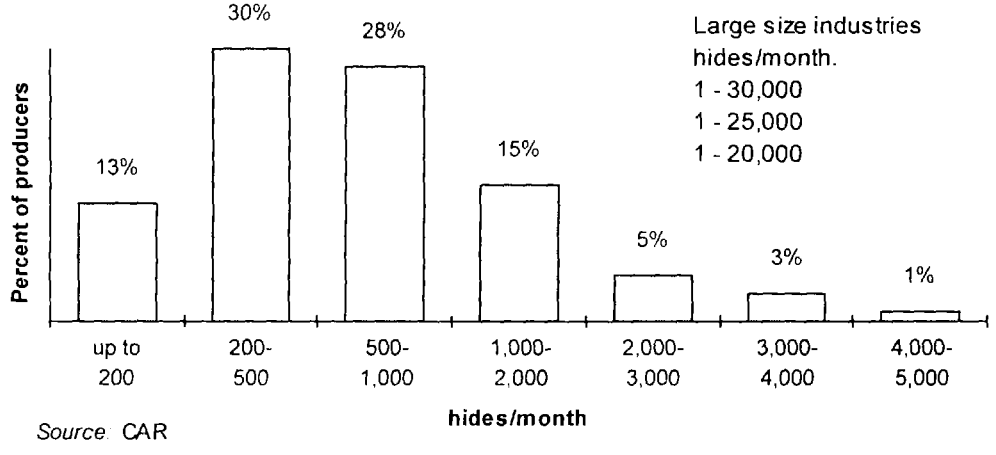
21. Wet blue is a chromium treated hide, which takes a bluish color.

tanneries themselves. Water use, supervised by EAAB, is also difficult to estimate because illegal connections are common and metering coverage insufficient. Figure 3 presents a distribution of industry size according to installed production capacity. A common classification practice in San Benito to determine industry capacity is the number and size of tanning drums.

Industrial Processes in San Benito

45. Tanneries in San Benito use the same leather processing principles applied in many other countries. As illustrated in Figure 4, this process can be broken down into three principal operations: (a) preparation in the beamhouse; (b) tanning in the tanyard; and (c) finishing, including dyeing and surface treatment. Table 5 presents an overview of the process steps and the output products as found in San Benito.

Figure 3. Industry Size in San Benito



Source: CAR

Figure 4. Leather Production Process in San Benito

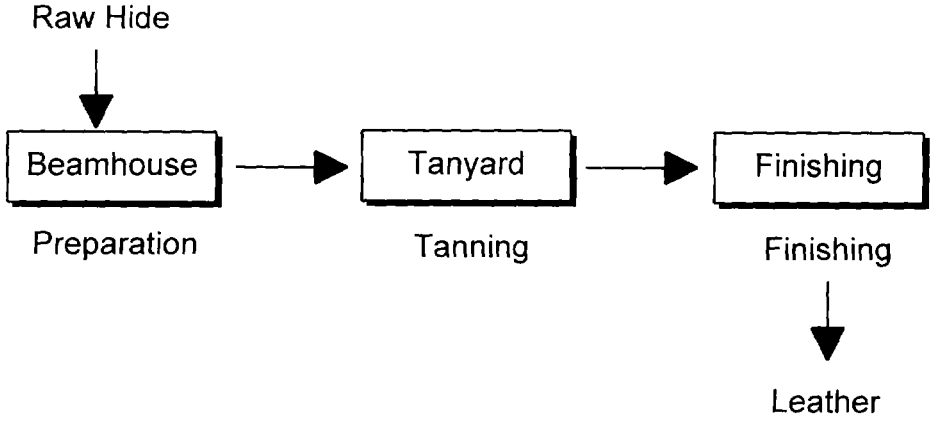


Table 5. Leather Processing Steps and Outputs

Phase	*Product input*	*Processing steps*	*Output*
Beamhouse	raw hides	soaking, fleshing, liming, dehairing	pelts
	pelts	Splitting	grain splits (flores), flesh splits (carnazas)
Tanyard	grain splits (flores)	deliming & bating, pickling, chrome tanning, shaving	wet blue
	grain splits (flores)	deliming & bating, picking, vegetable tanning	vegetable tanned hides
	flesh splits (carnazas)	deliming & bating, pickling, chrome tanning	wet blue, tanned splits
Finishing	wet blue, vegetable tanned hides, tanned splits	retanning, coloring, fat liquoring, drying, finishing	finished leather

