FORWARD

Accompanied with the transformation at root from planned economy into socialist market economy, the duty of municipal administration changes continuously. The Municipal Government is increasingly responsible for more and more service, protection and management tasks of urban environment. Often the environmental management was separated from the development planning with the lack of systematic cooperation and procedures between different departments. Although the industrial enterprises are granted greater independence in business step by step and do their business increasingly according to the regulation through the market, but the price of natural resources and energy source aren’t reasonable, which leads to the growing consumption. Besides this, the urban environmental infrastructure owes more debt, which leads to the unreasonable waste and the increase of pollutant discharge. Facing these difficulties, the urgent matter is to enhance the urban environment management through amplifying the necessary rules and regulations and improve the financing and management capability.

Based on the consensus on promoting the sustainable development and the situation needs, the Shenyang Municipal Government signed the project named “Management Sustainable Development in Shenyang” together with UNDP (Development Program, United Nations) and China’s International Center for Economic and Technical Exchange (CICETE) in May 1997. This project will promote the sustainable natural, economic and social development of the Shenyang urban region through following actions. (a) Strengthening local capacities for drawing up strategic planning and enhancing environmental management based on the active participation of the Municipality and its partners in the public, private and community sectors. (b) helping to formulate the cross-sector environmental management strategies for sustainable development including the extensively accepted action plans. (c) On the base above, organizing priority project proposals for practicable capital and technical assistance investments and submitting to the investment organization. The project is one of the sustainable development projects of global large cities aiming at sustainable development of the city. It will provide technical and organizational supports to environment planning and management make an
exploration and provide experiences and lessons for other cities from home and abroad.

The Environment Profile of the Shenyang Municipal Area is an initiating information for the Sustainable Shenyang Project. It provides not only the basic data/reference for the people who are engaged in the management, planning or other jobs in relation to environment but the further discussions on the complicated cross-sector environment problems with main departments and persons in charge assigned. A basic conception on environmental management and planning is thus proposed for propagation and promotion participated by all the people. The Environment Profile of the Shenyang Municipal Area is an important preliminary groundwork for implementing the project, also the basis of the city consultation conference that will be held in the next stage of the project. We have set up a technical supporting group for Shenyang’s Sustainable Development Projects during the preparation of the Profile, and sought widely the opinions from different organizations and people concerned.

In January 1996, Shenyang Municipal Government together with UNEP-IETC Sustainable City Development Program drew up the Environment Profile (the first draft) in combination with Sustainable Shenyang Project. Because of the limit time, data collection, experience and information acquisition, and the demand of the project document, the Shenyang Municipal Government began to update the profile with the EPM procedures in July 1997. The whole updating process got the help from Mr. Chris Radford (UNCHS-SCP) and Mr. Douglas McIllum (a specialist for international projects). Mr. Lu Lei (Beijing Representative Office, UNDP), Ms. Wang Weili (China’s International Tech-Economic Exchange Center) and Mr. Shi Han (China’s Agenda 21 Management Center) also provided active supports to the completion of the Profile. The following authorities contributed data and materials and a lot of worthful opinions to the update of the Profile. The Policy Research Group under the Shenyang Municipal Committee of the Communist Party of China, the General Office of Shenyang Municipal Government, Shenyang’s Environment Protection Bureau, Construction Commission, Planning Commission, Science and Technology Commission, Economy and Trade Commission, Municipal Construction Bureau, Statistics Bureau, Health Bureau, Water Conservation Bureau and Forestry Bureau, etc.

The Profile was completed in the initial stage of the project implementation. So, time, data collection, experience and information
acquisition was all limited. As a working document, this environment report must be reviewed, updated and expanded periodically. We had no intention of complicating the initial environment report, and some of more difficult issues are to be resolved later. The details of various data should be balanced properly in the subsequent editions of the Profile. It would be ideal to obtain enough data to elucidate further the tendency of time and space distributions of resources and contaminants. Accompanied with the further implementation of Shenyang’s sustainable development projects, we will update this Profile periodically.

The Profile, as the facility and a guide serving the people, shall not only be the way and means absorbing public participation and understanding public wishes, but also a basic principle to guide our works.
CONTENTS

Executive Summary---English
Executive Summary---Chinese

Chapter 1: Introduction to Shenyang
  1.1 General Situation
  1.2 Population Characteristics
  1.3 Economic Structure & Activities
  1.4 Key Physical Features

Chapter 2: Activity Sectors
  2.1 Manufacturing
  2.2 Housing
  2.3 Energy
  2.4 Transport
  2.5 Recreation, Open Spaces and Natural Areas
  2.6 Water Utilities
  2.7 Solid Wastes Management

Chapter 3: Environment Setting
  Environmental Resources
    3.1 Groundwater
    3.2 Surface Water
    3.3 Air
    3.4 Land
    3.5 Scenery and Ecology
  Environmental Threat
    3.7 Air Pollution
    3.8 Water Pollution
    3.9 Flood

Chapter 4: Management Setting
  4.1 Key Stakeholder
  4.2 Urban Management Structure & Functions
  4.3 Strengthening the Management Setting
Executive Summary

In the past 18 years, Shenyang’s economy developed significantly with its GDP grew up rapidly at a mean annual speed up to 10%. People’s living standard had been improved greatly. However, Shenyang’s economy thus grew up at a great expense that a huge investments was inputted together with high consumption of resources and increasing degradation of ecological environment. A series of environmental problems (e.g., the weak infrastructure in comparison to the rapid economic growth; shortage of water resource with insufficient water supply; low environmental quality; water pollution, serious atmospheric pollution; and no efficient disposal for garbage and other solid wastes, etc.), were caused by the rapid economic growth. These have restricted the social and economic developments to some extent.

With city introduction of Shenyang, the Profile states the main activity sectors influencing Shenyang’s sustainable development (including the manufacturing, housing, energy, transport, recreation, open spaces and natural areas, water utilities and solid waste management), environmental resources (including groundwater, surface water, air, land, scenery and ecology) and environmental threats (including flood, industrial risk and toxic pollution/wastes). Furthermore, it discusses the dialectic relations among the activity sectors, environment resources and threat and the existing operating mechanism of management, thus making the constructive suggestions to strengthen the management mechanism.

It is revealed through discussion that there are three most acute contradictions between development and environment at present in Shenyang:

- Firstly, Shortage of water resource, the serious pollution of surface water and groundwater. The environmental indices of the Shenyang section of either Hunhe River or Liaohe River have exceeded the 5th-class water body requirements according to the National Surface Water Quality Standard (the worst class of the NSWQS). Hunhe River’s water body requirement should have achieved 3rd-class National Surface Water Quality Standard as present situation. It has lost its natural function of river because the Dahuofang Reservoir controls its surface runoff. There isn’t diluting water in run dry period. It has
become a sink of wastes in Shenyang and Fushun Cities. 60% of the drinkable water resources on both banks of Hunhe River have been affected to different extents by the replenishment of surface water along the river. In Shenyang, the serious water pollution is in pairs with shortage of water resource. The water resource is distributed unevenly not only in place but also in time. The water resource per capita in Shenyang is only one-thirtieth of that in the world and one-eleventh in China. A multi-centre groundwater lowering funnel has been formed now, 250 sq. km in area and 25~37m deep, due to overexcavation and negligence of natural conditions. On the other hand, the development of water resource and level of utilization are relatively low. In Shenyang, the repetition rate of industrial water utilization is only 75%. The unit water consumption of industrial products is too high. Also, the living water is wasted seriously. At present, no wastewater disposal plant is running and no such water-saving equipment as quality-division supply and intermediate water recovery plant provided in Shenyang. The loss due to water-supply pipeline failure has been over 10% of total supply. All the above caused the unreasonable utilization and waste of water. The rapidly increasing water consumption of urban water has to bring high pressure to bear on the construction of water supply/drainage pipeline network. At the same time, water quality is polluted seriously.

The structure of energy consumption with coal as the predominant source, which causes serious air pollution. According environmental functional zone requirements, the air environment quality should have achieved 2nd-class National Quality Standard in the city proper of Shenyang. But the coal-smoke type air pollution is formed directly by the energy consumption structure of which the coal is predominant, i.e. 71% of the all. In addition, the coal used lacks pre-treatment and most of it is consumed via direct burning, thus forming very high ash amount and sulfur content. In Shenyang, the burning plants are mainly of small/medium size with out-of-date combustion mode and without desulphurizing unit. The low-level emitting of coal flue gas causes a large amount of smoke, dust and sulfides produced in burning process to emit into air, thus forming serious air pollution. The pollutants are mainly the smoke dust, carbon oxides, sulfur oxides, nitrogen oxides and benz(A)-pyrene. They have caused serious air pollution. It is more serious that the energy consumption structure with coal used dominantly cannot be changed in a considerably long time to come.
Accompanied with the processes of urbanization and industrialization and the growing increase in living energy consumption, the threat caused by air pollution will be more severe if there are no breakthroughs made for burning technique and of fuel transform.

Noise and solid waste pollution is still protruding. According monitoring in functional zone, there are six functional zone environmental noise average value have exceeded the National Standard except industrial zone. At the same time, urban district has been still surrounded by city domestic rubbish which had been unlimited piled. It has not only influenced the city image but also further polluted the water and the air.

The main reasons of above-mentioned questions include three respects. First, the structural pollution hasn’t been resolved, the structure of energy consumption with coal as the predominant source, which causes serious coal-smoke type air pollution. The layout of the city is unreasonable, the serious pollution enterprises concentrate on the central city region, and the residential area mixes with the industrial area. The structure of industry and product is unreasonable, the economic development still doesn’t shake off the extensive management which pays attention to the increase of the amount, and the most technical competence is in the fifties or the sixties conditions. The waste of natural resources and energy sources is more serious, which leads to the increase of pollutant discharge amount. Second, there are more environmental outstanding amounts, the city’s infrastructure is relatively slow to the development of economy, which doesn’t adapt the need to protect the environment. The third, weak links still exists between environment and resource, which can not entirely adapt the extensive requirement of environment and resource protection.

The severe environmental situation has sounded an alarm for Shenyang: the traditional development mode cannot be sustained for long. It needs that we have to consider comprehensively the economical development in combination with the resource, environment, population and other factors and, based on that, adjust the direction of economic development and industry mix in accordance to sustainable requirements. The technical level must be raised up in various fields so as to develop the low-input, low-pollution or non-pollution products with high output, benefit and added value. Clean industrial production should be effected with emissions controlled. Ecological agriculture and non-hazard foods must be developed to the full extent. Fine environment should be provided in both urban and
countryside construction and the tour service shall be combined with ecological environment protection. We shall advocate resource-saving living and consuming manners without pollution or at least less pollution so as to implement a good circulation. Otherwise, the exhausted resource and destroyed environment will be accompanied with the growing economy. These shall not only cancel out the economic accomplishment we have already obtained but do damage seriously to Shenyang’s long-term development.

To realize the sustainable objectives as above, we shall make sustained efforts in many fields. But the crucial ones are to strengthen the set-up of capacity and to perfect the decision-making mechanism of laws, economy and society for sustainable development. The aim is that each of the sectors concerned shall perform its own duty with the participation of whole society that is required to make contribution the sustainable development. Such comprehensive departments as the commissions of planning, economy and trade, construction, science and technology and education are required to prepare successively the tech-economic policies beneficial to sustainable development and to organize or support its implementation. The municipal construction departments are required to strengthen the infra-structural constructions, i.e. the wastewater disposal plants, centralized heating, fuel gas and green belts. The resource management concerned of forestry, agriculture and water conservation are required to strengthen the ecological environment construction, establish a forestry ecological system with various economic benefits available, make efforts to develop ecological agriculture, do well the protection and recovery of vegetation and prevent water and soil from loss. Industrial bureaus are required to strengthen the management of enterprises, organize and spread over clean production, make efforts to reduce pollutants’ emission and set up a self-restricted mechanism for enterprise environment protection. The excavation of high-sulfur and high-ash coals should be limited with coal washing/dressing improved and clean coal supplied more and more. The power-heating combination production shall be developed further with coal consumption rate lowered greatly in power plants.

The implementation of sustainable development will be a long-term hard work in Shenyang, and its essential is to strengthen the set-up of capacity. It is not our purpose to solve all Shenyang’s environmental problems by depending on sustainable projects only, such as urban weak infra-structure, low average quality of urban environment, serious pollution,
too large consumption of resource and energy especially the industry mix of which the heavy industries are traditionally predominant. These are really very pressing and difficult problems.

The sustainable development, as a cause of the whole people, will not succeed without widely public participate. In addition to making efforts and investments, in a real sense, the public participation means that public should participate all of the policy/scheme-making processes. Except for the delegates of People’s Congress and local officials, the public has the right to understand all the contents and processes of local sustainable development and the rights to protect their own interests and to improve living environment. In view of operable level, the first is to ensure that public is able to acquire various data exactly on time. Next, we must provide equal opportunities to every one for decision-making and, finally, we shall set up a mechanism to adopt public opinions and protect public interests, thus ensuring the public supervision institutionally.

We must be clearly aware what we are face--the problems environment, resource and society. Taking a long view of sustainable development, the burden will be heavy and the road is long. We hope these projects will be proposed in conformity with Shenyang’s actual conditions and available to implement through developing Sustainable Shenyang Project, and that a series of suggestions of investments and technical supporting projects will be in wide connection with international supports.
Chapter 1. Introduction to Shenyang

1.1 General Situation
Shenyang is located in the south of Northeast China PRC and the mid-north in Liaoning Province. The spacing is 115 km from east to west and 205 km from south to north, with a total area 12,980 sq. km in which the urban area is 189 sq. km. Now the city includes 9 urban districts, i.e. Dadong, Shenhe, Heping, Tiexi, Huanggu, Dongling, Yuhong, Xinchengzi and Sujiatun; and 4 counties are under the jurisdiction of Shenyang City (See Fig. 1), i.e. Xinmin, Liaozhong, Kangping and Faku.

Shenyang ranks fourth on the list of China’s metropolises, next to Shanghai, Beijing and Tianjing. It is the provincial capital of Liaoning, also political, economical, cultural, communication, science/technology and financial center of Liaoning Province. As the largest city in Northeast China, Shenyang is also the communication hub and goods distributing center of the area.

1.2 Population Characteristics
At the end of 1996, Shenyang had a population of 6.71 million. The birth and death rates are 7.84‰ and 6.47‰, respectively. The natural and mechanical population growth rates are 1.38‰ and 0.5‰, respectively, and the migrate-in and migrate-out rates are 1.52‰ and 1.02‰, respectively. It is predicted that Shenyang’s population and floating population will increase further up to 7.50 million and 1.50 million, respectively in 2010. The population will be up to 10.0 million in 2050. The urban level will rise up to over 80% in 2010 from 61% in 1992.

In Shenyang area including the urban districts, the population is distributed extremely unevenly. The population density decreases successively in such an order: the urban districts, the towns where the country or sub-city governments locate, towns where the township village governments is seating on and, finally rural habitants. In respect to population distribution of different places, the densest one is urban districts, where occupy more than half of the city’s population and have a density 200 times higher than that of north, west and east villages and towns (see Fig. 2). As shown in the growth tendency, the growth rate will be relatively fast in rural areas and counties/sub-cities, and that of urban inhabitants has already shown a tendency to decrease especially the five central urban districts where the growth rate indicates negative values.
The needs for infrastructure and natural resources are increasing due to the population growth and the improvement of living standard which, at the same time, put heavy burden on the ecosystem.

1.3 Economic Structure and Activities

Dominated by heavy industry, Shenyang’s economic structure was established in the period of the first Five-year Plan (1950-1955) as a key industrial base of China. Due to the economic structure reform and implementation of market economy, Shenyang remains a continuous 2-digit annual economic growth rate, especially after 1992. The proportions of primary, secondary and tertiary industries have changed from 10:46:44 in 1990 into 7.9:42.9:49.2 in 1996. The city’s overall function has been improved, and the structures of urban layout, energy, industry and product adjusted. Several new industrial zones are established in the city, while at the same time, restrict strictly new pollution sources, carry out treatment strategies on old sources, move some of the heavy polluters out of the city, and encourage the use of cleaner energy. As a result, the values of the City’s main pollution indicators remain at the same level as in early 80s’. Despite of this, many state-owned, large/medium-scale enterprises still operate with poor economic benefit. This situation occurs due to many problems within the operating system, industrial structure, management, which are formed gradually in a long process. At present, 96% of the city’s growth value comes from rural industries. The manufacture industries in Shenyang rank down gradually among those in other rapid-developing cities in China.

As a core city surrounded by several resource-rich cities in the central part of Liaoning, Shenyang has its iron ore supply source that is the largest and most concentrated in China, coal/non-ferrous metals with auxiliary raw materials and building materials source. In addition, the Liaohe Oil Field discovered in the 60s extends through to the nearby districts of Shenyang from Yingkou seashore. The oil field is plentiful in reserve and available to supply partly gas/oil to Shenyang. The mineral resource in the central part of Liaoning is not only plentiful but of best combination and, besides, such industrial cities as Anshan, Benxi, Fushun and Tieling are all the surrounding cities of Shenyang, thus promoting the development of manufacture industries in Shenyang to a great degree.

1.4 Key Physical Features

Shenyang area’s ground feature is mainly of plain with flat terrain and average elevation about 50m. The hills and mountains are concentrated in the northeast and southeast parts, belonging to the extension of Liaodong
Hill-land. In the west part, the alluvial plain due to Liaohe and Hunhe Rivers slopes down slightly from east to southwest.

Shenyang is located in the North Temperate Zone, and its climate is of semi-moist continental monsoon type. Seasons are distinct from each other. The average temperatures in summer and in winter are 23.3 and –7.0 respectively. Winter is the longest season of a year in which up to 5 months that heating is need. The average annual rainfall is 756 mm, mainly in June, July and August. South or Southwest wind dominant in summer, while North or Northwest wind in winter. Normally, the wind speed varies from 2.9 to 4.0 meter per second. The record highest wind speed is 29.7 meter per second. The annual temperature and rainfall distributions both decrease successively from southwest to northeast, wind speed in the west of the city is usually higher than that in the east.
Chapter 2. Activity Sectors

A city’s development should be sustainable. In order to reach this goal, managing the use of natural resources in a sustainable way is of great importance. In this chapter, relations between main activity sectors and the environment are described. Each branch on a chosen activity sector discusses respectively the characteristics and importance of the sector, impacts of resources on the sectors, threats of environment on the sector, impacts of the sector on resources and environment, and the concerned institutional structure.

