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The Role of Clean Technological Change and Networking in the Emergence of Small-Scale Enterprise Clusters: An Empirical Study in the Red River Delta of Northern Vietnam

Dimitrios Konstadakopulos

Abstract

This paper reports on a survey on the environmental conditions in three small-scale enterprise clusters in the Red River Delta of northern Vietnam. The survey attempted to identify the existence and contribution of environmental innovation networks that influence the behaviour of clustered enterprises. It also sought to measure the extent of the enterprises' exposure to regulatory, market, and community pressure in relation to government initiatives aimed at persuading them to adopt clean technologies. It appears that the most important influence is that of the enterprises' customers (many of which are located overseas), who are most likely to be the source of knowledge in relation to new environmental technologies. The Vietnamese media (in particular, national television) are the next most important source of such knowledge, followed by trade associations. Statistical findings show that the adoption of new, clean technologies is influenced by the enterprises' location. It was also established that community pressure to reduce pollution is mostly ineffectual, as are regulatory measures and monitoring by local authorities. (Manuscript received September 5, 2008; accepted for publication November 25, 2008)

Keywords: Clean technologies, clusters, environmental degradation, networking, Red River Delta, Vietnam

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Studie

Zur Rolle von Umwelttechnologiewandel und Netzwerk-Beziehungen bei der Herausbildung von regionalen Verbünden kleiner Unternehmen im Delta des Roten Flusses in Nordvietnam

Dimitrios Konstadakopulos

Abstract

Die vorliegende Studie basiert auf einer Umfrage unter drei regionalen Verbünden (*Cluster*) kleiner Unternehmen im Delta des Roten Flusses in Nordvietnam. Das Ziel der Umfrage war, den Zusammenhang zwischen dem Verhalten von Unternehmen bzw. der Einführung sauberer Umwelttechnologien in diesen Clustern und der Existenz von umweltrelevanten Innovationsnetzwerken zu erforschen. In diesem Zusammenhang ging es auch darum, zu messen, in welchem Maße der Markt und/oder Regierungsinitiativen auf umwelttechnologische Entscheidungen der befragten Unternehmen Einfluss genommen haben. Es zeigt sich, dass die Unternehmen ihr Wissen über neue Umwelttechnologien in erster Linie von ihren Geschäftskunden, zweitens aus nationalen Medien und drittens von Wirtschaftsverbänden bezogen haben. Aus der statistischen Analyse der Umfragedaten geht hervor, dass die Einführung neuer, sauberer Energien eine Funktion der geografischen Lage der Unternehmen ist. Es wurde zudem deutlich, dass Gemeinden und lokale Behörden keinen effektiven Druck auf Unternehmen zum Abbau ihrer umweltschädlichen Emissionen ausüben können. (Manuskript eingereicht am 05.09.2008; zur Veröffentlichung angenommen am 25.11.2008)

Keywords: Saubere Technologien, Unternehmenscluster, Umweltdegradation, Netzwerkbeziehungen, Delta des Roten Flusses, Vietnam

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1 Introduction

The remarkable growth of small-scale enterprise clusters in the Red River Delta of northern Vietnam parallels that of the national economy. Vietnam, one of the fastest-growing economies in Asia, experienced an average gross domestic product (GDP) of more than 7.5% over the last decade, by opening up its domestic market to world-wide trade and investment (ADB 2008). Following the so-called *doi moi* (renewal) market-based reforms of 1986, Vietnam has gradually integrated into the world economy. By allowing farmers to diversify into non-farm cottage industries, exploiting global demand for ceramics, textiles, furniture, footwear and a wide range of handicraft products, economic liberalisation has fostered rapid growth. As a consequence, numerous craft-village clusters have emerged in the Red River Delta, each one specializing in the production of a range of handicrafts and their complementary products[1].

Generally speaking, clusters thrive because of what spatial economists call "agglomeration economies". Similar enterprises are clustered together in specific locations, thereby reaping the benefits of efficiency gains due to economies of scale and scope. Nowadays, a growing literature on clusters[2] – or industrial districts, as they are also known – suggests that information and knowledge flow more efficiently and can be shared by all because of close physical proximity of numerous competing enterprises. As Alfred Marshall put it nearly a century ago: "The mysteries of trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously" (Marshall 1920:IV.X.7). Clustering also can encourage enterprises to import new technologies[3] and assimilate foreign know-how, thus augmenting their capacity to produce value-added products.

However, the remarkable growth of the Red River Delta enterprise clusters

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1 It is estimated that Vietnam has about 2,017 traditional trade villages, the majority of which are located in the Red River Delta (IGES 2007:24).

2 There is a rich literature on this subject, too broad to be discussed here. For a comprehensive discussion on the literature on cluster theories and policies in particular, see Karaev et al. (2007). The development of the handicraft clusters in the Red River Delta of Vietnam (unlike the clusters in the Mekong Delta) is a consequence of various factors, such as the accumulation of artisan skills over a long period, the existence of "sunk costs", and proximity to essential natural resources. See Konstadakopulos 2008:52-55.

3 The term "clean technologies" (as used in this paper) is similar to other terms used in the discourse of environmental degradation and climate change, such as "environmentally clean technologies", "environmentally sound technologies" or "clean energy technologies".

is putting pressure on the Delta's ecology and natural resources. For instance, smoke, soot and dust emissions, coupled with waste and untreated effluents from industrial plants and workshops, are contaminating the air, water and soil of the densely populated areas of the Delta (Ahn 2006; Konstadakopulos 2008). It is reported ('Pollution at Bat Trang an unsolved puzzle' 2006) that local pollution causes hundreds of deaths from pollution-related cancer each year. Empirical research in developing countries has shown that environmental regulations in small-enterprise clusters are largely unenforceable, for the following reasons: firstly, the political will for enforcement is weak, given the fact that small enterprises provide much-needed employment to the poor, who could otherwise be unemployed; and secondly, the numerous and mostly 'informal' enterprises within a cluster are able to evade environmental regulations. However, research has shown that small enterprises might be willing to adopt new technologies voluntarily, or at least with very little prompting (Blackman/Kildegaard 2004). (In contrast, the previously mentioned Marshallian cluster refers to self-organised and self-motivated market-led dynamics, in which the unlocking of individual freedoms allows entrepreneurs to adopt new technologies willingly, rather than because of a duty to comply with environmental legislation.) Furthermore, new technologies capable of meeting the future energy demands of small firms, and reducing the level of air, water, noise and soil pollution in a cluster, are widely available.

Within this context, the paper[4] aims at ascertaining which factors and actors determine firms' decisions to adopt clean technologies. The existing literature regarding the adoption of clean technologies in small-scale enterprise clusters in developing countries is somewhat limited. Up to now, the focus has generally been on the potential economic gains accrued by enterprises through the adoption of new technologies, or on the way in which clustered firms cooperate in the adoption of innovation (Hannes/Stokke 2001; Sandee/Rietveld 2001).

