

# Compliance of Leather Tanning Industry with Environmental Regulations in Vietnam

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## **Abstract**

*Vietnam's rapidly increasing leather and footwear export trade has made a significant contribution to the country's economic development over recent years. However, the rapid growth of the leather industry causes considerable pollution, which poses increased risks to the environment and human health. A number of policies have been introduced by the government of Vietnam to mitigate the environmental pollution from the tanning industry. They include requirements for tanneries to (i) submit environmental impact assessment reports, (ii) install wastewater treatment systems, and (iii) pay wastewater fees. However, many tanneries in Vietnam did not comply with these regulations. This study aimed at investigating the compliance of Vietnam's tanneries with environmental regulations and to explore policy recommendations for improving their compliance based on a survey of 54 tanneries in Hanoi, Quangnam and Hochiminh city. The results showed that medium-sized and large tanneries responded positively to environmental regulations while none of the small household tanneries surveyed were found to comply. The main reasons for the latter's non-compliance were found to be the lack of technical and financial capacity. Nonetheless, the compliance rate of tanneries in general was found to be much higher than that of other industrial sectors in Vietnam. Inspections, production capacity, location of firms, and type of tannery were found to be significant factors affecting compliance. Raising the penalties for non-compliance, increasing monitoring activities to detect offenders, and employing a multi-stakeholder and collective action approach were seen as possible strategies to bring about the greening of the tanning industry.*

**Keywords:** Leather tanning industry, environmental regulations, compliance, Vietnam.

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## 1. Introduction

The Vietnamese economy grew rapidly at an average rate of 7.6% from 1991-2006. This growth has continued to date and it has greatly elevated Vietnam's international standing from its former placing in 1990 when the country was amongst the world's poorest with a GDP per capita of US\$ 98 (ADB, 2008). By 2007, its GDP per capita reached around US\$ 836 and Vietnam approached the status of a lower middle income country by World Bank standards. Its export base also shifted from primary commodities to manufactured goods such as electronics, garments and footwear. The ratio of manufactured exports to total exports, which hovered around 28% in the second half of the 1980s, increased to approximately 50% by 2007. Also, during the last decade, Vietnam's exports have increased by 20% annually. Export turnover in 2010 reached US\$ 68 billion, five times more than in 2000 and 2.5 times that in 2005 (MOIT and LEFASO, 2010).

Currently, leather and footwear products are one of Vietnam's four major export items in terms of value. In the last ten years, this industry has developed dramatically, and in 2010, the export value of leather and footwear products was US\$ 6.19 billion, accounting for 9.1% of Vietnam's total export value (MOIT and LEFASO, 2010). This success has come at a cost. The rapid growth of the leather industry has resulted in considerable pollution, which poses increased risks to the environment and human health. Leather tanning is a multi-step process in which raw hides or skins are converted into finished leather, but which produces significant amounts of solid and liquid

waste pollutants.

In Vietnam, leather tanning was long regarded as a low-tech industry with a small workforce, thus it was not seen as an industry that should be seriously considered from both social and environmental points of view. Recently however, the fast growth of the leather industry and growing public awareness of the risk of pollution to human health and the environment have attracted increased attention from communities, local authorities, and environmental scientists. The leather tanning industry has been categorized as one of the most pollutant-causing industries in the country and was put on the list for relocation from a number of urban areas. The environmental impact of leather tanning is especially complicated with respect to small and medium-sized tanneries. These firms are often located in highly populated areas so their waste discharges have a particular significant impact on their neighborhoods. What's more, leather production in Vietnam is still relatively small-scale and can presently meet only about 30% of the demand from local industry. This indicates that there is likely to be significant growth in domestic leather production and unless steps are taken to deal with the problem, in its associated pollution.

Under such circumstances, this research was designed to assess the effectiveness of the current environmental regulations governing the tanning industry and to explore policy recommendations for improving the compliance of the tanneries with environmental regulations. The specific objectives were as follows:

(i) To do an overview of the tanning industry and environmental regulations and institu-

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tions governing tanning enterprises in Vietnam.

(ii) To investigate the level of compliance of tanneries with environmental regulations and determine the costs of compliance.

(iii) To identify the factors affecting the environmental compliance of tanneries.

(iv) To draw policy implications and make recommendations to improve the compliance of tanneries in Vietnam with environmental regulations now and in the future.

The study focused on the environmental compliance of the tanneries since this was a crucial factor in the sustainable development of the leather and footwear sector. The study results are expected to be used by policy-makers and local authorities to better design and enforce environmental regulations on tanning companies.

## **2. Methodology**

### **2.1. Data collection**

The compliance of tanneries with environmental regulations was the core issue in this study. The research team used both secondary and primary data.

The secondary sources of data on the leather and tanning industry in Vietnam included officially and unofficially published information, reports on the studied sector, technical and scientific journals, other domestic and international publications including from branch associations, policy documents, archives/files from relevant management agencies, and scientific data from previous technical and/or monitoring reports by relevant institutions.

The primary data for the research came from two sources: the field survey of tanning

firms and face-to-face in-depth interviews with relevant actors and stakeholders.

The survey development process involved both focus group discussions and pre-testing of a draft of the questionnaire. Each is briefly described below along with the key characteristics of the survey template used.

#### *2.1.1. Focus group discussions*

Several focus group discussions (FGDs) were conducted with tanning entrepreneurs, workers, service providers, governmental and environmental management officers of different levels, representatives of branch associations, economic agents, and research institutes. These FGDs were held as a platform for participants to discuss (i) their opinions about the development of the tanning industry in Vietnam; (ii) the level of public awareness about environmental issues involving the tanning industry; (iii) the appropriateness of environmental regulations and their effects on the tanning industry; (iv) emerging problems in implementing the regulations; and (v) proposed solutions to improve the compliance of tanneries with the regulations.

#### *2.1.2. Pre-test*

Following ‘best practice’, a draft of the survey template was pre-tested with two tanneries in Hanoi to ensure that the questions were understood by the respondents. The issues to be examined in the course of the pre-testing included (i) whether there was any lack of clarity or misunderstanding of the questions presented to the respondents; (ii) whether there were a large number of unanswered questions; and (iii) whether the length and format of the questionnaire were appropriate. In general, the

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respondents did not find it difficult to answer the questionnaire. The questionnaire was then revised and finalized to address the concerns raised by the respondents in the pre-test. It was also an opportunity for the research team to gain experience in working with tanning firms and to find the best strategy of approaching the respondents and asking questions.

### *2.1.3. Key characteristics of the survey template*

In keeping with best practice in the conduct of a survey exercise, the questionnaire started with an introduction read out by the enumerator/surveyor, which first explained to the potential respondent the overall purpose of the survey and then sought the explicit consent of the potential respondent to participate in the survey. The questionnaire proper comprised four main parts.

The first part of the questionnaire sought information on the tannery's profile, including name, address, location, size, legal status, market share, etc. The second part aimed at collecting information about the environmental performance of the tanneries in terms of waste, waste treatment facilities, etc. The third part of the questionnaire consisted of questions on the perceptions and attitudes of the tanneries and their motivation to bring about environmental improvement. Finally, the last part of the survey questionnaire was on the respondent's suggestions to improve the situation.