2.1 Manufacturing

2.1.1 Characteristics and importance of the Manufacturing

Shenyang, as one of the highly industrialized areas in Northeast China, has highly centralized manufacture industries with machine-building, metallurgy and chemical as the majority, including petrochemical, coal mining, iron and steel making, smelting, light industry, textile, electronics, farming machinery and car-building, etc. There are 7,385 manufacture enterprises. In 1996, the total output value was up to 58.1 billion RMB, while the output value of heavy industries was 1.3 times higher than that of light industries. In 1996, 39% of the population (including rural and suburb) were employed in processing industries. Large and medium-scale State-owned enterprises predominated in the city’s processing industry, with their output value and the number of employees count for 60.4% and 64.6%, respectively.

2.1.2 Relations between Resources and Manufacturing

Water used by manufacturing activities in Shenyang mainly comes from tab water, as well as wells and surface water body. During the period from 1991 to 1995, the total water consumption of manufacturing is 2,463,061,800 tons, of which 607,632,300 tons is fresh water and the rest 1,855,429,500 tons is reused water. In other word, 75.53% of the total water consumption is reused water. According to the distribution of water consumption, the power/heat generation and supply industry is the biggest consumer, which consumed 566,169,700 tons or 22.99% of the total amount in the same period, while the chemical engineering industry and the pharmaceutical industry go next to it. For fresh water consumption, the biggest consumer is the chemical engineering industry with 111,379,600 tons or 18.33% of total consumption, while the pharmaceutical industry and
the machinery industry next to it. The power and heat generation and supply industry and the ferrous metal smelting and processing industry list at the top for the water recycle, with recycle rates of 92.04% and 86.33% respectively.

Figure 3. The change status of total water consumption of manufacturing

Shenyang’s industrial enterprises mainly rely on coal combustion for energy. Coal consumption is 72.65% of the total fuel. Next is fuel oil, which accounts for 21.41%. Besides, gas and coke are also used for manufacturing. About 67% of total fuel consumption occur in Tiexi District, while the biggest consumer is power and heat generation/supply industry which consumes 38.37% of total industrial fuel consumption. Machinery industry and transportation industry are also big coal consumer of the city, which contribute to 13.84% and 12.28% of the total fuel consumption respectively. Meanwhile, the fuel oil consumption is fairly balanced among industries.

As the city’s manufacturing industries develop in a high speed, the resources such as water and energy are in great demand (see fig 3, fig 4 and table 3).

Table 1 The energy structure and consumption from main industrial pollution sources of Shenyang (1996)

<table>
<thead>
<tr>
<th>Energy categories</th>
<th>Energy Consumption (ten thousands tons/ten thousands square meters)</th>
<th>Equivalent to Ten thousands ton</th>
<th>% of the total</th>
</tr>
</thead>
<tbody>
<tr>
<td>coal combustion</td>
<td>861.74</td>
<td>615.28</td>
<td>72.65</td>
</tr>
<tr>
<td>fuel oil</td>
<td>126.90</td>
<td>181.34</td>
<td>21.41</td>
</tr>
</tbody>
</table>

Shenyang Sustainable Cities Program
2.1.3 Impacts of the Manufacturing on the Environment

2.1.3.1 Impacts of the Layout of the Manufacturing

Because of the lack of knowledge on ecology and environment protection in previous planning and construction, Shenyang’s industrial layout is unreasonable, e.g. Highly centralized industries in urban district; a number of industries including iron, copper, coal and petroleum processing were built up around the central urban district. Highly centralized factories group makes highly concentrated pollution. Organic and non-organic pollutants produced pollute air, water, body and soil seriously. In addition, the noise, shock, heat and microwave radiation are also very serious. The environment pollution leads to reduce the environmental proportion with imbalance of ecology and to threaten citizens. Over 90% of industrial enterprises are centralized in urban districts and, on the other hand, factories and residential quarters are distributed in 5 districts to form a jagged pattern (see Fig. 5). The fact that the residential quarters mix with heavy industry areas invokes serious environmental health problems. A lot of residences are just in the highly polluted areas even close to several most polluted factories (See Fig. 6). In order to reduce the effect, many factories have to adjust their operation time or move away. At the same time, there little space for these factories to expand. This restricts the development of

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**Shenyang Environmental Profile-1997**

<table>
<thead>
<tr>
<th></th>
<th>1978</th>
<th>1996</th>
<th>1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel gas</td>
<td>70540.73</td>
<td>40.28</td>
<td>4.76</td>
</tr>
<tr>
<td>coke</td>
<td>10.26</td>
<td>9.96</td>
<td>1.18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>846.86</strong></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4. The Change status of energy consumption of manufacturing**

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Shenyang Sustainable Cities Program
factories to a certain degree. At present, the Municipal Government is making efforts to change such features of structural layout and the relationship between industrial areas and residential quarters. The measures taken include the followings. The first is that the government has already planned to move away heavy industries from the central urban districts if capital is allowable. The second is the Economic and Technologic Development Zone, located in the southeast to Tiexi District, has already absorbed non-pollution type enterprises to invest and establish new factories there. However, the more realistic way to reduce pollution in a short period is to re-plan and reform the operation conditions of existing enterprises. To move away such factories, it is also necessary to rebuild the public transit system and to establish several service departments and environmentally sound industries near the center of residential quarters. An additional trouble is that the distance the employees shall go to work will be longer than before either at walk or by bike, thus aggravating the traffic blockage.

2.1.3.2 Impacts of Technology Level of the Manufacturing

All the technological processes of smelting, oil refining and natural gas processing are very old, especially those of most of the large/medium-scale State-owned enterprises are still staying at the level of 1950s or 1960s, featured with low efficiency and benefits, high energy consumption and serious pollution. This status is difficult to change in a short period. The quality of seriously polluted environment is not probably to improve at root. Shenyang was polluted seriously by industrial emissions in so much that it has become one of the most polluted cities in the world. Serious damage to environment and over-consumption of energy in heavy industries have not only wasted raw materials and funds but restricted the quick transformation of industrial structure.

2.1.3.3 Impacts of the Manufacturing on Air Quality

Table 2 shows the evaluation result of the air pollutants from key industrial sources.

<table>
<thead>
<tr>
<th>Order</th>
<th>Pollutant</th>
<th>Equivalent pollution load**</th>
<th>Load ratio (%)</th>
<th>Standard (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(total)</td>
<td></td>
<td>4352034.00</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SO₂</td>
<td>2860127.00</td>
<td>65.72</td>
<td>0.15</td>
</tr>
<tr>
<td>2</td>
<td>NOₓ</td>
<td>823563.30</td>
<td>18.92</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Shenyang Sustainable Cities Program
According to an analysis on the distribution of air pollutants emission among the key polluters, Tiexi District is the biggest source with 86.37% of the city’s air pollution load comes from this area, Dadong District is the next which contributes 6.94%. From another point of view, the biggest industry contributor is the non-ferrous metal smelter and processing industry with the power and heating generation/supply industry next to it, while the contributions to the city’s total air pollution load are 61.5% and 11.03% respectively.

What worth mentioning is the Shenyang Smeltery. As a main polluter in Shenyang, Shenyang Smeltery is a big contributor for SO₂, as well as Pb and other harmful elements contained in all suspended particles of the city. According to the measurement results provided by monitoring departments, the SO₂ leaked out by the smeltery is about 5% of the total in Shenyang. Including the leakage and the SO₂ emission through fall stacks, the contribution rate of SO₂ by the smeltery is up to 44.5% in summer and 12.2% in winter. In this respect, Shenyang Government has decided that in the smeltery the copper smelting process must be reformed with lead smelting plant moved away.

Table 3  List of Key Industrial Air Pollution Sources in Shenyang

<table>
<thead>
<tr>
<th>Order</th>
<th>Polluter/ Enterprise</th>
<th>EPL** Load ratio (%)</th>
<th>EPL per 10m RMB output value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Pb</td>
<td>315142.90</td>
<td>7.24</td>
</tr>
<tr>
<td>4</td>
<td>Smoke &amp; Dust</td>
<td>252803.50</td>
<td>5.81</td>
</tr>
<tr>
<td>5</td>
<td>CO</td>
<td>35812.22</td>
<td>0.82</td>
</tr>
<tr>
<td>6</td>
<td>Fluoride</td>
<td>35122.01</td>
<td>0.81</td>
</tr>
<tr>
<td>7</td>
<td>HCl</td>
<td>21405.34</td>
<td>0.49</td>
</tr>
<tr>
<td>8</td>
<td>Chromic salt</td>
<td>3247.33</td>
<td>0.07</td>
</tr>
<tr>
<td>9</td>
<td>Sulphuric acid (fog)</td>
<td>2871.40</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>Aromatic compounds</td>
<td>1798.40</td>
<td>0.04</td>
</tr>
<tr>
<td>11</td>
<td>Sulphide</td>
<td>100.88</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>Nitric acid (fog)</td>
<td>39.23</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* Refer to the importance of each pollutant to the city
** Equivalent Pollution Load = amount of Pollutant/ standard
<table>
<thead>
<tr>
<th></th>
<th>Plant Name</th>
<th>Total</th>
<th>%</th>
<th>Pollutant Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shenyang Smeltery Plant</td>
<td>2594597.00</td>
<td>59.62</td>
<td>3.8774</td>
</tr>
<tr>
<td>2</td>
<td>Shenyang Co-generation Plant</td>
<td>479897.70</td>
<td>11.03</td>
<td>11.0555</td>
</tr>
<tr>
<td>3</td>
<td>Shenyang Heavy-duty Machinery Plant</td>
<td>122827.00</td>
<td>2.82</td>
<td>0.5327</td>
</tr>
<tr>
<td>4</td>
<td>Shenyang Aircraft Manufacturing Co.</td>
<td>85264.26</td>
<td>1.96</td>
<td>0.1903</td>
</tr>
<tr>
<td>5</td>
<td>Shenyang Non-ferrous Metal Processing Plant</td>
<td>76361.71</td>
<td>1.82</td>
<td>0.5506</td>
</tr>
<tr>
<td>6</td>
<td>Northeast Auxiliary Agents General Plant</td>
<td>72314.65</td>
<td>1.66</td>
<td>1.4597</td>
</tr>
<tr>
<td>7</td>
<td>Shenyang Cable Plant</td>
<td>69500.72</td>
<td>1.60</td>
<td>0.1664</td>
</tr>
<tr>
<td>8</td>
<td>Shenyang Snowflake Beer Co., Ltd.</td>
<td>60901.45</td>
<td>1.40</td>
<td>0.4696</td>
</tr>
<tr>
<td>9</td>
<td>Shenyang Liming Engine Manufacturing Co.</td>
<td>51708.93</td>
<td>1.19</td>
<td>0.2008</td>
</tr>
<tr>
<td>10</td>
<td>Shenyang Fertilizer General Plant</td>
<td>50150.28</td>
<td>1.15</td>
<td>0.6524</td>
</tr>
<tr>
<td>11</td>
<td>Northeast Machine Manufacturing Plant (general)</td>
<td>50115.98</td>
<td>1.15</td>
<td>0.3987</td>
</tr>
<tr>
<td>12</td>
<td>Shenyang No.1 Machine Tools Plant</td>
<td>49124.71</td>
<td>1.13</td>
<td>0.3693</td>
</tr>
<tr>
<td>13</td>
<td>Shenyang Locomotive / Carriage Manufacturing Plant</td>
<td>43620.11</td>
<td>1.00</td>
<td>0.3863</td>
</tr>
<tr>
<td>14</td>
<td>Glass Factory of Shenyang Starlight Building Materials Group Co.</td>
<td>34378.26</td>
<td>0.79</td>
<td>0.7637</td>
</tr>
<tr>
<td>15</td>
<td>Shenyang Mining Machinery Factory</td>
<td>33373.70</td>
<td>0.77</td>
<td>0.2382</td>
</tr>
</tbody>
</table>

* Refer to the importance of each polluter to the city’s air pollution
** Equivalent Pollution Load = amount of Pollutant/ standard

### 2.1.3.4 Impacts of Manufacturing on Water Quality
According to a comprehensive evaluation on water pollutants
discharged from industrial sources from 1991 to 1995, the key water pollutants in Shenyang are volatile phenol, COD and oil (see table 4). Tiexi District accounts for 41.46% of the total pollution load. Heping District goes next to it and contributes 26.52%. The most polluting industry to water quality is the cokery and gasification industry, which contributes 34.46% of the total pollution load, while chemical industry and pharmaceutical industry next to it with 26.05% and 14.74% contribution respectively.

<table>
<thead>
<tr>
<th>Order*</th>
<th>Pollutant</th>
<th>Equivalent pollution load**</th>
<th>Load ratio (%)</th>
<th>Standard (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(total)</td>
<td>409568.24</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Volatile Phenol</td>
<td>280327.40</td>
<td>41.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>COD</td>
<td>9947.34</td>
<td>20.27</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Oil</td>
<td>7182.00</td>
<td>14.49</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>Aniline</td>
<td>4987.34</td>
<td>10.06</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>Cu</td>
<td>2195.20</td>
<td>4.43</td>
<td>0.03</td>
</tr>
<tr>
<td>6</td>
<td>Organic Cl</td>
<td>1127.95</td>
<td>2.28</td>
<td>0.02</td>
</tr>
<tr>
<td>7</td>
<td>Sulphide</td>
<td>1002.34</td>
<td>2.02</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>SS</td>
<td>929.96</td>
<td>1.88</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>Nitrobenzene</td>
<td>471.16</td>
<td>0.95</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>Cyanide</td>
<td>296.15</td>
<td>0.60</td>
<td>0.1</td>
</tr>
<tr>
<td>11</td>
<td>Chloride</td>
<td>236.03</td>
<td>0.48</td>
<td>0.1</td>
</tr>
<tr>
<td>12</td>
<td>Pb</td>
<td>219.23</td>
<td>0.44</td>
<td>0.03</td>
</tr>
<tr>
<td>13</td>
<td>Organic P</td>
<td>195.52</td>
<td>0.39</td>
<td>0.05</td>
</tr>
<tr>
<td>14</td>
<td>Cd³⁺</td>
<td>171.01</td>
<td>0.34</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td>Zn</td>
<td>129.60</td>
<td>0.26</td>
<td>0.041</td>
</tr>
<tr>
<td>16</td>
<td>Cr</td>
<td>84.26</td>
<td>0.17</td>
<td>0.08</td>
</tr>
<tr>
<td>17</td>
<td>Fluoride</td>
<td>57.26</td>
<td>0.12</td>
<td>1.0</td>
</tr>
<tr>
<td>18</td>
<td>Ni</td>
<td>8.81</td>
<td>0.02</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Refer to the importance of each pollutant to the city
**Equivalent Pollution Load = amount of Pollutant/ standard

Shenyang Sustainable Cities Program
### Shenyang Environmental Profile-1997

**Table 5  List of Key Industrial Water-Pollution Sources in Shenyang**

<table>
<thead>
<tr>
<th>Order *</th>
<th>Polluter/Enterprise</th>
<th>EPL**</th>
<th>Load ratio (%)</th>
<th>EPL per 10m RMB output value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>49568.4</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Shenyang Oil Gasification Plant</td>
<td>13144.8</td>
<td>26.52</td>
<td>0.9230</td>
</tr>
<tr>
<td>2</td>
<td>Shenyang Cokery</td>
<td>3886.57</td>
<td>7.84</td>
<td>0.0709</td>
</tr>
<tr>
<td>3</td>
<td>Shenyang No.6 Pharmaceutical Plant</td>
<td>3738.36</td>
<td>7.54</td>
<td>0.0336</td>
</tr>
<tr>
<td>4</td>
<td>Northeast Pharmaceutical Plant General</td>
<td>3566.04</td>
<td>7.19</td>
<td>0.0095</td>
</tr>
<tr>
<td>5</td>
<td>Northeast Auxiliary Agents Plant General</td>
<td>3400.72</td>
<td>6.83</td>
<td>0.0686</td>
</tr>
<tr>
<td>6</td>
<td>Shenyang Chemicals Co., Ltd.</td>
<td>2813.98</td>
<td>5.58</td>
<td>0.0114</td>
</tr>
<tr>
<td>7</td>
<td>Shenyang Organic Chemicals Plant</td>
<td>2526.71</td>
<td>5.10</td>
<td>0.0735</td>
</tr>
<tr>
<td>8</td>
<td>Shenyang Resins Factory</td>
<td>1571.21</td>
<td>3.17</td>
<td>0.2308</td>
</tr>
<tr>
<td>9</td>
<td>Shenyang Grease Chemical Factory</td>
<td>1359.23</td>
<td>2.74</td>
<td>0.0074</td>
</tr>
<tr>
<td>10</td>
<td>Shenyang Gourmet Powder Factory</td>
<td>1340.12</td>
<td>2.70</td>
<td>0.0153</td>
</tr>
<tr>
<td>11</td>
<td>Shenyang Snowflake Beer Co., Ltd.</td>
<td>1201.22</td>
<td>2.42</td>
<td>0.0093</td>
</tr>
<tr>
<td>12</td>
<td>Shenyang Smeltery</td>
<td>986.40</td>
<td>1.99</td>
<td>0.0015</td>
</tr>
<tr>
<td>13</td>
<td>Shenyang Non-ferrous Metal Processing Plant</td>
<td>944.42</td>
<td>1.91</td>
<td>0.0066</td>
</tr>
<tr>
<td>14</td>
<td>Shenyang Art Paper Mill</td>
<td>922.92</td>
<td>1.86</td>
<td>0.0330</td>
</tr>
<tr>
<td>15</td>
<td>Shenyang Paper Board Plant</td>
<td>880.64</td>
<td>1.78</td>
<td>0.0509</td>
</tr>
<tr>
<td>16</td>
<td>Shenyang Xinchengzi Chemical Plant</td>
<td>794.31</td>
<td>1.60</td>
<td>0.0409</td>
</tr>
<tr>
<td>17</td>
<td>Shenyang Low-voltage Switches Factory</td>
<td>628.91</td>
<td>1.27</td>
<td>0.0138</td>
</tr>
<tr>
<td>18</td>
<td>Shenyang No.2 Paper Plant</td>
<td>610.12</td>
<td>1.23</td>
<td>0.0868</td>
</tr>
<tr>
<td>19</td>
<td>Shenyang Cable Plant</td>
<td>584.74</td>
<td>1.18</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

* Refer to the importance of each polluter to the city’s water pollution
** Equivalent Pollution Load = amount of Pollutant/ standard

### 2.1.4 Countermeasures in the Manufacturing
To solve the problems of serious industrial pollution, the municipal government has decided that, in the period of the 9th Five-year Plan, the total amount of emissions should not increase and the emission must be controlled within the standard for the factories/works listed above. Three measures have been taken as follows. The first is to move away the old factories/works or reform them technically in combination with the adjustments of industry mix, energy mix and urban layout. The next is to control strictly the new projects to be constructed together with the evaluation of influences on environment and the environment protection activities so as to control the new formation of pollution. The last is to strengthen the activities to put existing pollution under control in combination with implementing clean production and ratifying ISO14000 i.e., Environment management quality standard --- conduct tests first then spread over step by step.