The paper will also attempt to identify, map and analyse environmental innovation networks[5] facilitating the adoption of new technologies, that might

[4] The paper draws from "Locating Environmental Innovation Networks in Small-Scale Enterprise Clusters in the Red River Delta of Northern Vietnam", which was generously supported by the Research Committee of the Association of South East Asian Studies in the UK (ASEASUK). The suggestions made by two anonymous referees on an earlier draft of this article are highly appreciated. The author is responsible for all remaining errors.

be operating in three small export-orientated enterprise clusters in the Red River Delta. Relatively little is known about the impact of such networks on reducing environmental degradation in clusters of developing countries, particularly since they are generally in the early stages of adopting environmental regulations. Environmental innovation networks can help us identify the pathways across which innovation flows. It appears that clusters need external contacts and synergies, in terms of new technological opportunities, in order to combat environmental degradation. However, it is important to note here that adoption of new technologies depends not only on exogenous supply of technology but also on the endogenous innovation capacity of the individual enterprise.

A further aim of the paper is to help the relevant stakeholders design policies for the promotion of clean technologies suitable to a cluster's unique conditions. It is envisaged that clean technologies could improve the productivity of clustered enterprises in the Red River Delta and ensure their long-term survival, thus revitalising many of the Delta's craft clusters. In the early twenty-first century, Vietnam's government has been promoting the development of "handicraft villages" (*Viet Nam News* 2008) by providing employment opportunities for rural communities, thus reducing the Delta's high levels of poverty[6].

The research methodology adopted was in the form of face-to-face interviews with the owners or managers of enterprises, in September 2007. The company interview survey, involving 51 randomly selected small enterprises, was carried out in the handicraft clusters situated in the semi-rural areas around Hanoi, specifically the villages of Bat Trang (ceramics) in Ha Noi province, Van Phuc (textiles) in Ha Tay province, and Dong Ky (furniture and woodcarving) in Bac Ninh province. Based on an earlier, similar, survey by the same author in 2003[7], the survey was designed to collect information about the operation of handicraft enterprises, gauge their awareness regarding the state of environmental pollution within their cluster, and assess the degree of exposure of the sampled enterprises to external pressures to adopt ecological practices and clean technologies. It also

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[5] The concept of "environmental innovation networks" is discussed by Steward and Conway (1998). A definition of the terms "innovation" and "environmental innovation" is discussed by Mirata and Emtairah (2005).

[6] For a detailed discussion of the relationship between industrial clusters and poverty, see UNIDO (2004).

[7] "The Adoption of Information and Communication Technologies (ICTs) in Small-Enterprise Clusters in Vietnam".

aimed to collect information on firms engaged in environmental innovation, and map their interaction within their innovation network. Finally, in April 2008, a small number of semi-structured interviews was carried out in each of the clusters studied, involving government officials (members of the People's Committee), heads of trade associations, and the owners or managers of enterprises not previously surveyed.

The organisation of the paper is as follows: first, a review of the evolution of Vietnam's environmental legislation aimed at pollution abatement at the enterprise level; next, a description of the environmental conditions in the handicraft clusters of the Delta, and an account of the data collected and the methodology that guided their collection; then a discussion of the statistical model and its analysis; and finally, a summary of the findings and the drawing of conclusions.

2 The Evolution of Vietnamese Environmental Policy

The dismantling of collective farming in Vietnam in the 1980s set the stage for the reallocation of rural household labour from subsistence agriculture to no-farm activities. Industrial production increased substantially, as it took advantage of rural labour and the increased demand for consumer goods (Kerkvliet 2005:218). At the same time, institutional changes initiated by economic reform facilitated further industrial development, but also raised concerns regarding the protection of the country's natural environment. Such concerns surfaced in the mid-1980s, before the arrival of western donors, signalling the birth of Vietnam's environmental policy, and reference was made to sustainable development in the *Official Gazzette*[8]. The concept of sustainable development – the outcome of the 1987 Brundtland report – provides us with an important starting point for discussion. The report highlighted the importance of the three components of sustainable development: economic growth, environmental quality and social equity (WCED 1987; Baker et al. 1997). Sustainable development policies emanate from government and often imply some sort of implementation and enforcement. However, as in many developing countries, including Vietnam, a chronic failure in implementation of environmental legislation has been observed (see, for example, Sikor/O'Rourke 1996; O'Rourke 2002; 2004; Dieu et al.

8 The above information was provided by an anonymous referee.

2003; Khoa 2006). It appears that a number of national contextual determinants is responsible for delays or non-implementation. These include: the level of environmental awareness of the public; national regulatory provisions and incentives for pollution abatement; the institutional capacity of national and subnational levels of government and regulatory agencies; and the type of industry subject to environmental regulation.

Vietnam, as in the majority of developing countries, began to develop environmental policy in a more considered way from the early 1990s, coinciding with the United Nations' Earth Summit in Rio de Janeiro in 1992 (Weidner 2002:1345-8). The year before, in preparation for the Summit, the Vietnamese government drew up a 10-year national Plan for Environmental and Sustainable Development for 1991-2000. The Plan recognised the urgency of environmental issues in Vietnam and set out a programme of action aimed at developing the appropriate organisational structures, management programmes, policies and legislation. This Plan was influenced by the country's emergence from international isolation, and benefited from the support of the Swedish Government and two United Nations' institutions, namely the United Nations Development Programme (UNDP) and the United Nations Environmental Programme (UNEP) (ADB 2000:60). As a consequence, two important pieces of environmental legislation emerged: the framework Law on Environmental Protection (1993)[9] and the Water Resources Law (1998). These were followed by policies on reforestation, sustainable development, and the protection of biodiversity,[10] as well as a number of governmental action plans.

The first serious attempt at combating industrial pollution and encouraging the application of clean technologies came with the publication of Politburo directive

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[9] In 2006, a revision of the Law on Environmental Protection introduced the 'polluter pays' fees, the application of sanctions for polluting industries, the notion of corporate environmental responsibility, and the use of other incentives for the adoption of clean production techniques.

[10] Two other important initiatives were initiated during the 1990s, the Biodiversity Action Plan (1995) and the Five Million Hectares Reforestation Programme (1998). The Strategic Orientation for Sustainable Development (2004) is Vietnam's response to the United Nations' Agenda 21 initiative. Chapter 34 of Agenda 21 mentions the employment of 'Environmentally Sound Technologies (EST)' for the protection of the environment and calls for their transfer to developing countries (http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter34.htm accessed 28 June 2008). Agenda 21 has been instrumental in providing the legal basis for Vietnam to enact a number of regulations for the application of clean technologies (Khoa 2006:141).

No. 36-CT/TU in 1998. This directive, on 'Promoting environmental protection in the period of national industrialisation and modernisation', was followed in the same year by the establishment of the Vietnam National Cleaner Production Centre (VNCPC) at the Hanoi University of Technology, a joint initiative by the United Nations Industrial Development Organisation (UNIDO) and UNEP, and financed by the Government of Switzerland (Khoa 2006:141). Soon afterwards, VNCPC assisted in the creation of the first cleaner production demonstration project in Ho Chi Minh City, aiming at the prevention of pollution in the food processing, pulp and paper, and textile sectors (Frijns 2003:143). Vietnam's espousal of environmental concerns, due to its increasing industrial pollution, was formalized by the signing, in 1999, of the United Nations' International Declaration on Cleaner Production, and the drafting of a National Action Plan for Cleaner Production 2001-2005, approved in 2002. These three initiatives – the Cleaner Production Centre, the International Declaration, and the National Action Plan – are seen as the start of the institutionalisation of clean production in Vietnam (Khoa 2006:142). The Prime Ministerial Decision No. 64 of 2003 attempted to deal with environmental pollution originating from industrial establishments. It explicitly stated that clean production and environmentally friendly technologies should be adopted by polluting enterprises, enhanced by financial incentives in the form of tax rebates or soft loans from the Vietnam Environment Protection Fund.[11] At the same time, several pollution-prevention and cleaner-product projects were initiated with the support of international agencies and donor countries. Nonetheless, as O'Rourke aptly noted at the time:

> Vietnam appears to combine the worst of both Soviet-bloc environmental callousness with East Asian development-at-all-costs. Beginning from a base of 1950s-vintage highly polluting heavy industry, adding the recent expansion of export-oriented light industry, and acknowledging the state's limited capacity for environmental regulation, the country seems destined for rapid urban and environmental degradation (O'Rourke 2002:222).

