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Expected biophysical, social and economic benefits of Cleaner Production (CP) implementation: a tanner's experience

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Abstract

Cleaner production (CP) is not only related to the quality of the productive processes in terms of new technologies and pollution prevention of the biophysical component. CP should essentially include also the socio-cultural and economic components in order to take into account a large perspective and to obtain sustainable solutions that integrate the involved local communities aiming at increasing their productivity. Taking into account the complexity of the Villapinzón's tannery case, this paper shows the biophysical, socio-cultural and economic possible benefits of the CP strategies implementation in the six chosen tanneries, as a result of a collective analysis of the previous deliverables made by each member of the SWITCH's UNAL team. The complexity led to consider also the legal aspects and the interinstitutional management from the very beginning.

Integrating the analysis of the three components was done by an Environmental Impact Assessment based on Conesa (2003) that basically aims at integrating and unifying at the same scale all factors to be modified by CP. Through this methodology, an expert's panel in the subject assigns to each factor a relative importance value.
In the phases where the real valuation begins, a cause-effect matrix was built. This matrix consisted on a square of double input in which columns correspond to the actions and the rows, the susceptible factors to be impacted. An informatics' application was used, this application uses the visual basic 5.0 language, and it includes phases between 4 and 7.

This initial work, done before the implementation of CP, suggests from the matrix, that the actions that produce major effects on the factors susceptible to be modified are associativity, wastewater chromium recirculation, ecological unhairing and interinstitutional management. The latter supports and confirms the focus that this process has had already, from the first phases of the conflict resolution approach with the environmental authority.

Based on the matrix, the qualification of all factors of the components are visualized and unified. The benefits are observed at a same scale and the expected scenario with CP is clearer.The CP strategies proposed and the methodology worked created a possible scenario where the negative impacts can also be checked. These results serve as a model to be applied to other tanning industries in Colombia and in the world.

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According to the paradigm shift that SWITCH aims to achieve, water use will be reduced by 60% by means of simple solutions. The latter will mean water quality improvements that entail social and economic benefits to the related population.

Keywords: Tannery, Cleaner Production, Environmental Impact Assessment.

1 Introduction

The Institute of Environmental Studies at the National University of Colombia is engaged in the exploration of Clean Production (CP) implementation in leather manufacturing as part of the SWITCH (Sustainable Water Management Improves Tomorrow's Cities' Health) initiative. This project aims to develop scientific, technological and socio-economic solutions that will contribute to more efficient urban water use.

The study to improve efficient water management of the tannery industry is currently taking place in the Villapinzon municipality, of the Cundinamarca province of Colombia. One of the clearly defined strategies to accomplish this objective was the definition of CP production criteria to be adopted by 6 companies out of the 130 in the region. These companies were chosen for their relative ability to produce considerable results in pollution reduction and water savings through simple modifications in the traditional production processes of the region. In order to achieve sustainability, the implementation of CP modifications must also include social and economic elements to the analysis.

1.1 Objective

Establish the possible social, economic and biophysical (environmental) benefits of implementing CP practices in 6 tanneries of the Villapinzon municipality as a pilot project to be extended to other tanneries in the region.

2 Current Situation

2. 1 Biophysical Situation

The municipality and tanneries of Villapinzon deposit their effluents without any sort of treatment to the Bogotá River, fluvial artery of the country. The values of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) in the river are found at approximately 70 mg/L and 100 mg/L respectively. According to Autonomous Regional Corporation (ACR) Ruling 043 of 2006, these values exceed water quality parameters of the Bogotá River whose limits for the year 2020 are 7 mg/L for BOD and 10 mg/L for TSS. Pollution caused by organic and chemical substances, as well as organic discharge, chromium, sulphur and chlorides affects a considerable area of the Colombian territory. For this reason it is a national priority to provide a water management solution to the region, as was established by CONPES[4] document 3320 of 2005.

2.2 Sociocultural, Economic and Institutional Situation

[4] Consejo Nacional de Política Económica y Social (National Council on Economic and Social Policy). Document that defines national policy on the strategy to guarantee the restoration of the Bogotá River.

In the majority of cases the educational level of tanners and their employees do not exceed primary education. Their training and competence in traditional hide tanning was inherited from their predecessors through a transgenerational process (Vargas, 2007). This original process was later transformed to a chemical-based process with the consent of the regional authority of the ACR nevertheless without the establishment of proper training and regulatory procedures (Sanz, 2007ª). The implementation of an environmental regulatory framework established by the respective authorities has been incoherent and difficult to accept by the affected community, generating an inefficient and highly contaminating effluent discharge management.