### *2.1.4. Survey implementation*

The survey was implemented by means of direct interviews conducted by enumerators. These enumerators were post-graduate students taking their Master's Degree in

Environmental Economics from the Hanoi National Economics University and researchers from the Vietnam Development Forum (VDF)<sup>1</sup>. Training was provided to the enumerators on how to approach the respondents and administer the questionnaire to ensure the reliability of the process.

The survey was conducted in the northern, central and southern provinces of Vietnam. The survey team received very good support from the local authorities and representatives of LEFASO to facilitate the enumerators' access to the tanneries. Most interviews took 45 to 60 minutes each to complete. A small gift was presented to the participating tanneries as a token of appreciation.

## **2.2. Data analysis**

### *2.2.1. Descriptive statistics*

Descriptive statistics were used to describe the status/characteristics of the tanning firms and their environmental performance. The characteristics of the surveyed tanneries included capacity, firm size, ownership, labor force, location, etc. This method also provided simple summaries about the responses of different groups to the given questions.

### *2.2.2. Comparative analysis*

Comparative analysis was used to show the difference between the tanning groups in terms of productive resources, performance, environmental situation, attitude towards environmental compliance and the regulations, etc. The comparative analyses showed how the different stakeholders perceived their roles/responsibilities in greening the tanning industry and how these perceptions affected or influenced their actions.

### 3. Overview of the tannery sector in Vietnam

#### 3.1. The role of the tanning industry in the Vietnamese economy

The leather and footwear sector is a rapidly growing one worldwide. The major sources of supply are the European Union (EU) and developing countries (in Latin America and South Asia in particular). Like the garment industry, the production of leather goods and footwear in developing countries, including Vietnam, is fast-growing. Vietnam ranks fourth in the world's export of footwear. In the EU market, Vietnam is the second major provider of footwear after China, with 13.7% of the market share in 2005 (MOIT and LEFASO, 2010). Vietnam, thanks to its competitive advantage of having a low-cost and hardworking labor force, is expected to become a bigger exporter of footwear and leather goods in the years to come.

The export of leather and footwear products brings in a large foreign income to Vietnam. In 2000, the export turnover of footwear was USD 1.7 billion, which accounted for 11.9% of the total national export turnover and ranked third in the country's export list, behind crude

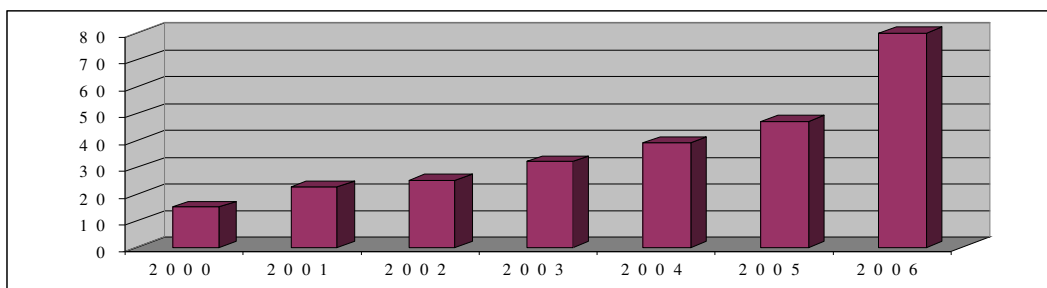
oil and garments. This figure reached USD 6.19 billion in 2010.

In order to meet the increasing demand for finished leather to produce leather goods and footwear, the tanning industry in Vietnam also increased its production capacity by about five times, from 15.1 million sq. ft. to 80 million sq. ft. during the period 2000-2006 (Figure 1).

However, local production of leather far from meets domestic demand. Schmick and Thomas (2001) found that in Vietnam, leather production could only meet about 30% of the total demand. This means that there is a great potential for this industry to grow significantly in the coming years. The production of finished leather is mainly concentrated in tanneries in HCMC where over 70% of the total national leather volume is produced.

In 2008, the leather industry employed 6,030 workers, accounting for about 1% of the total labor force of the leather and footwear industry with an average number of 183 workers per tannery (Table 1). In the leather industry, 5.48% of the workers were university graduates, 25.53% were skilled and experienced technicians, and the rest (68.63%) were unskilled workers. These employees worked in

**Figure 1: Vietnam's production of finished leather (Unit: million square feet)**



Source: Adapted from the LEFASO website <http://lefaso.org.vn/>

**Table 1: Employment statistics of the leather industry in Vietnam**

	Number of firms		Number of employees			Total output (in VND billion)		
	Total	%	Total	On average	% of total	Total	On average	% of total
Leather industry	33*	4.06	6,030	182.7	0.97	1,244	37.7	4.74
Leather and footwear industry	812	100	623,905	768.3	100	26,190.5	32.3	100

Sources: MOIT (2010) and GSO (2010)

Note: \* Household enterprises in tanning villages not included

33 companies, most of which were located in the Hanoi and Hochiminh city (HCMC) regions. Another 200 workers worked in tanning villages spread over Hung Yen and Quangnam provinces (GSO 2010; MOIT and LEFASO, 2010).

### 3.2. Environmental problems caused by the tanning industry

Leather tanning is a multi-step process in which raw hides or skins are converted into leather. Tanning involves treating raw hide material (animal hides and skins) with many different chemicals (including toxic chemicals) and a lot of water (about 50 m<sup>3</sup>/per ton of raw hide). The process emits much solid and liquid waste, namely, chromium salts and organic matter such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and chlorides<sup>2</sup>; which pollute rivers, soil and air. Most tanning factories, however, cannot afford to invest in waste treatment facilities.