In 2001, amid the upsurge of environmental-related anxiety, Vietnam's gov-

[11] The Vietnam Environmental Protection Fund was created in 2002 (Decision 82/2002). It is financed from domestic sources (mostly environmental fines) and foreign sources (mostly international donors). The fund aims at providing enterprises with low-interest loans or direct subsidies in conjunction with borrowing from other official sources. During its first three years of operation it helped approximately 700 enterprises to reduce their pollution levels (*Quang Ngai* 2005).

ernment devised the National Strategy for Environmental Protection (NSEP) for 2001-2020. Three years later, the Politburo adopted a resolution on Environmental Protection in the Period of Industrialisation and Modernisation Enhancement. In the Action Plan of 2005, designed to implement the above resolution, the government stated that its aim was to strengthen the existing incentive schemes and penalty mechanisms[12] and to utilise environmental funds for pollution abatement. However, despite these initiatives, the goal of alleviating environmental degradation in the Red River Delta still seems a long way off. The latest *State of the Environment* report (MoNRE 2005; see also ADB 2006) paints a picture of large-scale ecological destruction in the Red River Delta. But the government has not only to reduce pollution in the Delta, but also to fulfil its obligations regarding the implementation of multilateral environmental agreements, such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol, and in particular the Clean Development Mechanism (CDM), a scheme whereby foreign corporate investments can be channelled into developing countries through the sponsoring of carbon-cutting projects.

Vietnamese environmental management became more committed with the creation in 2002 of the autonomous Ministry of Natural Resources and the Environment (MoNRE), although its predecessor, the Ministry of Science, Technology and the Environment (MoSTE), established in 1993, paved the way. MoNRE has an overall mandate on environmental strategy, legislation and policy formulation, as well as on the management of natural resources. It was also granted powers in relation to creating new environmental entities, undertaking environmental research, conducting environmental impact assessments, setting up environmental quality data, and collecting data. In response to the Kyoto Protocol obligations, the Ministry of Natural Resources and the Environment published a report in 2004, outlining its strategy for the CDM (MoNRE 2004). It is widely acknowledged that the adoption of the CDM might help to combat climate change, which otherwise could have a devastating effect on Vietnam, and in particular on the Red River Delta's low-lying land.[13]

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12 It appears that the main economic instruments currently practised in Vietnam are user charges on drinking, waste water, and some energy products. Fines, albeit small, are also imposed by the provisional departments of the Ministry of the Environment and Natural Resources for violation of environmental protection legislation (VNCPC 2005:48).

13 With a predicted one-meter rise in sea level by 2100, it is feared that 5,000 km^2 of the Red

The other main ministries in Vietnam which hold important environmental functions are agriculture and rural development (with regard to forestry and rural development), construction (urban water supply and sanitation), industry (pollution from state-owned enterprises and mining activities), and fisheries (marine and inland fisheries). Co-ordination between MoNRE and these other ministries has been somewhat inefficient, given the fact that the Ministry lacks resources, and that a number of unplanned tasks have been imposed by both the government and the Office of the Prime Minister (VNCPC 2005:32). Nevertheless, MoNRE, assisted by the Vietnam Environmental Protection Agency (VEPA), has benefited from other support entities, such as the National Water Resources Council[14], a high-level advisory body overseeing the country's rivers and water resources.

MoNRE supervises the 61 provincial Departments of Natural Resources and the Environment (DoNREs). These are within the provincial government (known as the Provincial People's Committee),[15] representing central government at the provincial level. They are responsible for environmental management and land administration within their geographical boundaries, and their function is extensive, including, *inter alia*, responsibility for monitoring environmental quality (air, water, soil and noise); pollution control, including industrial discharges; and resolving environmental disputes caused by pollution incidents within their administrative area. (DoNREs also have offices at the district level, although these mostly focus on land administration rather than environmental

River Delta would be flooded (IPCC 2007). See also Chaudhry and Ruysschaert (2007) for a detailed account on the effects of climate change on Vietnam's development.

[14] The creation of this specific institution was the outcome of the enactment of the Water Resources Law in 1998. However, as the World Bank Development report suggests, this law urgently needs to be revised in order to clarify and rationalise the roles of various levels of government, coordinating entities and businesses, as well as to separate the state water resource management from the water service function (World Bank 2006:131).

[15] There are three levels of sub-national government in Vietnam: provinces (61), districts (598), and rural communes, semi-urban areas and urban wards (10,500). At each of these administrative levels, People's Committees represent the executive branches of government, and they are generally controlled by the Communist Party of Vietnam (Mattner 2004:122). Endemic corruption is entrenched within the Communist Party, and the majority of business people and the general public consider corruption to be the country's most serious problem. See, for instance, Gainsborough (2003), Kerkvliet (2005) and World Bank (2005). However, during his fieldwork, the author was not told of any incidents of corruption, although it might be the case that enterprises have simply learned to live with it.

issues.) However, as Khoa notes (2006:24), there are significant differences in the function, structure and size of the DoNREs, not only because of variations in provincial land area, level of industrialisation, and economic development, but also the priority given by the administration and the local community to environmental protection.

Various government organisations and NGOs are making efforts to raise environmental consciousness amongst both the public and private enterprises, as awareness of preserving the environment is low. Moreover, at the local level, public participation in environmental initiatives is "not systemically organised". As Parenteau and Nguyen Quoc Thong note, in their perceptive article on public participation:

> Local authorities get information on projects at the very last minute, just before implementation. Public participation comes afterwards, mainly to ease implementation. Unions act mainly as transmission lines for the Party and the people's committees. Exceptions were encountered in the programme's small projects where, for example, the Women's Union, apparently the most active of the unions, played a leading role (Parenteau/Nguyen 2005:247).

Nevertheless, the Vietnamese government is well aware of, and sensitive to, the country's serious environmental problems. A comprehensive range of environmental laws and regulations are now in place. Furthermore, Vietnam's institutional capacity and environmental sustainability are gradually improving[16] (see Table 1 for progress made in relation to access to water and sanitation). It now participates in the various global environmental fora; the country's universities are gaining considerable expertise on the management of natural resources and environment-related issues; and networks providing key resources of expertise and links to research institutions and government are now flourishing[17]. Yet, despite the progress made in establishing a system of pollution control,

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16 In the most recent *Environmental Sustainability Index 2008*, which ranks the environmental health of 149 countries, Vietnam is 76th position, well ahead of its neighbours, Laos (101th), China (105th), and Cambodia (136th). This is a significant improvement on 2005, when Vietnam was in 127th position, suggesting that, despite the chronic weakness of state policy, the Vietnamese population is adopting environmental management practices. http://epi.yale.edu/Downloads and http://www.yale.edu/esi/ESI2005_Main_Report.pdf (accessed 03 July 2008).

