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URBANIZATION AND ITS IMPACTS ON WATER ENVIRONMENT IN TUMEN RIVER BASIN

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ABSTRACT: The trans-boundary scope of the Tumen River Basin (TRB) going through China, Russia and DPRK has been defined, and on the basis of this, status of urbanization and its impacts on water environment in recent 20 years in TRB have been analyzed. Urbanization in TRB can be characterized as: 1) There is medium level of overall urbanization in TRB. Certain distance still exists compared with developed countries. And it is lower than the average urbanization level of Russia and higher than that of China. 2) There is unbalanced distribution of urbanization development in TRB. Urbanization in China part owns the character of low starting point and high-speed development. In Russia part, character of urbanization can be described as high starting point and stable development. In DPRK part, urbanization level is low, and motive power lacks. 3) Due to large population, in China part there is broader region urbanized, larger radius and higher frequency of human activities, which lead to heavier pressure on environment. Meanwhile, the paper has pointed that impacts of urbanization on water environment are as follows: 1) Urban population growth and industry development increase the demand for freshwater, and also exacerbate the contradiction between limited water supply and increasing freshwater demand. 2) Urban infrastructure doesn't match with urban productive function especially treatment facilities, which results in the pollution of the Tumen River. 3) The pollution situation in the Tumen River got peak point in 1995, and presently, such situation has been improved in great scale, due to effective interventions adopted. However, there still exist 2 enterprises that are urgent to be harnessed. Moreover, pollution of municipal sewage will become more and more apparent. 4) The influence of urbanization on soil is mainly caused by industrial effluent and slag, and polluted water irrigation. Soil and water loss has also been a serious problem caused by urbanization. 5) Urbanization results in the decrease of wetlands area. Furthermore, the paper has given a brief account of the perspective and recommendations on urbanization and environmental impacts.

KEY WORDS: Tumen River Basin (TRB); urbanization; water environment

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1 INTRODUCTION

Urbanization is a process that allows population and industry to highly concentrate. It is inevitable that this kind of process will have deep impacts on eco-environment.

The Tumen River is an international water body. Scope of the Tumen River Basin(TRB) can be defined as(only in this paper) : Yanji, Tumen, Hunchun, Longjing, Helong and Wangqing of Yanbian Korean Autonomous Prefecture in China, Khasan District, western Ussurijsk, western Nadezhdinsk and southern Oktyabrsky in Russia, and Rajin-Sonbong, Chongjin, Hoeryong, Undok, Saebyol, Onsong, Musan and Puryong in DPRK.

The Tumen River and its tributaries rise in inland ranges and have relatively large catchments and long courses. The Tumen River has a length of 516km and a total catchments area of 33 168km^2, of which 22 618km^2 are in China. Its main tributaries are the rivers of Gaya, Buerhatong, Hailan, Hunchun and Wangqing. TRB lies in the northeast part of Eurasia continent. It covers Changbai Mountains, the Tumen River system, and many valleys and basins, with the Sea of Japan surrounding it, possessing complicated natural conditions and sensitive eco-environment. Cen-

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tral part is the frontier areas where China, Russia and DPRK border on. Meanwhile, exterior districts — Mongolia and ROK — have close relation with central part. Geopolitics, economic relation and human background are all very complicated, due to different political beliefs, economy systems and national interests which make sensitive eco-environment easy to lose control (YU, 1999).

The climax of urbanization in TRB started from the end of the 1980s, signified by the large-scale development of Hunchun in Jilin Province of China. Fifteen years ago economic focus and urbanization climax laid in Russia part; China owned only 2 small cities: Yanji and Tumen; DPRK owned one port city of Rajin. In recent 15 years, economy in Russia part hasn't developed greatly due to many reasons, nor has urbanization. DPRK part added two cities of Rajin-Sonbong and Hoeryong. However, owing to economic depression, overall urbanization level hasn't changed a lot. While in China part, under the reform and open-up policy, economic level has been improved rapidly. Especially from 1990, Hunchun became focal point of development, which served as the prelude of TRB development. Urbanization upsurge has been formed gradually. In recent 15 years, comprehensive ability of original cities has been strengthened, and 3 county-level cities: Hunchun, Longjing and Helong have been added to the city list(UNDP, 2001).