#### 3.2.1. Leather tanning processes

Tanning essentially involves the reaction of

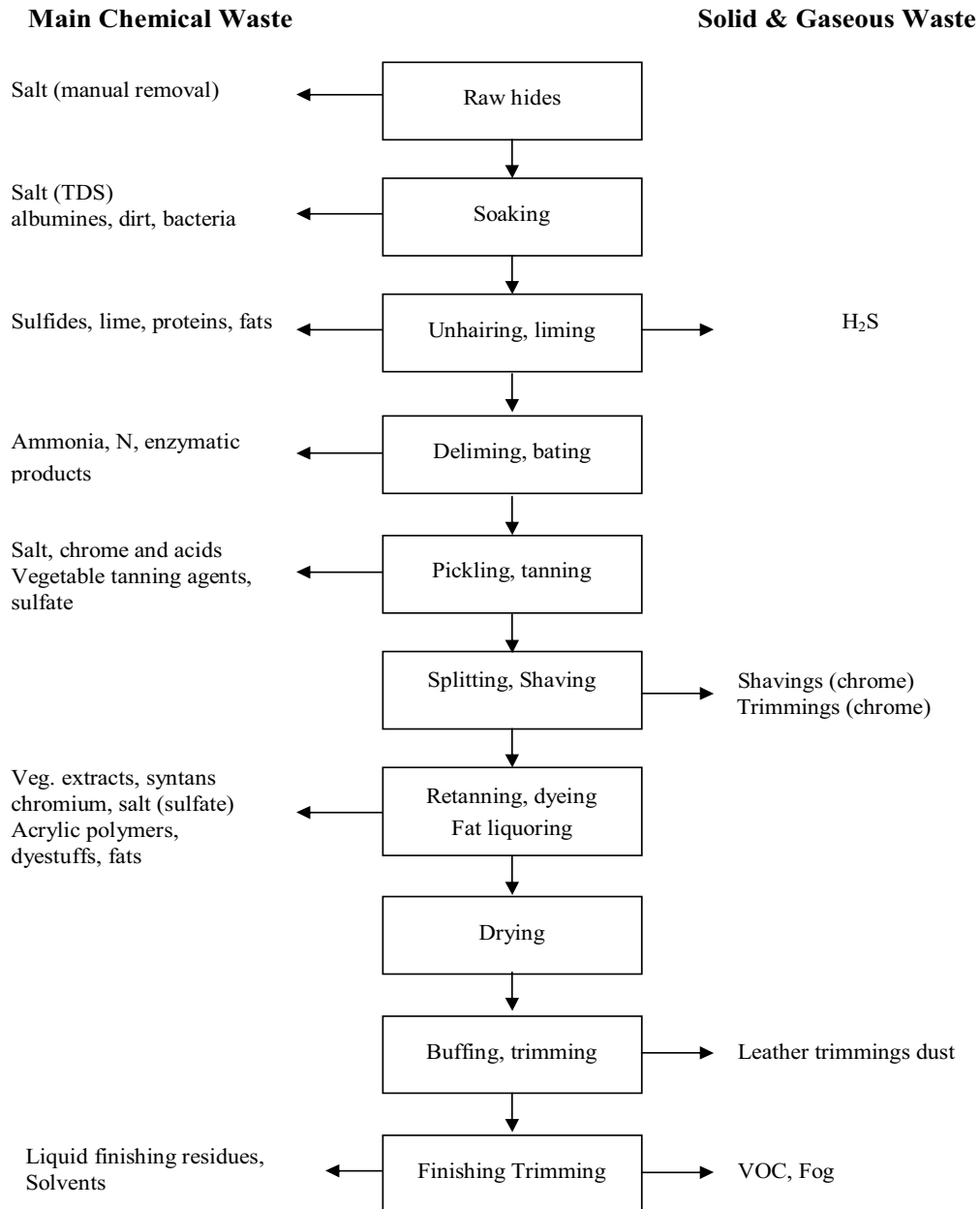
collagen fibers in hides with tanning agents. A wide variety of methods are used. In Vietnam, there are two main groups of tanning methods used in practice, i.e. vegetable tanning and mineral tanning.

*Vegetable tanning:* Extracts from a number of plant species were first discovered early in human history as having tanning properties and became used as agents in tanning hides. In the extracts, there can also be non-tanning components, which although easily washed out, have an important influence on the specific properties of the final leather product.

*Mineral tanning:* Compounds of chromium, zirconium, aluminum and iron belong to this group. Due to their much smaller molecular size, mineral tans give rise to significantly less filling of the leather. Their major advantage is that they are able to link together into much larger complexes, which can grow sufficiently to bridge adjacent protein molecules giving a high degree of stability to the structure. Chromium is predominantly used as a tanning agent because it is cheap, despite growing pressure to replace it with less hazardous agents such as aluminum.



**Figure 2: Leather tanning processes and pollutants**



Source: PISIE (2004)

Notes: VOC = Volatile Organic Compound; TDS = Total Dissolved Solids

Fog = a collection of water droplets or ice crystals suspended in the air at or near the surface

Syntans = A synthetic tanning agent of polymerised aromatic hydroxyl compounds, designed to perform various functions, depending on the structure, including assisting chemical processes

According to the European Commission (2003), the whole tanning process can typically be divided into four main groups of operations: (i) beam house operations, (ii) tan yard operations, (iii) post-tanning operations, and (iv) finishing operations. Tanning processes vary according to the type of leather produced: (i) wet-blue leather from hides, wool skins, or dewooled or fell mongered pickled-pelts from sheepskins; (ii) finished leather or (iii) sole leather. The chemicals used and the pollutants generated vary widely, although there are some similarities in the processes.

### 3.2.2. Pollution from the tanning industry

The rapid development of Vietnam's tanning industry has caused three main environmental problems: (i) discharge of untreated wastewater into rivers and other water sources, (ii) air pollution and odor, and (iii) discharge

of solid waste into the environment. Besides these, minor problems such as noise are also associated with tanning activities. Figure 2 shows the pollutants generated at each step of the tanning process.

#### *Water pollution*

Since most of the tanning processes are performed using water, generating wastewater is one of the main concerns. By consuming a large amount of groundwater for processing, the chrome tanning industry generates a huge amount of wastewater, which has a high pH value and contains high concentrations of hazardous chemicals including chromium salts and very high levels of BOD, COD, TSS and chlorides (Table 2).

#### *Air pollution*

Although gaseous emissions from the tanneries are often of less concern compared with

**Table 2: Wastewater parameters at the different stages of tanning**

Processes	Water (m <sup>3</sup> /t)	pH	TSS (mg/l)	COD (mg/l)	BOD <sub>5</sub> (mg/l)	S <sup>2-</sup> (mg/l)	Cr <sup>3+</sup> (mg/l)
Soaking	2- 4	7,5 - 8	400 - 800	600 -1200	400 -700		
Liming	2-3	11- 13	600 - 800	1200 -1800	500 - 700	250 - 300	
Washing 1	2	10- 12	200 - 300	800 - 1000	100 - 150	50 - 100	
Washing 2	2	9- 10	100 - 200	300 - 500	100 - 150	20 - 50	
Deliming Bating	2- 4	8- 9	250 - 300	400 - 900	80 - 150		
Washing	2- 4	8- 9	80 - 170	100 - 200	40 - 80		
Acidifying	1- 2	3- 4	50 - 100	100 - 200	70 - 130		300 - 400
Washing	2	4- 5	100 -150	200 - 300	60 - 100		50 -100
Neutralising	2- 4	4,5- 6	400 - 500	400 - 600	200 - 300		
Retanning	1- 2	4- 6	500 - 800	900 - 1300	350 - 700		
Dying and fat liquoring	1- 2	5- 6	500 - 700	500 -1000	200 - 400		
Washing	7- 9	7- 9	70 - 150	180 - 350	80-150	2 - 6	8 - 15

Source: Tran (2008)

Notes: TSS = Total suspended solids; S<sup>2-</sup> = Sulfite; Cr<sup>3+</sup> = Chromium III



wastewater discharge, the odor and release of Volatile Organic Compounds (VOC), organic solvents and other toxic substances such as sulfides and ammonia are nevertheless a problem. At high enough concentrations in the air, some of these gases can be toxic to humans. In addition, particulates are generated during the drying processes such as milling, buffing and spray finishing, and contain some amounts of chromium and a number of other chemicals, which can be dangerous to human health.