17 See for instance Khoa (2006) for an illuminating network analysis of cleaner production in Ho Chi Minh City.

implementation and enforcement is patchy. Limited capacity at the local level, lack of coordination, confusion over who is in charge of inspections, and weak public participation all undermine the enforcement of environmental legislation. In addition, as van Rooij points out, in his analysis of the implementation of environmental law in neighbouring China, that enforcement problems might be linked to the lack of local legitimacy caused by the conflicting interests of various stakeholders (van Rooij 2006). Nevertheless, as we shall see in the next section, many of the Red River Delta's small-enterprise clusters are seen as "pollution havens" (World Bank 2005:151; for a review and critique of the extensive literature of pollution havens, see for instance Brunnermeier/Levinson 2004).

Table 1 *Some Trends in Emissions and Pollution, and Access to Water and Sanitation, in Vietnam, East Asia and the Pacific, and Low-Income Countries*

Emissions, Pollution, Water and Sanitation	Vietnam	East Asia & Pacific Group	Low-Income Group
CO2 emissions unit of GDP (kg/2000 PPP USD GDP)	0.4	0.6	0.4
CO2 emissions per capita (metric tons)	0.9	2.7	0.8
CO2 emissions growth (%, 1990-2003)	71.9	40.6	29.4
Particulate matter (urban-pop.-weighted avg., μg/cu. M)	65	72	77
Access to improved water source (% total population)	85	79	75
Access to improved sanitation (% of total population)	61	51	38
Deforestation (average annual %, 1990-2005)	-2.5	-0.2	0.5

Source: World Bank 2006; from World Development Indicators; the Little Green Data Book.

3 The Survey Data

In order to identify which enterprises in the Red River Delta adopt clean technologies, and to understand how they interact within their innovation network, a survey was undertaken, involving 51 firms located in the three different small-scale handicrafts clusters previously mentioned. An additional task was to evaluate the prevailing environmental conditions in these clusters, and ascertain the factors affecting local environmental management capabilities.

The three clusters surveyed were chosen because of their importance in the local economy and their association with images of pollution and environmental degradation ('Pollution at Bat Trang: SOS' 2007). A questionnaire survey was developed (see appendix), and translated into Vietnamese. A pilot was then conducted, with the help of an assistant/interpreter from the Centre of Sustainable Development in Hanoi, experienced in social survey techniques. After the satisfactory testing of the pilot survey, the research team visited at random a number of enterprises and, by interviewing their owners or managers, were able to survey a total of 51 companies.

Table 2 *Enterprise Characteristics and Adoption of Clean Technologies in the Red River Delta, 2006*

	Bat Trang (Ceramic Cluster) (n=15)	Dong Ky (Furniture Cluster) (n=16)	Van Phuc (Silk Cluster) (n=20)	Total (n=51)
Average number of years in operation	15.1	11.1	16.6	14.4
Average number of full-time employees	39.7	49.7	6.9	29.6
Average turnover per firm in thousand VND (USD)	4,655,670 (291,000)	3,156,250 (197,000)	2,168,450 (135,528)	3,209,882 (206,000)
Average exports as percentage of firm's turnover	83%	37%	0.03%	47%
Number of enterprises having adopted some clean technologies (i.e. gas kilns, chimney filters, waste-water treatment facilities)	13	3	1	17(33%)
Percentage of annual expenditure on pollution Control	0.34%	0.22%	0.06%	0.21%

Source: own survey.

Of the 51 enterprises that composed the data set, 15 (30%) were ceramic firms in the village of Bat Trang in Ha Noi province, 16 (31%) were wood-carving and furniture firms in the village of Dong Ky in Bac Ninh province, and 20 (39%) were textile enterprises in Van Phuc, Ha Tay province; all of these lie within a few kilometres of the capital, Hanoi. The vast majority of enterprises in the

sample were private firms – the exception being one household enterprise and one co-operative establishment – and, on average, they employed 30 people, were 14 years old, and achieved sales in 2006 of 3,210 million Vietnamese dong (VND), or approximately USD 206,000 (see Table 2). Exactly half of the sampled enterprises stated that they export on average 47% of their products overseas; exports varied from 2% to 98% of the total output of the enterprises. However, there were sectoral differences: whereas the vast majority of firms in the ceramic village of Bat Trang exported abroad, only one enterprise in Van Phuc[18] reported doing so.

4 The State of the Environment in the Industrial Clusters of the Red River Delta

The rapid growth of the Red River Delta handicraft clusters has led to increasing demands of natural resources, such as water and raw materials (timber, clay, stone, seagrass, metals, etc), as well as greater use of energy, transportation and other infrastructure services, all of which generate more pollution and waste. In the three clusters surveyed, noise, air and water pollution are the main problems. Due to the historical development of the clusters, the vast majority of enterprise owners reside in the village, and living quarters and industrial production are intermingled, sometimes with damaging consequences: in Van Phuc, for example, noise pollution from the antiquated electric shuttle looms and spinners is terribly pervasive. Air pollution is also an increasing environmental problem, due to the combined emissions from handicraft enterprises and mobile sources (mostly poorly maintained lorries, cars and motorbikes). Coal is still the principal fuel for ceramic kilns, dry wood chambers and textile dye works, as well as cooking and heating, and smoke pollution in Bat Trang originates from small pottery kilns which use coal or even firewood. Most kilns are located in the enterprise's back yard, creating air pollution hazards for their neighbours, from fine particles, carbon monoxide, nitrogen oxide and sulphur dioxide, to mention just a few. According to the Department of Natural Resources and Environment in the province of Ha Noi, particulates in the form of dust in Bat Trang exceed environmental standards by 3 to 3.5 times, while concentration of carbon dioxide and sulphur dioxide is 1.5 to 2 times above the limit ('Pollution at

18 Most of the village's textiles are destined for the tourist shops in Hanoi.

Bat Trang: SOS' 2007). According to VEPA, each resident of Bat Trang breathes the equivalent of 2 kg of dust per day, and more than 70 per cent of the village's population suffers from respiratory disease, while more than 80 per cent are affected by the infectious eye disease of trachoma. The Agency also reported the results of a survey that identified 126.6 cases of cancer per 100,000 of population, 40 of which were fatal lung cancer ('Pollution at Bat Trang an unsolved puzzle' 2006).

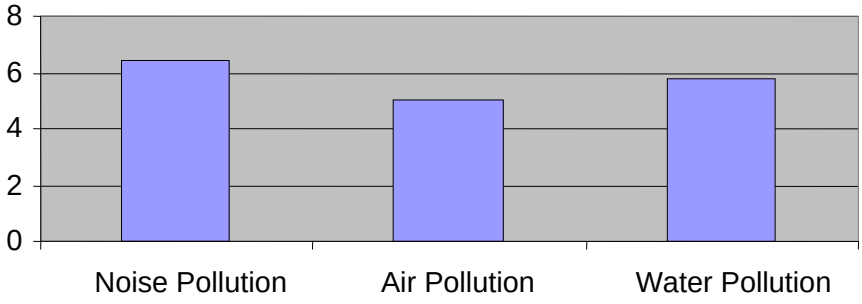
In world terms, Vietnam has a relatively low level of energy consumption,[19] and subsequently lower CO_2 emissions than the rest of the East Asia and Pacific countries. However, both production and consumption of energy is increasing rapidly, resulting in higher CO_2 emission (Table 1). The country is experiencing more and more incidents of power blackout, as demand for electricity surges. This was the case in the textile cluster of Van Phuc during the winter of 2008, when many of village's looms were idle for several weeks, due to rationing of the electricity supply – apparently not an unusual event in rural areas of the Delta during the January to May dry season, when the hydro-electric plants at Hoa Binh and Thac Ba, which generate most of the Delta's electricity, have to release water from their reservoirs to irrigate the region's winter-spring crops.