Operations are based on economic subsistence and the technology used is old. Average monthly production is 500 to 800 skins/month (Sanz, 2007a). The efficiency of the production line is weak. The majority of the tanneries are family businesses containing 4 to 10 employees (micro and small enterprises) and offer employment to 60% of available human capital in the region, generating approximately 700 opportunities of direct employment and 4000 indirectly (Sanz, 2007a). For over two years the UNESCO-IHE (Institute of Water Education in The Netherlands) through a doctoral study in conflict resolution (Sanz, *op. cit*.), has advanced efforts to organize and raise the awareness of the tannery community and other actors to include technical solutions that are innovative and consistent with the necessities and interests of the sector.

2.3 Regulatory Situation

With the support of the Bogotá Chamber of Commerce (BCC), 80 tanneries with Environmental Management Plans have been legalized. The legal problems that these companies face are in the process of being reconciled. Of the 130 tanneries in the region, only 21 have authority to operate and the majority of companies are facing penal processes for contamination with very expensive fines difficult to pay.

3 Methodology

To identify and analyze the expected environmental benefits[5] in Villapinzon, the actual impacts caused by the tanneries were studied at a biophysical, sociocultural, legal, economic and institutional level. Subsequently in a prospective scenario, the potential impacts were evaluated with and without CP implementation in the tanneries. These potential impacts were identified through a bibliographic review of successful tannery case studies in the world. The methodology for qualitative environmental impact assessment proposed by Conesa *et. a.l*, 2003, was adopted to identify environmental factors susceptible to impact and the actions generated by the project that could also generate impacts based on the elaboration of double-input cause-effect matrices. The actions are the selected CP strategies and another group that was labeled “general actions” which include Best Operative Practices (BOP), associativity, interinstitutional management and management/disposal of solid waste. The identification of the environmental factors in the biophysical, sociocultural, economic, and institutional and environmental management component was based on proposals supported by panel of experts that collaborated in the identification, evaluation, classification and estimation of the factors (Delphi Method). The qualitative valuation of impact was executed through a double-input matrix, where the columns correspond to the actions and the rows correspond to the factors susceptible to impact. An informatics’ application, using visual basic 5.0 language, was used to carry out the qualitative valuation with the inclusion of 11 impact attributes, as is required by the related legislation on Environmental Impact Study in Colombia (Toro y Requena, 2007).

[5] Understanding the environmental topic like the interrelationship between ecosystems and culture.

With the list of environmental factors for every component, the environmental impact assessment and the analysis made under every discipline, it was possible to obtain the expected benefits from CP implementation. For every one of the six tanneries, the initial material and energy flow balance of the productive process and actual cost analysis was performed, as well as information collection of the community through interviews, personal histories and participant observation.

4 Results

In this section, a summary of the results of the qualitative valuation are presented through a matrix detailing the importance of the environmental impacts in the present state and the prospective scenario once CP implementation has occurred and showing associativity and interinstitutional management as conclusive elements. An analysis of the actions that will likely produce the greatest impacts will also be detailed, including the corresponding variables that will be most affected by CP implementation. Finally, tables 3, 4, 5 and 6 list the most outstanding expected benefits for every one of the factors that could be influenced by these actions.

4.1 Action and Variable Analysis

Table 1 presents the summary of scores obtained during the application of the matrix examining the importance of every impact generated by the actions over every variable. It exhibits the highest scores by group of actions, and later compares among groups of actions to identify which one can produce the biggest impact and can automatically be considered strategic to the project. In this table the group of actions corresponds to a classification made out of the actions that will be implemented and respectively tested on the impact it could generate over every environmental factor[6]. The second column corresponds to the action that obtained the highest score over the rest of the actions in the group. The third column presents the score achieved by this action and in the fourth column the percentage weight of that score compared to the scores of the other actions of that group.

Table 1. Summary of scores obtained during the application of the impact-importance matrix of every group of actions to be implemented in the project[7].

GROUP OF ACTIONS	HIGHEST SCORE ACTION	OBTAINED SCORE	PORCENTAGE (%)
General Actions (group 1)	Associativity	40752	26
Actions at River Bank Phase (group 2)	Ecological Unhairing	19853	24
Actions at Finishing and Tanning Phase (group 3)	Wastewater Chromium Recirculation	15883	18

[6] Every action that is part of every group is found in report D 4.2.3 –c. Environmental, social, and economic benefits of the implementation of feasible process modification. SWITCH, Universidad Nacional de Colombia, Bogotá

[7] The complete impact-importance matrix with the scores of all the actions and environmental factors can be found in Annex I of report D 4.2.3 –c.

Table 2. Comparison of obtained scores for every group of actions to implement

	Group 1	Group 2	Group 3
SCORE	156413	82756	88934
%	**48**	25	27

The action with the most important positive impact is *associativity*, especially over the economic, sociocultural/regulatory, and institutional and environmental management variables. Actions labeled as "general" exhibited impacts significantly higher than strictly technical actions, thereby indicating that the effort that people can exercise in their respective labor, would generate a bigger impact than changing the technology of some operations.

