Chapter 6 Measuring the Environmental Impact of Regional Economic Growth: An Inter-regional Input-Output Approach

Le Ha Thanh[32]
Vietnam Development Forum and
National Economics University
Bui Trinh & Duong Manh Hung
General Statistical Office

In recent years, Hanoi has enjoyed the positive results of policy reforms including economic growth averaging 11 percent per annum, increased inflows of foreign investment, and improved living standards for its citizens. Along with rapid growth and industrialization, however, Vietnam in general and Hanoi in particular are facing serious environmental damage such as water and air pollution from factories and households, and contaminated water sources due to the over-use of chemical fertilizer and pesticide in farming.

To attain sustainable development, Hanoi must immediately address its environmental problems through a mixture of measures: law and regulation, environmental technology, economic policies, enhanced participation of people, and increased environmental awareness of all stakeholders.

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Environmental and economic policies, if applied appropriately and in a timely manner, can often mitigate environmental damage as the economy grows. Without such policy combination, however, the result will be widespread environmental degradation.

This chapter has two distinct purposes. First, it discusses the general environmental situation and environmental awareness of various stakeholders in Hanoi (Sections 2 and 3). Second, it presents an empirical framework to study inter-regional environmental impacts through production linkage (Sections 4 and 5). Section 1 is a general statement of the problem, and Section 6 is a conclusion.

1. Linking economic and Environmental accounts

Analysis of the relationship between economic growth and environmental quality has become an important topic in recent discussions. Strategy for sustainable development must be based on a full understanding of interaction between these two aspects. Growth--or more generally, changes in economic activities--gives rise to environmental changes. An increased level of production and transaction generally leads to an increase in the pollution level. Increased pollution has both stock and flow characteristics, resulting in both short-term and long-term cumulative environmental effects on various geographical scales. Changes in economic linkage or policy in any sector also affect the level and geographical distribution of production activities, which in turn has consequences on environment.

From the macroeconomic viewpoint, linking economic data in monetary terms and environmental data in physical terms is the normal way to describe the relationship between economic activities and environment. Recently, the United Nations published a handbook on the integrated System of Environmental and Economic Accounting (SEEA), which instructs the way to link physical and monetary accounts through so-called satellite accounts. The idea is not new. In more than three-and-half decades ago, Leontief (1970) constructed a framework for including pollutants and pollution abatement cost into the input-output (I-O) model. His proposal was soon taken up by other researchers and adopted in over twenty countries.

This approach was also adopted in Vietnam. In 1996, a group of independent researcher[34] used the I-O model to examine the environmental impact of economic activities in the Red River Region in Northern Vietnam. In 2000, the same framework was adopted for HCMC. Although the focus and scope of analysis differ among studies, they basically used the same technique. There are several benefits of using the inter-regional I-O model. First, it is able to assess the impact of region-specific economic activities. Second, the model provides a useful tool to study spatial linkage in the national economy, which is captured by *induced* and *outflo*w effects. Third, it is an effective framework for making long-range forecasts.

Despite these advantages, there are also some drawbacks in using the inter-regional I-O model. Compared to the national I-O model, the inter-regional I-O model requires more data on flows of goods and services between sectors and between regions. Moreover, some organizations and activities cannot be easily attributed to a particular region, including the provision of public services by the central government. Another problem is posed by a firm whose main office is located in Hanoi or HCMC but has plants in several regions. However, even with these shortcomings, we believe that the use of the inter-regional I-O model can enhance the quality of policy formulation. Not only does it facilitate the identification of relevant variables and relationship among them, but also it produces quantitative information on environmental impacts.

The main purpose of this study is to present a concrete framework for measuring inter-regional, inter-industrial dependencies among regions and quantifying environmental effects arising from interdependent economic activities. For this, Hanoi is selected as the focal location and water pollution is taken up as the object of this study. More specifically, we will choose the biochemical oxygen demand (BOD) as the key parameter to gauge pollution. We employ the inter-regional multiplier decomposition method, developed by Miyazawa (1976). We will construct a three-region inter-regional I-O model. But before presenting this model, we will review the water pollution

[34] The research group includes Dr. Kim Kwang Moon (Toyohashi University of Technology, Japan), Mr. Francisco T. Secretario (Former ADB Expert), Mr. Bui Trinh (General Statistical Office, Vietnam), and Dr. Hoang Tri (Center for Environmental Research and Education, Vietnam).

situation in Hanoi and public awareness of pollution, which provide a background for our empirical part.

2. Water pollution in Hanoi

Hanoi is situated at $20^0$57' North and $105^0$35' to $106^0$25' East. It is 93 kilometers long from north to south and 30 kilometers wide from east to west. Hanoi's climate is characterized by tropical monsoon with the average temperature of 23-24^0C and the average moisture of 81-82 percent. Temperature may drop to 5^0C in winter and rise to 37-38^0C in summer. About nine to ten storms pass Hanoi every year. It rains about 140-160 days a year with an annual rainfall of 1,500 mm. Main wind direction is southeast monsoon in summer and northeast monsoon in winter. Hanoi is located in the Red River Delta. The urban area and adjacent districts are situated between the Red River and the Nhue River. The water level in the Red River fluctuates from 2 to 12 meters. Its average water flow is 380-436 m^3/s. The water level in the Nhue River is 5.35 to 5.63 meters. These rivers are the main sources of agricultural irrigation. Four other small rivers, namely, To Lich, Set, Lu, and Kim Nguu, receive and discharge wastewater from the city.