Water resources are also coming under strain. Rainfall in the Red River Delta varies throughout the year, with floods a common occurrence during the rainy season from May to October; however, in the dry season, water is becoming scarcer and its quality is deteriorating in both rural and semi-urban areas of the Delta. This is mainly due to heavy silt loads, as soil from industrial activity enters rivers and canals, diminishing surface water quality – an issued raised by interviewees in Bat Trang. Untreated sewage is the second most serious pollutant, especially in the semi-urban areas of the Delta such as Van Phuc, in which human waste comprises 70 to 90 per cent of the total organic load in rivers and other waterways. Industrial pollutants are also entering surface water and groundwater, especially in Van Phuc (textile dyes) and Dong Ky (solvents). A worrying trend is apparent in the Red River Delta, where organic and degradable industrial wastes are being replaced by those that are more toxic and persistent (ADB 2000:29). In

[19] Vietnam is ranked 105 out of 177 countries in relation to electricity consumption per capita, according to the *2007/2008 Human Development Report* produced by UNDP. However, the annual percentage change of demand during the 1990-2004 period was exceptionally high. Online: http://hdrstats.undp.org/indicators/209.html (accessed 11 June 2008).

Dong Ky, water is taken from shallow wells, which are unprotected and therefore likely to be polluted; local residents believe that these are causing waterborne diseases. All three clusters have observed signs of faecal contamination. Sewage systems, where they exist at all, are largely in the form of various kinds of open drainage, such as ditches and street gutters, most of which discharge untreated sewerage into the nearby rivers and fields.

Figure 1: Seriousness of Pollution Reported by Enterprises (n=51)



Source: own compilation.

Pollution Levels

So how do our sampled enterprises perceive the seriousness of the various forms of pollution in their cluster? Figure 1 shows that noise, air and water pollution are all considered at least moderately serious (as judged on a scale of 1 to 10, where 1 represents "not serious at all" and 10 represents "very serious"). There are striking differences among the three clusters: for instance, noise and water pollution are considered excessive (8.5 and 9.15 respectively) in Van Phuc; water pollution is the main issue in Dong Ky (above average, at 6.0); while in Bat Trang both noise and air pollution are only slightly above the average. (For logistical reasons, soil pollution and waste management were not quantified in the survey, but they are undoubtedly equally pressing concerns.)

Depletion of Natural Resources

Deforestation has been a perennial and widespread problem in Vietnam: 50% of the forest was lost during the 40-year period 1943-1983. In the 1990s, in

recognition of this decline, the Vietnamese government launched an ambitious reforestation programme; however, it was plagued by problems, largely due to institutional constraints, poor technical capability, and constantly changing programme objectives (ADB 2000:15).

Forest loss has been particularly rapid in the northern regions of Vietnam (ADB 2000:14). The three provinces in which the survey was undertaken have lost almost all of their forest cover, and during the survey the wood-carving village of Dong Ky was under police investigation and in the national headlines because of an illegal logging incident[20]. At present, most of the timber used by the enterprises in Dong Ky is imported from Laos (often illegally through clandestine operations), as logs or as sawn wood.

When the sampled enterprises were asked to assess the local sustainability of their main resources (i.e. clay, timber or silk), the overall impression given was that this was not yet a serious concern (a rating of 7.5, where 1 is "not sustainable at all" and 10 is "totally sustainable"). Again, however, there were differences between our clusters: depletion of resources was not viewed as problematic in Bat Trang, whereas in both Van Phuc and Dong Ky, resources were considered only moderately sustainable.

Community Pressure

An important objective of the survey was to identify and then measure the enterprises' exposure to community pressure. Eleven firms (22%) were aware of instances where neighbours, local community leaders, or members of the People's Committee had complained to companies in their village about pollution from a plant or workshop. Five of these (10% of the total) reported that the complaint was made specifically about pollution from their premises. Following Rock and Aden (1999), it is possible to construct from this a Community Pressure Index (CP) that identifies an enterprise's exposure to community pressure (i.e., when the interviewee was aware that other enterprises in the cluster were exposed to community pressure, the weight given was 1, and when his or her own enterprise was subject to direct exposure to pressure, the weight given was 2; see Questions 3 and 4 in the Abbreviated Questionnaire Survey in the Appendix). Similarly, an Environmental Market Pressure Index (EMP) was constructed by measuring

[20] This occurred in Hanoi and involved specimens of the rare Dalbergia Tonkinesis tree (known in Vietnamese as the *sua*); *Viet Nam News* 2007.

the indirect pressure from buyers or customers (i.e., when the interviewee was aware that other local enterprises were exposed to pressure from their buyers or customers, the weight given was 1, and when his or her own enterprise was subject to direct exposure to pressure by buyers or customers, the weight given was 2). In response to such pressure, the owners or managers of ten firms (20%) reported having entered into some kind of pollution control agreement with local or provincial authorities.

The author's impression is that the majority of interviewed enterprises did care about their local environment. In addition, a number of individuals were grateful for the fact that a foreign academic had raised the issue of pollution in their cluster.

Adoption of, and Expenditure on, Clean Technologies

During the period 2001-2006, a total of 15 firms (29%) incurred some expenditure on pollution abatement; this included annual operation and maintenance costs, which across the 51 sampled firms amounted to an average of 6,950,000 VND (USD 434), representing just 0.21% of their total turnover. In the same period, 17 firms (33%) reported having installed some pollution control equipment, such as electric or LPG kilns, chimney filters, waste water facilities etc. When they were asked to indicate who recommended this pollution control equipment to their business, universities were mentioned three times, while other companies located in the same cluster were acknowledged twice, as were provincial or local government; however, the majority (10 firms) had introduced it on their own initiative. Again, there were significant differences between the three clusters: most of the enterprises which had installed pollution control equipment were based in Bat Trang, with only a few in Dong Ky, and just one in Van Phuc.

It should be noted that there are various external constraints on the adoption of pollution control technologies which were not drawn out by the above questions. It is hypothesised that seven such constraints could prevent enterprises from either adopting or improving their pollution control. The Pollution Control Constraints Index (PCC) shown below in Table 3 was computed by assigning a weight of 3, 2 and 1 respectively to the constraints ranked first, second and third in importance by our sampled enterprises. The main constraints were: shortage of capital, reported by 76% of firms; lack of knowledge about the benefits of pollution control technologies (33%); and poor market conditions (25%).

*Table 3 Major Constraints on Enterprises Adopting or Improving Pollution Control Technologies (2007)**

Constraints	Ranking	Percentage of Positive Responses
Shortage of capital	39	76
Lack of knowledge about the benefits of pollution control equipment	17	33
Poor market conditions	13	25
Shortage of trained workers	6	12
Lack of incentives for adopting pollution control equipment	5	10
Other (i.e. shortage of land)	5	10
Lack of good managers	0	0

*Note: * Enterprises were asked to identify just 3 major constraints from the 7 listed in the questionnaire.*
Source: own survey.