2.1.5 Institutions in the Manufacturing

In processing/manufacturing administration, the Municipal Economy & Trade Commission is responsible for medium/long-term development programme and planning, also for guiding, coordinating, supervising and checking what all the processing/manufacturing industries in Shenyang are doing according to these plans. The Foreign Economy and Trade Commission has the rights to coordinate and guide all the enterprises involving foreign investments. The municipal management bureaus for individual industry, such as for machinery, petrochemical, light industry, metallurgy, electronics and textile industry, as well as the Northeast Pharmaceutical Group, the Golden Cup Automobile Co. Ltd. Under China’s No. 1 Motor Vehicle Plant, the Machine Tools Co., Ltd., The Power Transmission & Transformation Co., Ltd., the Farming Machines Co. are responsible for the guide coordination and service on their own duties respectively. As for the enterprises directly under the ministries of central government or provincial authorities concerned, they are under the jurisdiction of the higher authorities, respectively. According to the “Laws of Environment”, the environment protection departments concerned supervises and administers allsidedly the processing / manufacturing industries in Shenyang for their emissions/pollution, and has the right to carry out the legal punishment.

2.2 Housing

2.2.1 Characteristics and importance of the Housing
Since the reform and opening to the world, the urban housing rapidly develops in Shenyang. The total area had been increased to 98.93 million sq.m in 1996 from 49.07 million sq. M in 1985, increasing 101.6%, with floor space per capita increased to 7.22 sq. M in 1996 from 4.42 sq.M in 1985 or 63% increased. The distribution of housing/living areas is shown in Fig. 5.

A reform of housing system is now carried out allsidely in Shenyang to cancel gradually the non-compensation housing distribution and encourage citizens to buy their own residences. A tendency of housing commercialization for private ownership has obviously speeded up.

Inhabitants’ living standard has been improved along with the economic development and increasing incomes, and the income sources and consumption orientation both varies. According to sampling investigation, the incomes available to distribution was 4352.6 yuan per capita in 1996 from 2092 yuan in 1992, with an annual average growth rate up to 15.8%. However, viewing from a long-term tendency, the incomes of employees in the enterprises involving foreign investments will increase rapidly and those of employees in state-owned and collective enterprises will decrease down, with the difference between the former and latter further enlarged and the number of poors increased. According to the minimum living standard of which the annual income per capita is defined as 1,800 yuan at present in Shenyang, the number of poor increased 57.1% in 1996 in comparison to 1995 (See Table 6).

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>1992</th>
<th>1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of persons of each household</td>
<td>Person</td>
<td>3.33</td>
<td>3.21</td>
</tr>
<tr>
<td>Number of existing employees of each household</td>
<td>Person</td>
<td>2.15</td>
<td>2.04</td>
</tr>
<tr>
<td>Number of persons supported by employees, per capita</td>
<td>Person</td>
<td>1.55</td>
<td>1.57</td>
</tr>
<tr>
<td>Income available to distribution, per capita</td>
<td>RMB yuan</td>
<td>2091</td>
<td>4353</td>
</tr>
<tr>
<td>Consumable expenditure</td>
<td>RMB yuan</td>
<td>1909</td>
<td>3858</td>
</tr>
<tr>
<td>Consumable expenditure for foods</td>
<td>RMB yuan</td>
<td>1009</td>
<td>1923</td>
</tr>
</tbody>
</table>

----- Quoted from “Shenyang Almanac”(1997)
Shenyang’s commerce/service trades are supplying the commodities and providing services not only to the city itself but also to the whole Northeast China area. The commerce/service system is a large business operation one including all the businesses, such as supply, wholesales, retails, warehouse and services. The Taiyuan and Central Streets are the two busiest commercial centers in Shenyang (See Table 6 and Fig. 5). There is a multi-component business mix including state-owned, collective, private, solely foreign-funded venture, joint venture, joint stock and limited liability companies. In 1996, the number of commercial network points was 158 thousands, i.e., 23.6 per 1,000 persons, and the number of employees in commerce/service business was 67.4 thousands or 17.6% of the total number of employees in Shenyang. There were 15,926 restaurants at different levels in 1996, with the number of employees up to 89.076 or 2.3% of the total.

2.2.2 Resource use by the Housing
The resource occupation rate and consumption per capita grow up so rapidly accompanied with the improved living standard and increased floor space that the water supply, gas supply and usable land are all in tension. The drinkable water consumption was increased to 1.011 million ton/day in 1996 from 0.427 million ton/day in 1985. The living gas consumption was increased to 0.519 million m³/day in 1996 from 0.329 million m³/day in 1985. Pressures for water and gas supplies are both insufficient, so these supplies in part of residential quarters are often stopped intermittently. Most of inhabitants centralize in central urban districts where the land is lacking for further development and inhabitants don’t wish to move out because of poor transport facilities. Thus, the land utilization intensity increases more and more. At the same time, the developing cost of new...
housing increases up since that the original inhabitants must move away for new housing construction.

2.2.3 The impact of Environmental Hazards on the Human Health

It is shown from the research results that the resident health has been affected by the environmental hazards in various ways. This impact of environmental hazards on the human health is very complex process with characteristics of more factors, more media, lower dose and longer-term action on the human body. The affection is varied with variation of the factors in the circumstance such as physics, chemistry and biology etc.

The diseases of the tumor and the circulation system (like cardiovascular etc.) are increased with environmental deterioration. The death cause of the city resident in resent years was shown in figure.8

2.2.4 Contribution of the Housing to the degradation of Environmental Resources to Environmental Hazards

2.2.4.1 The Impact of the Housing to the Degradation of the City Biology

The dense and compact buildings and roads in urban districts cause the whole city to be covered by various types of buildings and concrete roads with much fewer lands available in comparison to suburbs and countryside. Such building materials as concrete and cement differ from the land and green plants in the absorption and reflection of sunlight and heat, so low humidity and high temperature feature the microclimate in urban districts. In the increasingly developing urban districts, the tall buildings were constructed everywhere and a lot of streets/roads look like gorges where people is staying under a large area of shadow. In addition, the stereotyped and disorganized buildings have not any esthetic rhythm in view of architectonics especially the jagged building groups combining new with old buildings.

2.2.4.2 The Impact of the Housing to the Degradation of the Environmental Resources

Unawareness of resource saving and environment protection and lack of necessary facilities do damages to resource and pollution to environment. The lacks of necessary resource-protection materials, such as the energy-saving wall body utilizing industrial wastes, industrial
energy-saving composite wall body and temperature-holding doors/windows, cause the unreasonable wastes of resource. Lacks of the utilities for water saving, sorted water supply and flow-divided drainage, in addition to the excreta and phosphorous-containing detergents drained, cause the water pollution. Because all waste flows have not been retreated further and, finally, converge together to come into rivers and lakes via underground drainage networks, where the aquatic animals/plants and algae will overbreed.

### 2.2.4.3 Contribution of the Domestic Waste Water

The proportion of the domestic wastewater in the wastewater was increased gradually to 5% in 1995 from 27% in eighties early. It contains a large amount of organic pollutants, which make the quality of HunHe worse. In 1995, discharge BOD and COD 1093.6 tons, total nitrogen 3581.5 tons; total phosphorous 1449.0 tons.

**Table 7 Discharging Pollutants of City Domestic Waste Water**

<table>
<thead>
<tr>
<th>Year</th>
<th>The discharging water amount per day</th>
<th>COD ton/year</th>
<th>Total nitrogen ton/year</th>
<th>Total Phosphorous ton/year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per day</td>
<td>Per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>58.1</td>
<td>21265</td>
<td>850.6</td>
<td>2785.7</td>
</tr>
<tr>
<td>1991</td>
<td>61.6</td>
<td>22546</td>
<td>901.8</td>
<td>2953.5</td>
</tr>
<tr>
<td>1992</td>
<td>65.8</td>
<td>24083</td>
<td>963.3</td>
<td>3154.9</td>
</tr>
<tr>
<td>1993</td>
<td>70.7</td>
<td>25876</td>
<td>1035.0</td>
<td>3389.8</td>
</tr>
<tr>
<td>1994</td>
<td>73.3</td>
<td>26828</td>
<td>1073.1</td>
<td>3514.5</td>
</tr>
<tr>
<td>1995</td>
<td>74.7</td>
<td>27340</td>
<td>1093.6</td>
<td>3581.5</td>
</tr>
</tbody>
</table>

### 2.2.4.4 Contribution of the Domestic Waste Gas

The domestic waste gas comes from mainly domestic coal burning in which the consumption of the coal was 2,874 million tons in 1995 and increased 20.6% comparing to in 1990.

**Table 8. Discharging Pollutants of the Domestic Waste Gas**

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal consumption</th>
<th>Discharging pollutants ton/year</th>
</tr>
</thead>
</table>

Shenyang Sustainable Cities Program
2.2.4.5 Contribution of the Domestic Solid Waste

The quantity of the domestic solid waste is gradually decreased. In 1995, the housing rubbish was 2.15 million tons which was increased 25% comparing with in 1990; the excreta was 2.03 million tons which was decreased 41.2% comparing with in 1990; the medical waste was 2,100 tons which was decreased 42.5% comparing with in 1990.

**Table 9. Investigation of the Domestic Solid Waste**

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic Rubbish</th>
<th>Excrement and urine</th>
<th>Medical waste</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>172</td>
<td>345</td>
<td>0.365</td>
<td>517.4</td>
</tr>
<tr>
<td>1991</td>
<td>196</td>
<td>285</td>
<td>0.120</td>
<td>481.1</td>
</tr>
<tr>
<td>1992</td>
<td>198</td>
<td>285</td>
<td>0.160</td>
<td>483.2</td>
</tr>
<tr>
<td>1993</td>
<td>204</td>
<td>203</td>
<td>0.187</td>
<td>407.2</td>
</tr>
<tr>
<td>1994</td>
<td>210</td>
<td>203</td>
<td>0.200</td>
<td>413.2</td>
</tr>
<tr>
<td>1995</td>
<td>215</td>
<td>203</td>
<td>0.210</td>
<td>418.2</td>
</tr>
</tbody>
</table>

2.2.4.6 Contribution of the Commerce/Services to the degradation of Environmental Resources to Environmental Hazards

The recreation services develop rapidly in Shenyang. Thousands of nightclub singsong houses and dancing halls, such as LTV, Kara OK and discotheques, have been opened for publics near or in residential quarters even at the ground floors of residence buildings. In addition, many shops and restaurants also opened at ground floors with doors opening to streets.

Shenyang Sustainable Cities Program
These recreation places, shops and restaurants emit oily smoke, dust and noise to disturb people, especially most of their waste gas/water are directly emitted and drained out without any treatment. An important factor of environment pollution is thus formed and becomes more and more intemperate.

### 2.2.5 Institutions in the Housing

The Real and Estate Administration (Bureau) is responsible for the management of living utilities in all residence areas. The Public Security Bureau is responsible for noise management. The Water Supply Company is responsible for the drinking water. The Administration Division of Environment and Sanitation (belongs to the Urban Construction Bureau) is responsible for the housing rubbish. In addition, the Inhabitants Committees of all residential quarters shall be responsible for unified supervision and control of environment protection. The Industry and Commerce Administration Bureau is responsible for the administration of the commerce and service enterprises. The Trade and Commerce Administration Bureau is responsible for the coordination and guidance of the commerce and service enterprises.

The Municipal Education Commission is responsible for the long-term planning, annual plan, school development planning and layout and teacher training for various educational institutions, with organization, coordination and supervision carried out.

The Municipal Public Health Bureau is responsible allsidedly for citizens’ health and medical works, as well as the acquisition and statistics of the data concerned. The Sanitation and Antiepidemic Station and Cardiovascular Diseases Treatment and Prevention Center are both under the jurisdiction of the Public Health Bureau. The station is responsible for the supervision to all medical affairs in relation to environmental hazards in Shenyang and for monitoring the quality of atmospheric environment and the epidemic diseases. Since 1980, the station was responsible for the local management of the task of global environment monitoring network, assigned by WHO (the task was transferred in 1990 to the Environment Monitoring Central Station directly under the Municipal Environment Protection Bureau). The Cardiovascular Diseases Treatment and Prevention Center was set up in June 1983 and responsible for the local Monitoring Network assigned by WHO (Monica). The network was composed of 21
monitoring points at urban, township or village level network. By the networks, 650 thousand people have been investigated with all cardiovascular disease cases registered up.

2.3 Energy

2.3.1 Characteristics and importance of the Energy

Coal is the predominant energy source in Shenyang area, about 71% of the total (See Tables 4 and 5), 73% of the total consumption in commercial energy source and 75% of industrial fuel for power. In addition, 65% of chemical raw materials and 85% of urban living fuel are supplied by coal. The ratio of industrial coal to living coal is about 3:1 in consumption. Coal, as well as the heating, electric power and a part of gas for living uses mainly supply the power, heat and electric energies necessary for industrial processes. Although the total consumption of coal is very high in Shenyang, the coal consumption per capita is low, i.e. less than 1 standard ton --- just 1/4 and 1/10 of the consumption per capita in the world and in developed countries, respectively.

The gas sources of Shenyang comprise three parts: natural gas from Liaohe Oil Field, local oil gasification and coke-oven gas. The gas supply is now limited to the existing urban districts with about 1,100 km of piping network provided. The numbers of households utilizing piping as and LNG are about 548,000 and 213,000 respectively, and the gasification rate of the city is up to 97.76%. The average gas supply is about 1 million m3/day in which 0.623 million m3 or 62.3% are supplied for living and 37.7 million m3 or 37.7% for industries and public buildings.

Shenyang is a loading center of the Northeast China power network. In
1996 the actual power supply was 8.77 billion kWh, mainly supplied by such power stations as Qinghe, Fengman and Liaoning with distribution/transmission/regulation through Northeast China power network. In Shenyang area, there are some heats power stations, e.g. The Shenhai, Shenyang and Huanggu, with installed capacity 573,000 KVA available in total. They have the functions combining power generation with centralized heating.

The centralized heating area is about 40 million sq. M in Shenyang’s central urban districts, up to 51% of the total heating area.

Table 10. Applications of Energies in Shenyang
(Data in 1990)

<table>
<thead>
<tr>
<th>Application</th>
<th>Unit (converted into million std. Tons)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industries: Heating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>3.7</td>
<td>34</td>
</tr>
<tr>
<td>Raw material</td>
<td>1.6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>7</td>
</tr>
<tr>
<td>Public utilities:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating (space/water)</td>
<td>3.3</td>
<td>31</td>
</tr>
<tr>
<td>Power</td>
<td>0.7</td>
<td>7</td>
</tr>
<tr>
<td>Food cooking</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>Transport: Truck</td>
<td>0.4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10.7</td>
<td>100</td>
</tr>
</tbody>
</table>

2.3.2 Resource use by the Energy

The energy consumption is highly concentrated since the population and productions are highly centralized in Shenyang. Most of the coal consumption in Shenyang is supplied from other places inside or outside Liaoning Province and only a small part is from this area. Coal consumption increases year by year, but coal is of non-recoverable resource. Viewing from such a fact, the coal supply will be a nonnegligible factor influencing potentially Shenyang’s development in future.

Accompanied with the continuous decrease in natural gas supplied from Liaohet Oil Field, much less with the out-of-date equipment of the Oil Gasification Plant and Coke-Oven Gas Plant in Shenyang which are both available to supply a limited amount of gas, the gas supply has gone short either for industries or for living. At present gas supply is hard to follow up the rapidly developing requirements for housing, industrial and commercial
2.3.3 Contribution of the Energy to the degradation of Environmental Resources to Environmental Hazards

A large amount of energy consumed necessitates a large amount of wastes, especially in coal burning process, to be emitted into atmosphere, mainly including the smoke, dust, carbon oxides, sulfur oxides, nitrogen oxides and benzo-(a)pyrene, etc. Serious air pollution of coal-smoke type has thus been formed since in Shenyang the energy consumption mix is predominated by coal. Most of the coal is put into combustion directly without pre-treatment and with high contents of ash and sulfur. In addition to the coal used, most of the burning equipment in Shenyang is of small/medium sizes with very backward combustion process provided without desulphurization units. The low-level emission causes further the more serious air pollution of smoke dust and sulfides formed in combustion process. Moreover, a large number of boiler rooms and small-size furnaces/ovens spread over the whole city cause the low-level and large-area smoke/dust pollution to damage human health.

It is inevitable to maintain the existing energy mix of which the coal is predominant for a considerably long time. Accompanied with the developments of urbanization and industrialization and the growing energy consumption, the threat due to air pollution will be more serious if no great breakthrough is made in combustion technology and coal conversion.

Now the primary energy utilization density and energy mix have been readjusted in Shenyang’s urban districts. The measures taken are developing the heat-power plants and centralized heating, making effort to develop the mixed gas of liquidified petroleum gas with air and supplying liquidified petroleum gas through centralized pipings in sub-districts. Such a combination will improve both the heat supply and gas supply capacities so as to get rid of the combustion process with raw coal directly burnt in central urban districts step by step. The state authorities concerned as one of the two pilot cities where the household furnaces/ovens using raw coal are planned to abolish have listed Shenyang City.