46. Perhaps the most important tool in the San Benito tanneries is the tanning drum. These drums are made based on traditional blue prints, adapted to the physical conditions of each individual tannery (e.g., there is a small drum factory in San Benito). As most tanneries are installed in previous or current residences, the drums installation and work area do not follow strict operational or industrial safety guidelines. The tanning drum is a multipurpose tool for most of the small tanneries, using them both in the beamhouse and tanning processes without any adaptation or modification of rotation speed or loading techniques.

47. The processes illustrated are adapted freely by individual tanners. The technology passed on through generations is used without actual measurements or modifications. Only simple marks in the drums and different types of containers are used as guidance for loading processes and mixing chemical inputs.

Pollution in San Benito

48. Since the processing principles used in San Benito are the same as in other tanneries in the world, the liquid and solid wastes generated are also similar. The quality and characteristics of tannery wastes depend on the types of processes used and on inputs such as chemicals and water. The main chemicals and other material inputs, as well as the main tanning processes and their associated wastes are shown in Table 6.

49. A wide range of processes and chemicals are used in San Benito, but actual measurements of the area's pollution loads and of individual tanneries are scarce. Physical conditions in the tanneries together with the uneven conditions and coverage of the sewer network have impeded comprehensive sampling and analysis

programs. In addition, there is a resistance from informal entrepreneurs to permit entrance to installations for monitoring programs. Most pollution estimates are either based on theoretical analysis or on random samples from the area. Table 7 presents average pollution concentrations in the final outfall of the sewage collector in San Benito.

50. Peak pollution loads can be considerably higher. Different firms in San Benito carry out the same process at the same time, which makes peaks even more significant. Table 7 also displays peak pollution concentration in a sewer outlet from an area in which most firms were carrying out the same operation (beamhouse).

Table 6. Characteristics of Tannery Wastes

Process	*Inputs*	*Solid wastes*	*Liquid wastes*
Beamhouse	Raw hides/pelts	organic substances	high chlorides & Ca++
soaking	water	hair, fat, fleshings,	dissolved proteins,
fleshing	sodium sulfide	trimmings	high pH ; HS^- and $S^=$
liming	lime		
dehairing			
splittings			
Tanyard	Splits	chrome shavings.	high pH
deliming	sodium bisulfate	chrome trimmings	acid wastes
bating	ammonium sulfate		with Cr+++
pickling	sulfuric acid		organic acids.
chrome tanning	chromium sulfate		
vegetable tanning	formic acids		
shaving	water		
Finishings	Wet blue	shavings	oils, dyes
retanning	sodium bicarbonate		
coloring	grease, dyes		
fat liquoring	oils		
finishing			

Table 7. Liquid Waste Characteristics in San Benito

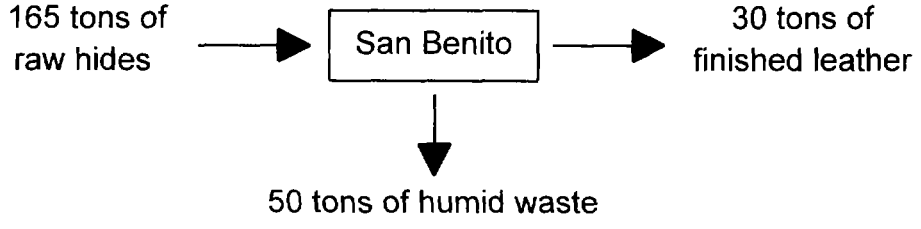
Effluent	*Average concentration (mg/l)*	*Peak concentration (mg/l)*
pH, units	9.1	12.5
COD	2,200	31,000
Nitrogen	250	–
Total solids	11,300	60,000
Suspended solids	700	13,000
Volatile suspended solids	330	–
Total chrome	41	–
Total sulfur	54	630
Grease and oil	350	–

Source: UNIDO, 1993.