#### *Solid waste*

Solid waste and by-products such as hair, trimmings, fleshings (bits of flesh scraped from the hides or skins of animals), shavings, fats, grease, etc. are also generated from the tanning process. A number of authors report on the large amounts of tanning solid waste. Alexander et al. (1991), for instance, estimates

that the tanning of one metric ton of wet salted hides produces about 700 kg of waste and by-products, including about 250 kg of tanned solid waste, 350 kg of non-tanned waste, and 100 kg of wastewater. The European Commission (2003) reports that only 20-25% of the weight of the raw hide is processed into leather while the rest plus the chemical inputs end up as either waste or by-products in both liquid and solid forms. Poor management of the solid waste can create not only unhygienic conditions at the workplace and neighborhood, but can also contaminate the soil.

#### **3.3. The Government's response**

Recently, the fast growth of the leather industry and the growing public awareness of the risks it poses have led to some government actions. The leather tanning industry is now categorized as one of the worst polluting

**Table 3: Legislative bodies at various levels of government in Vietnam**

<b>Legislative body</b>	<b>Legislative instruments</b>	<b>Comments</b>
National Assembly	1. Law 2. Resolutions	Highest form of legislation in Vietnam
Standing Committee of the National Assembly	1. Ordinances	Passed when National Assembly is not in session
Government	1. Decrees 2. Decisions 3. Regulations	Generally used to implement laws and ordinances, and provide additional details
Ministries, Offices equivalent to ministries, Governmental Offices	1. Decisions 2. Instructions 3. Circulars	Provide guidance on how a particular ministry will administer laws, ordinances, decrees and regulations
People's Committees at (a) provincial level (b) district level (c) commune level	1. Decisions 2. Instructions at: (a) provincial level (b) district level (c) commune level	

Source: UNDP (1995)

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industries in the country and a number of urban leather tanning firms have been scheduled for relocation. Other policies have been introduced by the government of Vietnam to mitigate environmental pollution of the tanning industry. In Vietnam, there are three main levels of environmental policies: (i) the National Law on Environmental Protection (LEP) 1993, amended in 2005, (ii) regulatory instruments issued by the government, and (iii) regulatory instruments issued by ministries and provincial governments.

Indeed, more than 600 regulations directly or indirectly related to environmental protection have been approved in Vietnam in the last ten years. These include requirements to comply with waste material concentration standards, to properly manage all kinds of waste from production processes, and to compensate for environmental damage caused by business activities. However, in this study, the main focus is the environmental regulations that require tanneries to: (i) submit environmental impact assessment (EIA) reports, (ii) install wastewater treatment systems (WWTSs), and (iii) pay wastewater fees. These policies were selected as the key focus for the study because they were thought to be practical and effective in the context of Vietnam.

## **4. Results and discussions**

### ***4.1. Profile of surveyed firms***

This study involved a field survey of tanning firms in Hanoi, HCMC and Quangnam regions in 2012. The main objective of the survey was to assess their motivations and practices and find opportunities and ways to improve their environmental performance. Interviews were conducted to investigate how

the tanneries really perceived the impact of environmental regulations and other factors on their environmental performance. The evaluation was more qualitative in nature as it was difficult to conduct technical environmental assessments at the visited tanneries. However, valuable insights were obtained from which important policy implications have been drawn.

The survey involved firm managers, supervisors, and environmental officers as they were deemed to be in the best position to talk about their firms' perceptions of the environmental situation and factors affecting their environmental performance.

The survey targeted all the tanneries in Vietnam. As of November 2012, however, only 54 tanneries, which represented almost 90% of the total number of tanneries in Vietnam, had responded to the survey. The respondents varied in terms of region and ownership. The summary of respondents by location in Table 4 shows that 38.8% came from the north of Vietnam; 5.6% came from the central provinces; and 55.6% were from HCMC and surrounding areas in the south. As for the breakdown by ownership, 88.9% were Vietnamese private enterprises while 11.1% were foreign-invested enterprises (Italy, Taiwan, France and Korea). There are no state-owned enterprises in this sector.

The location and working conditions of the visited tanneries were diversified: 46.3% were located inside industrial parks/zones (IPs/IZs) while 53.7% were located within densely populated residential areas in HCMC, Hanoi and Quangnam provinces. The latter tanneries formed 'tanning villages' in Phu Tho Hoa in

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**Table 4: Summary of respondent firms by region, ownership and type**

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	No. of firms	%
<b>Region</b>		
Northern region	21	38.8
Central region	3	5.6
Southern region	30	55.6
<b>Total</b>	<b>54</b>	<b>100</b>
<b>Ownership</b>		
Vietnamese (private)	48	88.9
Foreign (private)	6	11.1
<b>Total</b>	<b>54</b>	<b>100</b>
<b>Type of Enterprise</b>		
Household enterprise	21	38.9
Company	33	61.1
<b>Total</b>	<b>54</b>	<b>100</b>

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the south (HCMC) and Pho Noi in the north (Hanoi region) and Tam Ky in the central region (Quangnam Province).

Located on a small piece of land, ranging from 300 to 2,200 m<sup>2</sup> (typically about 500 m<sup>2</sup>), the production activities of household enterprises in tanning villages are confined by fences and most of them have had to construct a (temporary) second floor for their production, mainly made of wood with corrugated steel sheet roofing. In all cases, the owner-families lived within the premises. Most of their available land was utilized for production. The working environment was very poor; the smell of chemicals and raw materials was pervasive. Some workers protected themselves with soft mufflers and rubber gloves.

About 96% of the interviewed firms could be classified as small and medium-sized tanneries in terms of production scale and labor. The production scale of the surveyed tanneries

differed from one to the other. This study classified them into three categories. There were 30 small enterprises (with a production capacity of less than 4,000 kg/day), 22 medium-sized enterprises (4,000–10,000kg/day) and two large enterprises (above 10,000 kg/day).

The number of workers per firm varied from 10–200 persons. The tanning villages operated mainly on a family basis and labor comprised family members and relatives. In most cases, family workers played lead roles in the management and running of the enterprises. Most of the workers, including the majority of household tannery entrepreneurs, had a very low level of education. Some larger tanneries, however, employed highly qualified staff to see to the technical aspects of the business.