The centralized heating is also developed rapidly, but not of all-round development. The decentralized heating area is up to 49% of the total with average thermal efficiency below 50%. The average thermal efficiency of all the boilers in Shenyang is about 60% and that of furnaces/ovens is about...
As for household cookers and ovens, the average thermal efficiency is just 15-20%.

### 2.3.4 Institutions in the Energy

The fuel supply Co., Under the Municipal Materials Administration Bureau, is the main department responsible for the fuel supply in Shenyang. However, accompanied with the developing market economy, the company’s function providing a main channel for coal supply was gradually weakened and a new situation takes place, through which the coal is supplied by the state, collective and private enterprises all together. The Northeast China Power Administration is responsible for the power production and supply to the whole area of the Northeast China, while the Shenyang Power Administration is manly responsible for the power transmission to urban districts and routine management. The Thermal Power & Heat Supply Co., Under the Municipal Real & Estate Administration Bureau, is the most important department responsible for heat supply, and the Shenhai and Shenyang Heat-power Plants, under the Northeast Power Administration also undertake the task for centralized heating. The Gas Supply Co. is the main department responsible for the gas production, delivery and management in Shenyang.

### 2.4 Transport

#### 2.4.1 Characteristics and importance of the Transport

Shenyang is the biggest economic center in Northeast China and the communication hub where the trunk railways, highway and airlines converge on as fine as a spider’s web. The highway transportation in Shenyang developed rapidly, Accompanied with economical development.

The urban road network in central districts are mainly composed of 3 loops, 14 radicalized roads and 2 crossing trunk roads (north-to-south and west-to-east each). There are 2,097 roads/streets in urban districts, 19.5956 million sq.M in area and 1473.71 km in length in total, with a density 7.96 km per square kilometer. An expressway network has been formed (called as “Three loops with four radiations”) including Shenyang’s three loops (inner, middle and outer) and four radiations, i.e., From Shenyang to Tieling, Dalian, Fushun and Benxi.

The number of motor vehicle is increasing rapidly (see Table 11). There were 258,918 vehicles in 1995, 76% higher than 1990 with annual
increment up to 12%, among which 2,562 vehicles were for public transit with 2009.5 km long running distance available. The volume of passenger transport in 1995 was 546.40 million person-time.

Table 11 Growth of Various Vehicles in Shenyang

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Public trucks</td>
<td>44749</td>
<td>49848</td>
<td>52547</td>
<td>56569</td>
<td>59194</td>
</tr>
<tr>
<td>Private trucks</td>
<td>26198</td>
<td>31138</td>
<td>38815</td>
<td>48248</td>
<td>54526</td>
</tr>
<tr>
<td>Buses, minibuses and cars</td>
<td>4915</td>
<td>4981</td>
<td>5518</td>
<td>6788</td>
<td>7913</td>
</tr>
<tr>
<td>Private buses, minibuses and cars</td>
<td>6230</td>
<td>7335</td>
<td>9918</td>
<td>13173</td>
<td>16868</td>
</tr>
<tr>
<td>Light motorcycles</td>
<td>32970</td>
<td>44230</td>
<td>55510</td>
<td>63724</td>
<td>66914</td>
</tr>
<tr>
<td>Others</td>
<td>46981</td>
<td>52261</td>
<td>55469</td>
<td>53364</td>
<td>53503</td>
</tr>
<tr>
<td>Total</td>
<td>162007</td>
<td>189793</td>
<td>217777</td>
<td>241866</td>
<td>258918</td>
</tr>
</tbody>
</table>

There are bikes more than 2.60 million in Shenyang, or over 80% of total traffic volume. So many bikes disturb and restrict seriously the development of public transit since a large number of bikes occupy so large portion of road area at low speed with high flexibility. The interdisturbance between motor vehicles and non-motorized carriers aggravates the traffic blockage and congestion. The average speed of motor vehicles is decreased successively, and now it becomes lower than 20 km/hr on 46% of the total number of urban roads.

Shenyang’s Transport can see Fig. 11.

2.4.2 Resource use by the Transport and Telecommunications

The core urban districts (within the inner loop) have become a “Focus” of urban transport, because the housing/commerce, finance, recreation and administrative department are all lying in there intensively, with highly concentrated employment chances provided and frequent trade activities. Within the inner loop, the land area available to use is only 37.6% of the total area of existing urban districts, but the traffic volume is up to 67.9% of the total. In addition, land in the core districts runs short since these districts have been highly developed. A contradiction between the development of transport and that of other construction projects is therefore highlighted. As for the volume of passenger transport per unit road area, a bus is just 1/10 in comparison to a car and 1/6 to a bike, much less the unit energy consumption and pollution --- the pollution due to a passenger in
car is 10 times higher than one in bus.

2.4.3 Contribution of the Transport to the degradation of Environmental Resources to Environmental Hazards

To deliver the flows of people, energies to be used and materials, most of motor vehicles are concentrated in urban districts. In addition, out-of-date traffic facilities remain unchanged. Traffic congestion and accidents thus take places frequently. Vehicles are generally not in good order. Pollutants emitted are mainly of such harmful matters as carbon monoxide, carbon hydrides, nitrogen oxides and lead. Tail gas exhausted increases more and more because of traffic congestion and increasing vehicles’ acceleration, idle and running.

Table 12. Pollutants emitted by vehicles in Shenyang

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>0.0390</td>
<td>0.0458</td>
<td>0.0525</td>
<td>0.0603</td>
<td>0.0709</td>
</tr>
<tr>
<td>CO</td>
<td>4.4543</td>
<td>5.2244</td>
<td>5.9924</td>
<td>6.8753</td>
<td>8.0821</td>
</tr>
<tr>
<td>NOₓ</td>
<td>0.9613</td>
<td>1.1275</td>
<td>1.2932</td>
<td>1.4838</td>
<td>1.7442</td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td>0.8546</td>
<td>1.0024</td>
<td>1.1498</td>
<td>1.3192</td>
<td>1.5507</td>
</tr>
<tr>
<td>Pb</td>
<td>0.0673</td>
<td>0.0790</td>
<td>0.0906</td>
<td>0.104</td>
<td>0.122</td>
</tr>
</tbody>
</table>

Although vehicles contribute relatively low pollution to air, their exhausts are emitted at low level and will cause serious damage to human breath organ especially that of the numerous bike-riders who go to work by bike almost everyday. The low-speed vehicles that are still running in urban districts make the pollution due to carbon-hydrogen compounds more serious. Thus, the contribution rate of tail gas from vehicles to ground air pollution is up to about 90%. The inner, middle and outer loops constructed successively in Shenyang are able to divide vehicle flows to reduce the traffic pressure in central urban districts.

The lack of parking areas is a very serious social problem in Shenyang. Stopping a vehicle arbitrarily with road area occupied is a common sight. This is caused by that no attention was paid to parking when planning the urban layout. The parking problem shall irretrievably become regret later along with the swift and violent increase in vehicles if we don’t
keep some spaces for future in urban planning.

2.4.4 Institutions in the Transport
The Transport Bureau is responsible for the administration of Shenyang’s traffic especially the preparation of standards of traffic marks, cargo transport and requirements for motor vehicles under the assistance of Traffic Technology Institute, Highway Administration Department and Highway Design Institute. The General Public Traffic Company is responsible for the public traffic of the whole city. The Traffic Policemen Branch Team is responsible for the traffic security, management, supervision and command and the training for drivers. The Environmental Monitoring Center of SYEPB is responsible for the measurement of the tail gas exhausted of the vehicles.

2.5 Recreation, Open Spaces & Natural Areas

2.5.1 Characteristics and importance of the Recreation, Open Spaces & Natural Areas
In Shenyang there is a total area 18,320 ha of green belts including 5,070 ha in the existing urban districts with a coverage rate up to 28.98%. Most of the inhabitants cannot use effectively these green belts. Parks and public recreation facilities are rather few in Shenyang. The largest park is Beiling Park located at the north of Huanggu District, about 330 ha. Other parks include the Shenyang Zoo, Youth, Lu-xun, Nanhu, Zhongshan, Wanliutang, Dadong, Bitang, Bainiao, Labor Parks, etc., 10-50 ha each. Citizens are not always convenient to enjoy these parks.

The public green sites mainly comprises three types: spot, belt and area. The first includes 3 scenic spots and 2 natural areas, all of which are Shenyang’s important tour resources. The second includes the green belts on both sides along highway railways and rivers, mainly along the Song-Liao Channel and Liaohe River. The third is the shelter green area systems composed of three parts: the windbreak-sand fixation forests built up in the wind/sand shelter zone to the north and west of the Liaohe River; the farmland/forest-nets and green belts around villages in the south of the Liaohe River; the water-source conservation forests to be developed further in the east low hilly land (See Fig. 12).

2.5.2 Resource use by the Recreation, Open Spaces & Natural

Shenyang Sustainable Cities Program
Shenyang Environmental Profile-1997

Areas

As an ancient city, Shenyang’s urban districts have been developed at high-density level with few lands available to develop further. Often the green belts were occupied for other uses. The areas of public green belts are thus decreased gradually with much less recreation places and natural areas provided.

The vegetation especially the trees grow poorly in Shenyang, with withered leaves and dead branches often seen and leaves falling down earlier. The reason is that the underwater level has been lowering down, thus causing the vegetation to absorb water insufficiently.

2.5.3 Contribution of the Recreation, Open Spaces and Natural Areas to the degradation of Environmental Resources to Environmental Hazards

Green area increased year by year. It was 5.5 sq. M per capital in 1996, still lower than the state standard, i.e. 7-11 sq.M and much lower than that of foreign modernized cities where the standards are 40-90 sq. M per capital. The scenery and environment qualities of Shenyang parks are barely satisfactory in addition to high density of visitors, so unable to meet the requirement for enjoyment rest and relaxation.

The green areas are distributed unevenly because of reasonable layout, rare in old urban districts and more in peripheral zones, especially rare between residential quarters and industrial areas or railways. Such a layout makes the ecological functions unable to give full play to the improvement of environment.

2.5.4 Institutions in the Recreation, Open Spaces and Natural Areas

The municipal Construction Bureau is responsible for the management and maintenance of the parks and other recreation places in existing urban districts. The Green Area Department is responsible for building green belts in urban districts and the Forestry Bureau for the nature protection to public green areas, and recreation places outside the existing urban districts. In addition, a management committee was appointed for the Huishan Hill Scenery Spot.

2.6 Water Utilities
2.6.1 Characteristics and importance of the Water Utilities

The water supply area of Shenyang has reached 186 sq.km. Except that the Dahuofang reservoir in the upstream each day are supplying 500,000 T tap water to Shenyang, the other part of tap water are collected from underground water sources. The water supply pipeline network has reached 2438 km, and the length of pipeline network is increased 30 km annually. The total water consumption in 1995 is 2232 million cu m/a, this number has exceeded the city’s sustainable available water volume nearly one-fourth, in which the city’s tap water supply total volume is 660 million cu m/a, and the water consumption of the industrial enterprises is 370 million cu m/a.

The drainage of the city’s region is divided into three drainage systems: the southern, northern and western parts, and divided into eight drainage holes which are respectively discharged into Hunhe River, Xinkaihe River and Xihe River (See Fig. 13, Fig. 14). The drainage has basically adopted the combined-flowing system. The total drainage pipeline network is 1,616.2 km.

Because the water consumption in the central region of the city is concentrated, the development of the city is uncoordinated with the increase of water supply. The average pressure of the pipeline network in the regions of city/street is decreased to 0.88 kg/sq.cm. The qualified rate of water pressure in pipeline network of the city/street is only 50%. The area of low-pressure regions is increased to 99.9 sq. km, which occupy 53.7% of the water supply area.

2.6.2 Resource use by the Water Utilities

The water volume used for industry and living of the inhabitants is insufficient, the contradiction of water demand by agriculture and industry is obviously. The city’s water supply volume is increased gradually, from 153,000 cu m/day in 1948 increased to the present 1,800,000 cu m/day; the water supply volume is increased 12 times. However, the population at the same time is increased 20 times, the industrial total production value is increased 110 times. The increased of water supply speed is greatly inadapting the demand in the city’s development.

2.6.3 Contribution of the Water Utilities to Environment

The water quality is seriously polluted. Estimated only for Shenyang,
the organic pollutants which are discharged into the Hunhe River annually have reached 120,000 t. The main environmental target of the Shenyang section of Hunhe River and the Shenyang section of Liaohe River have exceeded the five kinds water body’s standard of the State’s standard for environmental quality of surface water. The Hunhe River has become the pollution-accepting river of Shenyang and Fushun. Because the supplementing of surface water from the Hunhe River influences it, the underground supplementing water is rather bad, so that the water sources of the municipal administration were polluted. The pollutants of water quality are mainly organic matters. The pollution of water sources in the upstream of Shenyang section of the Hunhe River is rather light, the water sources of the midstream is worse, and the downstream is rather seriously. The farther of the location the pollution is rather lightly. It may be seen that the role of Hunhe River on the pollution of the city’s water supply is very great.

In recent years, along with the development of the city’s construction, although the water supply pipeline network has been renewed, reformed and perfected, but it is still unable to satisfy the requirement of the city on the water supply pipeline network. Because the increasing of subregion’s residences and water storing pools, it is required to raise the grade and the diameter of the pipe diameter of the municipal administrative water distribution pipeline network. Until today, there were still a part of water supply main lines, which installed in the period of the Japanese occupation and puppet regime. Leakage in such pipelines is serious; its leakage rate reaches 11.5%. Undoubtedly, such a situation will give more difficulties on the city’s water supply, which is originally in very short supply. The function of the whole city’s water supply pipeline network is unperfected. It is unable to realize water supply according to different quality and reuse of water, so that the very valuable water sources are commonly wasted.

Because lack in fund, until the present time there is no constructed and operated sewage treatment plant in Shenyang, so that large quantities untreated sewage are directly discharged into the rivers. The waterways was already become the storing site of industrial and civil wastes. Because the serious degree of the discharged wastes, the water quality is damaged. Along with the different parameters, the discharge volume of the wastes is varied. These values had seriously exceeded the 5th class standard of the state, which cause serious pollution on the underground water, intensify the destroyment of the water environment ecological system and wasting in water resources. Today, Shenyang is actively constructing the sewage
treatment plant in the northern part of the city, which has a daily treatment volume of 400,000 t, and prepares for the construction of larger size sewage treatment plant in the western part.

The polluted water from the western part of Shenyang (Weigong open ditch) which mixed with water from Hunhe River were used for irrigating the Zhangshi irrigation region in over 20 years, the result was that 42,000 mu rice field were suffered from cadmium pollution. The Shenfu irrigation region had used waste water of petroleum and chemical industry from Fushun for irrigating crop fields, every day had accepted over 300,000 T waste water from Fushun, so that the rice quality of the irrigation region was remarkably dropping. The Hunpu irrigation region has also adopted the polluted water from Hunhe River water and the untreated Xihe River water. Some peasants even had used the city’s sewage for irrigation in unpermitted condition, which causes death of rice seedlings and no harvest.

The water drainage pipeline network is unperfected, the function in local regions are in confusion. The reform of old pipeline network in the lowland region is slow, so that the ability of the output is inadequate. Water is accumulated in the rain season, the drainage in the ordinary time is not smooth, a part of the pipeline network were unrepaired for a long time, waste water is directly flowing out the ground surface, so that it causes direct influences on the living environment of the people. The increasing water consumption from the other hand had claimed the improving of drainage capacity, and forms a pressure on the water drainage pipeline network.

### 2.6.4 Institutions in the Water Utilities

The Municipality Tap Water Corporation is a unit, which responsible for supply water to the city. Under the Corporation there is Water Saving Office, which is specially responsible in water saving in the city. Under the Bureau for City Construction is set up Water Drainage Department, which is responsible in the construction, management and maintenance of water drainage system in the city. The construction of the city’s sewage treatment plant is also responsible by the Municipal Urban Bureau.

### 2.7 Solid Waste Management

#### 2.7.1 Characteristics and importance of the Solid Waste Management
The solid wastes of Shenyang includes living garbage from the city’s inhabitants, commercial garbage, the garbage formed in maintenance and management of municipal administration and the various waste residues, dust and other wastes which are discharged into the environment in the process of industrial production (See Table 13). The organic matter content of the whole city’s living garbage occupies 34.96%, inorganic matter content occupies 58.14%, wasted products occupied 6.90%, and its heat value is 1215.3 k cal/kg.

At present, the medical treatment garbage in Shenyang is basically realizing sanitary burning treatment. The living garbage is basically buried for land filling. In the aspect of treatment of industrial solid wastes, besides the comprehensive utilization, it is basically sealed up, unorganized for pile up or buried for land filling (See Fig. 15).

Table 13  Formed Solid Wastes in Shenyang (1996)

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity (Ten thousand t/a)</th>
<th>Percentage of Total Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>314.6</td>
<td>73.3%</td>
</tr>
<tr>
<td>Living</td>
<td>114</td>
<td>26.6%</td>
</tr>
<tr>
<td>Medical Treatment</td>
<td>0.365</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total</td>
<td>429</td>
<td>100</td>
</tr>
</tbody>
</table>

The piling up of solid wastes has occupied large area of land. The industries which form industrial solid wastes are mainly the mining industry, chemical industry, coal cooking industry, metallurgical industry, electric power industry; etc. The average of annual formed industrial solid wastes is about 2.8 million t, in which the harmful wastes are 300,000 t.

The living garbage of Shenyang is basically used for filling land and pits. There are three fixed discharge and treatment sites in the surrounding of the city, but it has not reached the unharming treatment targets. According to the related statistics, from 1949 when our State was established to the end of 1995, there were 27 million T living garbage used for filling land. According to the monitoring of space remote sensing in 1981, there are 526 sites unorganized for piling of garbage, which occupies about 3.06 million sq. m.