51. Wastewater flow measurements have also been limited by the above mentioned conditions. Recent estimates of total liquid industrial waste discharge range from 2,200 cubic meters to 4,100 cubic meters per day. The beamhouse stage produces 60 to 80 percent of this waste, the tanyard stage 30 to 40 percent, and the finishing stage 5 to 10 percent. Water consumption per unit input or output is hard to determine because of the lack of clear production records, and the uncertain and at times illegal water connections. Estimates by PROPEL indicate consumption of around 31 cubic meters of water per ton of raw hide processed, which is 35 percent greater than the worldwide average water consumption for an efficient plant. All wastewaters are discharged into the Tunjuelito River without any treatment. The river already is overloaded with pollutants before it enters the San Benito area, since it receives high loads of industrial and domestic wastes upstream.

52. Solid waste management is also a serious problem in the San Benito area. Sludge, humid tannery wastes, fleshings, and trimmings are inadequately disposed of and can be seen in large amounts in the streets and along the Tunjuelito River. Around 50 tons per day of solid wastes are generated in San Benito, as illustrated in Figure 5.

Figure 5. Daily Solid Waste Production in San Benito



Source: UNIDO

53. The uncontrolled urban and industrial expansion of the neighborhood has occupied important areas of the Tunjuelito River's floodplain. Frequent flooding and lack of capacity in the existing sewerage system have created serious environmental and health conditions in the area. These conditions are exacerbated by continuous clogging of the sewer network due to solid wastes and precipitates from the industries. Although the construction of a wastewater pumping station has somewhat mitigated the existing situation, critical conditions still persist in the neighborhood specially during the rainy season.

54. Wastewater and solid waste treatment and management practices are not altogether absent from San Benito. Some technological processes, heralded worldwide as "clean technology," are routinely (albeit unknowingly) carried out by most

tanneries: fleshings from raw hides are sold commercially for the production of grease and animal feed (around 10.5 tons per week); 70 percent of the fleshings and cuts produced in San Benito are sold to companies that produce gel and dog-chews (some exported to the United States); most tanneries perform the dehairing after the liming process, which is the recommended technology for a high chrome penetration (and hence less chrome in effluents) in the posterior tanning process; and most tanneries have grease traps and screens in-house, though lack of maintenance and backstoppings is a continuous problem.

55. Yet, some waste reutilization practices generate even greater environmental problems in San Benito. Small firms along the Tunjuelito River boil the trimmings from the finishing process to obtain grease. Any available waste is used as fuel, including finished leather trimmings. The smoke and ashes of this process may contain toxic substances like calcium chromate—a known carcinogen. Ashes and wastewaters are discharged directly into the river.

Proposed Technical Solutions

56. Pollution problems in San Benito have received increasing attention from municipal and environmental agencies, yet most proposals have never been implemented. Two of the most recent technical solutions deserve attention due to their different approaches. A study was financed by UNIDO as part of the program for Technical Assistance for the Tanning Industrial Area of San Benito in 1993-1994, and the "Ecoefficiency Program for the San Benito Tanning Sector" was prepared by PROPEL in 1995. These two proposals are examined in detail below.

The UNIDO Proposal

57. As part of a technical assistance project for Colombia, UNIDO contracted a study of the environmental problems in San Benito. Field work was carried out during 1993 and the final report was delivered in July 1994. The main objectives of the study were to (a) set forth proposals for the resolution of recurrent flooding in San Benito, (b) propose a program for the implementation of clean technologies in San Benito, (c) design an end-of-pipe wastewater treatment plant for both industrial and domestic wastewaters in San Benito, and (d) identify pretreatment technologies to be implemented in each individual tannery.