Hanoi is not only the capital of the country but also the major junction of roads, railways, and airways. The average economic growth of Hanoi since 1990 was 11 percent. Its GDP per capita was VND18.2 million in 2004. Industrialization and urbanization have accelerated in Hanoi, a city that also serves as a major commercial center of the country. A large number of hotels, restaurants, and representative offices are being built or established.

Rapid economic growth is often accompanied by environmental degradation. Water pollution, air pollution, overuse of chemical fertilizers and pesticides are often cited as major environmental problems that have resulted from economic growth in Hanoi. Among them, water pollution is considered to be very serious. In particular, the surface water of lakes and rivers in Hanoi has been seriously contaminated with industrial wastewater that has high organic concentrations of biological oxygen demand (BOD_5), NH4+, and chemical oxygen demand (COD). Their levels are 2 to 10 times higher than permissible limits, and concentrations of other pollutants, such as NO_3, TSS, total coliform, nutrients and phosphorus, also exceed standards by 2 to 20

times. The Nhue River and four small rivers mentioned above are heavily polluted and in need of rehabilitation and protection.

The drainage system in Hanoi is a combined one that discharges storm water, domestic sewage, and industrial wastewater in the same channels. The system is operated with a self-flow principle. Wastewater from Hanoi is discharged into the above-mentioned rivers, which drain into the Nhue River after passing through Thanh Liet Dam. These rivers are also used for irrigation in Thanh Tri and Tu Liem Districts. The To Lich River, once a beautiful blue river used by boats and other means of water transportation traveling to ancient Thang Long, has become a small blackwater canal with unpleasant odor. Ponds and lakes in Hanoi, which are part of the attraction of the city, are under threat of becoming wastewater reservoirs. Hoan Kiem Lake, West Lake, Truc Bach Lake, Bay Mau Lake and other lakes are in the state of eutrophication.

Table 1 Water Quality of Selected Lakes in Hanoi

Parameter	West Lake	Bay Mau Lake	Hoan Kiem Lake	Thu Le Lake
Temperature, ^0C	20-30	20-31	20-30	20-30
DO, mg/l	6.44	1.0	6.0	3.20
COD, mg/l	34.00	310.00	281.00	110.00
BOD, mg/l	8.10	81.0	126.0	-
NH_4^+	0.56	3.50	-	-
NO_2^-	0.09	3.60	-	-
PO_4^{3+}	0.48	0.80	0.10	0.15

Source: Hanoi Department of Science, Technology and Environment, *Current Situation and Environmental Impact Assessment for Hanoi*, 1996-2004

Hanoi discharges about 500,000 m^3 of untreated wastewater into its drainage system every day, of which more than 100,000 m^3 come from industries (including the chemical industry). The rest is composed of toxic wastewater from hospitals and domestic wastewater. The combined drainage system, which discharges wastewater together with storm water, aggravates pollution.

Domestic wastewater

The population of Hanoi is increasing rapidly. It is estimated at 3.12 million in 2005, of which 1.95 million live in the urban area. In addition, Hanoi has more than 12,000 daily visitors and thousands of workers from other provinces come to Hanoi to find jobs. Domestic wastewater of over 350,000 m^3 per day is the largest part of wastewater sources in Hanoi. Water from septic tanks, unhygienic latrines, and domestic chemicals is a serious source of pollution. Average amounts of waste per capita are estimated as follows: 6-12 grams of nitrogen, 2-3 grams of phosphorus, and 400 kinds of bacteria, germs and protozoa, hundreds of which affect people's health. Domestic wastewater is particularly high in nitrogen, phosphorus, and bacteria, especially coliform bacteria. Wastewater, gutters and canals are breeding places for flies, mosquitoes, and other disease-transmitting insects, which can cause widespread epidemics.

Industrial wastewater

Industrial wastewater is a major cause of water pollution in Hanoi. A total of 274 large industrial plants are located in the city, of which 68 are heavy polluters. In addition, there are 540 service firms, 450 handicraft cooperatives, 3,350 small manufacturing firms, which together make the pollution problem in Hanoi very serious. In particular, industrial wastewater from chemical, textile, leather, pulp and paper, food processing and mechanical plants is severely damaging local water quality. Over 100,000 m^3 of industrial wastewater is discharged daily into water bodies with toxic substances such as heavy metals, high organic contents and inorganic substances. High levels of BOD and COD mean a reduced amount of dissolved oxygen in water, which directly affects aquatic life and the aquatic system. Industrial plants in Hanoi which use obsolete technology and equipment and without wastewater treatment further aggravate the situation. The amount of waste produced in these plants is much higher than that of the standard production line. Most firms that need to install wastewater treatment facilities are short of funds and do not have access to relevant technology. This makes industrial waste pollution difficult to solve.

Wastewater from hospitals

Wastewater from hospitals is extremely hazardous and hence must be properly managed. A study by National Institute of Occupational Health and Environment (NIOEH, 2003) shows that wastewater from hospitals is voluminous and contains many contaminated organic substances, chemicals and infectious bacteria. Most hospitals do not have wastewater treatment facilities. In some hospitals, wastewater treatment equipment has been installed but is not used because of the high cost of operation and the lack of a proper drainage system. Discharge of these pollutants without treatment into the city's drainage system or lakes and ponds near the hospital has an adverse impact on the environment and people's health. Table 2 shows the amount of wastewater from fourteen hospitals in Hanoi.