Tables 3 through 6 exhibit the expected benefits. Scoring obtained in the impact matrix is placed with the respective variable in order to show what variables are most susceptible to impact. In the biophysical component, the most significant impact would be generated on the variable *territory*, given that the factor under influence is conflict over water use. The second variable that would be impacted at a significant level is *quality of water*. In the sociocultural component, the most significant impact would be generated on the variable *education*. In the economic component, the *productive systems in the area of influence* would comprise great impact because better water quality would be used for cultivation. *Productivity* is a very important variable given that negative impacts could be generated over some of its factors. The cost of operation after CP implementation could rise compared to business as usual without CP. Nevertheless, in the prospective scenario[8] the Net Present Value (NPV) for the tanneries is higher with CP implementation than without it. In the institutional and environmental management component, the most significant impact would be generated on *community participation*.

4.2 Expected Benefits

The following tables summarize the expected benefits by component according to the environmental impact assessment.

Table 3. Expected benefits in the biophysical component with CP implementation

VARIABLES	IMPACTED FACTORS	EXPECTED BENEFITS
Water (301)[9]	COD / BOD	Reduction because of biodegradable tanning agents (90-94%), ecological unhairing (40-50%), recirculation of soaking water during unhairing (15-40%) and defleshing before unhairing.
	pH	Discharge pH control (By effluent segregation)
	TSS	Reduction because of implementation of ecological unhairing (50%) and recirculation of soaking water during unhairing (50%)
	Sulphide	Reduction because of implementation of ecological unhairing (50%) and recirculation of soaking water during unhairing (50-70%)

[8] The prospective scenario consists of the inclusion of public services costs such as water, wastewater treatment, solid waste disposal, reduction in legal expenses such as legal counsel and fines, and expenses from taxes that currently do not exist.

[9] Score obtained with impact matrix for every variable.

	Chromium	Reduction of its concentration in the effluent becuase of high exhaustion of chromium (33%), wastewater chromium recirculation (90%) and chromium recovery (90%)
	Ammonia nitrogen	Reduction because of deliming with nitrogen exempt products (90%) y deliming with CO_2 (63%).
	Chlorides	Reduction through salt recovery during skin rinsing (10%) and the implementation of pickling without salt (90%).
	Water Consumption	An anticipated reduction in water consumption of approximately 60% with the implementation of BOP, recirculation strategies and water reutilization
Public Services and Infra-structure (146)	Infrastructure Upgrade	New infrastructure is not necessary at first glance. However, a secondary treatment plant should be considered for the effluent.
	Solid Waste Management	Adequate management and disposal of solid waste, integrated with BOP and the future construction of industrial landfill in the municipality is expected.
Risks (97)	Risks for industry, operational health and public health	Risk reduction within industry through BOP. It is also expected to reduce risk not only for the municipality but downstream on the Bogotá River as well.
Territory (901)	Water Use Conflict	Interinstitutional management and the efficient water use are expected to eliminate conflict between stakeholders.

Even if CP strategies are applied, wastewater treatment is indispensable before final discharge. Treatment will be significantly less costly given that the amount of treated wastewater will be inferior.

Table 4. Expected benefits in the sociocultural/regulatory component with CP implementation

VARIABLES	IMPACTED FACTORS	EXPECTED BENEFITS
Education (769)	Capacity-building and development	Though capacity-building and development it is expected that tanners and operators can learn everything relevant to quality tanning and adequate environmental management. It is also expected that they be able to build aptitudes toward the importance of associativity and teamwork in order to actively participate within all processes.
Social Perceptions (520)	Overcoming Mental Barriers	It is expected that the actors can adopt and learn new practices in order to eliminate the mental barriers created through time.
	Behavior Change	Given that tanning is a traditional practice in the region and therefore significantly part of local culture, it is expected in the long run that tanners and operators will modify inadequate practices.
	Public Opinion	Improvement in the productive process and reduction in environmental pollution is likely to improve the deteriorated image of tanneries in public opinion.
	Group and Community Relationships	Strengthening of group and community relationships in order to enable the continual improvement of the environmental, as well as their economic situation.
	Relationship with Institutions	Relationship improvements with institutions in order receive their support.
Quality of Life (115)	Welfare	Increase in quality of life of the population improving access and quality of health services, retirement, leisure, housing and state of the environment, morbidity and mortality due to environmental causes.

Regulatory (614)	Law Enforcement	Environmental regulation compliance due to pollution reduction.
	Company Legalization	Associativity and interinstitutional management will encourage that all stakeholders achieve formality under the law.
	Advances and closure of judicial processes	Advancement of the requirements established by the control and regulatory bodies in order to solve and avoid new judicial processes due to contamination.
	Environmental Certification	In the long run it is expected that tanneries receive environmental certification, while also attaining access to international markets.