With regard to raw material, the input hides/skins were classified into three main types according to animal: cattle, water-buffalo and crocodile. The majority of the tanneries

**Table 5: Summary of respondent firm characteristics**

	<b>Northern Region</b>	<b>Central Region</b>	<b>Southern Region</b>	<b>Total</b>
<b>Location</b>				
Inside industrial zones	2	0	23	<b>25</b>
Outside Industrial zones	19	3	7	<b>29</b>
<b>Total</b>	<b>21</b>	<b>3</b>	<b>30</b>	<b>54</b>
<b>Production capacity</b>				
Less than 4,000 (small)	19	2	9	<b>30</b>
4,000-10,000 (medium)	2	1	19	<b>22</b>
More than 10,000 (large)	0	0	2	<b>2</b>
<b>Total</b>	<b>21</b>	<b>3</b>	<b>30</b>	<b>54</b>
<b>Ownership</b>				
Vietnamese (private)	21	3	24	<b>48</b>
Foreign (private)	0	0	6	<b>6</b>
<b>Total</b>	<b>21</b>	<b>3</b>	<b>30</b>	<b>54</b>
<b>Type of enterprise</b>				
Household enterprise	19	2	0	<b>21</b>
Company	2	1	30	<b>33</b>
<b>Total</b>	<b>21</b>	<b>3</b>	<b>30</b>	<b>54</b>

processed cattle and water-buffalo hides/skins while only two worked with crocodile skins.

A cross-tabulation analysis of the characteristics of the surveyed firms showed a number of interesting trends (Table 5). It appeared that the large and medium facilities were located mostly in the south within industrial estates. All southern tanneries were officially registered. In contrast, the tanneries of the northern and central regions were mainly small and household enterprises. About 92% of them were located outside industrial estates. There were also no foreign-owned companies in the northern and central regions.

#### **4.2. The impact of environmental regulations on tanning firms**

The discussions that follow are on the quan-

titative impacts of the regulations on tanneries since time series data on changes in the environmental performance of the tanneries was not available. These quantitative impacts include the degree of compliance of tanneries with three chosen environmental regulations.

The study used compliance as the indicator of positive impact of the regulations on environmental performance. According to a study on the compliance of Vietnamese paper-making plants with environmental regulations, compliance is a behavioral response to regulatory requirements (Dung, 2009). Similarly, Environment Canada (2003) defines compliance as a state of conformity with the law. The United States Environmental Protection Agency (USEPA, 1992) defines environmental compliance as the full implementation of envi-

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ronmental requirements. Hence, compliance indicators should be measurable pieces of information about the behavioral response of those regulated to the regulation/s in question.

It was hypothesized that those tanneries which had submitted their EIA reports were expected to be less pollution intensive in comparison with those which had not. The tanneries which had installed wastewater treatment facilities and those which paid water pollution charges were also hypothesized to be more motivated to reduce pollution.

#### *4.2.1. Compliance with requirement to submit EIA report*

According to the LEP of 2005 and Decree 80/ND-CP guiding its implementation, companies, depending on their location, sector and capacity, are required to submit their EIA reports to the authorities for evaluation and approval prior to commencing operations. Thereafter, the tanning companies should submit an environmental monitoring (EM) report twice a year. The EIA and EM reports should be prepared by certified environmental consulting firms from the Environmental Monitoring and Analytical Center under the provincial DONRE. -

The survey results showed that 33 (61.1%) of the 54 respondent tanneries had submitted EIA and EM reports while 21 (38.1%) had not. All of the firms which had not submitted their environmental reports were household enterprises located in tanning villages.

#### *4.2.2. Compliance with requirement to install wastewater treatment systems*

According to Article 37(a) of the 2005 LEP, manufacturing, business and service establish-

ments must have a system, which satisfies environmental standards, installed for the collection and treatment of wastewater. If wastewater is transferred to a common/shared WWTS, then the firms must comply with the regulations issued by the organization responsible for the management of such common system.

In accordance with QCVN 40-2011 on industrial wastewater, wastewater discharge standards are divided into two levels, A and B<sup>3</sup>. For example, the permitted standard for BOD is less than 30 mg/l for Level A, less than 50mg/l for Level B. For COD, the standard is less than 75 mg/l, less than 150mg/l while for TSS, it is less than 50 mg/, less than 100 mg/l, all for levels A and B, respectively. Level A standards require the most extensive and sophisticated wastewater treatment. According to QCVN40-2011, industrial waste treatment facilities are expected to treat wastewater to at least Level B standards.

All tanneries are required to establish WWTSs to treat their wastewater up to Level B. For those located inside IPs/IZs with common WWTSs, they must comply with the regulations issued by the IP/IZ infrastructure company. Their wastewater must be treated up to Level B before being discharged into the common treatment system, which will further treat the water up to Level A.

Among the 54 visited tanneries, 35 of them had installed WWTSs while the rest had not. Twenty-five (25) of these 35 tanneries were located in IPs/IZs while the remaining 10 were located in cities. Two of the 35 firms had installed simple sediment tanks for wastewater treatment while the other 33 had installed

modern WWTs.

#### 4.2.3. Compliance with requirement to pay wastewater charges

According to Decree No. 67/2003/ND-CP<sup>4</sup> signed by the Prime Minister of Vietnam on 13 June 2003, all production and business units, including tanneries, should bear the cost of polluting the environment by paying wastewater charges. Wastewater charges are calculated based on the pollution loads that an enterprise imposes on the environment. The pollution level is calculated based on the quantity and toxicity of the pollutants contained in the wastewater. The quantity of pollutants is identified based on mass ( $m^3$ ) and concentration (mg/l).

This study discovered three groups of tanneries related to compliance with the wastewater charges regulation. Twenty-five (46.3% of the total) tanneries which were located in IPs/IZs and connected to common wastewater treatment plants (WWTPs) of the IPs/IZs did not pay wastewater charges according to Decree No. 67/2003/ND-CP. Instead, they paid wastewater treatment (WWT) fees to the industrial infrastructure companies for wastewater discharged into the common WWTPs. The WWT fees applied in industrial estates are not uniform. They range from VND 3,900 per

$m^3$  (Vinh Loc IP) to VND 6,240 per  $m^3$  (Hiep Phuoc IP)<sup>5</sup>. The average monthly payment was found to be VND 26.4 mil. In the case of tanneries located in IPs/IZs, the payment of sewerage connection fees is understood as compliance with the wastewater charges requirement.

Of the 29 tanneries located outside IPs/IZs, eight (14.8% of the 54) paid their wastewater charges according to Decree No. 67/2003/ND-CP with average monthly payments of VND 0.3 mil) while the remaining 21 tanneries (38.9%) did not pay anything.

In general, the three mentioned regulations have been successful in inducing compliance by the tanning facilities judging by the relatively high percentages of such found through the survey. More than 61% of the surveyed firms had submitted their EIA and EM reports and paid their wastewater fees while around 65% had installed WWTs or were linked to a common sewerage system in their respective IPs/IZs.

This compliance rate appears to be much higher compared with paper-making plants and companies in the food processing industry (Table 6). Recent studies on compliance with environmental regulations in Vietnam documented evidence of fairly low compliance (Dung, 2009; Thanh, 2009). The percentage of

**Table 6: Compliance with environmental regulations across industrial sectors in Vietnam (%)**

Sector	Environmental regulations			
	EIA submission	Installation of WWTs	Payment of wastewater fees	Source
Paper-making	10.9	5.1	49.1	Dung (2009)
Food processing	49.6	20.1	27.7	Thanh (2009)
Leather tanning	61.1	64.8	61.1	Current study



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paper-making plants complying with the EIA submission, WWTS and wastewater fees regulations was 10.9%, 5.1% and 49.1%, respectively (Dung, 2009). For food processors, it was 49.6%, 20.1% and 27.7%, respectively (Thanh, 2009).