58. The final report recommends a program with six components to be implemented in two phases. Phase I would include (a) implementing minimum pretreatment technologies in each tannery, (b) constructing a stormwater sewer for San Benito, (c) constructing a new sewerage system for both industrial and domestic wastewaters, (d) constructing a single end-of-pipe wastewater treatment plant for the combination of industrial and domestic wastewaters, and (e) implementing a clean technology reconversion program. Phase II, to be implemented as more stringent

legislation is put in place, would consist of building a biological wastewater treatment plant. Phase II also recommends the creation of a company or the involvement of a NGO in the construction, operation and maintenance of the wastewater treatment plant; operation and maintenance of pumping stations and drainage systems; technical assistance to firms complying with environmental regulations; and collection of treatment charges to be levied on users.

59. *Pretreatment in Individual Tanneries.* The study recommends the installation of microfiltering equipment in each firm or grouping of firms as a way to reduce solid waste loads on the sewerage system. All other in-house treatment options were discarded because of the lack of physical space in the tanneries and the neighborhood. The principal objective of the proposed filtering system is to protect the sewer network.

60. *Stormwater Sewer.* A new stormwater sewer is recommended that would drain towards three pumping stations, which in turn would discharge directly into the Tunjuelito river. According to the report, the physical conditions and capacity of the existing sewerage system do not permit its use for either a stormwater system or industrial and domestic wastewater sewer.

61. *Wastewater Treatment Plant.* At a first stage, a primary treatment plant would treat combined domestic and industrial wastewaters. The proposed plant would consist of an equalization tank, an aeration system with blowers and air diffusers, followed by coagulation and flocculation chambers, and finally settling tanks. Treatment plant effluent would be discharged into an existing collector of Bogota's sewer network. Expected treatment efficiencies and effluent characteristics of the wastewater treatment plant are shown in Table 8. It is expected that the effluent would meet sewer discharge regulations established by EAAB, however, the proposed wastewater treatment process would also generate over 50 tons of sludge per day. This sludge, together with the solid wastes generated by the industrial process and the proposed microfiltering systems in the individual tanneries, would

Table 8. Expected Efficiencies and Effluent Characteristics of the Proposed Wastewater Treatment Plant.

Effluent	*Efficiency (percent)*	*Effluent characteristics (mg/l)*	*EAAB requirement (mg/l)*
pH		8	5–9
COD	65	770	1,000
Suspended solids	80	150	1,000
Grease and oils	85	50	250
Total chromium	95	24	5
Total sulfur	90	25	--

Source: UNIDO.

generate more than 100 tons of solid wastes per day. The report recommends hauling all wastes in large 10-ton trucks to Bogota's industrial landfill, but does not provide a cost figure for this solution.

62. *Clean Technology Program.* The report identifies the following procedures as possible areas for improvement in the industrial processes of San Benito: (a) more efficient use of products and materials; (b) replacement of chemical products by less polluting ones; (c) recycling and reuse of liquors in some specific processes; (d) water recycling from "clean" processes to "noncritical" processes; and (e) reduction in water consumption. The report does not propose a strategy for the implementation of this program and raises some concerns about the economic and commercial implications of changes in the processing steps of the industry as a whole.

The PROPEL Proposal

63. PROPEL financed and designed a study on San Benito's pollution problems and proposed a program for improvement. Their approach is based on the concept of industrial "ecoefficiency," which combines reconversion to clean technologies and increasing productivity. This is quite different from UNIDO's end-of-pipe treatment focus. PROPEL's suggestions are based on industry surveys and specific monitoring of 13 tanneries in San Benito. Out of these 13 tanneries, 4 were studied in detail in order to analyze their administrative and commercialization practices. The proposal would basically implement a program of clean technology reconversion in San Benito and promote the implementation of a managerial model for the industry.

64. *Clean Technology.* Based on accepted worldwide practices for pollution abatement in tanneries, PROPEL suggests a set of possible changes in operational processes and technologies to reduce pollution in San Benito. These recommendations are presented in Table 9. Emphasis is placed on process changes and chemical inputs rather than equipment and infrastructure replacement. Although the report suggests an implementation strategy based on pilot demonstrative projects, the study does not detail an implementation plan.