Table 2 Wastewater from Hospitals in Hanoi

No.	Hospital	Area (ha)	No. of beds	Wastewater	
				Flow rate (m^3/day)	Treatment system
1	Bach Mai Policlinic	14.00	1,000	450	No
2	Saint Paul Policlinic	1.92	500	300	No
3	Dong Da Policlinic	2.00	300	160	No
4	Traditional Medical		250	100	No
5	K-Hospital		150	30	No
6	Huu Nghi Hospital	2.00	350	700	Yes
7	Children's Hospital		450	600	Yes
8	Maternity Hospital	2.20	200	120	No
9	Optical Center Hospital	0.25	220	148	No
10	108 Hospital	10.00	600	350	Yes
11	Tuberculosis Hospital	3.30	375	200	Yes
12	Viet Duc Hospital	3.00	600	300	Yes
13	Hai Ba Trung Hospital		375		Yes
14	Railway Hospital		300	170	No

Source: NIOEH, *Hospital Waste Management in Hanoi*, 2003

Wastewater from agricultural runoff

Runoff from paddy and cereal fields and vegetable and fruit gardens carries with it a great amount of agro-chemicals such as fertilizers and pesticides, which are intensively applied to increase yields. Chemical fertilizers are rich in ammonium, nitrate, and phosphate, and cause eutrophication of lakes, ponds, and rivers. Pesticides are dangerous to the ecosystem because of toxic organic compounds they contain. Farmers in the suburban area of Hanoi apply night soil and mature to vegetables and other crops, which contaminate water and food with protozoa, germs, bacteria, and escherichia coli.

Overall, Hanoi's rapid economic growth poses a serious threat to environmental quality. Even at this early stage of development, environmental pollution is increasingly severe. Low levels of technology, weak legal enforcement by authorized organizations, and shallow awareness of environmental quality are the main factors that contribute to the intensifying environmental problems in Hanoi.

3. Public awareness of Environmental problems

Environment protection is the responsibility of not only relevant official agencies but the whole society. As environmental problems have complex and interrelated spatial and temporal dimensions, their situations and solutions should receive more attention and participation of all stakeholders.

However, the fact is that the majority of stakeholders see little benefit from environment protection at present. Even among community leaders and enterprise managers, knowledge about environmental protection and allocation of responsibility are likely to be ambiguous and insufficient. Let us take a look at Hanoi's current situation.

The government

Environmental issues were first added to the political, economic and social agenda of the Vietnamese government in the early 1990s when increasing concern was expressed over environmental deterioration under rapid

economic growth. Even though the first major environmental consideration was expressed in the 1960s, the legal right to clean environment was not added to the Constitution of Vietnam until 1992. Enactment and amendment of several environment laws and the establishment of the Environmental Administration followed. In 1993, the Environmental Administration, which had been a vice-ministerial office, was upgraded to the Ministry of Science, Technology and the Environment (MOSTE) under a cabinet ranking minister. In 1992, the original Law on Environmental Protection was established with specific legislation on individual environment-related issues, such as air quality standards, water environment preservation, noise and vibration control, hazardous chemicals controls, environmental pollution damage disputes, solid waste management, and marine environment. Despite these changes, attention from the leaders has not been adequate.

Furthermore, the system lacks proper managing mechanisms and organization. According to preliminary data, there are more than 300 social and economic organizations nationwide whose activities are directly or indirectly related to environment protection. This is a centralized system headed previously by the Ministry of Science, Technology and Environment (MOSTE) and now by the Ministry of Natural Resources and Environment (MONRE), under which departments and research institutes of the Ministry and general departments at local governments are organized. Each of the country's sixty-four provinces has a department, companies or agencies responsible for environmental protection. These organizations are the main forces in implementing environment protection at the local level. However, their environment managing systems are still backward, and their organizational structure is not up to assigned responsibilities.

The number of officials in the Environmental Protection Agency is only 70, and there are only two to four environment officials for every million people. In comparison, China has 20 environment officials per million people, Thailand has 30, and Cambodia has about 100. In Hanoi, there are only 15 officials in the Environmental Department. According to Decree 67/CP on industrial effluent charge, which became effective on May 1, 2004 in Hanoi, more than 20,000 enterprises in Hanoi had to pay industrial wastewater charges. However, the actually collected sum in the year 2004 in Hanoi was zero, and expected collection for the first six months of the year 2005 was

estimated at only 600 million VND. Meanwhile, collected charges in other cities and provinces such as HCMC, Binh Duong, Soc Trang and Quang Ninh were much higher. This example reveals the overloading of the environment managing agency in Hanoi. Moreover, collection of charges or fees should be handled by separate bodies instead of being the function of managers and professionals at the environment managing agency.

Table 3 Collection of Industrial Effluent Charge

	City/province	Effective date	Collected sum in 2004 (mil. VND)	Estimated collection in the first 6 months of 2005 (mil. VND)
1	Hanoi	1/5/2004	0	600
2	Binh Duong	1/1/2004	800	1,250
3	Dong Nai	1/1/2004	1,730	2,000
4	HCMC	1/1/2004	290	2,427
5	Quang Ninh	1/1/2004	983	2,250
6	Thai Nguyen	2/3/2004	395	638
7	Thua Thien Hue	1/1/2005	0	0
8	Hai Duong	1/1/2005	0	50

Source: Department of Environment, MONRE

Another problem of environmental management in Hanoi is unrealistic targets. Recently, the Hanoi People's Committee approved the "Action Program on Environmental Protection of the Hanoi Capital." It is stated that, by the year 2010, 20-25 percent of total wastewater in Hanoi should be properly treated, and wastewater treatment plants should be installed in 80 percent of industrial parks in Hanoi, and so on. However, there is a significant gap between Hanoi's targets and actual progress. According to the Hanoi Department of Natural Resources and Environment (DONRE), approximately 500,000 m^3 of wastewater is released into Hanoi's drainage system everyday, of which 100,000 m^3 is industrial wastewater. The figure is expected to reach 700,000 m^3 per day by the year 2020. Almost all industrial plants at present directly discharge untreated water into water bodies and the drainage system. About 40 large factories have plans to install pollution

control devices or wastewater treatment facilities, but only a few have actually done so, and even fewer have systems that treat wastewater up to stipulated standards. A survey of Hanoi DONRE in 2004 showed that 90 percent of industries in Hanoi operated without wastewater treatment systems. Worse, there are only three central wastewater treatment plants in Hanoi with limited capacity, and most of them are still in the investment process. Any target that disregards these facts can hardly be achieved.