Environmental Market Pressure

We also asked owners and managers the following two questions:

1. Are you aware of any instances where buyers/customers have asked whether local plants are operating in compliance with government environmental regulations? (If so, assigning a weight of 1)
2. Have any of your buyers/customers considered the environmental performance of your plant/workshop before buying from you? (If so, assigning a weight of 2)

Sixteen enterprises stated that their own buyers or customers had put direct pressure on them to comply with national environmental regulation; these were mainly customers from Japan (mentioned 9 times), Europe (6 times), and the United States (4 times), but also included two multinationals, namely IKEA and the Walt Disney Corporation. Ten companies – the majority located in the ceramic cluster of Bat Trang – reported pressure for compliance from indirect buyers or customers. When managers were asked whether they received a low-interest (subsidised) loan for the purchase of pollution control equipment, only four (8% of the sampled firms) had done so (denoted with variable LOAN = 1, 0 otherwise).

Government Monitoring and Sanctions

Given the fact that the monitoring and enforcing of environmental regulations is highly uneven across the three clusters, a composite Government Monitoring and Sanctions Index (GMS) was constructed, again following Rock and Aden (1999:363), as follows:

> GMS = FGM +2*WL, where FGM is the frequency of government monitoring in the last 12 months, and WL = the number of warning letters the enterprise received during the last 12 months.

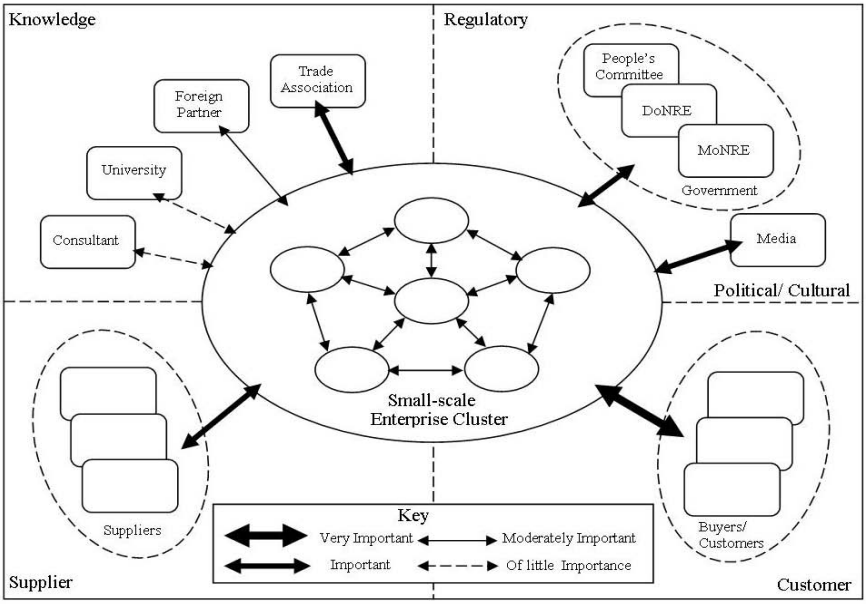
Fourteen enterprises (27% of the sample) reported having been inspected at least once by government (four of them twice) during the last 12 months. In addition, four firms received a warning letter (one letter originated from the provincial DoNRE, while three came from the local commune).

Environmental Innovation Networks and Knowledge Exchange

Another important aim of the survey was to identify and map the existence of environmental innovation networks that might exist in the three clusters examined. Earlier research had pointed to a lack of information on the way clustered small enterprises in the Red River Delta interact in knowledge networks where technological innovation processes are taking place (Konstadakopulos 2005; 2008). The visual mapping of environmental innovation networks might help us to portray the full pattern of significant relationships (informal and formal), and might reveal the diversity of actors (external and internal) that are operating in the development of environmental innovations in our clusters. Steward and Conway (1998) used such an approach in an analysis of environmental innovations in British and German companies. Liff and Steward (2001) also employed the same approach to map the different actors and relationships in the social network of a British "community e-gateway" facility providing public access to computers and the Internet. Steward and Conway's graphical representation (Figure 2) depicts networks on an actor-positioning template, allowing for the presentation of internal and external interactions in a cluster, and the location of certain actors in specific areas of the graphic. The internal environment of the cluster is represented by the ellipse, while the external environment of the focal innovation actors is depicted as "four zones of relevance to environmental innovation" (i.e., supplier, customer, knowledge, and regulatory/political-cultural) (Steward/Conway 1998:241-3). The key actors in these four zones are enterprises,

customers, suppliers, trade associations, knowledge institutions and government departments.

Figure 2: Environmental Innovation Network Map of Small-scale Enterprise Clusters in the Red River Delta (2007)



Source: Template adapted from Steward and Conway (1998); own survey.

This approach has similarities to the analytical framework of environmental innovations in small and medium-sized enterprise that was developed in Europe by Hansen et al. (2002). They note (p.44) that the environmentally innovative capability is "the result of an interplay between the *strategic orientation*, the *network relations*, and the *competencies* of the company". A firm's strategy is mainly orientated towards the acquisition of competitive advantage. The adoption of new technologies is either necessary for improving the quality of its product, or in order to comply with environmental regulations imposed by the competent authority. The environmental strategic orientation of most firms, they add (p.45), can be environmentally positive, neutral or negative,

although small enterprises are more likely to belong to the second and third of these categories. However, it is also likely that a company aims to maximise short-term profits, especially in situations where property-rights are viewed as insecure. The adoption of new technologies, therefore, may involve trade-offs between quality gains and cost reductions and may suggest that the use of "old" and environmentally damaging technologies is part of cost-reduction strategies, rather than seeking to gain competitive advantage (over the longer term)[21].

Hansen et al. (2002) add that most firms operate in a thick network of relationships and ties with customers, suppliers, competitors, trade bodies and public institutions. This network of relationships – based on formal contracts, or informal interactions which are like to generate mutual trust and exchange of information and knowledge – influences the capacity of individual enterprises to be innovative (p.46). Furthermore, the internal competencies and capabilities of individual firms, in the form of "knowledge, skills, values and organisational routines", also shape the course of environmental innovation (p.48).

The environmentally innovative capabilities of enterprises are apparently augmented when such enterprises are clustered together. The potential networking of clustered enterprises brings about additional technological externalities, such as the strengthening of knowledge exchange. In the context of globalisation, an important objective of the survey was to establish the relationship between local clusters and international customers, and determine whether owners had heard about new technological products and processes which are environmentally friendly. 35 per cent stated that they knew of such new technologies. In an attempt to tease out more information from managers, we presented them with a list of eleven possible sources of new environmentally friendly technologies, asking them to select only the three most important ones. Table 4 shows that the firms' buyers or customers (mentioned 14 times) are the most likely to be sources of knowledge in relation to new environmental technologies, followed by the media (and in particular television), mentioned 9 times, and trade associations (8 times).