65. *Managerial Model.* The analysis of the administrative and managerial functioning of the subsample identified cumbersome and inefficient practices that exacerbate environmental problems, impede the implementation of proposed solutions, and reduce economic efficiency. The proposed model is based on the identification of key managerial activities, and their grouping by processes. The model also defines commercial, production, administrative and financial policies which promote the concept of "ecoefficiency." In addition, the model suggests managerial procedures for key areas in a typical tannery. Finally, the report develops a software program for cost, pricing, and benefit analysis in the context of a San Benito tannery.

Table 9. Proposed Clean Technologies—PROPEL

Process	*Actual practice*	*Actual pollution*	*Proposed technology*	*Environmental benefit*
Beamhouse				
Rawhide handling	Salting	High chloride content	Freezing	No chlorides
Dehairing	Dilution of hairs	High BOD/COD, SS	Hair recovery	Lower BOD and suspended solids
			Enzymes	Sulfur reduction
Tanyard				
Deliming	Ammonium salts	High ammonium contents and alkalinity	CO_2 use	Low ammonium contents and alkalinity
Tanning	Chrome use	High chrome contents in effluents and solid wastes	Chrome production	Chrome reduction in effluents
			Tannings alternatives of chrome	Absence of chrome in effluents and solid wastes

Additional Policy Options

66. Both proposals described above include elements discussed in the policy options section of this paper. For example, UNIDO takes an end-of-pipe approach, which relies heavily on infrastructure investments. Implicitly, it depends on the government not only for regulations but also for financing investments, as described in paragaph 34 on the role of government in technology development. Alternatively, PROPEL takes an interactive approach with the tanneries by promoting more environmentally sound techniques that also yield profit gains for the informal firms. In fact, PROPEL's proposal combines information gathering and dissemination with the technology development function, appropriating some of the potential functions of government.

67. Both proposals fail to answer some key questions. How will pilot programs (in the case of PROPEL) and improved infrastructure (in case of UNIDO) be financed? How will participation of informal firms be fostered? What will be the government's (the regulator's) function, if any? And how can instruments be combined to achieve the most optimal result? Recognizing the complexity of the problems, the lack of sufficient information, and the likely absence of an "optimal solution," the ideas below are provided as complements rather than substitutes to current and future proposals. We follow the policy paths suggested in Figure 1.

Background Factors

68. *Concealment Costs.* As discussed previously, concealment costs in the case of tanneries are not as low as in other informal industries. In the San Benito case, this is clear given that the industry is located in a well-known and clearly delineated area of Bogota. In fact, in another Colombian city (Ibague), a similar albeit less extensive situation existed, and the authorities opted to close down the industry. The spatial concentration of the industry also facilitates ambiance monitoring, since authorities may measure water quality before and after San Benito in the Tunjuelito River.

69. *Inputs and Outputs.* Estimates indicate that raw hides are responsible for 60 to 80 percent of the firm's total cost. The remainder is shared by water, electricity, chemicals, and labor, among others. Raw hides and labor are primarily informal, and utilities, though supplied by the government, fall into the informal category due to illegal connections. Chemicals are probably the most formalized of the inputs, since it is originally supplied by large multinational companies through local vendors. Yet these account for a small percentage of total costs.[22] Outputs are, of course, mainly informal.

70. *Miscellaneous.* There are several additional factors policymakers may wish to consider when addressing the environmental situation in San Benito. First, it should be analyzed from a cross-sectoral and cross-spatial perspective. For example, the question of how important San Benito's discharges are in the overall contamination of the river should be thoroughly considered. In addition, there are indications that land use may be changing in the area, thereby limiting the useful life of any large-scale investment.[23] Secondly, tanners' political influence seems to be playing an important role today, but it is unclear whether this will continue in the future given the changes in the neighborhood.

Policy Suggestions

71. Given the background factors and the options displayed in Figure 1, a feasible path may be to use tradable permits both as direct and indirect instruments. Regarding pollution, a tradable permit scheme may be designed taking into consideration the different activities (therefore contribution to pollution) of the informal agents and the different types of contaminants according to their environmental hazards. The regulator would set total permissible pollution levels and tradable permits for the firms, which would trade according to their needs perhaps using local vendors. The regulator could

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22. There are also indications that firms may divert chemicals to illegal industries like narcotics. Even in a formalized environment, this may lead to overestimations of input needs.