It can be said that environment concern in Hanoi still remains political orientation at the macro level and has not received adequate attention of policy makers to make it concrete and effective.

Enterprises

Sustainable development is not only the responsibility of the government. Commercial enterprises, which play the main role in socio-economic development, should be responsible for a large part of the environment problem. Enterprises should simultaneously pursue the goal of running successful business and make profits while meeting the society's demand for clean environment. For most enterprises and their managers, however, profit motive is often the primary concern to be achieved by any means.

Business strategy of an enterprise is affected by many factors including production technology, availability of human resources, information, and environment. Globally, business strategy is increasingly influenced by environmental concern which is expressed through the voices of company shareholders and the belief that becoming a "green" company is a pre-condition for cost reduction and market share increase. Many enterprises now regard environment management as a strategic tool for enhancing competitive advantage.

In Vietnam in general and in Hanoi in particular, environmental issues attract serious attention of foreign companies only. For instance, Japanese enterprises tend to follow strict environment standards, especially the wastewater effluent standard. Some companies set up their own standards

which are even stricter than Vietnamese regulations. In industrial parks invested by Japanese, such as Thang Long Industrial Park, a very strict environment management system is implemented with Japanese expertise. Such self-imposed higher standards improve the environment quality of Hanoi.

On the other hand, state-owned companies are the ones that pollute most. In Hanoi, virtually no state-owned factories have wastewater treatment plants. Most of the old industrial parks have no sewage treatment station. Usually, industrial wastewater is only partly treated and then released directly into the receiving water bodies, which significantly damages environment. Even among the "best" performing companies in Hanoi, 100 percent compliance with environmental standards remains elusive[33].

The majority of enterprises think that environmental protection is the responsibility of the government. Take the program of "Cleaner Production," for example. This program was popularized and has been applied in Vietnam since 1998 in a number of industrial sectors. It encouraged to improve production efficiency, reduce consumption of resources, lower waste disposal and wastewater treatment costs, and improve occupational health and safety. For producers, "Cleaner Production" meant conserving energy and inputs, avoiding the use of toxic substances, and reducing the volume and toxicity of all emissions and wastes. For products, it required reduction of negative impacts throughout their life cycle, from raw material extraction to ultimate disposal. For services, incorporating environmental concerns in designing and delivering services was required. If this campaign was executed broadly, Vietnam would have enjoyed both economic returns and environmental benefits. Even with outdated technology and limited financial resources, environment could have been improved.

[33] Nine enterprises are mainly responsible, in terms of volume, for wastewater directly or indirectly discharged into the Nhue River and the Day River. When they were investigated by the inspectors of MONRE in July 2006, all enterprises were found to be violating environmental regulations except Hanoi Textile Joint Stock Company.

However, after seven years of application, there are only 130 enterprises in 28 cities and provinces that participate in this program funded by the government and foreign partners. This number is too small relative to the total number of enterprises in the country. Currently, only less than 1 percent of enterprises in HCMC have applied "Cleaner Production" to minimize environmental pollution. The situation in Hanoi is said to be much more limited than HCMC. Meanwhile, 90 percent of citizens continue to complain about environment quality in Hanoi, especially about pollution caused by industrial activities.

Table 4 Potential Benefits of "Cleaner Production" in Vietnam's Industry

Parameters	Possible reduction (%)
Industrial water used	40 – 70
Electricity and energy	20 – 50
Materials generating toxic and dangerous wastes	50 – 100
COD concentration	30 – 75
BOD concentration	50 – 75
Total Suspended Solid (TSS)	40 – 60
Heavy metals	20 – 50
"Green house" effects	20 – 50

Source: Vietnam Center of "Cleaner Production"

Inadequate environmental concern among businesses in Hanoi is also demonstrated by a program of disclosing environmental information of individual enterprises. Public disclosure of such information is supposed to exert social pressure for environment protection pressure on enterprises. Since 2002, a pilot program to rank enterprises in Hanoi has been implemented two phases. The first phase was conducted in February 2002, and the second phase was conducted six months later. Fifty enterprises in food processing, dyeing and textiles industries were selected. Criteria for evaluating them were as shown in Table 5.

Enterprises were classified into five groups: "very good", "good", "meet requirement", "does not meet requirement", and "bad". In the first phase of the survey, there was no enterprise which was rated "very good" or "good". "Meet requirement" enterprises accounted for only 10 percent, and the remaining 90 percent were classified as "does not meet requirement" or "bad". In the second phase, the situation improved but not significantly. The number of enterprises in the lowest two categories still accounted for 76 percent of the total.