21 This point was made by an anonymous referee.

Table 4 *Sources of Knowledge Regarding the Existence of Environmentally Friendly Technologies (2007; N=51)*

Rank / Sources	Times mentioned
1. Buyers/customers	14
2. Other (mostly media, and in particular TV)	9
3. Trade association	8
4. Government	7
5. Supplier	7
6. Other similar firms in the same industry/locality	5
7. Foreign partner	5
8. Research organisation/University	3
9. Consultants	2
10. Training institutions	1
11. Other firms in different industries	0

Source: own survey.

Owners and managers were asked to rate such interactions with their most significant innovation partners, on a scale of 1 (representing "not important at all") up to 10 (representing "extremely important"). The average rating was 8.3, indicating a significant emphasis on such interactions. When they were asked who was likely to initiate such interactions for gaining information and knowledge on new environmentally friendly technological products and processes, the most common response was their own company (mentioned 26 times), followed by their innovation partner (11 times). The geographical location of such partners was most often "elsewhere in Vietnam" (mentioned 38 times), or abroad (27 times), rather than in the cluster itself, or in its province (mentioned only 6 and 3 times respectively).

Finally, the survey attempted to establish how often enterprises had sought help or advice from local government on the acquisition of pollution control equipment and information on compliance with environmental regulations, as well as how to deal with banks and senior levels of government. Managers reported that they rarely approached the local authorities (perhaps suggesting a lack of opportunity to obtain personal benefits by engaging in a corrupt activity); when they did, it was to obtain information on compliance with environmental regulation.

5 Statistical Tests

One of the main aims of the survey was to determine whether the sample enterprises are investing in environmentally friendly technologies. From the survey results, it is possible to construct two dependent variables. The first of these is ENVTECH, in which a score of 1 denotes that the enterprise has adopted such technologies, and 0 when it has not. The second variable (ENVEXP) is the average annual pollution expenditure between 2001 and 2006. It was hypothesised that certain characteristics of enterprises in general (i.e. size, years of operation, turnover, percentage of output being exported, or the industrial sector in which the firm operates) could affect the adoption of clean technologies. It was expected that the Bat Trang pottery enterprises, with their long history of pollution, would have invested more on clean technologies than those in the other two clusters. Thus, an additional variable (CLUSTER) was constructed, denoting the location (and sector) of each surveyed enterprise. Two multiple regression equations were constructed:

ENVTECH; ENVEXP = f(EMPL, YEARS, TURN, EXPT, CLUSTER, LOAN, GMS, CP, EMP).

ENVTECH represents whether or not the enterprise has adopted clean technologies, and ENVEXP denotes the annual amount spent on pollution abatement. Independent variables include the characteristics of enterprises (EMPL, YEARS, TURN, EXPT) and their sector/location (CLUSTER); a measure of whether or not the firm has received a subsidised loan for purchasing such technology (LOAN); measures of regulatory actions (GMS); and community (CP) and environmental market pressure (EMP). Results of the regression tests are shown in Table 5.

It can be seen that the adoption of new technologies (ENVTECH) is influenced by the age of the firm, and its sector/location. It appears that the older enterprises (denoted by the YEARS variable) based in Bat Trang (denoted by the CLUSTER variable) are more likely to adopt clean technologies than the companies based in the woodcarving village of Dong Ky or the textile village of Van Phuc. Turnover (TURN) measures of regulatory actions (GMS) and community pressure (CP) are irrelevant, and the corresponding variables are removed from the model.

Table 5 Regression Equations on the Adoption of Clean Technologies (2007; N=51)

Variables	ENVTECH Coefficient (t-values)	ENVEXP Coefficient (t-values)
Constant	-0.526033 (-0.45)	8526835 (1.95)
EMPL	0.0010530 (0.13)	40900 (0.65)
YEARS	0.0497649 (2.62)**	
EXPT	0.000000 (1.50)	0.0005082 (1.18)
CLUSTER	-2.61962 (-2.14)*	-6156726 (-2.26)*
LOAN		27592405 (3.42)**
CP		2884063 (0.87)
EMP	-0.352340 (-0.41)	
Log likelihood	-8.583	
R-Sq (R-Sq (adj))		39.4% (32.6%)
Number of observations	51	51

*Note: *significant at the 0.05 level; ** significant at the 0.01 level.*
For the binary dependent variable ENVTECH, the Logit regression technique was used. For the continuous dependent variable ENVEXP on pollution control expenditure, the Ordinary Least Square regression was used.
Source: own survey.

However, the export variable (EXPT) and environmental market pressure (EMP) are included, although they are not statistically significant. Moreover, the EMP variable has the wrong sign.

The regression analysis, employing environmental expenditure (ENVEXP) as a dependent variable, indicates that such expenditure is influenced by the locality in which an enterprise is located (CLUSTER), as well as by whether the enterprise in question received a financial incentive in the form of a loan (LOAN) for the

purchase of clean technologies. The employment (EMPL), export (EXPT) and community pressure (CP) variables are also included, as they improve the overall explanatory capacity of the model. The value of the adjusted R-square, which adjusts for the inclusion of these variables, was increased to 32.6%, suggesting that they improve the model more than would be expected by chance (Table 5). However, these variables are not statistically significant. In both models, we observe that export-orientated enterprises located in the ceramic cluster of Bat Trang are more likely to adopt clean technologies and make pollution control expenditures than are those based in Dong Ky or Van Phuc. At the same time, there is tentative evidence to suggest that the offering of financial incentives, and exposure to community and market pressure, might be prerequisites for making handicraft enterprises adopt such technologies, or for substantially increasing their pollution abatement expenditure. These findings are certainly intriguing, but they pose the following question: Why is it mainly the enterprises of the Bat Trang ceramic cluster that have adopted clean technologies?

The interviews conducted with owners, managers and local officials suggest that this is due to affordability (the turnover of ceramic firms of Bat Trang is almost twice that of the textile firms of Van Phuc), as well as to a combination of market, regulatory and community pressures. For instance, one small firm in Bat Trang reported that their main customer, from Japan, had recommended the use of a gas kiln in order to improve the quality of the product, and this had unexpectedly resulted in environmental gains. Another manager mentioned that it was his company's Japanese and Australian customers who had introduced them to clean technologies. A third firm stated that they had received a letter from their province's DoNRE, requiring them to construct a wastewater facility, because of their size.

Another entrepreneur in Bat Trang revealed that she had received complaints from neighbours, and customers from Europe and Japan had subsequently suggested the adoption of new clean technologies. However, she considered the quality of information received on such technologies, from both the local and provincial levels of government, to have been extremely poor. Eventually, the local association provided some useful information regarding new kiln technologies, as well as a loan (although the interest rate was fixed at a commercial level). In the end, her company purchased a new gas kiln, which was made in Vietnam, though under a license from a Taiwanese company.

A few other firms in Bat Trang also mentioned that foreign customers from

Japan, the US and Europe are increasingly exerting pressure on local enterprises to use non-toxic paints, and to stop employing child labour. In contrast, market pressure in the cluster of Dong Ky is virtually non-existent, as the majority of furniture customers are from China and Vietnam, who are generally more interested in competitive prices than consequences for the environment. However, the provincial and local government have been active in the development of this cluster, having provided land and loans for the building of a functional enterprise centre – consisting of showrooms, workshops and living quarters – on the outskirts of the village (Konstadakopulos 2005:33). In Van Phuc, as many interviewees pointed out, it is the low profitability of its small textile firms that impedes the purchase of expensive machinery and the implementation of pollution prevention investment.