Urbanization development in TRB mainly occurs in China part in recent 10 years. Correspondingly, urbanization pressure on eco-environment has also occurred in this period. In other words, water environment in China part faces more serious urbanization threats.

2 STATUS AND VARIATION OF URBANIZATION IN TRB

Large-scale development in TRB began in 1990. Therefore, urbanization has occurred mainly in the recent 10 years.

2.1 Status of Urbanization in TRB

Altogether 18 areas were involved in TRB in 1999. In China part, total land area amounted to 24 160km^2. Total population was 1485 thousand, increased by 6.7% compared with 1990, more than 744 thousand of which was urban population. There were 5 cities and 1 county-level capital. Urbanization level equaled to 50%, increased by 8%. Urban land area was 83km^2, increased 47%. In Russia part, total land area was 7070km^2. In 1999, total population amounted to 56.2 thousand, decreased by 6.5% compared with 1989. Altogether 6 cities and 1 county-level capital belonged to this district. Urban population was 30.4 thousand, decreased by 5% compared with 1990. Urbanization level was 54.1%, decreased by 0.9%. Urban land area was 78km^2, decreased by 1km^2(Table 1).

Table 1 The status of the urbanization in TRB(1999)

Item	Total of China and Russia	China	Russia
Total population(thousand)	1541.2	1485	56.2
Urban population(thousand)	774.4	744	30.4
Ratio to total(%)	50.2	50.0	54.1
Total land-use area(km^2)	31230	24160	7070
Urban land-use area(km^2)	161	83	78
Ratio to total(%)	0.5	0.3	1.1
Number of cities	12	6	6
Urban density(city/km^2)	0.00038	0.00025	0.00085
Urban population density (person/km^2)	4810	8964	390

Note: The cities include county-level capitals.

It should be noted that investment and traveling behaviors from exterior districts (exterior district refers to the related areas in ROK, Mongolia and areas beyond TRB of China, Russia and DPRK.) have been increased a lot, which accelerates urbanization development in TRB. For instance, ROK and Mongolia are direct participants of TRB development. Therefore, urbanization and its impacts on environment in TRB closely relate to the two countries. However, based on national and regional interests, these areas have close political and economic relations with TRB. Especially, the economic relation of ROK and TRB is closer. For instance, investment, joint enterprises, transport lines, traveling and touring all accelerate urbanization process, and also affect eco-environment indirectly (WANG, 2001).

Currently, there are not many large-scale economic activities of Mongolia in TRB. But the desire of positive cooperative development exists and in the future its impact on urbanization in TRB must be stronger.

2.2 Changes of City Amount

The changes of city amount are shown in Table 2.

Table 2 Changes of city amount in TRB

	China	Russia	DPRK	Total
1980	2	6	1	9
1990	4	6	1	11
1999	5	6	3	14
Increased cities	Hunchun(1988) Longjing(1988) Helong(1993)	–	Rajin-Sonbong Hoeryong	–

2.3 Changes of Urban Population

The changes of urban population are shown in Table 3(ZHU, 2001).

Table 3 Changes of urban population in TRB

	China ($\times 10^3$)	Russia ($\times 10^3$)	The total of China and Russia	
			Population($\times 10^3$)	Increase rate(%)
1990	579	32.0	611.0	–
1995	703	31.5	734.5	3.8
1999	744	30.4	774.4	1.3

2.4 Changes of Landscape

Changes of landscape are expressed as: humanization of natural landscape; industrialization of agricultural landscape and urbanization of rural landscape; degeneration of original landscape.