23. Surrounding neighborhoods appear to be increasingly occupied by upscale commerce and lower-middle-class to middle-class housing. This may place upward pressure on land prices, driving informal tanners out of the area.

therefore monitor ambiance levels, checking randomly and as necessary compliance at the firm's level. The regulator would also focus on the permit market, so as to avoid unfair competition (e.g. cornering attempts).

72. The high concealment cost of this industry may thus allow for the design of a direct instrument such as a tradable pollution permit. A policymaker concerned with pollution would set targets, and issue permits accordingly. On the industry side, this type of system may also be better received than a pollution charge, since the pollution level impact is more easily understood and firms may be less tempted to avoid the regulation. If the regulator is particularly concerned by the use of chromium-rich substances in the production process, a tradable pollution permit may be complemented by a tradable quota system. This indirect instrument would take advantage of the formal nature of chromium-based inputs, establishing total limits and guaranteeing compliance at the origin of the input (i.e., large multinational companies and importers). Finally, it should be noted that some level of enforcement is necessary, and combining these economic instruments with some command and control measures may ultimately be the most effective way of addressing contamination in San Benito.[24]

73. These tradable permit/quota systems may be quite complementary to the other proposals. For example, a tradable permit scheme may increase the firm's interest in undertaking appropriate technology due to the goal of polluting less (and buying less permits). It would benefit more efficient firms by ultimately driving inefficient firms out of the market. It would promote information dissemination and learning through market trading, and may generate revenues for infrastructure improvement.

CONCLUSION

74. Government efforts to address contamination usually focus on the large formal industries. This emphasis can be partially explained by the greater pollution loads that large formal industries produce and the potentially lower costs of regulating them. Yet in many instances this may not suffice, and costly cleanup investments such as sewerage treatment facilities may be lost due to this oversight. Pollution problems from the informal sector thus tend to be linked to improper disposal, and may have local importance. In some specific cases, however, informality can be so widespread that its contamination may take proportions similar to the case of large formal industries.

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24. Even though chemical inputs take a small share of the firm's overall cost structure, an effective tradable quota system may stimulate firms to either be more efficient or switch to more environmentally benign processes. Yet this system should be complemented by measures that avoid cheating and illegal smuggling of inputs in the area.

75. This paper designs an initial structure of policy options available to environmental policymakers. Yet, data complexity both on the informality and on the environmental aspects preclude any ex-ante right or wrong approach to the problems. The paper emphasizes the need to use indirect instruments when addressing urban informal sector pollution, but recognizes that this alone may neither be sufficient nor optimal in all cases. It also notes the risks of only using direct instruments, since given institutional constraints and enforcement capabilities theses instruments may lead to more pollution by increasing the number of firms in informality.

76. Finally, the paper illustrates the problem of informality and pollution through a case study of leather tanning in Bogota. Recognizing its limitations, a system of tradable permits combining indirect and direct instruments is suggested to complement existing proposals. From the case study, it is also evident that when addressing informal pollution, environmental policymakers have to take a sectoral approach within a well-established, cross-sectoral framework.

Annex: Examples of Informal Activities and Pollution in Mexico and Peru

1. While the informal leather tanneries of San Benito provide a unique opportunity for a detailed case study, the issue of how to address pollution created by informal industry poses a challenge for policymakers thoughout the hemisphere. Yet taking even the first step toward effective regulation requires basic knowledge of the activities and the contamination produced by the informal sector, and in most cases this data is conspicuously lacking. To broaden the perspective of the paper, this annex provides anecdotal examples of informal industrial activities and urban contamination in Leon, Mexico, and Lima, Peru.

Leon, Mexico

2. Most of the leather tanning industry in the State of Guanajuato is based in Leon.[25] Table A-1 provides a summary of the industry's structure. Almost all leather products in Leon originate from salted bovine hides tanned with chromium, and the city is one of the major production centers of leather goods in the country.