Table 5 Criteria for Evaluating Selected Businesses in Hanoi

Criteria	Content
1	Follow Vietnam Standard 5945-1995 for BOD, COD, TSS, color and pH level
2	Number of complaints from the community
3	Number of environmental accidents
4	Have a wastewater treatment system
5	Self-assessment on environment and information system
6	Amount of water used
7	Enterprise's commitment on environmental protection
8	Apply "Cleaner Production" program
9	ISO 14000 certificate

Source: Hanoi DOSTE

From these results, we can conclude that most enterprises in Hanoi are not seriously concerned with environmental problems. Environment protection is considered to be a burden to be avoided as much as possible rather than an opportunity to expand business or enhance reputation.

Table 6 Classification of Enterprises in Hanoi by Environmental Criteria

	Total	Very good	Good	Meet requirement	Does not meet requirement	Bad
First phase						
Number	50	0	0	5	29	16
%	100	0	0	10	58	32
Second phase						
Number	50	1	1	10	24	14
%	100	2	2	20	48	28

Source: Hanoi DOSTE, "The report on the classification result of 50 enterprises in food processing, dyeing and textile industry in Hanoi," 2002

The grass roots

It is often stated that people must be at the center of development as well as environmental protection. Many international and government projects in Hanoi aim to raise the awareness on environmental protection among local communities. Since the Law on Environmental Protection came into effect in 1994, some progress has been made, although public awareness on environment in some aspects, especially at the grass-root level, remains weak. In Hanoi, the habits of communities regarding environmental protection have improved. People have stopped throwing garbage on streets, or started to collect garbage to make green manure, and some have become willing to apply clean production processes. In many places in Hanoi, especially in rural areas, environment protection is imposed by village regulation. Local people also played an important role in planning and supervising the application of village regulation. Despite these achievements, however, we still cannot say that environmental protection has been ingrained in everyone's mind and daily behavior.

A small survey was carried out by the author in the summer of 2005. The questionnaire had two parts. The first part asked respondents to indicate the

level of agreement with a number of statements about environment. The second part requested them to describe the environmental situation in the locality in which they lived. The survey was conducted in five districts of Hanoi: three in inner Hanoi (Hoan Kiem, Hai Ba Trung, Thanh Xuan) and two in outer districts (Gia Lam, Thanh Tri). In each district fifteen households were randomly selected, with a total of 75 households.

Virtually all respondents (98 percent) agreed that environmental problems were becoming more threatening today and ought to be solved. A majority of people (67 percent) thought that environment would further worsen unless measures to attain sustainable development were properly implemented. Types of concern depended on location. The survey showed that the urgent problem in suburban areas was water contamination due to the misuse of agricultural chemicals and fertilizers, while in inner city the crucial problem was water and air pollution. Generally, water pollution was considered to be the most important issue among environmental problems in Hanoi.

The survey also identified two distinct groups of people: those interested and those with no interest in environmental quality. Those with interest in environmental quality expressed their willingness to participate in environmental activities. If people are really interested, they can be mobilized to actively solve environmental problems. However, 45 percent of the respondents felt that, although environment was important, the problem that must be solved first was economic development. 35 percent of inner city people agreed with this statement, while as many as 60 percent of suburban people endorsed this view. Our survey confirms that, in a developing country like Vietnam, a fairly large proportion of people, especially those in rural areas, think that economic development should be placed before environmental protection. This is also consistent with the argument that people's awareness on environmental problems is generally low when the living standard remains low (Nguyen Van Thuong, 2005).

However, difference in economic development among localities cannot be the only reason for the gap in people's awareness on environmental conservation. The survey also reveals that, although average income in

Hoan Kiem District is higher than in other districts in Hanoi, people's awareness on environmental protection is relatively low. In addition to the level of economic development, there seem to be other factors that affect people's environmental awareness, including difference in the educational level and the degree of seriousness of environmental damage in each area.

In the survey, the roles of the community, women's union, youth union and other public organizations in protecting environment were highly affirmed and appreciated in both inner and suburb areas of Hanoi. For example, the case of Van Dien Commune was frequently cited by 90% of interviewees: under the pressure from the community, the local authority and functional agencies forced the polluters to obey the law.

From the survey's results, we can conclude that most people are aware of environmental quality but they have no deep interest or knowledge about the matter. People in different localities and with different levels of education have different degrees of awareness on the problems. Furthermore, 80 percent of the surveyed thought that environmental protection was a task of the government, and that environmental problems could be solved only by advanced technology. The crucial link among government, enterprises and grass roots in protecting environment is not well understood or practiced.

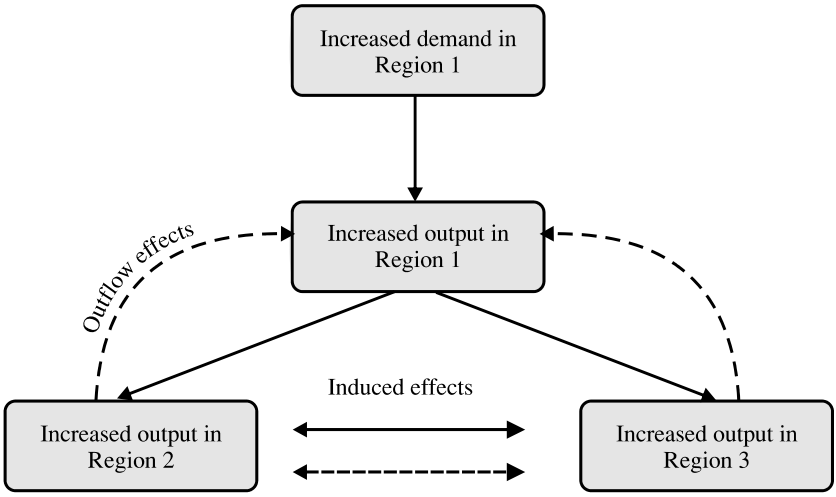
To close this section, we would like to quote the words of Mr. Jordan Ryan, former UNDP representative in Vietnam:

> *"...ultimately action on sustainable development must be national and local. This calls for effective public administration, inclusive governance that involves communities and a real commitment to equity. Sustainable development will not be made reality just through national policies or institutions but field by field, forest by forest, factory by factory. This requires the strong commitment and participation of people, authorities and all other stakeholders at local levels, including the private sector."*
> (a statement at the meeting on Official Ideological Propaganda and Sustainable Development, June 2004)

4. The framework for Measuring environmental impact of Regional economic growth

This section turns to the presentation of a three-region inter-regional input-output (I-O) model in order to quantify the impact of regional economic growth on environment. The inter-regional I-O framework, first developed by Miyazawa (1976), and elaborated by Miller and Blair (1985) and Sonis and Herwings (1993), provides the basic framework for building the model. The inter-regional I-O model presented below is an extension of the I-O model of AREES in 2005. When this model is used for impact analysis, specification of flows among regions permits the estimation of impacts that are not explicit in models dealing with the entire country or one region of a country only. Interaction among regions is described in Figure 1.

Figure 1 Inter-regional Effects in a Three-region Model



The sequence in this figure should be interpreted as follows. Suppose a new economic activity emerges in Region 1 which increases an industry's final demand in that region. A demand increase in Region 1 will raise output in that region. This increased output in Region 1 will necessitate new flows of

goods and services from Regions 2 and 3 into Region 1 through input-output linkage. In order to meet Region 1's new demand of goods and services, industries in Regions 2 and 3 have to expand their production. This is called the *induced effects*. This may, in turn, create new demand for goods and services produced in Region 1. As a result, output in Region 1 may increase additionally. This boomerang impact is known as the *outflow effects* .

Mathematically, the basic relationship can be written, as in any national I-O model, as follows.

$$X = (I - A)^{-1} Y \qquad (1)$$

where

X is the vector of total gross outputs of industries,

$(I-A)^{-1}$ is the Leontief Inverse matrix calculated from the I-O table, containing coefficients representing the use of each input in the production of each output; and

Y is the vector of total final demands

For the purpose of inter-regional I-O analysis, we assume that the Vietnamese economy is divided into three regions: (1) Hanoi, (2) HCMC, and (3) ROV. Then, direct input matrix A can be written as:

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \qquad (2)$$

In Equation (2), each element is itself a matrix given by A_{ij} where subscript i refers to the producing region and subscript j to the consuming region. Thus A_{11}, A_{22} and A_{33} are the internal A matrices for Hanoi, HCMC and ROV

respectively, while all other off-diagonal matrices are inter-regional trade matrices. For example, A_{21} shows technical coefficients for Hanoi's consumption of HCMC's products.

By applying the same process to the other matrices, equation (1) can be restated in multi-regional format as:

$$\begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} = \begin{bmatrix} I-A_{11} & -A_{12} & -A_{13} \\ -A_{21} & I-A_{22} & -A_{23} \\ -A_{31} & -A_{32} & I-A_{33} \end{bmatrix}^{-I} \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix} \quad (3)$$

In this case, X_{11} shows output generated in Region 1 (Hanoi) by final demand in Region 1, X_{12} shows output generated in Region 1 by final demand in Region 2, and so on. Similarly, where there are *n* sectors in each region, the *3n×3n* Leontief inverse matrix breaks down the output multiplier for each sector *i* in each region into local output and imports required per unit of final demand for that sector.

The sub-matrixes $(1 - A_{11})$, $(1 - A_{22})$ and $(1 - A_{33})$ measure the impact on each of the regions of changes in exogenous demand in the same region. The column totals from these sub-matrices therefore give the *intra-regional* impact of final demand, while the other sub-matrices show the impact of trade between regions, namely the *outflows effects*.

As a rule, the general inter-regional I-O model can be extended to identify the environmental impact of economic activities from different sectors of the economy. The sectoral emission coefficients only relate to emission resulting directly from the production process. However, the production process also places an input demand on other sectors, thereby raising their production and emissions. It should be noted that inter-regional effects in this model are confined to those arising from input-output linkage in production only. The model does not incorporate other possible spillovers such as cross-border flow of wastewater from an upstream region to a downstream region or water pollution by households stimulated by higher regional income.

Raw data on environmental emission that are being collected and compiled have to be converted to a format that can be used in the inter-regional I-O model. This is done in the following three stages. In stage 1, the total amounts of pollution for the whole country as well as different regions are estimated. In stage 2, the total amount of pollution is allocated to individual sectors. This allocation should be based on the relationship between the type of pollutant and each industrial sector. Finally, in stage 3, an environmental coefficient is computed by dividing the value of the environmental indicator for each industrial sector by the output of that sector in the studied region.

Direct emission coefficients matrix V^* can be represented by the following block matrix:

$$V^* = \begin{bmatrix} V_1^* & 0 & 0 \\ 0 & V_2^* & 0 \\ 0 & 0 & V_3^* \end{bmatrix} \qquad (4)$$

where V_1^*, V_2^* and V_3^* are net direct emission coefficient matrixes of the first, second and third region, respectively.

The residual matrix induced by the components of final demand can be calculated by the matrix equation:

$$V = V^*X = V^*.\ B.Y \qquad (5)$$

where

V is the matrix of total residual categories induced by the components of final demand and inter-regional trade,

V^* is the matrix of direct residual coefficients

X is the matrix of sectoral outputs; and

$B = (I-A)^{-1}$ is the inter-regional inverse coefficient matrix

V can be decomposed into V^1, V^2 and V^3. In that case, V^1 is the matrix of total impact on residuals of Region 1, V^2 represents the matrix of total impact

on residuals of Region 2, and V^3 is the matrix of total impact on residuals of Region 3.