Given this, the encouraging conclusion is that tanning firms have generally responded positively to environmental regulations. However, attention should be paid to the cost of compliance that could make the regulated firms less competitive, among other things.

#### ***4.3. The costs of compliance vs. the costs of non-compliance***

Compliance induces costs. From the theoretical point of view, there is no single definition about the cost of compliance. The US Environmental Protection Agency's report on environmental investments (USEPA, 1990) set the stage for a national debate about environmental costs with an estimate that the US spent approximately 2.1% of its Gross National Product in 1990 to comply with environmental regulations. Beyond these direct costs, there has been concern that environmental regulations may lead to job loss, reductions in international competitiveness, and declines in economic growth. At the same time, claims are made that environmental regulations generate positive externalities and result in net benefits to society. Porter and van der Linde (1995), Romm (1994) and others suggest that investments in new processes and technologies to comply with environmental regulations often result in increased productivity, higher-quality output, greater employment, and increased competitiveness. Romm (1994) cites export opportunities in the growing international mar-

ket for green technologies as a benefit of environmental regulations.

In this study, compliance costs are understood as the costs that occur when tanning companies comply with the environmental regulations on the submission of EIA reports, installation and running of WWTSs, and payment of wastewater fees. Compliance with environmental regulations can be expensive and non-compliance with these regulations may result in adverse publicity, potentially significant monetary damages and fines, and suspension of business operations.

Discussed below are comparisons between the costs of compliance and the expected costs of non-compliance of tanneries showing the trade-offs involved. The expected cost of non-compliance can be calculated based on Decree 117/2009/ND-CP dated 31 December 2009 on administrative violations of the LEP.

##### *4.3.1. Submission of EIA report*

The study discovered that the cost of preparing the EIA reports varied from VND 150 mil to VND 250 mil. The cost of preparing an environmental monitoring report was on average, VND 20 mil, depending on the company's production scale and negotiation with the consulting firm. Collectively, these add up to the full cost of compliance.

Article 8 (point 6) of Decree 117/2009/ND-CP states that a fine of between VND 200 mil and 300 mil will be imposed for failing to have the EIA approved by competent state agencies. Meanwhile, the expected cost of non-compliance with EM report submission varies from VND 10 mil to VND 15 mil.

The expected cost of non-compliance with



**Table 7: Costs of compliance and non-compliance with EIA and EM report submission regulations**

Type of requirement	Full cost of compliance	Expected cost of non-compliance	Remarks
EIA report	VND 150-250 mil	VND 200-300 mil	One time prior to operation
EM report	VND 20 mil	VND 10-15 mil	Twice a year

the EIA submission regulation appears to be higher than the cost of compliance. This could act as an incentive for tanneries to improve their compliance. Fines are treated as the costs of doing business and it is assumed that polluters will want to minimize the amount of expected compliance costs and penalties.

#### 4.3.2. Installation of a WWTS

The investment cost of a WWTS depends on the treatment capacity and technology involved. It was found in the study that a simple sediment tank cost only VND 20–30 mil while a modern wastewater treatment system cost from VND 1,500–5,000 mil. The operational costs for electricity, chemicals, labor and other induced costs per month were about VND 2 mil for sediment tanks and VND 25 mil for modern WWTSs.

The fine imposed on tanneries for failing to build or install; improperly building or

installing; and failing to operate or regularly operate or improperly operating environmental treatment facilities is between VND 130 mil and VND 170 mil. Table 8 shows the costs of compliance and non-compliance with WWTS regulations.

The expected cost of non-compliance with the requirement to install a WWTS is relatively low compared to the cost of having a modern WWTS but as much as six times higher than having a low-tech WWTS. In the case of a modern WWTS, this would encourage a high level of non-compliance.

#### 4.3.3. Payment of wastewater charges

There are two types of tanneries which pay wastewater charges. The tanneries located in IPs/IZs which are connected to common WWTPs of the respective IP/IZ pay on average VND 26.4 mil per month in wastewater fees (Table 9). The fee is set by the industrial

**Table 8: Costs of compliance and non-compliance with WWTS regulations**

Type of WWTS	Full cost of compliance	Expected cost of non-compliance
1 Modern WWTS		
Investment cost	VND 1,500-5,000 mil	
Operational cost	VND 25 mil	VND 130-170 mil
2 Simple sediment tank		
Investment cost	VND 20-30 mil	
Operational cost	VND 2 mil	

**Table 9: Costs of compliance with wastewater charge regulations**

	Type of tannery	Cost of compliance	Expected cost of non-compliance
1	Tanneries with connection to common WWTS of IPs/IZs	VND 26.4 mil	According to the contract
2	Tanneries outside IPs/IZs	VND 0.3 mil	0

infrastructure companies. The fine or penalty for non-payment is regulated under the contract signed between both parties for wastewater treatment services.

The second group of tanneries pays its wastewater charges according to Decree No. 67/2003/ND-CP. The average monthly payment is VND 0.3 mil. There are no fines or penalties imposed on firms that fail to pay their wastewater charges. Decree 117/2009/ND-CP does not cover non-compliance by firms subject to wastewater charges. Thus the expected cost of non-compliance is zero.

#### **4.4. Factors affecting environmental compliance**

##### *4.4.1. Production capacity*

Production capacity appears to be an important determinant of the environmental behavior of tanneries. The tanneries that had a higher production capacity demonstrated better environmental performance than those with

smaller capacities. No small-scale tanneries were found to have complied with environmental regulations in terms of submission of their EIA reports, payment of wastewater fees or the installation of WWTSs. On the other hand, all except one of the 22 medium-sized enterprises and both the large tanneries had complied with the regulations.

##### *4.4.2. Location*

In this study, location was considered in two ways i.e., by (i) geographical region and (ii) whether the tannery was located inside or outside an industrial park/zone. The data in Table 11 shows that the tanneries in the south seemed to comply better with environmental regulations than those in the central and northern regions while the tanneries located inside IPs/IZs had better environmental performance compared to the ones located outside the zones.

These findings reflect the prominent role

**Table 10: Compliance of tanneries with environmental regulations by production capacity**

Regulation	Small	Medium	Large
EIA submission	0/30	21/22	2/2
Payment of wastewater fee	0/30	21/22	2/2
Installation of WWTS	0/30	21/22	2/2

**Table 11: Compliance of tanneries with environmental regulations by location**

<b>Regulation</b>	<b>Northern Region</b>	<b>Central Region</b>	<b>Southern Region</b>	<b>Inside IPs/IZs</b>	<b>Outside IPs/IZs</b>
EIA submission	2	1	30	25	8
Payment of wastewater fees	2	1	30	25	8
Installation of WWTS	4	1	30	25	10

that the local governments and local stakeholders play in the enforcement process. Some IPs/IZs in the south tended to impose stricter environment standards, for example, by setting up their own standards for wastewater effluents. Such self-imposed higher standards apparently served to improve environmental performance of the firms.