Table A-1. Characteristics of Tanneries in Leon, Mexico

Size	*Employees per firm*	*Number of firms*	*Percentage of firms*	*Number of employees*	*Percentage of total production*
Cottage	1-6	443	75.9	2,545	15.2
Small-scale	7-16	118	20.2	2,414	21.3
Medium-scale	≥ 17	22	3.8	2,194	63.5
Total		583		7,153	

3. None of the tanneries in Leon have wastewater treatment systems, and the impact of the tanneries' pollution is aggravated by the relatively low water flow rates in the city (2.4 cubic meters/sec). The authorities have required the registered tanneries that discharge in the sewerage system to install traps, which prevents solids from clogging the system. Yet inspections reveal that these are rarely serviced, and when they are the waste is discharged directly and without previous treatment into the Turbio River. Additional environmental problems are caused by the inappropriate discharge of dissolved solids and chromium-rich substances, and precarious transport

25. This mini case study is based on Marquez (1992) and Bartone and Benavides (1992). In Marquez, field data conflicted with other data sources. The author explains the discrepancy by the mistrust of informal agents in the research, which they feared was somehow connected to regulators and tax authorities. This is a common obstacle in informal sector studies.

of solids to makeshift tallow factories on the outskirts of the city (15 kilometers away). These practices threaten the city's water sources (river and wells) and provoke discomfort in the population. Table A-2 illustrates the magnitude of the problem.

Table A-2. Total Annual Waste Load Produced by Tanneries in Leon

Size	*Effluent (lps)*	*Chromium (tons)*	*TDS (tons)*	*Flesh (tons)*	*Hair (tons)*
Cottage	19	73	6,574	2,320	580
Small-Scale	26	103	9,247	3,264	816
Medium-Scale	104	307	27,561	9,728	2,432
Total	149	483	43,382	15,312	3,828

4. The authorities are aware of the problems, but so far have had no success in addressing them. For example, the Center for Tanneries Research and Technical Assistance of the State of Guanajuato tried to convince tanners to recycle their dehairing and tanning liquors, but failed due to lack of technical capacity, inadequate funds, and space limitations. The next attempt to improve the situation will be to relocate the industry, by 1997, into carefully designed areas with ample wastewater treatment facilities. Federal and state authorities will provide a grant to cover 70 percent of the treatment plant's total cost, and the tanners and local water and sewerage utility will cover the remainder.

Lima, Peru

5. As mentioned previously, informal activities in Peru are perceived as significant for the country's overall economy.[26] Like most formal activities, the urban informal sector is mainly concentrated in the Lima/Callao metropolitan area. To partially circumvent the lack of information in this area, a survey was conducted to identify potentially polluting industries in Lima. It is estimated that 30 percent of this small-scale industry is informal; that is, not registered with the appropriate authorities. These include textiles (weaving and dyeing), tanneries, metalworkings, and electroplating, among others. Highlights of the survey regarding pollution in Lima are summarized in Table A-3.

6. Villaran et.al. (1991) concludes that although the volume of wastes in some cases may be low, the type of waste and inappropriate disposal methods are still a major reason for environmental concern in the city.

26. This mini case study is based on Villaran et.al. (1991) and Bartone and Benavides (1992).

Table A-3. Estimates of Monthly Waste by Industrial Category in Lima

Description of industry	*Type of residue*	*Volume (tons)*	*Destination of residue*	*Characteristics of residue*
Textiles (dyeing)	Alkaline liquid wastes	474	Public sewer or local river	Dangerous
Tanneries (mainly alpaca hides)	Liquid residue formed from detergent and organic substances	240	Public sewer	Dangerous
	Liquid residue formed from alum, carbon sulfate, bicarbonate and formaldehyde	160	Public sewer	Dangerous in higher concentrations
Metal finishing	Liquid residue with caustic soda	36	Public sewer	Dangerous
Electroplating	Liquid residues, in different stages, residue formed from caustic soda, sodium cyanide, sodium hydroxide or zinc, sodium carbonate, detergents, fumes.	144	Private collector and ground	Dangerous in high concentrations

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