6 Implications for Policy Makers

This paper has highlighted the worrying level of environmental degradation and resource depletion in our small-scale enterprise clusters in the Red River Delta. Because of this situation, it could be argued that Vietnam's progress towards sustainable development is being hindered by environmentally unsustainable methods of production. The paper has also included an evaluation of how clustered enterprises perceive the seriousness of various forms of pollution within their cluster, and how they are responding to the environmental challenges facing their industrial sector. It was established that approximately one third of our sampled enterprises are investing in some form of cleaner production technologies. It appears that this is the result of external pressures from customers (not all of them related to environmental improvements) as well as neighbouring residents, although it is important to point out that the evidence is somewhat tentative, as it is not supported rigorously by our statistical analysis. For instance, we do not have evidence that clean production regulations had an impact on the adoption of clean technologies by our sample enterprises. In addition, it appears that current environmental policies in Vietnam do not influence the large majority of enterprises, in terms of changing their behaviour. As we found from our interviews with some decision-makers in the clusters, our sample enterprises provide much needed employment in their cluster, and this makes local authorities reluctant to enforce environmental regulations. It was further established that some financial incentives, in the form of subsidised loans, appear to have increased expenditure on pollution abatement in our sample firms. It is

not surprising, therefore, that most enterprises stated that shortage of capital is one of the main constraints on adopting clean technologies. Unfortunately, two thirds of our sample enterprises had not yet invested in any pollution control equipment.

Nevertheless, since the late 1990s the Vietnamese government has embarked on various initiatives, including environmental funds, a number of which are supported by international donors, and these have encouraged the adoption of clean technologies in high-polluting industrial sectors (Khoa 2006:142-3; Thong/Perera 2006). Many of these initiatives are based upon the assumption that the diffusion of such technologies is determined by making relevant information available to all enterprises.

Our key positive result is the identification of the most important actors that are instrumental in the development of environmental innovations within our clusters. The survey data indicates that, in the Red River Delta, the enterprises' customers and buyers are one of the principal promoters of technological innovation. As previously mentioned, overseas customers often persuade their companies to adopt clean technologies, which sometimes necessitates considerable expenditure. It will therefore be important to investigate how international actors encourage environmental improvements in firms.

Our findings mirror those of the World Bank (2005:93), where overseas customers concerned about corporate social responsibility (either directly or through third parties) specified social and environmental standards that had to be met. Enterprises usually accept the terms, hoping to attract their custom. However, this does not mean that customers are the only, or even the most important, reason why enterprises voluntarily adopt clean technologies. The Vietnamese media, environmental authorities (at central and local levels), trade associations and universities all help to raise awareness, through case studies, information exchange, demonstration projects, training, and technology transfer.

Drawing from our findings, it would seem that there are ways to make adoption of clean technology in the Delta's craft clusters more effective. Firstly, provincial government needs to increase its efforts to inform small enterprises about the latest sector-specific environmentally friendly technologies. Our survey and interview results suggest that, for a variety reasons, not every enterprise participates in knowledge exchange networks. Assistance programmes may therefore need to be identified and promoted within the most significant networks in the clusters.

A second approach would be to increase effectiveness, by linking financial and/or technical assistance with enforcement. Thirdly, partnering with public- and private-sector knowledge institutions should be encouraged. In this respect, local environmental authorities must act as a neutral party in the implementation of localised technological demonstrations. Another form of partnering is to work with overseas customers, which were perceived in our survey to provide the most important information on, and knowledge of, pollution control abatement.

As the economic, social and developmental consequences of global environmental problems such as climate change become increasingly intertwined with international trade, the transfer of environmental technology takes on ever greater significance, particularly for developing countries. Foreign business connections and knowledge networks are now considered the best means of promoting clean technologies. China and India, which are emerging as significant players in such technologies[22], could perhaps show the way for other developing countries to follow. However, many such countries, including Vietnam, also urgently need to improve their environmental standards, increase pollution charges, and upgrade their weak environmental regulatory policies.

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Appendix

Abbreviated Questionnaire Survey Administered to Owners and Managers of Enterprises in the Red River Delta of Northern Vietnam

1. How do you assess the seriousness of the following forms of pollution in your locality? (To be judged on a scale of 1 to 10, where 1 represents "not serious at all" and 10 represents "very serious".)
   Noise pollution 1 2 3 4 5 6 7 8 9 10
   Air pollution 1 2 3 4 5 6 7 8 9 10
   Water pollution (river/pond) 1 2 3 4 5 6 7 8 9 10
2. How do you assess the sustainability of local resources in your locality? (1 is "not sustainable at all" and 10 is "totally sustainable".)
   Resource depletion 1 2 3 4 5 6 7 8 9 10
3. Are you aware of any instances where neighbours, local community leaders, or members of the People's Committee have complained to companies in this village about pollution from any plant/workshop?
4. Has a complaint ever been made specifically about pollution from *your* plant/workshop?
5. Has your business entered into any kind of pollution control agreement with local leaders?
6. During the period 2001-2006, did your business install pollution control equipment (such as electric or LPG kiln, chimney filters, waste water facilities etc)?
7. In the same period, what was your average annual capital cost for pollution control (VND, in millions)?
8. In the same period, what were your average annual operation and maintenance costs for pollution control (VND, in millions)?
9. Who introduced such pollution control equipment to your business?
10. Which of the following constraints prevent you from adopting or improving pollution control? (Please choose THREE only)
    1. Shortage of capital
    2. Shortage of trained workers
    3. Lack of knowledge about the benefits of pollution control equipment
    4. Lack of incentives for adopting pollution control equipment
    5. Lack of good managers

6. Poor market conditions
7. Other (please specify)

11. Are you aware of any instances where buyers/customers have asked whether local plants are operating in compliance with government environmental regulations?

12. Have any of your buyers/customers considered the environmental performance of your plant/workshop before buying from you?

13. Have any of your buyers/customers offered to help you reduce emissions from your plant?

14. Has your plant received a low-interest (subsidized) loan for purchase of pollution control equipment?

15. How many times has the government monitored emissions from your plant in the past year?

16. Have any of the following government enforcement actions been applied to your company?

1. Warning letter from the Department of Natural Resources (DoNRE)
2. Warning letter from the local commune
3. No warning letter

17. Do you know, or have you ever heard, about new technological products and processes which are environmentally friendly?

18. With which of the following do you normally interact for gaining information and knowledge regarding new technological products and processes which are environmentally friendly? (Please choose THREE only)

1. Buyers/customers
2. Suppliers
3. Other similar firms in the same industry/locality
4. Other firms in different industries
5. Foreign partners
6. Government
7. Trade association
8. Research organisation/University
9. Consultants
10. Training institutions

19. How would you rate the single most important of these three interactions with regard to your most significant innovation partner? (1 represents "not important at all" and 10 represents "extremely important".)

1 2 3 4 5 6 7 8 9 10

20. Who is likely to initiate such interactions for gaining information and knowledge regarding new technological products and processes which are environmentally friendly?

1. My company
2. My innovation partner
3. Both

21. Where are your innovation partners located?

1. In the locality/village
2. In the province
3. Elsewhere in Vietnam
4. Abroad

22. How often have you sought help or advice from local government on the following issues?

Often / Occasionally / Never

1. Acquisition of pollution control equipment
2. Information regarding compliance with
3. Environmental regulations
4. Dealing with banks
5. Dealing with senior levels of government