2.7.2 Contribution of the Solid Waste Management to Environment

Shenyang Sustainable Cities Program
The industrial solid wastes are menacing the environment. They have influences on the growth of the living things, and are harmful on the human health. In 1996, the annual comprehensive utilization quantity of the industrial solid wastes is 1.64 million t, which occupies 52% of the total quantity. Besides the several small-type treatment installations of the individual enterprises which are carrying out treatment, most of the other industrial solid wastes are only sealed up or piled up at their will, which resulting in piling up of large heap of solid wastes and occupy large area of land. Many industrial waste residues contain water-soluble substances. They may pollute the soil and water body through leaching. The industrial wastes in the powder form may fly in the air by wind, which pollute the atmosphere. Some of them may dissipate odorous gases and toxic gases. Nowadays, the government of Shenyang is constructing a landfilling and treatment site of industrial solid wastes by applying loan from the World Bank.

Now, the treatment capacity of living garbage is very low, it is short of fixed treatment site for discharging garbage. The function and size of the present garbage treatment site are greatly not satisfying the requirement of accepting and treating the city’s garbage, so that a part of the living garbage is in a situation of unorganized discharging at their will. Such out of control not only is harmful to the sight and may harm the image of the city, the more serious consequence is polluting the groundwater, but also the secondary dusting which is a serious pollution. There are 175 sites along the Hunhe River, Puhe River, Xinkaihe River, Nanyunhe River and Xihe River where the city’s garbage are piled up, and their total area is about 810,000 sq. m, which occupies 29% of the overall piled up area in the whole city. This is also the important reason, which causes pollution to the surface water and the groundwater along the rivers.

After the garbage is piled up for a period of time and acted by microorganisms, not only it will produce odorous gases polluting the environment, but also there is a danger of explosion caused by marsh gas. Two times of incidents caused by obsolete-type garbage burying sites were occurred in Shenyang. After such a site is leveled, factory buildings are constructed on the site. Because the buried garbage produces combustible gases, explosion incidents were occurred when fire was encountered.

In 1988, the Zhaojiagou garbage treatment site had begun with “Experiment on burning of medical treatment garbage” project; in 1990, the Caozhongtun garbage treatment site had carried out “Demonstration on
sanitary burying living garbage with natural permeation-prevention project. However, the present treatment mode for garbage is remarkable backward. Large quantity reclaimable and reusable matter in the garbage is not efficiently utilized. They were discharged into the environment to become pollutants. Viewed from a long-term angle, to carry out garbage classification for reclaiming and reuse is our direction for the development. The key problems at present are: At first is, the discharge of garbage has not carrying out classification; the second is, there are short of capability and investment for reclaiming garbage; the third is, the value of the resources are unreasonable.

2.7.3 Institutions in the Solid Waste Management

The industrial departments now mainly do the treatment of industrial solid wastes, thus under the management of environment protection departments; the factories have carried out the treatment and utilization for themselves. The living garbage and hospital garbage are collected and treated by the responsible environment sanitary department that is subordinated to the Municipal Bureau for City Construction.
Chapter 3  Environmental Setting

Human activities have resulted in the depleting of natural resources and the increase of investment and operational cost of economic activities, and influenced the directions of investment as well. So have the environmental hazards. The potentialities of Shenyang’s sustainable development is more and more under the threatens of environmental deterioration, which affects not only public health and human wealth, but also economic and social development. This chapter describes the environmental resources and their hazards, their features, the interactions between environmental resources and their hazards and human activities, and management system.

Environmental Resources

Environment and resources are the basic conditions for existence and development of human being. The sustainable development of the human social is depended upon the sustainable utilization of natural resources. However, the limitation of environment and resources with the unlimited human requirement has formed a pair of permanent contradictions. Nowadays, Shenyang is also faced with the real problems of resources shortage and environmental pollution.

3.1 Groundwater

3.1.1 Characteristics of the Groundwater
The groundwater resource of Shenyang region is 2.12 billion cu m/a. It is not evenly distributed. The plain region belongs to rich water region; on both banks of the Liuhe River and the Puhe River as well as their near plain before the mountains are the weak water regions; and the hilly regions in the eastern part are the poor water regions.

3.1.2 The use and demands those Activity Sectors make of Groundwater
The water supply in Shenyang depends on the exploiting of the groundwater. Up to the end of 1990, there are 1075 groundwater wells in the entire city, in which 345 wells are for water resources of municipal
administration with the capacity of 1.42 million m³/day, and 730 wells are self-prepared wells for industry with the capacity of 423,000 m³/day. Today, the groundwater collection in the city region is already imbalance. The groundwater in the city is mainly used for household and industrial purposes, and in the countryside some groundwater is used for irrigation of rice field. According to the statistics of the municipal water administration the total amount of water supply from 1980-1991 has doubled.

The development and utilization degrees of our water source are rather low. The reutilization rate of water for industry in the whole city is only 75%; the exhaustion of water source in each unit industrial product is too large. The waste of water for living in the city and the lack in equipment for the reutilization of treated water are very serious, only the loss of water in the water supply piping network has accounted for more than 10% of the total tap water supply. Now, there is none municipal wastewater treatment plants in operation. It has resulted in unreasonable utilization and waste in water supply.

3.1.3 The impacts of Activity Sectors on the Groundwater

The groundwater resource of Shenyang region has been reaching a crucial point day by day. The water demand for industry and civil use is mainly depended on the exploitation of Hunhe River and the alluvial fan region of Liaohe River. In the city region, the groundwater exploited from the alluvial fan region of Hunhe River is 5,000 - 10,000 T each day. The groundwater exploited from the alluvial fan region of Liaohe River is also more than 5,000 T/day. Because of the overexploitation the groundwater level is dropping continuously, by the end of 1980s, forming two ground funnels centered in Tiexi District and Dadong District with expansion areas of more than 70km² and 40 km² respectively.

**Table 14. Comparing of groundwater deep level between 1991 and 1995**

<table>
<thead>
<tr>
<th>Year</th>
<th>Eastern areas</th>
<th>Middle areas</th>
<th>Western Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>17.78</td>
<td>12.26</td>
<td>11.85</td>
</tr>
<tr>
<td>1995</td>
<td>13.82</td>
<td>10.38</td>
<td>11.75</td>
</tr>
<tr>
<td>Comparative Value</td>
<td>Down 3.96</td>
<td>Down 1.88</td>
<td>Down 0.10</td>
</tr>
</tbody>
</table>

Expect that the groundwater quality in the northern part is rather lightly polluted, the groundwater in most regions is all polluted in some
degrees. The Hunhe River, Xihe River and the man-made waterways, which have been polluted by receiving a large amount of untreated industrial wastewater and sewage and the leakage from uncontrolled garbage dumping and the pits left by the exploiting of sand from Shenyang and Fushun, have changed natural background conditions of the groundwater by filling in to groundwater in a long period of time. Therefore, the groundwater quality has been worsening gradually. The pollution of groundwater has shown a remarkable law according to different belt. The tendency is the industrial concentrated region of the city as the center and the Hunhe River, Xihe River and the discharge/irrigation main ditch as the axis, the pollution distribution law has shown from heavy to light towards their both sides. The quality of potable water sources situated on both banks of Hunhe River, which accounts for 60% of the whole city’s total supplies, is very bad. The raising up of mortality of digestive cancers is possibly related with this reason (See Table 15, Fig. 16).

### Table 15 Differentiating of the Grades of Groundwater Quality

<table>
<thead>
<tr>
<th>Grades</th>
<th>Best</th>
<th>Good</th>
<th>Rather Good</th>
<th>Rather Bad</th>
<th>Very Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>F value</td>
<td>&lt;0.80</td>
<td>0.80~&lt;2.50</td>
<td>2.50~&lt;4.25</td>
<td>4.25~&lt;7.20</td>
<td>&gt;7.20</td>
</tr>
</tbody>
</table>

The results of the single-item evaluation of water quality show that the groundwater pollution is serious. The main pollutants are N-NH3, -NO2, NO3, volatile phenol, Cr6+, total hardness, and Cd2+. There are 30.1%, 33.3%, 39.7%, 19.1%, 11.1%, and 1.6% of water supply surpassing the national III class standards of groundwater quality respectively. From long run, the pollution area of N-NO2 is in a tendency of expanding.

The shallow water layer is sucked empty resulted from over-exploitation of groundwater, that is the balance of exploitation and reserving is destroyed, so that it causes high mortality of the vegetation in the city’s region and subsiding the ground surface. The subsiding of ground surface has destroyed building and production installation, the uneven subsiding in a region may lead buildings to inclining, cracking, even falling down. It may destroy the underground piping system and the railway track as well; the bituminous road surface may appear cracking. The development of a city requires expanding land for utilizing, hence, a
vicious circle of land development, destroy and shortage is formed. The sucked volume of groundwater should be controlled for the prevention of subsiding of the city’s ground surface. Thus, the contradictions between the supply and demand of water have been formed.

3.1.4 The Management System of Groundwater
The Shenyang Tap Water Corporation, as the water supply department for the whole city, is responsible for the maintenance and management of the water source wells and the designated water source protection regions. It has 7 water treatment plants for drinking water supply and one water-saving office in charge of supervising the whole city’s water saving. It is also responsible for monitoring the quality of the groundwater and drinking water of the city.

3.2 Surface Water

3.2.1 Characteristics of Surface Water
The resource of surface water in Shenyang region is about 1.14 billion cu m/a. There are two main river systems: the Liaohe River system and the Hunhe River system. The latter is situated in the eastern part of the region, and the former is situated in the western and northern parts of the region. The Hunhe River is flown into the Liaohe River in the southeastern part of Shenyang, and then it is flown into the Bohai Sea in Xipaotai of Yingkou City. These two rivers have 15 main tributaries, and each tributary has many small rivers which flown in (See Fig. 17). The total length of the overall 1 rivers which are go through Shenyang region is 1076 km, in which large type rivers are the Liaohe River, Hunhe River, Raoyanghe River and Liuhe River; medium type rivers are the Puhe river, Yangximuhe River, Beishahe River and Xiushuie River; small type rivers are the Wanquanhe River, Changhe River, Baitabaohhe River, Mangniuhe River, Zuoxiaohhe River, Xihe River and Xiaoshahhe River, in which the Xihe River has already become the pollution drainage ditch of Shenyang. Except that the Beishahe River flows into the Taizihe River, the other rivers flow into the Liaohe River or the Hunhe River.

The rivers of Shenyang region (especially the small rivers) are mainly seasonal rivers, their flow in rain season (from June to September) is very large, but in the other seasons they are nearly absent of water.
3.2.2 The Use and Demands those Activity Sectors make of the Surface Water

Except that the Dahuofang reservoir in the upstream each day has conveyed 500,000 T tap water towards Shenyang through water delivery pipe, the main function of surface water is for irrigating crop fields and ensuring water for recreation, scenery and ecology in the city and its surrounding regions. The Shenyang section of Hunhe River is a main river section of Shenyang City region. Its water volume is controlled by Dahuofang reservoir in the upstream, so that it has missed the hydrological characteristics of natural river, the ecological balance of its water system has been destroyed. The flow of the river in the irrigation season is 65m3/sec.; in dry season there is no diluting water source for water purification, the flow of the river water is about 7m3/sec. And it becomes the pollutants receiving river of Shenyang and Fushun, so that the water quality is highly polluted.

Because of water shortage it is difficult to be meet the gradually increased demand of water for living, industry and agricultural irrigation in the city. Transmitting water from far distance (such as water from the north transmitted to the south, water from the east transmitted to the west) may not be practical in the near future due to economic and financial limits. Therefore, it is necessary to make the best use of the water resource in reasonable, efficient and saving ways to solve the situation of “Getting food depends on the nature”.

3.2.3 The impacts of the Activity Sectors on the Surface Water

The surface water pollution of Shenyang is mainly from industrial and domestic wastewater produced in the Shenyang and domestic wastewater produced in the upstream cities (such as Fushun). Shenyang, a very populated, industrial condensed city, has no municipal wastewater treatment facilities under operation. In some regions of Shenyang, water pollution has already become one of the key factors restricting the development of economy.

The contents of toxic chemicals (such as phenol, chromium, cadmium, mercury, etc.) in the water of Hunhe River and Xihe River have exceeded the normal standards due to having received a large amount industrial wastewater and domestic wastewater from the cities. The domestic wastewaters, which haven’t been efficiently treated before being discharged, have caused serious problems of organic pollution. In recent
years, the flow of the wastewater, which is normally untreated before being discharged, has been gradually increased by the rapidly developed industrial enterprises in the suburban districts.

The construction of cities and drainage systems has increased the impermeable areas of buildings and roads and the problems of water discharge. Some projects (such as water discharge project for violent raining) has decreased water permeation and increased runoff, so that the surface water may not efficiently fill in the groundwater. Consequently, the water circulation of the natural kingdom has been destroyed.

The pollution sources which influence the environment of Shenyang region are not limited to occur in Shenyang administration region, it is also formed in Fushun, a city which is situated in the eastern part of Shenyang and has many petrochemical enterprises. The Hunhe River receives more than 60% of industrial and municipal wastewater from that city. It has increased the deterioration of water quality of Hunhe River, which flow into Shenyang region. The city of Tieling, which is situated in the northern part of Shenyang, is a large agricultural city. The municipal wastes generated in this city are flown towards the south and gives influence to the water quality of Hunhe River in Shenyang.

The environmental monitoring results show that the main pollutants in Shenyang section of Hunhe River are: COD, BOD, oil, volatile phenol, N-NH4 and permanganates and heavy metals. In general, the water quality of the Hunhe River has surpassed the V class of the national environmental quality standards of surface water. Especially in dry seasons, there is no other natural water source for supplement, only the domestic and industrial wastewater are discharged into the river and cause more serious pollution.

3.2.4 The Efforts Shenyang Has Made for Solving the Surface Water Pollution

In order to solve the problems of water pollution, Shenyang has taken some practical actions to prevent and control industrial pollution, and, at the same time, to clean up the pollution in Nanyunhe River and Xinkaihe River. Two municipal wastewater treatment plants are under construction and design respectively so as to treat the wastewater generated in the city centrally. According to the requirement of cleaning-up the pollution of Liaohe River of the NEPA, Shenyang has set targets to clean up all polluted water bodies which surpass the V class of the national environmental quality standards of surface water by the year 2000. And reach the IV class
of the national environmental quality standards of surface water by the year 2010. The leading group of pollution clean up of Liaohe River Shenyang section has been established and relevant measures have been put forward.

3.2.5 Management System of Surface Water

Shenyang Water Conservancy Bureau is responsible in strengthening, managing and maintaining the waterways and reservoirs, and also responsible in allocating the surface water resource of the whole city, agricultural irrigation, and so on. The municipal construction bureau is responsible for the management of the surface water that can be used for the purpose of sightseeing and tourism. Shenyang environmental monitoring center is responsible for monitoring the environmental quality of the waters. Shenyang environmental bureau is in charge of supervising the polluters by pollutant discharge permit system, pollutant discharge registration, and pollution levy system. The municipal construction bureau is responsible for the construction of the two-wastewater treatment plants.

3.3 Air

3.3.1 Characteristics of the Air Resource

Because the fluidity and the regenerative feature of the atmosphere resource, it is usually considered as an inexhaustible resource. This invisible resource, however, is one of the basic conditions on which people depend for existence.

In winter when it is the thickest (about 200 m) and the strongest the inversion layer is formed under the height of 200 m. This inversion layer is usually appeared in the early of evening, and its thickness is continuously increased. In the midnight, the inversion layer is usually extended to the earth’s surface. When the inversion layer is shifted downward and the temperature decreases, the earth’s surface and the discharged pollutants floating in the low altitude will be emerged in the inversion layer. In the morning, the temperature of the earth’s surface begins rising up, the inversion layer begins retreating from the earth’s surface and return to a high altitude.

The prevailing wind is from the south to the north in Shenyang (see Fig. 18). Because of influenced by the monsoon, along with the seasonal variation, the variation of wind direction is rather remarkable. In winter, the cold atmosphere from the north mainly influences it; the wind from north is
prevailing. In spring, because the warm atmosphere is beginning active, wind from the north and the south is usually appearing alternately, but the frequency of wind from the south is increasing remarkably. In summer, the warm atmosphere from the south mainly influences it, so that wind from the north and the south usually appeared alternately. The mean wind speed in Shenyang is 2.9-4.0 m/sec. The monitored value of wind speed in the city is 40% smaller than in the suburban region. In an altitude of 100 m, the mean wind speed of the atmosphere is 2.5 times larger than on the earth’s surface. The heights of most chimneys in Shenyang region are within such a range. The discharged pollutants within this height are situated in the inversion layer, so that the opportunity of these pollutants to mix with the rather clean atmosphere in high altitude is decreased. Therefore, the case of high sulfur dioxide concentration is appeared on the earth’s surface in each evening and morning.

3.3.2 The impacts of the Activity Sectors on the Air

At the same time in utilizing the atmosphere resource, the resources which are buried underground are also exploited and utilized, especially the combustion of the energy sources have exhausted large amount of oxygen and discharge large amount sulfur dioxide, carbon dioxide and other waste gases, so that the original ingredients of the atmosphere is changed. Therefore, it is resulted that the atmosphere resource destroyed by the human being themselves. The main atmosphere pollution sources of Shenyang are the combustion of fuels, tail gas from production process and motor vehicles and dust blown by the wind.

Urbanization has changed the land face, and changed the reflection and radiation properties, heat exchange and roughness of the earth’s surface, so that the physical properties of the atmosphere have been influenced. The unpermeable buildings and roads cover most of the earth’s surface. The dropdown rainwater is quickly discharged into the sewer, so that the water volume of the flood peak may be increased. The water vapor evaporated into the atmosphere is remarkably decreased, the evaporation ability of the city region has approaching two times the rainfall, because the air temperature of the city is rather high, the result is that the humidity of the city has drop down. Because the city has exhausted large amount energy sources, releases large amount heat, hence the air temperature of the city become far higher than the nearby suburban, so that a heat island is formed. Because the city has discharged large amount various kind gases and
particulate, the composition of the atmosphere is greatly changed, in which smoke and dust, hydrocarbon and polycyclic arena and other hazardous gases are increased. Such phenomena not only will rise up the atmosphere temperature, but also the visibility and sunshine in the city become bad. The industry, cars and domestic furnaces have continuously dissipated smoke and dust, they are suspended in the sky, so that the cloud, mist and rainfall in the city are increased, the air in the city become turbid, the visibility is decreased, the sunshine and the sun radiation are decreased. Because the clouds cover the sky, the sunshine rate may decrease to 58%. In the last ten years, there are a mean of 33.5 misted days in each year, and 61% of the misted days are occurred in winter. Because the air temperature in the city region is higher than in suburban, so that the polluted warm airstrip in the city region is risen up, then it is spread from the high altitude to the surrounding regions, and the rather fresh cool air in the suburban is blown to the city region from the low altitude, and a local circulation is formed. An atmospheric exchange between the city region and the suburban is strengthened, but to a certain extent a screen overspread is formed in the sky. Moreover, because the city is enlarged and high buildings are increased, the wind speed in the city is gradually slower, so that the air pollutants are not readily spread to a larger range. Especially when there is existed an inversion layer, the air pollution become more serious.