The role of CP implementation at the social level is fundamental because it is an activity executed by a group of individuals that must incorporate the new process, generating a series of mental barriers that must be broken, in order to achieve an improvement in quality of life through sustainable management of natural resources.

Table 5. Expected benefits in the economic component with CP implementation

VARIABLES	IMPACTED FACTORS	EXPECTED BENEFITS
Productivity (346)[10]	Product Quality	Increase in final product quality.
	Utility	Increase in utility in prospective scenario.
	Cost of Industrial Wastewater Treatment	Decrease given pollution discharge would be notably inferior compared to the discharge from the traditional process, as well as for the reduction of volume of water used.
	Costs of Solid Waste Disposal	Decrease given adequate management of solid waste and their by-product value.
Economic Incentives (577)	Tax Reductions	Reduction in the retributive tax rate and other schemes designed to tax the use of natural resources.
	Incentives for Environmental Investments	Decrease in income tax in investment in CP activities to 20%.
	Access to natl/intl markets increasing competitiveness	Given an increase in final product quality, it is expected that the sector can gain access to national and international markets, and increase their competitiveness.
Infrastructure (258)[11]	Infrastructure Investment	Negative impact because of investment in infrastructure. It is different for every one of the 6 companies and can vary between €1000 y €5500.
	Access to Lines of Credit	Improvement in the access to credit given legalization and closure of judicial processes.
	External Benefits	Costs of water treatment for irrigation and health costs for water consumption downstream decrease.
Productive Systems in Area of Influence (520)	Agriculture	Increase in crop quality along the Bogotá River.
	Production Line	Significant opportunity in the purchase of raw materials and sale of skins given inclusion to the production line of leather products manufacturing.

[10] Score obtained in the impact matrix by the variable. This variable exhibits negative impacts, decreasing its respective value, nevertheless showing the importance of the impact over the variable.
[11] Score obtained in the impact matrix by the variable. This variable exhibits negative impacts, decreasing its respective value, nevertheless showing the importance of the impact over the variable.

The economic factor is also relevant given that any new activity developed in this sector is expected to be profitable. Furthermore, it significantly influences the environmental aspect, having in mind that even if the cost of equipment, inputs or labor costs might increase with CP implementation, the quality of leather and the savings incurred in other areas, such as natural resources, investment in judicial processes or the elimination and disposal of waste, guarantee that the increase in utility will be significant.

Table 6. Expected benefits in the institutional component with CP implementation

VARIABLES	IMPACTED FACTORS	EXPECTED BENEFITS
Institutional Capacity (158)	External and Internal Coordination	It is expected to improve interinstitutional coordination to produce more coherent project development.
	Control and Monitoring of Environmental Quality	Stricter control and monitoring is expected so that tanners understand the necessity of complying with environmental regulation.
	Leadership and participation	Associativity is expected to increase the presence of public and private entities strengthening participation.
	Resource Management Capacity	Institutions are expected to manage resources and support the adoption process of cleaner technology for the tanneries.
Community Participation (180)	Community Organization for Environmental Management	It is encouraged for tanners to organize in order to make better decisions and generate alternative solutions to improve environmental management from the perspective of the community.
	Community Education in Participation	An expected rise in government programs designed with the objective of education the community to enhance participation.
	Processes Underway and New Social Initiatives	It is expected that new social initiatives to solve community problems are created and project underway continue to advance.

5 Discussions and Conclusions

The results of this Environmental Impact Assessment suggest that associativity should be considered the most fundamental action to secure the success of CP implementation in the long run since it was the highest scoring action in the qualitative matrix analysis. The above mentioned confirms the results obtained from the beginning of this project where the emphasis on associativity was key to the strengthening strategy of this group of tanneries excluded from formality.

The matrix is able to visualize and unify the classification of the factors under study in such a way as to exhibit, under the same scale, the benefits of the various dimensions that compose the environment, therefore facilitating the understanding of the expected interactions with CP implementation.

The provided technical solutions, that could improve the environmental quality at the biophysical level, should be implemented jointly with actions such as associativity, institutional management and BOP, that will impact the diverse environmental factors. This implies that changes in individual behavior generate more significant impact compared to impact generated by technological change.

From the analysis provided on the expected benefits of CP implementation in the tanneries of Villapinzon, it can be concluded that the project can contribute to the paradigm shift that SWITCH wants to achieve, refering to the best use of water given required quality conditions. Furthermore, with simple solutions, water consumption will decrease and the quality of water will improve notably, increasing at the same time social and economic benefits. The solution does not depend on important technological developments, but on a change in the way water is percieved and consumed in order to achieve its best use.

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