#### 4.4.3. Type of tannery

The surveyed tanneries could be divided into companies and individual household enterprises. The distinction between the two types is that companies are officially registered and run their business in accordance with the corporate laws of Vietnam while household enterprises are not registered and have a quite free hand in running their business. It was found that companies complied better with environmental regulations than household tanneries. None of the individual household enterprises had submitted EIA reports, paid wastewater fees or installed WWTSs. They usually

released untreated wastewater directly into water bodies, which significantly damaged the environment.

However, as shown in a numbers of studies such as Magat and Viscusi (1990), Wang (2000), and Dung (2009), the differences in production capacity, locality and type of firms are not the only reasons for the variances in environmental behavior. Other factors such as regulations and inspections, also affect environmental behavior.

#### 4.4.4. Inspections

The expectation was that regulations would act to prevent tanning firms from having a poor attitude towards environmental protection. Regulation enforcement serves to ensure that firms comply with regulations. It was found that southern tanneries located inside IPs/IZs had been inspected more frequently compared to the ones located in the central and northern regions.

**Table 12: Inspection of tanneries**

	<b>Northern Region</b>	<b>Central Region</b>	<b>Southern Region</b>	<b>Inside IPs/IZs</b>	<b>Outside IPs/IZs</b>
% of tanneries inspected	0.09	0.33	100	100	100
Average number of inspections per tannery per year	0.31	1	3.86	4.08	2.8

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#### 4.4.5. Public pressure

Environmental performance is expected to be closely related to public pressure. Many studies have used the number of citizens' complaints as a parameter to reflect the level of public pressure on industrial polluters' behavior. Similarly, in this study, the respondents who were under much public pressure were found to exhibit better environmental compliance.

The study found that tanneries in the north and central regions were not under as much public pressure as those in the south. In the north and central regions, complaints from neighboring communities existed, but these were few because the majority of the tanneries were located within tanning clusters where most people had been running this business for a long time. These tanneries operated mainly on a family basis and used labor only from their own families or relatives. In some cases, in addition to family labor, they employed workers from the surrounding neighborhood. In all the cases, the owners' families lived within the business premises. In contrast, 100% of the tanneries in the south received complaints from local inhabitants. This led to a number of inspections of the tanneries.

#### 4.5. Reasons for not complying with environmental regulations

The results of the survey conducted showed that 100% of the tanneries in the south did comply with environmental regulations. The percentage of tanneries in the northern and central provinces which complied was relative small, accounting for only 12.5% of the total surveyed firms. The main reasons for non-compliance with regulations are discussed

below.

#### *Lack of technical and financial capacity*

The non-compliant tanneries were mainly individual household enterprises in tanning villages located outside IPs/IZs. Their working environment was very poor. The average monthly income of the workers varied from VND 1.5–2 mil, which was just enough to cover basic living expenses. Discussions with local authorities revealed that they perceived the high cost of compliance as the main underlying reason for non-compliance by household tanneries. As these tanneries could not prepare the EIA and EM reports by themselves, they would have to hire environmental consulting firms at an average cost of VND 200 mil for the EIA report and VND 20 mil for the EM report. The costs of installation of a modern WWTS and running the system would be even higher than shown in Table 8. Thus compliance with environmental requirements would place a heavy burden on small and medium-sized enterprises, and also reduce the competitiveness of their products.

#### *Weak enforcement*

The second underlying reason for non-compliance was weak enforcement. The Vietnamese institutional framework for the environment appears to be well structured, but its actual functioning is far from effective. The household tanneries in Hanoi and Quangnam regions are good cases in point. They have survived so far without complying with any environmental regulations with no action being taken against them for such omissions. Although in principle, the expected costs of non-compliance were quite high (see Table 7 for instance), the local DONREs were unable

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to enforce any fines.

From the survey and FGDs, it was found that there were at least two reasons for weak enforcement. The first reason was the heavy workload of the environmental agencies. The number of environmental staff in Hanoi and Quangnam provinces in particular and in Vietnam in general is very small in comparison with other countries. Vietnam has only two to four environmental officials for every one million persons. In comparison, China has 20 environmental officials; Thailand has 30, and Cambodia has about 100 per one million persons (Thanh, 2009). The second reason pertained to the inadequate awareness of the local authorities. Although located amidst highly populated urban areas, the tanneries in the north and central provinces did not attract more attention from the authorities than any other industry. Most of the local government officers consider environmental protection as a responsibility of MONRE and DONRE. It is understandable that limitations in knowledge and heavy administrative workloads have prevented local government officers from bringing about any real improvement to the environmental performance of the tanneries. To them, the only way to get rid of environmental pollution is not to have the polluting firms in their jurisdictions and the easiest way to reach this goal is to relocate the polluting tanneries out of their territories. As compensation for relocation, the tanneries received very few or even no inspections, fines or penalties.

#### *Low costs of non-compliance*

It is appeared that except for EIA report submission requirement, the costs of non-compliance with environmental regulations proved to

be lower compared to the costs of compliance for tanneries in Vietnam. Moreover, weak enforcement, low probability of being punished and lack of public pressures on polluting behaviour would encourage a high level of non-compliance with the regulations.

#### *Relocation program*

Categorized as one of the most polluting industries in the country, the leather tanning industry was put on the list for relocation out of a number of urban locations in the country. Nineteen of the surveyed household tanneries stated that they were to move to other places in the near future and that investment in environmental protection was, in their opinion, a waste of money. This is why they did not bother to comply with the regulations in their current locations.

#### **4.6. Recommendations**

Environmental economists have suggested that the effectiveness of environmental regulations can be enhanced by raising penalties for non-compliance, increasing monitoring activities to detect offenders, or by changing legal rules to increase the probability of conviction. If the probability of detecting polluting firms is low and penalties are perceived to be insignificant, the level of non-compliance is likely to be very high. Thus, to make tanneries comply with environmental regulations and develop in an environmentally sound manner, a number of actions should be taken.

#### *Increasing monitoring activities and improving the capacity of environmental authorities*

Inspections, monitoring activities and enforcement are strong determinants of envi-

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ronmental performance. Magat and Viscusi (1990) showed that inspections permanently reduced the level of emissions of plants by approximately 20%. Laplante and Rilstone (1996) later found that not only inspections but also the threat of inspections could reduce emissions by approximately 28%.

One obstacle in the monitoring and enforcement process in Vietnam is that the organizational capacity to manage the system is not sufficiently strong. While the responsibility for environmental management is huge, the capacity in terms of staff and resources is limited. It is understandable that limitations in knowledge and heavy workloads have so far prevented the relevant authorities from bringing about significant improvement in the environmental performance of the tanneries. Enforcement activities need personnel with relevant experience and knowledge who can manage and conduct effective monitoring and inspection measures. Environmental departments at all levels should therefore formulate plans to improve their human resources starting with introducing a staff development program.