The environment monitoring network of Shenyang Environmental Protection Bureau is composed of 15 fixed monitoring points which are situated in the city region of Shenyang. The main monitored pollutants are sulfur dioxide (SO2), total suspended particle (TSP), nitrogen oxides (NOx) and carbon monoxide (CO). The level of the monitored pollutants has shown that the quality of environment from 1990 to 1996 has been improved to some degrees (See Table 16, Table 17, Fig. 19, Fig. 20).

### Table 16 Classification of the Comprehensive Index Number of the Atmosphere

<table>
<thead>
<tr>
<th>Classification</th>
<th>Clean</th>
<th>Light Polluted</th>
<th>Medium Polluted</th>
<th>Heavy Polluted</th>
<th>Serious Polluted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>&lt;0.6</td>
<td>0.6&lt;1</td>
<td>1~1.9</td>
<td>1.9~2.8</td>
<td>&gt;2.8</td>
</tr>
<tr>
<td>Pollution Level of</td>
<td>Clean</td>
<td>Quality Standard of</td>
<td>Warning Level</td>
<td>Alarm Level</td>
<td>Emergency Level</td>
</tr>
</tbody>
</table>

Shenyang Sustainable Cities Program
<table>
<thead>
<tr>
<th>Atmosphere</th>
<th>Atmosphere</th>
<th>Atmosphere</th>
<th>Atmosphere</th>
<th>Atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 17 Annual Report Forms on Continuous Monitoring of the Atmosphere of Shenyang Environment in 1996

<table>
<thead>
<tr>
<th>Unit</th>
<th>Daily Mean Value Exceeding Standard Rate at Point(%)</th>
<th>Annual Daily Mean Value</th>
<th>Warm-ing Period</th>
<th>Non-warming Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP mg/m3</td>
<td>Mean Value</td>
<td>Times of Exceeding standard</td>
<td>Mean Value</td>
<td>Exceeding Standard Rate</td>
</tr>
<tr>
<td>SO2 mg/m3</td>
<td>65.2 0.422</td>
<td>1.1</td>
<td>0.497</td>
<td>85.7</td>
</tr>
<tr>
<td>NOx mg/m3</td>
<td>25.9 0.108</td>
<td>0.8</td>
<td>0.153</td>
<td>36.8</td>
</tr>
<tr>
<td>Benz(A)pyre ug/m3</td>
<td>22.4 0.075</td>
<td>0.5</td>
<td>0.11</td>
<td>43.1</td>
</tr>
<tr>
<td>Lead ug/m3</td>
<td>54 16.3</td>
<td>34.8</td>
<td>92</td>
<td>10.2</td>
</tr>
<tr>
<td>CO mg/m3</td>
<td>5 1.53</td>
<td>3.6</td>
<td>1.55</td>
<td>5.63</td>
</tr>
<tr>
<td>Dust Fall t/km2. Month</td>
<td>98.2 24.2</td>
<td>29.91</td>
<td>99.4</td>
<td>20.63</td>
</tr>
<tr>
<td>Alkal Flake</td>
<td>65 1.36</td>
<td>2.2</td>
<td>99.4</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Note: The warming period is from Nov. to March; the adopted Standard is GB 3094-1996 Second Class Standard; The dust fall has adopted provincial Shenyang Sustainable Cities Program
The heating of inhabitant has mainly adopted coal as the fuel. The high peak period of heating for the inhabitant is conform to the period of low wind speed and strong temperature inversion. Moreover, the heating time of the inhabitant is 18:00-20:00 and 6:00-9:00 each day. In this period of time, it is just right that the inversion layer is formed on the earth’s surface at nightfall and the inversion layer is still not retreat back in the morning. The pollutants formed in this period of time are the most readily covered by the inversion layer.

The heavy industry of Shenyang is technically backward, the energy consumption is very large, and there is no control system for gas discharge. These enterprises (wholly or to a great extend) are depending upon coal as the energy source. The coal produced at the local mines, which is used by these enterprises and the municipal administrative installations, has very high sulfur content. Inadequate combustion resulting also on the produced SO2 and particulates further which are discharged into the atmosphere. Because the enterprises which discharging large amount pollutants into the atmosphere (such as Shenyang Smelting Plant and Cooking & Coal Gas Plant) are located at the center of city region and technically backward, so that a heavy polluted belt is formed on a rather large area in the center of the city region. Some small factories are also distributed in the city region. The main heat source of these enterprises was formed in a small-type heating boiler, and the most of these boilers have low energy utilization rate and lack in tail gas controlling installations. The used volume of natural gas and fuel oil is very small, and the height of chimneys generally is only 10-40 m, so that their discharged matter may directly entering into the new built higher building in their surrounding region.

The quantity of automobiles in Shenyang is continuously increased in recent years. There are about 200,000 cars, trucks and passenger buses in Shenyang. Few of these vehicles are equipped with tail gas control equipment. Moreover, the management standard of tail gas of the motorized vehicles set by the State is very low. Even though the standards are not executed efficiently. The continuous increase of this kind of atmosphere pollution source is estimated contributing 10% to the total pollution in Shenyang. Moreover, the flow of automobiles at nightfall and in the morning is also the largest.
3.3.4 Competing interests between the Activity Sectors in using the Air

Because air pollution (especially high concentration SO2 pollution) has extensively and protracted nature, the historical and cultural buildings of Shenyang may be possibly damaged. The problem of acid atmospheric condition and the falling down of particulate that may cause damage to the building surface has not been studied. Compared with the city region, the environmental condition in the countryside and the periphery regions are in many aspects better. Along with increasing the distance with pollutant sources, the problem of the falling down of atmospheric pollutants is somewhat decreased. Along the direction of the main wind, the fall down passage is limited within a zone of the South-North direction. So, in most of the western parts of Shenyang, the possibility of atmospheric pollution is smaller than in the city region.

3.3.5 Specific management arrangements to deal with the conflict over the Air

Shenyang Environment Monitoring Center is subordinated to Shenyang Environment Protection Bureau. It is responsible in monitoring the atmosphere and environment quality situation of the whole city, to circulate a notice on the atmospheric and environmental quality situation of the whole city periodically. Shenyang Environment Protection Bureau is responsible in supervising and managing the behavior of discharging pollutants to the atmosphere in the whole city. Shenyang Meteorological Bureau is responsible in predicting and forecasting the meteorological and climatic information of the whole city.

3.4 Land

3.4.1 Characteristics of the Land

The land used by industry and inhabitants is roughly equal (See Fig.21), the land used for traffic and transportation, public installations and various purposes has occupied more than 10% of the land area of the city region, respectively.
3.4.2 The use Activity Sectors make of the Urban Land

The land in the city is very important for the sustainable development. Land may be used to eliminate the poor, solve the problem of inhabitants’ residence, public medical treatment, social services and so on. It also may be used to provide park, open space, water supply and drainage, disposal of solid wastes and other environmental basic installations; it may be used for recreation, amusement, marketing, traffic and other installations for reflecting the quality of people’s life as well.

The situation of land utilization in Shenyang may be summarized into two aspects. One aspect is, the land resources have been basically utilized, and have formed a basic pattern which roughly adapts the nature, the land utilization rate in eastern part was intensified, and in western & northern part (Liaozhong, Xinmin, Kangping, Faku) now the land utilization degree is being strengthened. The other aspect is, because in recent years the population is rapidly increased, the land development degree is improved continuously, so that the load of the land is greater day by day.

Because the city has a large population, the land used for residence, public installation, traffic, plating trees and flowers becomes very inadequate, especially because the distribution of District’s and Street’s enterprises are dissipated, the use of land in the city becomes more demanded. The area of the used land is increased, but the land resources suitable for agricultural cultivation are limited, hence, the phenomena of occupied cultivated land become more frequently, and the most occupied cultivated land is the more fertile land located near the inhabitants’ resident points.

Along with the increasing population, the constructed district will be developed from 189 km2 today to 300 km2 in 2010, and may reach 440 km2 after 2050. The per capita utilized land area will be developed from 56 m2 to 80 - 100 m2.
Nowadays, Shenyang Municipal Government has already put forward the layout for extending the city’s space. The key point of city construction will be shifted from the central city to the secondary and the satellite town step by step. The central region construction will be transformed from “extending from inside to outside” to regulate the structure of layout, from single-center transit to multi-center and developing actively far suburban city and township, then to a structure of regional city colony, so that a dissipation type layout structure of “One center city region, two independent secondary cities, six satellite cities, fifty small townships” will be formed step by step, and the function of the city will be transformed from industry-leading type to multi-functional benefit type.

3.4.3 The impacts of Activity Sectors on the Urban Land

Owing to the development of urbanization, the demand on the city’s land is rapidly increased. Urbanization has changed the compositions and properties of the pads. Brick and stone, glass, metals, cement, bitumen and other materials are used for artificial ground surface instead of replacing grassland, forest, soil and other natural ground surface, so that the land in the city has lost its original ecological adjusting function. Moreover, the digging of sand and soil, the stacking of garbage and backfill in the city and its surroundings have resulted that at the same time of utilization, the land resources of the city themselves are also polluted.

The part combining the city with the countryside may be roughly pointed out at the broad regions located between Sanhuanlu (Third Surrounding Road) and Erhuanlu (Second Surrounding Road). It is an extending of the constructed district of the city, a mutual-complementing belt of the function of city and countryside. Here is the mixed residing place of the peasants, inhabitants and persons from outside. The place where is the extending of the constructed district of the city is a region where the basic installations of the city are uncompleted, the management is in confusion, the administering and the sanitary of the environment are bad. Here there is almost no concentrated heating supply and gas supply. Most of the people have to adopt native heating radiator and small coal furnace when preparing food. Because the discharge altitude of these devices is low, hence, the air pollution is serious. Because the popularity of coal gas piping network is low, sewage is directly discharged into environment, and the distribution of road and railroad is concentrated, there are many large-type trucks in operation, there are much noise from the
factory and the construction site as well. Therefore, noise pollution is rather serious. Moreover, because the alternate distribution of inhabitant zone, industrial zone, railway, road and goods yard, the problem of noise is very serious. The part combining the city with the countryside is a disposal region of garbage. Not only this will occupy large area of land, but also will result in secondary pollution, thus it may continuously nibbling the isolating belt which is planted with trees as the ecological environment of the city.

3.4.4 Specific management arrangements of the Urban Land
Based on “Shenyang Overall Plan”, Shenyang Land Planning Bureau is responsible for examining, approving as well as supervising and inspecting the used land in the whole city. The Planning Design Institute and the Reconnaissance & Mapping Research Institute which are subordinated to it are responsible for supplying technical support to its work.

3.5 Landscape and Ecological Resources

3.5.1 Characteristics of Cultural and Resources of Historical Heritage
Shenyang, which used to be the capital of Qing Dynasty is a long-standing historical and cultural ancient city, possessed with rich cultural relics and historical sites. It is a city that is developed by undergoing feudal rule, separatist warlord regimes and occupation by Japanese and puppet regimes. The buildings built in each phase have various peculiarities. In 1986, Shenyang was arranged as a state-grade historical and cultural famous city by the state. There are 172 protected cultural relic units within the range of the city region. The main historical sites are ancient relics, ancient graves, beacon towers, relics of ancient city, ancient buildings and so on, in which the protected cultural relic units above the municipal grade amounted 60 sites (See Fig. 19).

The open space in the city region of Shenyang includes park, street, square, water system around the city, shelter forest of the city and so on. The city region now has all kinds of trees 3,38 million plants and lawn 3,17 million m2. It is benefit for protecting the environment, clarifying the air, beautifying the environment and promoting the healthy of the inhabitants.
3.5.2 The use Activity Sectors make of Landscape and Ecological Resources

Not only have the cultural relics and historical sites of Shenyang reflected the history and culture of Shenyang, but also they are an important constitution of the culture of Chinese nationality. Except that the Imperial Palace, Fuling tomb, Zhaoling tomb, Xinle and Zhenjiawazi relic have considerable historical value for studying history and architectural techniques, they are also well-known at home and abroad, so they are attracting numerous tourists from home to abroad and have considerable tourism value. Besides this, these cultural relics not only beautify the city, but also increase the well-known degree of Shenyang.

The most significant function of forest is that carries out circulation of matters and energy flowing as a lever in the system. It is the producer of the ecological system. Because of the destruction left before, basically, now they are still in a protected situation, other than being used. They not only act as ecological and natural landscape, but also become famous scenic spots for recreation and tourism for the city inhabitants.

3.5.3 The impacts of the Activity Sectors on the Cultural and Historical Heritage

Along with the speeding up of urbanization process, the construction of new buildings, the paving of roads, the fast development of industry, the concentrated buildings and the crisscrossed streets, the original forest and vegetation has been destroyed. The existed vegetation is also influenced by environment pollution. Owing to the air pollution (especially owing to some poisonous gases formed by industrial pollution), the non-seasonal fallen leaves and phenomena of dead twigs in trees within the city region are occurred commonly. At the same time, owing to the lowering of the water level, the growth of leaves is commonly slow and not luxuriantly. Even outside the city region, because of the long-term unreasonable economic actions, the urbanization has seriously destroyed the biological environment.

The development of city has formed a pressure on the humanities and historical heritage. The old city region will be reformed. Although the cultural relics themselves resulted in no direct influence to the surroundings, however, the result of the buildings built surrounding the cultural relics plus the original humanities and historical heritage are very uncoordinated.

From now to the future, Shenyang is the political, economic and
cultural center of Liaoning Province. It has a significant historical and cultural characteristics and riches in humanistic and tourist resources. It is a window of the Northeast region to carry out international come and go.

Owing to the pressure coming from the increasing population, the industrial development and the urgent pursuit of the modern city, we go into the large-scale development. The city construction has greatly changed the scene of the city, but at the same time it has also nibbled the surrounding forest, land and rivers. Owing to the development of modern science and technology, but also attributed the success to the continuously renewed building materials and ever-growing construction technology, we increasingly cast off the natural constraints. The scene of city approaches mutually day by day in the dust from the demolition of old streets and the mixing of concrete, popularity also becomes a living principle. The new construction technology, installations and materials make us excited all day. The skyscrapers, overpasses, curtain walls, neon lamps and so on are completely copied as an important symbol of Modern City. However, the traditional architectural culture is simplified or poured into plaster decoration and sculpture embellishing the cities, so that the individuality of the city is weakened and seems more like merchant chains, and wherever you go, you will have a similar sense. Traditional and natural individualities have been replaced by popular and modern individualities, and the original distinguishing features of the city have been lost unconsciously.

3.5.4 Specific management arrangements of Landscape and Ecology

Shenyang Forestry Bureau is responsible for protecting the forest, natural vegetation, wild animals and special ecological resources outside the city region. Shenyang Culture Bureau is responsible for the maintenance and management of historical heritage and cultural relics in the whole city. Shenyang Tourism Bureau is mainly responsible for the exploitation of the tourist resources.
3.6 Air Pollution

3.6.1 The Features of Air Pollution

Coal burning and the air pollution mainly cause the air pollution in Shenyang from Total Suspended Particles (TSP); falling-dust and sulfur dioxide (SO₂) are very serious. The daily, quarterly and annually monitoring data for the pollutants all surpass the relevant national standards several times, the average surpassing time is over 80 per cent. Compared with other big cities, such as Beijing, the pollution is more serious in Shenyang. In item of time-distribution, during the heating season in the winter, the pollution is the most serious, which make the residents live in the smog atmosphere. Compared the data of heating season with that of the non-heating season, the TSP is about 2 times of that of non-heating seasons, the surpassing time for SO₂ is 6-10, falling-dust is 1.5-2, and the pollution are the most serious in the mornings and evenings during the heating season. In term of the space-distribution, affected by the heating-island function, at the downtown area, the pollution is the most serious. If we take a look at the function areas, the pollution level in the traffic area is the most serious, the industrial and the residential area is in the middle, and the couture area is the lightest. Regard to the SO₂ pollution, the polluted area covers 16 square kilometers and the smealtary is the pollution center.

Table 18. Metropolitan Air Quality in North Part of China (in 1992)

<table>
<thead>
<tr>
<th></th>
<th>TSP mg/m³</th>
<th>SO₂ mg/m³</th>
<th>Fall Ton/month</th>
<th>Dust Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>0.034</td>
<td>0.117</td>
<td>17.71</td>
<td></td>
</tr>
<tr>
<td>Tianjing</td>
<td>0.269</td>
<td>0.199</td>
<td>14.25</td>
<td></td>
</tr>
<tr>
<td>Harbin</td>
<td>0.345</td>
<td>0.029</td>
<td>37.38</td>
<td></td>
</tr>
<tr>
<td>Changcun</td>
<td>0.312</td>
<td>0.016</td>
<td>44.67</td>
<td></td>
</tr>
<tr>
<td>Dalian</td>
<td>0.134</td>
<td>0.079</td>
<td>23.22</td>
<td></td>
</tr>
<tr>
<td>Main value of the</td>
<td>0.280</td>
<td>0.097</td>
<td>27.45</td>
<td></td>
</tr>
</tbody>
</table>
### 3.6.2 The risk of air pollution to the human health

The tumor-prevention office (under the Public Health Bureau) discovered the trend that the incidence of cancer is increasing (especially lung cancer). The cancer disease has close relationship with the environmental condition and the professional exposure. The research for lung cancer shows that the incidence of this disease is higher in the urban area of Shenyang, with the incidence of 27.08 persons per million people, and the incidence among the people who work in the areas with the higher concentration of TSP are much higher. For example, the incidence in the industrial area is higher than other areas, and the incidence in the urban area is higher than countryside. For this disease, the incidence for smoking group is higher 5 times than non-smoking groups. Also, this disease has relationship with air pollution. In 1979, lung cancer prevention monitoring net was established, and 333,000 residents have been examined through this net. As the establishment of the academy of environmental medicine, the research for the relationship between professional disease and the environmental pollution will be further improved.