Main reasons for this are the development of tourism, the exploiting of minerals and the collecting of woods, foods and raw materials, population agglomerating and industry transformation. In China part, these kinds of landscape changes are the most obvious.

2.5 Changes of Industrial Structure

The changes of industrial structure are shown in Table 4.

From Table 4, it can be concluded that the secondary and tertiary industries, which signify urbanization level in China part, have been increased greatly in the last decade. It shows the high-speed urbanization development in this area. In Russia part, due to social and economic reasons, economy development is unstable, thus result in the shrink of secondary and tertiary industries, which indicats there is no dramatic progress of urbanization in the last 10 years(China Statistics Bureau, 1990 – 1999).

2.6 Changes of Land-use Structure

The changes of land-use structure are shown in Table 5.

The area of arable land in China part has decreased gradually, and forest area has been increased, which is favorable to eco-environment. Meanwhile, urban constructed area has been increased and water area has been decreased, which bring about pressure on eco-environment. In Russia part, arable land area has been decreased, and forestland and grassland area have been increased. There is no great change about wetland and urban construction land area and there is no heavy pressure on ecosystem. The greatest change of land-use occurs in China part of TRB, correspondingly causing most serious impacts on environment.

Table 4 Changes of industrial structure in TRB($\times 10^3$$)

Item		China		Russia	
		Output value	Increase	Output value	Increase
GDP	1990	753600	–	322570	–
	1999	996683	243082	67398	– 255172
Primary industry	1990	91075	–	109627	–
	1999	131220	40145	61354	– 48273
Secondary industry	1990	327462	–	20076	–
	1999	435132	107670	1680	– 18396
Tertiary industry	1990	216004	–	192867	–
	1999	392106	176102	4364	– 188503

Table 5 Changes of land-use structure in TRB(km^2)

Item		Arable land	Grassland	Forest land	Water and wetland land	Urban construction land
China	1990	–	–	–	–	–
	1995	– 49.0	– 5.0	+ 10.0	– 14.0	+ 9.0
	1999	– 135.0	– 8.0	+ 45.0	– 29.0	+ 26.5
Russia	1990	–	–	–	–	–
	1995	– 93	No data	– 13	0	0
	1999	– 139	+ 108	+ 93	0	+ 1
The total of China and Russia	1990	–	–	–	–	–
	1995	– 142	–	– 3	– 14.0	+ 9.0
	1999	– 274	+ 100	+ 138	– 29.0	+ 27.5

2.7 Brief Summary

Overall urbanization level in TRB is in a medium size. There still exists certain distance compared with developed countries. And it is lower than average urbanization level of Russia and higher than that of China (in the view of China part and Russia part).

There is an unbalanced distribution of urbanization development in TRB. Urbanization in China part owns the character of low starting point and high-speed development. In Russia part, character of urbanization can be described as high starting point and stable development. In DPRK part, there is low urbanization level and lack of motive power.

Due to large population, in China part, there is broader urbanization region, larger radius and higher frequency of human activities, which lead to heavier pressure on environment.

3 URBANIZATION IMPACT ON WATER ENVIRONMENT

3.1 Increasing Need for Freshwater from Urban Expansion

In the last decade, due to new favorable policies and economy development in China part, overall urbanization speed in TRB has been accelerated a lot, though population in Russia part has decreased slightly. This results in population increase and industry development. Therefore, the need for freshwater has also increased greatly.

3.1.1 Urban population growth

As mentioned above, in the recent 10 years, urban population has increased greatly. This mainly occurres in China. It is no doubt that freshwater consumption in cities in China part has increased a lot(Table 6), due to the high-speed development of urbanization. Urban population had increased from 579 thousand in 1990 to 744 thousand in 1999. And the urbanization level had increased from 41.6% in 1990 to 50.1% in 1999. There was no great change of urban population in Russia. The volume of consumed freshwater hadn't changed a lot either. Moreover, it had decreased from 4 608 970 tons in 1995 to 4 112 835 tons in 1999. The concrete water consumption was shown in Table 6.