For each region, the matrix of total inter-regional environmental impact consists of three elements: internal impact, induced impact, and outflow impact.

$$V^n = V_1^n + V_2^n + V_3^n \qquad (6)$$

where $V_1^n = V_1^* + V_{1'}^n$ stands for internal impact, and

V_1^* is the matrix of direct residual coefficients of region *n*

$V_{1'}^n$ is the matrix of indirect input coefficients of region *n*

V_2^n is the matrix of induced impact

V_3^n is the matrix of outflow impact

In general, to address the pollution problem, the matrix of direct emission coefficients may be categorized into four groups, namely (i) water pollution, (ii) air pollution, (iii) solid waste, and (iv) others. Evidently, the final number of environmental indicators used in the model depends on data availability.

In sum, the environmental accounting framework developed for the inter-regional I-O system can explicitly analyze the roles played by inter-regional linkages as well as inter-industry linkages in environmental quality of regional economies. It can quantify environmental factors originating from the region as well as those originating in other regions.

5. Findings

This section reports major findings of the I-O analysis of regional economies with particular attention to Hanoi.

Table 7 presents computed intra-regional environmental multipliers in three regions. Environmental impact of an exogenous demand shock in each region is decomposed into internal and induced impact. Their sum, intra-regional impact, is also shown. For example, the multiplier (intra-regional impact) for

Hanoi's manufactured industrial materials is 0.000455. This means that, for every VND1 million of exogenous demand for manufactured industrial materials in Hanoi, 0.000455 ton of BOD load is generated, of which 0.000387 ton is emitted within Hanoi and the remaining 0.000068 ton is discharged in other provinces. Similarly, the multiplier for the same product is 0.000538 per VND1 million of demand in HCMC and 0.010850 per VND1 million of demand for the ROV. In all sectors, intra-regional environmental multipliers for ROV are significantly greater than those for Hanoi and HCMC.

Internal impact is larger than induced impact in almost all sectors and regions. This means that the largest part of environmental pollution occurs in the region where initial demand increase started. Proportion of pollution within and outside region is explicitly illustrated in Figure 2. Internal environmental impact accounts for 54-84 percent of total impact in Hanoi, 63-86 percent in HCMC and 61-86 percent in ROV.

As to induced impacts which capture spillover effects across regions, a closer examination of values in Table 7 is also warranted. Given a demand shock, manufacturers in Hanoi will source part of their increased inputs from producers outside Hanoi. In turn, these producers will obtain some of their increased inputs from Hanoi, which generates further rounds of similar interaction. It is this feedback mechanism that causes inter-regional multipliers to be larger than their intra-regional counterparts. This calculation quantifies the extent to which a change in Hanoi's final demand poses a threat to environmental quality of other provinces. Although induced impact is generally smaller than internal impact in absolute terms, it may be sufficient to cause significant damage in other provinces if the volume of demand in Hanoi or HCMC is large. This may explain why water quality in Hanoi's neighboring provinces such as Ha Tay and Ha Nam is poor; their water may be polluted because factories have increased production to serve the Hanoi market.

For most industries, total environment impact of Hanoi's demand is lower than that of HCMC or ROV. Every VND 1 million increase in Hanoi's regional GDP creates on average 0.000337 ton of BOD in Hanoi and elsewhere. The corresponding figures for HCMC is 0.000372 ton and that for ROV is 0.010528 ton. In the development process, Hanoi causes less pollution per every VND million of output than HCMC and ROV. When we compare output multipliers[35] of Hanoi, HCMC and ROV, in Table 8, it is clear that for most sectors studied here, the output multiplier of Hanoi is higher than those of the other two regions. From this viewpoint, it may be said that the quality of Hanoi's growth is more sustainable in terms of both economic effectiveness and environment friendliness.

As seen in Table 7, the most polluting industry in Hanoi is manufactured industrial materials with the multiplier of 0.000455, followed by education, health and social services with the multiplier of 0.000387. The situation is observed in HCMC is somehow similar. The most polluters are electricity, gas and water sector and Manufactored industrial materials. In ROV, the worst offender is processed food, beverages and tobacco with the multiplier of 0.017245.

[35] The output multiplier is a coefficient that shows the total value of inputs, both direct and indirect, that are used to produce one unit of output by any sector. It is computed as:

$$\Psi_j = \sum_{i=1}^{n} r_{ij}$$

where Ψ_j is the output multiplier of industry j, and r_{ij} is the *ij*-th element of the Leonief inverse matrix. The larger Ψ_j is, the more stimulating effect an industry j has on the overall economy because it purchases a large amount of other industries' products as inputs.