The statistics for the children in two kindgarden (with 49 children, most of them from Tiexi District, the age of 3-6 years old) show that the concentrations of lead in the bloods and the organs of the children are higher than the controlled group, and some children have some symptom for lead poisoning.

The cardiovascular system diseases have relationship with the life style and the environmental pollution. Since 1983, the incidence of high blood pressure is increased continually. The main causes for high blood pressure are smoking, alcohol drinking, fat, salt over taking, environmental noise and air pollution. In fact, high blood pressure is the major cause for cardiovascular system diseases and cerebral diseases.

In Shenyang, most of the facilities for removal of smoke and dust are

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**Shenyang Environmental Profile-1997**

<table>
<thead>
<tr>
<th>above five city</th>
<th>0.414</th>
<th>0.140</th>
<th>32.29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shenyang</td>
<td>0.3</td>
<td>0.060</td>
<td>8</td>
</tr>
<tr>
<td>The second class of National Air Quality Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
the dust remover with only signal –tube, which only have effects on the
bigger particles, so the TSP and the falling dust are stilling at the certain
level in the air of Shenyang, but 70 per cent of the dust in the air are
inhaling particles (IP). However, according to the national standards, the
rate for IP and TSP is 1:2, further, the flying dust mainly contain some
heavy metal and aromatic polycyclic hydrocarbon which are very
dangerous to human health.

Furthermore, the poisons sticking to the particles whose size is smaller
than 3 µm which stay in the air for longer period and can enter human
respiratory system even pulmonary alveolus easily. So, it is a severe
potential threat to human health. According to the statistics, the incidence
of lung cancer is 65 persons per 100,000 people, and in 1990, the
mortality for lung cancer is 44.1 person per 100,000 people.

3.6.3 The causes for the air pollution

The energy consumption structure of coal burning formulates air
pollution of coal-smoke. The main reasons for the pollution are following:
71 per cent of the energy resource being coal, lacking of pre-treatment of
c coal, most of the coal being burned directly, the concentration of dust and
sulfur being high, most of the burning facilities belonging to small or
middle style, the burning means being out-of –date, lacking of the facilities
of surfer removal, discharging at low level space. All of these make
contribution to the mass discharge of dust and sulfide during the burning
process and make the air pollution more serious. It is very difficult to
change the major energy structure from coal to other resources within short
period. As the urbanization is increasing, if there are no completely change
of burning technology and energy substitute, the air pollution threat is
hardly reduced.

In addition, the meteorological condition also make the pollution
distribution more difficult, and the fast increase of motor vehicle, city
storm and secondary flying dust make the pollution more serious.

3 6 4 The Existing Administration mechanism

The SEPB takes responsibility for the unit monitoring and
administration for the pollutant discharged to the air in Shenyang. The
SEPB is allows in charge of review and approval for polluted projects of new, innovation and expending. SEPB is an administration department to promote enterprises conduct pollution control measures, and to prevent air pollution comprehensively.

3.7 Water Pollution

3.7.1 The features of water pollution
Shenyang sector of Hunhe is the main river in urban area. The major water pollutants are organic matters. The water field of Hunhe and its branch as well as the entertainment parts does not meet the requirement of their function of water body. Water field situations are confused. The main items surpassing the standards of surface water are COD, Oil, phonic materials, N-NH4 etc, metal surpassing standards only seldom appear at a few monitoring sectors.

Underground is a major drinking water source. Some 60 percent of the underground sources come from Shenyang sector of Hunhe. The supply of river water cause underground pollution and the major pollution are organic materials. More than 50 percent of the urban drinking water sources are polluted in different degree and do not meet the drinking water standards.

3.7.2 Water pollution risk to human health
There are no researches directly showing the direct relationship between water pollution and human health in Shenyang, but some diseases, which have close relationship with drinking poor quality water, may have relationship with water pollution. According to the statistics from public health departments in 1990, the morality of four sorts of alimentary canal cancer is 55.4 person per 100 thousand people, and it was estimated that the high morality related to water pollution.

A investigation to the treats of industrial waste water among the residents living in east countryside show that the rice field polluted at middle degree by the polluted water irrigation net in eastern Shenyang and the Cd content of local residents have surpassed the degree of control group. Now, those polluted lands were used as industrial land and established Zhangshi.
Economic development zone on the land. Furthermore, the government takes measures to thoroughly inspect the wastewater containing heavy metal pollutants from Shenyang Smaltary.

3.7.3 The reason for water pollution
120,000 tone organic pollutants were discharged in to Hunhe from Shenyang annually and Fushun, another upper Reach City, also dumped a large amount of pollutants into the river. Additionally, there is no enough water to dilute and to self-clean the Hunhe river because of saving water at the upper reach Dahuofang reservoir. All of these make Hunhe become sewage of two cities, and the water environmental quality of the Shenyang sector of Hunhe surpassed the 5th class national standards for surface water.

The wastewater is not treatment and disposed efficiently, there are 526 refuse dumps around the city, the total space are 2,710,000 square kilometers. And 175 dumps scatter along the river of Hunhe, Puhe, southern canal, Xihe and the space are 810,000 square kilometers, accounting for 29 percent of the dumping space. Extract sand and soils as well as casual refill the caves furtherly make the water pollution more serious.

3.7.4 The Administration Mechanism for Water pollution control
The SEPB takes responsibility for the unit monitoring and administration for the pollutant discharged to the water body in Shenyang. The SEPB is also in charge of review and approval for pollution projects of new, innovation and expending. SEPB is an administration department to promote enterprises conduct pollution control measures, and to control water pollution comprehensively.

3.8 Flood
3.8.1 Characteristics of Flooding
The main reasons of the formed flood are the rain volume in the flood season is large and concentrated, forming rather large runoff, the texture of soil is rather sticky, the groundwater level in the flood season uprising or the water retaining ability of the soil is bad. Moreover, because the
variation of raining year by year and not evenly distributed, the reservoir in the upstream has retained the water for its aim, so that the adjusting ability of the reservoir has been weakened.

3.8.2 Impact of Flooding on the Activity Sectors

It was recorded in our city's history, 81 times flood which resulted serious disaster was occurred in the past 800 years. For example, serious flood has been occurred in the years 1949, 1951, 1953, 1995. In big flood of 1949, 20,773 ha land was submerged. The big flood in 1951 has submerged 16,300 ha land, the flow has reached 11,700 cu m/s, and some railways were collapsed. The flow of flood in 1953 had reached 14,200 cu m/s; the flood had result big losses on the bridges and railways. The flood in 1973 had killed 4 persons, so that the agricultural yield of that year was decreased 46%.

The Hunhe River was flooding in 1949, 1952, 1953, 1954, 1960, 1964 and 1995. When each time flooding occurred, it had submerged large area crop fields. When Raoyanghe River had flooded in 1963, many civil houses were collapsed, the victims of the disaster had reached 110,000 persons and 40,666 ha crop field was submerged. Since 1890, the downstream of Liuhe River were flooded 21 times; each time of flooding had changed its flow way. Since 1903, it had flooded 17 times. These floods had submerged crop fields and collapsed railways. The Puhe River was flooded in 1951, 1953, 1964, 1974, 1975 and 1995; each time of flooding had result serious losses on the crops and economy. The flood in 1995 had influenced roads, railways, bridges and houses within a large range, the harvest of 93,333 ha crop fields was wholly lost.

3.8.3 The influence of the Activity Sectors on Flooding

Owing to that in recent years the exploitation of sand was missed in balance, i.e. the annual exploitation was 3-3.5 million cu m, the annual deposited sand was 1.2 million cu m, the river course had been seriously undercut, so that the groundwater level was fall down. So, the variation of river course was intensified. Moreover, the unplanned and unruly digging and construction plus the jumbling of garbage, furnace slag and remnants of soil all have forced the main flow to change its direction, and the buffer zone area of flood is decreased.

According to the "Shenyang Overall Plan", there are 76 sq. km of the Hunhe River's left bank brought into the new planning area of Shenyang.
Hunhe River will become an inner river of Shenyang. However, the dykes of today have not attained the standard for preventing flood that occurred once in every 5 years. There is an urgent need for constructing new dykes, for the protection of economic construction on the left bank.

### 3.8.4 Conflicts between the Activity Sectors over the Flooding

The Hunhe River is the main river in the city region of Shenyang that need for flood prevention. In the upstream, there is Dahuofang reservoir. It has a water volume of 2100 million cu m, and has rather strengthened flood prevention installations. Because the basin of Hunhe River has a shortage of water sources and the distribution of empty time is not evenly, excessive retaining water will on the contrary form a great menace on Shenyang City which located on its downstream. The flood prevention standard on the two banks of Hunhe River is rather low. In the Right Bank, there is only a standard that is suitable for flood prevention occurred in every 30-50 years. Now the dykes are in broadening and strengthening, and the river course is in broadening, so that it may reach a standard which is suitable for flood prevention occurred in every 300 years. There is no dyke on the left bank. Along with the development of the city to the south, now it is under construction the standard of dykes, which is suitable for flood prevention occurred in more than 100 years.

### 3.8.5 Existing Managerial arrangements

Shenyang Water Conservancy Bureau is responsible for the flood prevention work in the whole city. It has right to organize the manpower of the whole city in carrying out maintenance of the river course, dykes and strengthening the large- and medium-type rivers and reservoirs for insurance.
Chapter 4 Management Mechanism

If we will realize a sustainable development, it is essential to bring the sustainable development into the important order of the day. Directed against the existing problems today, it is essential to reform our management mechanism which is unsuitable to the requirement of sustainable development, proceeding from an angle of economy, social, environment and resources, a management operation mechanism for making a common effect for the sustainable development should be established by the adequately participation of the government, public organization and the broad residents of the city.

4.1 Key Stakeholders

In Shenyang region, people have different understanding on who are the stakeholders of environmental issues. The viewpoint of individuals or organizations who are in charge of environment management and the viewpoint of the individuals or organizations who have direct influences to the environmental conditions as well as the viewpoint of the individuals or organizations which suffered from the influences of environmental quality are not the same. Generally, there three sectors existing in the society, they are public sector, popular sector, and private sector. Among those public sector is considered as the key stakeholders and the other two sectors are somewhat related to the government.
Shenyang Environmental Profile-1997

Fig.23 Various levels of the public sectors

Note order

Shenyang Sustainable Cities Program
Fig. 24 Environmental Protection Institutions in China
4.1.1 The Public Sector

In China, the organizational structure of the political power is highly centralized with proper decentralization. The local government is consisted of four levels. The actual situation of Shenyang is shown as Figure 20.

Central Government

The National People’s Congress is the highest legislation body of China. It is responsible to draw up laws, supervising the execution, examining and approving the items that have great influences on the environment. The State Council that is the highest administrative body of China may draws up laws and regulations concerning environment protection, and supplies the implementing detailed regulations of the related laws. The State Council is also responsible in drawing up the precedent fields of the sustainable development and the policies. These fields and policies have legal effect, implemented and executed by government departments of different levels. For the sake of coordinating the work on environment of the departments and other organization and body, the State Council has founded an environment protection commission which stride over the departments and the commissions, to examine the development policies and plans, to coordinate environment protection with the management of natural resources, and to determine important policy problems. Many functions of the Commission have been given to its executive body -- the Environment Protection Bureau of the State. The central government agencies related to the environmental protection are:

The Environment Protection Bureau of the State: To draft laws and regulations on environment protection; to release the administrative rules and standard for environment protection; to supervise the prevention, harnessing and control of pollution; to investigate significant pollution events, and make responds; to prepare environmental monitoring statistics and report on situation of environmental quality; to organize studies on environmental science; to evaluate, demonstrate and spread key new techniques; to carry out education and training on environment and to raise the consciousness of the public on environment; to carry out international exchange on environment.

Planning Commission of the State: to draw up the development plan of national economy and social, to supervise the implementation by the Central and local governments, and to draft the corresponding laws and
regulations.
Science & Technology Commission of the State: Responsible in drawing up the development of Science & Technology; policies and laws, to screen and put into effect the key scientific & technological items of the State, to coordinate the work in science & technology of the provincial and local government.
China Management Center of the 21st century agenda (ACCA21): It is a standing body jointly founded by the Science & Technology Commission of the State and the Planning Commission of the State for coordinating “China’s 21st Century agenda” and the sustainable development.
Ministry of Construction of the State: It has widely responsibility to the people, including city planning, management of the city’s basic installations, water supply & discharge, environmental sanitary and garbage of the city, and the management of the city’s traffic, heating and gas supply, efficiency of the energy sources, substitutive energy and to reduce disasters.
The Economic & Trade Commission of the State, Education Commission of the State, Ministry of Hygiene of the State, Ministry of Finance of the State, Ministry of Geology & Mining Products of the State, Ministry of Public Security of the State, Ministry of Traffic of the State, Ministry of Agriculture of the State, Ministry of Water Conservancy of the State, Ministry of Electric Power of the State, the People’s Bank of China as well as Ministry of Coal Industry, Ministry of Chemical Industry, Ministry of Metallurgy, Ministry of Traffic, Ministry of Machinery, Corporation of the Ministry of Weaponry Industry and other Ministries are responsible within their duties to carry out the related works in the range of the whole country.

Provincial Government
The Provincial People’s Congress is the legislation body of the whole province. It is responsible to draw up the local laws, to supervise & to implement and to examine & to approve the items that have rather large environmental influences. The Provincial Government as the highest administrative body in the province may draw up the regulations related with local environment protection, implemented and executed by the departments of the municipal government. For the sake of the work on environment of the departments and other organizations & bodies, the Provincial Government has founded an Environment Protection
Commission which stride over the departments, to coordinate the environment protection and management of natural resources as well as to determine the rather significant policy problems. The provincial government agencies related to the environmental protection are:

The Provincial Environmental Protection Bureau; the Provincial Planning Commission; the Provincial Commission for Science & Technology; the Provincial Department of Construction; The Provincial Commission for Economy & Trade, Provincial Commission for Education, Provincial Department of Hygiene, Provincial Department of Finance, Provincial Department of Geology & Mining Products, Provincial Department of Public Security, Provincial Bureau of Traffic, Provincial Department of Agriculture, Provincial Department of Water Conservancy, Provincial Management Bureau of electric industry, the Northeast Coal General Corporation, Bureau of Chemical Industry, Bureau of Metallurgy, Shenyang Bureau of Railway and other departments are responsible within their duty in the range of the whole Province to carry out the related works.

**Municipal (Shenyang) Government**

The Municipal People’s Congress which is composed of the representatives elected by various circles of the social has the legislation right on the local laws and regulations, but it is essentially to be complemented after approved by the Provincial People’s Congress. Because the size of Shenyang is rather large and the importance of its economy, the Government of Shenyang (the highest administrative body of Shenyang region) has enjoyed some rights which are equal to the Provincial Government. Several vice-mayors help the Mayor. They are responsible in the planning of the whole city and finance, the development of science & technology and the social, construction in the cities and the townships, development of industry and agriculture, commerce & trade as well as the civil administration affairs, etc. Under the Mayor there are the related Commissions, Offices, Bureaus; each Commission, Office, Bureau is geared to the corresponding departments of the State and Province (See Fig. 15). Under the Municipal Government there are the corresponding governments of the districts, counties, specifically to manage the affairs of the districts, counties. In the governments of each district, counties there are set up the corresponding Bureaus, which are geared to the functional department in the Municipal Government. The each Commission, Office, Bureau in the Municipal Government are geared to them, to carry out the
leading. The municipal government agencies related to the environmental protection are:

The Shenyang Environment Protection Bureau, the main bodies in the city to complement the laws and regulations of environment protection.

The Municipal Commission for Construction, which is responsible with the full powers to manage and to coordinate the work of the city construction.

The Municipal Planning Commission: To draw up the economic and social development planning of the whole city, and to supervise the implementation situation.

The Municipal Commission for Economy & Trade: To organize the complementation of each economic planning and economic coordination, and to coordinate the related problems in the implementation of planning.

The Municipal Commission for Science & Technology: It is a body of the Shenyang Municipal Government to manage to work of scientific research in the range of the whole city, and make a leading to coordinate the affairs of 21st century agenda of the whole city.

The Municipal Bureau for City Construction: Responsible to organize and to implement the construction, maintenance and management of roads, water discharge piping, park and the planting of tree & flowers in the whole city.

The Municipal Bureau for House Property: To manage the house properties of the whole city, under it there is set up the heating supply corporation, which is responsible the heating supply in the heating period of the whole city.

The Municipal Bureau for Traffic: Responsible in full powers the management of road conditions in the range of the whole city and the work of traffic & transportation, including passenger transportation, freight, the maintenance and inspection of the motorized vehicles.

The Municipal Bureau for Land Planning & Management: To draw up the overall planning of the whole city, to examine, to approve and to manage the work of site selection and point determining of land used for various construction items. Under it are set up the City Planning & Design Institute and the Survey Institute.

The Municipal Bureau for Hygiene: A management body which is responsible in handling medical treatment, epidemic prevention and other common health problem and the daily operation, responsible in collecting various information on diseases which are correlated with the environment,
and set up a plan for long term aim.

The Municipal Bureau for Public Security: Unitedly to manage the social security of the whole city, is responsible to manage the noise, traffic and dangerous substances in the social.

The Municipal Tap Water General Corporation: Is mainly responsible in the production and supply of tap water for the whole city.

The Municipal Gas General Corporation: Is mainly responsible in the production and supply of gas for the whole city.

The Municipal Bureau for Architectural Engineering: To manage the architectural industry, to guarantee the quality of architectural construction.

The Municipal Bureau for Industry & Commerce: Is a comprehensive economic management department of the Government.

The Municipal Bureau for Commerce: Is a functional department to manage commercial work of the municipal government.

The Municipal Bureau for Water Conservancy: Is responsible the work of water conservancy projects, irrigation and flood prevention & draining of flooded fields of the whole city.

The Municipal Bureau for Statistics: To sort out all-round the statistical resources of the national economy, to supply data basis and information for drawing up the economic policy and working out planning.