#### *Making the costs of non-compliance higher*

Becker (1968) in his study of crime found that firms greatly responded to the probability of detection and the severity of punishment if detected and convicted. Fines are treated as the costs of doing business and it is assumed that polluters will want to minimize the sum of expected compliance costs and penalties. This study found that the costs of compliance with WWTS installation and wastewater fee regulations proved to be higher compared to the costs of non-compliance for tanneries in Vietnam. This would encourage a high level of non-

compliance with the regulations in question.

In order to increase the compliance of tanneries with environmental regulations, it is recommended that the fines or penalties for non-compliance be 5-10 times the total cost of compliance. However, imposing high penalties could result in additional enforcement costs for the managing authorities. It has been estimated that in the US, 50 cents out of every dollar collected from polluting firms is spent on enforcement costs (Priyadarshini and Gupta, 2003). Incorporating the cost of enforcement into fines/penalties would be one way to transfer this cost to the violators.

#### *Raising public awareness on environmental issues*

Dasgupta and Wheeler (1997) documented the positive impact of public pressure on industrial polluters' behavior. Firms are more likely to cooperate with regulatory authorities when they are in a group of firms that receive more stringent regulatory inspection because of the nature of the surrounding community which exerts direct and indirect pressure on them. This makes the expected costs of non-compliance higher than they appear on the surface.

The tanneries in the south of Vietnam were found to be under much public pressure to be green. To improve the environmental performance of tanneries, it is recommended that public awareness be raised to increase informal community pressure on polluting tanneries. This may yield significant levels of compliance in a cost-effective manner.

#### *Relocation with support for waste treatment measures*



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A number of studies like Helland's (1997) and Cohen's (1999) have documented evidence of high compliance despite very low penalties. One reason given for this was the existence of economic incentives like cost subsidies in the form of tax breaks and special financing given to firms. Under the coercive relocation program, tanneries have to move their factories without any financial help. Thus waste treatment facilities might be the last thing they choose to invest in, especially for the small tanneries, after they have spent billions of Vietnam dong to obtain their land and set up operations. The relocation of factories without any support may only result in the relocation of polluters to suburban areas. One possible way to tackle this problem is to have a lending scheme with a low interest rate and which provides consulting services to help tanneries install and manage waste treatment systems. The Environmental Protection Fund and Recycle Fund could be tapped in establishing such a scheme.

#### *Multi-stakeholder approach*

The multi-stakeholder approach emerged from a perceived need for a more inclusive, effective manner to address urgent sustainability issues. It aims to bring together all major stakeholders in a new form of communication, consultation and decision-making on a particular issue. It is based on the recognition of the importance of equity and accountability among stakeholders.

In the case of the tanning industry in Vietnam, the key stakeholders would likely consist of industrial/economic, policy, and societal networks. The efforts of tanneries alone may not be sufficient in improving envi-

ronmental quality. Joint initiatives with MONRE, MARD, MOST and MOIT, for example, to introduce environmental-friendly technologies, regulations, and quality standards; facilitate information exchange; and develop collective actions are recommended. The enhancement of the role and functions of LEFASO and SLA to facilitate better horizontal cooperation among tanneries, along with their conventional function of providing support and guidance to tanneries, would also be beneficial.

#### **5. Conclusions**

Vietnam's rapidly increasing leather and footwear export industry has made a significant contribution to the country's economic development over recent years. Vietnam, thanks to her low-cost and hardworking labor force, is regarded as one of the most promising countries to become a leading exporter of leather and footwear goods. A major concern however, is that the production of finished leather causes considerable pollution. The fast growth of the leather industry and the increasing level of public awareness of the risks it poses have led to some government actions and regulations.

In general, the three regulations assessed in the study can be said to have been quite successful in influencing the environmental behavior of large and medium tanning facilities. This is reflected in the relatively high percentage of medium-sized and large tanneries which complied with these requirements. The compliance rate of tanneries in general was found to be much higher than that of other industrial sectors in Vietnam like the paper-making and food processing industries. The



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only part of the tannery sector that has not responded positively to environmental regulations is made up of small household tanneries. The main reasons found for non-compliance were the lack of technical and financial capacity and the low level of awareness among the small tanneries and governing environmental authorities. Small tanneries generally cannot afford the costs of compliance. This results in negative impacts on the surrounding environment and human health.

Compliance costs in this study are defined as the costs that are incurred when tanning companies comply with the environmental regulations on submission of EIA reports, installation of WWTSs, and payment of wastewater fees. The study discovered that the cost of preparing an EIA report was about VND 150–250 mil and the cost of preparing an EM report was about VND 20 mil. A simple sediment tank cost only VND 20–30 mil while the cost of a modern wastewater treatment system varied from VND 1,500–5,000 mil. The average monthly payment for wastewater fees was VND 26.4 mil for tanneries located in IPs/IZs and VND 0.3 mil for those outside such zones.

Non-compliance with environmental regulations can result in adverse publicity, potentially significant monetary damages and fines, and suspension of business operations. The expected cost of non-compliance with the requirement on EIA report submission was from VND 200–300 mil, higher than the cost of submission. This may serve as an incentive for tanneries to comply. The expected cost for

not having a WWTS varied from VND 130–170 mil, and the cost for not paying wastewater fees was zero. The costs of compliance with the regulations on WWTS installation and wastewater charges proved to be higher than the costs of non-compliance. This could encourage non-compliance over compliance.

The environmental performance of tanneries depends on several factors. It was found that national regulations represented one of the most influential factors affecting the environmental attitude of firms in the tanning industry. However, the effects of governmental regulations were seen to depend largely on the enforcement and inspection capacity of the relevant authorities. Factors affecting the compliance of tanneries such as production capacity, location of firms, and type of tannery were considered. The results indicated that tanneries with a higher production capacity were more likely to display better environmental performance than those with smaller capacities. Southern tanneries seemed to comply better with environmental regulations than those in the central and northern regions. The tanneries located inside IPs/IZs had better environmental performance compared to the ones located outside the zones.

Raising the penalties for non-compliance, increasing monitoring activities to detect offenders, and employing a multi-stakeholder and collective action approach are possible options to bring about the greening of the tanning industry.

#### Notes:

1. Vietnam Development Forum (VDF) is a joint research project between the National Economics

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University and the Graduate Institute for Policy Research. It aims at creating innovative research methodologies.

2. Biochemical oxygen demand (BOD) is the amount of oxygen required by aerobic micro-organisms to decompose organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution.

In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality.

Total Suspended Solids (TSS) are solid materials, organic and inorganic, that are suspended in water. These would include silt, plankton and industrial waste.

3. These levels are aimed at controlling the quality of industrial wastewater discharged into water bodies that are intended to be sources of domestic water (Level A) or sources of water with lower quality like lakes or rivers (Level B).
4. Decree 67 covers both household (or domestic) wastewater and industrial wastewater. However, this study focused only on industrial wastewater.
5. USD 1= VND 19,500 in this study.

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