Table 8 Output Multiplier of some selected sectors in Hanoi, HCMC and ROV

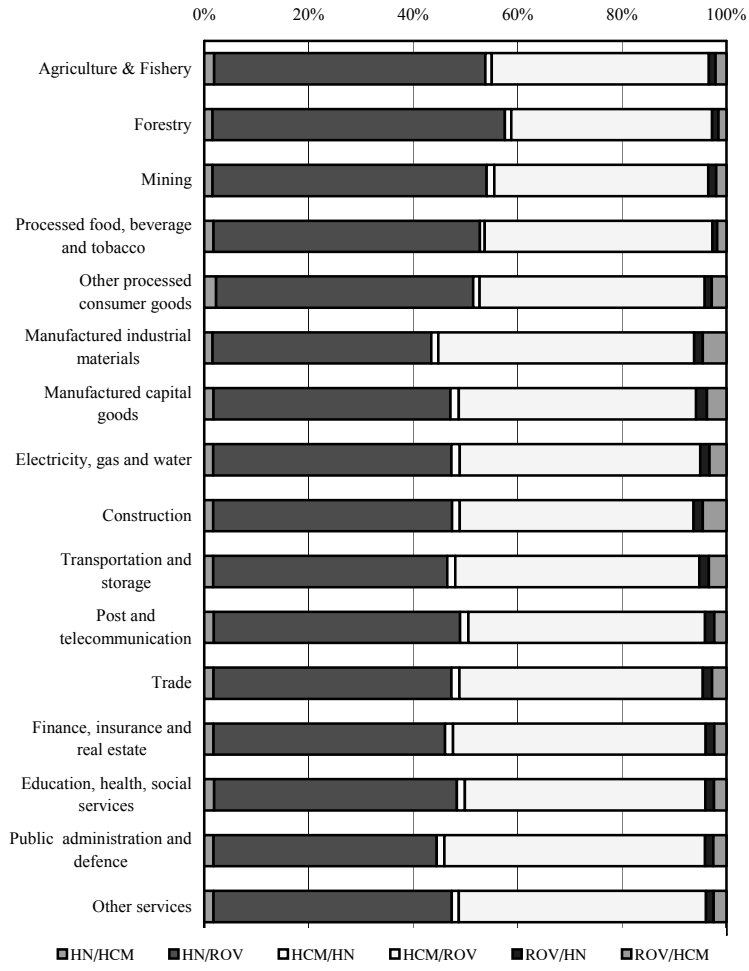
	Sector	Output Multiplier		
		Hanoi	**HCMC**	**ROV**
1	Agriculture and fishery	1.488	1.253	1.325
2	Forestry	1.481	1.204	1.179
3	Mining	1.563	1.208	1.258
4	Processed food, beverage and tobacco	1.569	1.825	2.028
5	Other processed consumer goods	1.562	1.536	1.902
6	Manufactured industrial materials	1.530	1.340	1.492
7	Manufactured capital goods	1.566	1.264	1.655
8	Construction	1.594	1.307	1.495
9	Transportation and storage	1.533	1.267	1.357
10	Trade	1.580	1.249	1.382
11	Education, health and social services	1.496	1.200	1.272
12	Other services	1.495	1.238	1.471

The quantitative pattern of how three regions affect one another is also of interest. Figure 2 shows relative sizes of multiplier impacts across regions after intra-regional impacts are removed. Dominant cross-regional effects run from the two largest cities to ROV, while interaction between Hanoi and HCMC as well as impact from ROV to the two cities is insignificant. This demonstrates the fact that the two largest cities with high concentration of industrial activities exert large spillover effects on other provinces both economically and environmentally. Hanoi needs more input from other provinces than other provinces need input from Hanoi, and similarly for HCMC. Thus production activities in Hanoi and HCMC are by far the most important determinants of environment in Vietnam.

Overall impact on environment depends not only on location of the demand shock but also on the sector in which demand initially increases. While our sector classification of sixteen industries is not detailed, we can already see

that processed food, beverage and tobacco industries carry the highest environmental consequence at both regional and inter-regional level.

Figure 2 Inter-regional Outflow Impacts



Another important point is that environment quality in Hanoi in particular and in Vietnam in general is affected by not only domestic demand but also international trade. In the period 2001-2005, the total trade of Vietnam

experienced high growth with the trade balance remaining in deficit. Although the trade balance has improved remarkably in recent years, the gap still remains at as much as USD4.65 billion. Due to time and data constraint, this paper did not examine the environmental impact of international trade in Hanoi, HCMC and ROV. According to qualitative assessments, it is suspected that international trade exerts a large negative impact on the environment quality of Vietnam.

6. Conclusion

Our analysis yielded several findings which may have policy implications for Hanoi's development.

First, nearly all stakeholders in Hanoi, including policy-makers, businesses and grass-root people, are aware of environmental degradation and the need to solve this problem. However, most of them also think that, in a developing country like Vietnam, economic development must have priority over clean environment. Environmental awareness of different stakeholders varies and depends on many factors. Among enterprises, main determinants include the type of ownership. For local people, environmental awareness depends much on the locality of residence, income, and the education level.

Second, the majority of stakeholders believe that environmental protection is a task of the government and that advanced technology can solve the problem. This partly comes from the lack of deep knowledge about the subject. Crucial link among government, enterprises and grass root is not yet recognized. For any practical sense, environmental concern is not properly considered and has not been prioritized in Hanoi. This is one of the many reasons that have contributed to the intensification of environmental problems in Hanoi.

Third, by using the inter-regional I-O model we presented a framework to measure economic and environmental interaction among regions. We have quantified some of the negative environmental impacts of Hanoi's development on other regions, and vice versa. These analyses, while only preliminary, have laid the foundation for a better understanding of the environmental-economic relationship among regions, which are likely to be useful in the policy-making process. Knowledge on complex interrelationship between economic activities and environment in different localities should help to forecast and evaluate the future state of environment conditional on economic and environmental policies.

Finally, our results suggest that the development strategy of Hanoi, or any other region, must be consistent with those of other provinces and the whole nation. The development of Vietnam, in turn, must be an integral part of East Asia's economic dynamism, of which environment is an important factor. Any strategy which disregards this fact can hardly successful.

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