4.1.2 The Popular Sector

Despite the participation of the privately owned department, social & regional and the non-governmental organizations are considered as a indispensable of the sustainable development, but until today the public organization in Shenyang is considerable less, and still has a considerable governmental flavor.

The Municipal Women Federation: Is a public organization responsible in the women problem.

The Municipal Federation of Trade Unions: Is responsible in the macroscopic management of trade union organizations of the whole city.

The Municipal Association for Science & Technology: Is an organization for the exchange of scientific & technological information, which is formed by members of science and technology of the whole city.

The Municipal Institute for Environmental Science: Is an organization for the exchange of scientific & technological information participated by the personnel who undergoing work in environment protection.

The Municipal Consultative Committee for Environmental Protection:
4.1.3 The Private Sector
Because the long-term enforcement in planned economy, in a very long period of time there is almost no private organization in Shenyang. Only in recent years, along with the implementation of the reforming and opening policy has appeared only a small number spontaneously non-governmental organizations, such as the Municipal Association of Consumer, Association for Protection of Wild Animals.

4.2 Urban Management Structures & Functions
With the practice of the past several decades, Shenyang has established a city managerial system, which clearly states the responsibilities of relevant agencies. The existing environmental management system has contributed a lot to the protection of environment and resources. But at the same time, it has some shortcomings that need to overcome. There is a long way to go to solve the conflicts between environment and resources. More efforts need to be made to solve the prioritized environmental issues.

4.2.1 Information and Expertise
Information and expertise are very important for the purpose of solving prioritized environmental problems through their collection, transfer, and processing to reflect and take all aspects into consideration to reach effective policy-making, control and management of prioritized environmental problems. They are the key channels of connecting all stakeholders. Management cannot be separated from control; control can not be separated from information and expertise. Information is the foundation for control land management. It is a “nerve system”, through which the laws, regulations, duties and requirements of the central government can be transmitted and carried out by local government at different levels. And local government will get new information during their actual implementation, which will be feedback to central government for new policy-making. Local government at different levels has to finish their jobs by carrying out policies, regulations and duties through cross-sectoral information and expertise exchange, cooperation and coordination. It is quite sure that few things can be done without information transfer.
Shenyang Environmental Profile-1997

For clarifying and solving the environmental and resource problems faced by Shenyang, the statistic data issued by Shenyang Statistic Bureau annually about environmental resources and population can be used to determine the main tendency influencing the environmental conditions. Shenyang Environmental Monitoring Center, which is under the leadership of SEPB, is in charge of monitoring the air, water, noise and solid waste environmental quality of the city. All main polluters monitor the pollutants they discharge to the environment themselves. At the same time, environmental protection laws and regulations stipulate that all pollutant discharging constructive projects must get permit before construction, and be checked and accepted after construction. If any change occurs, report should be made to the local authority. Shenyang has already had considerable quantity environmental data. These data is already adequate for clarifying some problems which are related with human health, to determine the main pollution sources and to draw up the related policies for reducing environmental pollution level these data are indispensable. But the information of menace of organic substances, the exposure conditions of the crowd and the biological resources are not enough for carrying out evaluation on the quantitative risk. If the evaluation of environmental risk should be an important part of the Sustainable Shenyang, it is necessary to measure these parameters. Statistics, sampling design, relation of time and space and relevant training in correlated field are very important to the success of project. Enriching the information base for the implementation of efficient urban environment management is essential.

Along with the further proceeding of the item, the collecting and reporting work concerning environmental data should be improved. The two problems merits attention is the quality of the data and the representatives. The data quality and the precision of the method for obtaining the data are related with the precision. In the aspect of representatively, to counting up and illustrating the variable of the space and the time may improve the quality of the data qualitatively and quantitatively (in other words, the data in that time and in that local whether or not typical).

It is probably that the considered most important problems in the future should be the ways for getting the data (that problems should be solved in the management circle). The sustainable development of Shenyang should all the correlated people who are interesting on the environment for knowing the environmental information of today. The collected
environmental information by each office should be periodically submits to the office of the item. Each work team should conditionally obtain the resources related with environment, the utilization mode, the health problem and the precise information, which documents are needed for collection, when to collect, how is the frequency, how to report the information, the solving of all these problems should be considered precedence.

The specific steps for obtaining the other environmental data are as follows:

1) To classify all the environmental data, so that they can readily be obtained -- these data may be obtained through different retrieval ways, such as the medium (water, gas, soil, and living things), the subject (human health, ecological resources), the sites, the time and the storing sites. The traditional method for classifying and reporting the data may also enable that the data are readily to be obtained. The main classification is as follows:

- Toxic in the air
- Dangerous chemicals
- Insecticides
- Industrial solid wastes
- Municipal administration solid wastes
- Danger of occupation
- Biological danger
- Statistics of human health

2) To carry out simple and clear stating on the environment problem which correlated with the data.

3) Aimed at the environment problem, to evaluate the quality of the existing data.

4) To determine the new data which should be precedentely obtained.

The important work on the item of sustainable development of Shenyang is to reform the various kind management works and their interaction. To improve in obtaining the data and the level of information exchange, it is required that the interaction between technical personnel and the administrative personnel should more perfects. Between the Bureau for Statistics, Bureau for Hygiene and Bureau for Environment Protection and the other departments should frequently carrying out technical exchanges. If the other organizations have some help on the item for sustainable development of Shenyang, these organs should also obtain the related
4.2.2 Policy Formulation

In the factors which influence the administration (management) mechanism and its operation, the right or not of the drawn out policies have decisive significance on the implementation result of the sustainable development. Shenyang People’s Congress may draw up local laws & regulations based on the specific situations and the real need of Shenyang, then put them into effect after they are submitted to Liaoning Provincial People’s Congress and approved. The Government of Shenyang may draw up local regulations based on the laws and the administrative laws and regulations of the State Council. But these laws and regulations and rules are frequently macroscopic, in the process of specific implementation may encounter many real problems. Hence, the related functional departments of the municipal government may draw up some policies which have more aimness and operable within the management jurisdiction of that department, to implement through a form of standard documents.

Observed from the present situation, Shenyang has set up a set of policies that correlated with the sustainable development of the city. The main laws and regulations are:

National laws and regulations:
- The environment protection act of the P.R.C. 1989
- The pollution prevention act of solid waste management of the P.R.C. 1995
- The forest act of the P.R.C, 1984
- The water act of the P.R.C, 1988
- The territory management act of the P.R.C, 1986
- The city planning act of the P.R.C, 1989

Provincial laws and regulations:
- The environmental protection regulations of Liaoning province

Municipal regulations:
- The air pollution and prevention regulation, 1996
- Management regulation of environmental protection of constructive projects in Shenyang

These laws and regulations form a relative complete legislative system for environment and resource protection. But in the specific
implementation of these policies, many problems may be encountered. With the variation of time and situation, especially China now is carrying out reform in the economic and political system, no matter is the management mechanism, the operation mechanism and the content, they are continuously varied, and new situation, new problems are continuously created, so that the policies exist considerable backward.

For the sake of leading the politics towards the rail of sustainable development, when we draw up policies it is necessary to grasp the following links: At first are leanings. Because sustainable is a strategic aim and a future undertakings, hence, to draw up its policies, we should predict the direction of development and the possible consequences, and to distinguish whether these consequences have a help on the sustain of the development. Therefore, the drawn up sustainable development policies should have leanings no matter in the theory, in the idea or in the action. The second is comprehensives. Because the basic aim of the sustainable development is to attain an aim that the human behavior is coordinated with the resources and the environment, thus in making strategic decision of the management, we should at the same time to take considerations on various factors, such as economy, social, nature, resources, environment and their interaction. The third is on administrative levels. In carrying out the process of sustainable development, we should make attention on the characteristics of different administrative levels, that is we should distinguish characteristics of the government of municipality (city), district (county), street (township) and industry department, to follow the objective laws and to draw up different policies, to ensure the rightness of the policies.

4.2.3 Policy Implementation

The coordination or the environmental policies are realized through Shenyang Commission for Environment protection. The Commission is consists of the representatives of various departments who are responsible in affairs on environment. The Municipal Bureau for Environment Protection and Bureau for Hygiene should supply the newest information concerning environment condition. The Planning Commission and the Commission for construction should supply the implementation situation and planning information of the various items. The Commission for Environment protection should make analysis and evaluation on the environmental situation of Shenyang based on the short-term and long-term
Shenyang Environmental Profile-1997

aim. Shenyang is just through this way to draw up the related policies of environment protection, and transfer the policies to the responsible unit for implementation.

Nowadays, although there was set up the Municipal Commission for Environment protection and the Mayor has the responsibility, the member units have carry out coordination, however, there is still existed a certain degree carrying out the work by oneself by each department in following the plan and guiding principle of the responsible central department. The implementation consequences were also not responded timely, so that the information base of policy making is not adequately, each department does things in his own way, so that the identity in implementing the policies by the departments is influenced. Our operation mechanism has still not reached the mechanism of comprehensive policy making, they consider only something as it stands, to do with short-term behavior, to make policy on single item is still playing role. Some remarkable examples are: After the city’s roads are paved perfectly, the tap water corporation will bury the water pipelines, the department of post & Tele communications will set the electric lines, the gas general corporation will bury their pipelines, the department of electric supply will bury electric cables, the result is that the perfectly paved roads are redigged and refilled, at last it become unlevelling. So, not only has wasted the resources, but also has increased the wastes, greatly reduced the quality of the project and the benefit. The policies that related with resources are still weak. There are many policies that are lack in limiting the resources by the policies themselves. The result is, the policy has led the behavior, the resources are acted on the matter, initiated a series environmental and ecological problems.

To invite widely the correlated people who are interested to participate the planning and implementing the administrative work on city’s environment is necessary. But such a concept is a completely new concept for the many people with different social and cultural background. In China, the correlated people besides the traditional organs of power are lack in experiences to participate on the work. Therefore, such a new concept of the modern environment management is needed slowly to be understood by the people. However, we may still to do some things, so that the correlated people who are interested in the environment management may efficiently to participate on this work. When we were preparing this report, we were beginning to seek the correlated people who are interested on the environment problems, and we have simply illustrated the role of them. In
the other step, in the initial stage of the sustainable development item of Shenyang, these correlated people will participate to this work. If we carry out investigation on the correlated people of all circles, and determine their interrelation, we will find out the correlated people who have representatives. These people may play a great promotion role on the prefectures of environment management work. After we have completed this work, then we may find out more correlated people to participate in this work.

4.3 Strengthening the Management Setting

4.3.1 At the Technical Level

The sustainable development is set up on the base of developed dispatchment of science & technology. Whatever the control of population, environmental and ecological protection, the change of economic development pattern or the social activities in managing the more and more people, all should have the aid of the means and measures of modern science & technology. The problems of population and food, urban and cultivated land, energy sources and pollution, and so on may be solved through raising the technical level, to reduce the use of resources, and further as large as possible to prevent destruction of the environment, and at last to realize the aim of sustainable development. To realize the scientific & technological progress, the understanding on science & technology should be improved, to apply the perfect production process by adopting science & technology, strategic decision and social management consciously.

Right now, with the help of the World Bank Shenyang has an industrial hazardous waste treatment and disposal facility under construction and a sub-project, Shenyang Master Planning, of EU-aid Liaoning Project to-be. All these projects will increase Shenyang’s capability of sustainable development and provide a good base for the project of Sustainable Shenyang. The effective implementing of these projects will help combine the world advanced technologies and management methodologies with Shenyang’s actual situations, enhance Shenyang’s capabilities of solving the problems it is facing and push forward the enforcement of Shenyang’s sustainable development.

The problem to be solved by sustainable development is the contradiction relation between the human and the nature, in which the
subject of contradiction is the human. The human education and to raise the population consciousness of the whole nation, the consciousness on environment, on ecology, on resource and on laws are the base for realizing the aim of sustainable development. Whatever to complete what kind of task, the problem of talented persons is the most importance. The more complex task, the more senior talented persons is needed. The problem of sustainable development is also the same. For its complementation, at first need the support of talented persons. The implementation of the sustainable development need also the manpower who grasp the modern management means and measures of planning and managing the environment, evaluating the geographical information system and environmental risk as well as estimating the techniques. Thus, it is needed for carrying out training for the post, and in the course of sustainable development to probe continuously and to accumulate experiences.

4.3.2 At Administrative/Managerial Level

In the entire implementation of sustainable development, the Government is always stands on the leading position. In the process from the unsustainable to the sustainable development, along with the transform from planned economy to market economy, the management function of the government and its functional departments is also changed. At first, from mainly to manage the economy transformed to manage the social (especially strengthening the management of the population, resources, environment, ecology and other aspects which influence the overall situation of the sustainable development), and also strengthening the management of the factors which may promote progress of the overall social, such as science & technology and education. The second, from direct management transformed to indirect supervision and management. The Government should mainly to draw up policies and plans, to supervise the implementation of policies, plans, laws & regulations. The Government should separate oneself from owing to direct facing the social that may cause oneself to stand on a position which difficult to advance or to retreat. It should mainly to take the whole situation into account, to add justice, to ensure the implementation of sustainable development. The third, considered from the angle of sustainable development, to set up an operation mechanism for administrative management which is dexterous and efficient and conform to the requirement of sustainable development.

Because the extensiveness of the environment domain, the involved
departments are rather much, but these departments and organs have the own corresponding power and ability. For the sake of a common aim of sustainable development, this common aim should become a strategy of common action. To solve the problem of environment, resources, economy and social it is needed to get their support. Therefore, the coordination between the departments is indispensable. Not only a longitudinal cooperation is needed between the identical department, but also is needed the more is the transversal cooperation between the different departments. Although the existing mechanism had play a great role in the past, however, the variation of the situation and the demand of the sustainable development, we should coordinated more closer and set up a mutual coordination mechanism which striding the departments.

In terms of social management, change single executive management into socialized management. Single executive management is too weak to solve all environmental problems that are very extensive and complex. No single organization can solve everything. Cross-sectoral cooperation, and broad-based agreed action plans, therefore, is needed to solve prioritized environmental problems the city is facing during its development one by one.

Sustainable development is an undertaking of the whole nation, hence, the absent of participation by the public is inconceivable. In the participation of the public is, besides to put forth their strength and their financial support, the true significance of the sustainable development is the participation of the public on drawing up the policies and the scheme in the whole process. Besides the representatives of the people’s congress and the local administrative officials may take in place for submitting opinions, the public have the right to understand the whole content and the process of the city’s sustainable development, and have the right to claim protection on their own benefit, and have the right to claim for improving the environment of living. Considered from specific operation of the administrative levels, at first, the public should be able to obtain various information timely and precisely; the second, the public should have an equal opportunity to participate in strategic decision; the third, should be set up a mechanism for accepting the public’s opinion and protecting the public’s benefit. It should be ensured that the work system is put under the supervision of the public.

4.3.3 At the Political Level
To implement the sustainable development is a long-term and difficult work. The essence of Shenyang’s sustainable development is strengthening the construction of ability. Its oneself is unable to solve the many environment problems of Shenyang, because the basic installations of the city are weak, the overall level of the quality of city’s environment is not high, the industrial structure is still mainly consist of the traditional heavy industry, the consumption of resources and energy sources are high, the environmental pollution is serious. These are the very urgent and very difficult problems to be solved which we confront. To solve them, only depended on the item is not enough. We earnestly wishing that the item would be made into a true implementable item that is conform to the real situation of Shenyang. We should be able to put forward a series of investment item and technical-aim item. It is recommended to be compiled according to international standard, making a widely contact with organs that will supply international aid. We are also wishing to have aids from the United Nations and governments of other countries as before.

Towards the sustainable development is a long process. China belongs to the third world, and is still an underdeveloped country, which is still backward in aspect of development and environment protection. Nowadays, the core of the sustainable development is still the development. Only as we developed, the existence of the people may be ensured and the living level and living quality may be raised and the quality of the development may be put into the agenda, the development may become a real truth. But only the sustainable development is a development on a real significance.

To set up the assurance mechanism of organization is an efficient way for implementing sustainable development. Only really to bring into play the forces of each aspect, that is from the government to the inhabitants of the city such, so that the sustainable development become the own understanding and the conscious action, the sustainable development may become possible. Departing from this prerequisite, development is only an empty talk, it is impossible to sustain the development.

Strengthening the exchange and cooperation may promote the implementation of sustainable development. The sustainable development is an undertaking of the whole mankind. We are urgently wishing to be able together making our effort with friends from all circles at home and abroad, to absorb the advanced idea and management method from abroad, for the sake of our today and for the tomorrow of the next generations, to make our efforts commonly. We are also wishing to get further experiences and
Lessons in this aspect, to make out contributions for the sustainable development of the whole world.
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Appendix 1. Brief Introduction of Shenyang Bureau for Environment Protection

Fig.1 Map of Shenyang Urban Districts
Fig.2 Shenyang’s Population Distribution Map
Fig.3 The Change status of Total Water Consumption of Manufacturing
Fig.4 The Change status of Total Energy Consumption of Manufacturing
Fig.5 Planning Map of Functional Areas and Classification in Shenyang
Fig.6 Shenyang’s Key Pollution Sources/Plants Map
Fig.7 The Drinkable Water Consumption in Shenyang
Fig.8 The Death Cause of Shenyang Residents in Recent Years.
Fig.9 Energy Structure in Shenyang (1996)
Fig.10 Distribution map of Shenyang’s mineral resources
Fig.11 Shenyang’s Transport
Fig.12 Shenyang’s scenery spots and natural areas
Fig.13 Shenyang’s Drainage Points Distribution Map
Fig.14 Waste water drainage and pollutants drained out in urban districts, 1995
Fig.15 Layout of solid waste disposal facilities in Shenyang
Fig.16 Distribution map of marks evaluated for underground water in Shenyang, 1995
Fig.17 Shenyang’s water system map
Fig.18 Wind occurrence frequencies (1991 ~ 1995)
Fig.19 Distribution map of routine atmosphere monitoring points in Shenyang
Fig.20 Isograph of average comprehensive indices of Shenyang’s atmosphere in the 8th Five-Year Plan period
Fig.21 Map of Urban Land Use
Fig.22 Historic and cultural sites planned to protection in Shenyang
Fig.23 Various levels of the Public Sectors
Fig.24 Environmental Protection Institutions in China
Fig.25 Organization of Shenyang Municipal Government