Table 6 Urban domestic freshwater consumption variation tendency

	Total consumption of freshwater($\times 10^3$t)		Urban population($\times 10^3$)	
	1995	1999	1995	1999
Yanji	22560	27000	282	312
Tumen	5680	6192	71	72
Hunchun	8580	9794	110	118
Longjing	6240	6391	80	77
Helong	6318	6806	81	82
Wangqing	5925	6474	79	83
Khasan district	4330	3857	31.5	30.4
Western Ussurijsk	–	–	0	0
Western Nadezhdinsk	–	–	0	0
Southern Oktyabrsk	–	–	0	0
Total	59633	66514	734.5	774.4

3.1.2 Industry development

Industry has become the leading industry in the national economy of China part. Up to 1988, nine major industrial systems had been generally established, which were food and tobacco, papermaking textile and clothing, building materials, petrol-chemistry, medicine, metallurgy, electric power and forestry. In the last decade, there had been great improvement in the industrial economy. Total industry output has increased from US$3 274 619 thousand in 1990 to US$4 351 321 thousand in 1999. It was inevitable that water used in industry had increased from 108 717 000 tons to 137 241 000 tons. In Russia part, water consumption in industry had decreased from 2 194 000 tons in 1995 to 433 000 tons in 1999(LI *et al.*, 1997).

3.2 Impact on Water Quality

Urbanization contributes a great deal to water quality decrease in TRB. Current situation and variance tendency of water quality in TRB are shown in Table 7 and Table 8 respectively.

From Table 7 we can see that 12 of the 21 sections reach the standard above grade Ⅳ, the regulated criteria, accounting for 57.1% in terms of water function assessment. The high levels of pollution in TRB result from several factors, the chief among which are the much greater density of population and the greater level of industry. Pollutants in TRB are all from China and DPRK part. Main polluting industries are chemical fiber industry and papermaking industry. The water in the upper reaches of the branches of the Tumen River system is fairly clean and basically not polluted by city activities. The water quality in the middle and the lower reaches of the branches and in the branches flowing across towns and cities is rather low. Serious pollution occurs in the Tumen River, the Gaya River, and the Hailan River, especially in the Tumen River. Along the course of the main stream of the Tumen River, the middle and lower reaches are both seriously polluted. Main pollutants are SS, COD, BOD_5, and NH_3-N.

Table 7 Assessment of the water quality of major rivers of the Tumen River system in 1999

River	Section	Water function grade	Comprehensive water quality grade	Exceeding criteria or not	Major pollutants
Tumen River mainstream	Nanping	Ⅲ	Ⅲ	N	Headstream-Chengchuan: no obvious pollution
	Tumen	Ⅳ	– Ⅴ	Y	Chengchuan River mouth – Kaishantun: SS, COD BOD_5, NH_3-N
	Hedong	Ⅳ	– Ⅴ	Y	Kaishantun – Tumen: SS, Ar-OH, COD
	Quanhe	Ⅲ	– Ⅴ	Y	Tumen – Hunchun River mouth: SS, COD, BOD_5, Ar-OH, NH_3-N Hunchun River mouth – Quanhe: SS, COD, Ar-OH, BOD_5
Hunchun River	Chunhua	Ⅱ	Ⅰ	N	Headstream – Taoyuan River: SS, COD
	Hunchun Bridge	Ⅲ	Ⅱ	N	Taoyuandong – Estuary: SS, COD, Ar-OH
	Sanjiazi	Ⅲ	Ⅲ	N	
	Xiweizi	Ⅲ	Ⅲ	N	
Gaya River	Tuanjie	Ⅱ	Ⅲ	Y	Headstream – Wangqing: SS, COD, BOD
	Baye Bridge	Ⅳ	– Ⅴ	Y	Wangqing River – Shixian: SS, COD, BOD_5 Shixian – Estuary: SS, COD, Ar-OH, Oil
Hailan River	Guanmen	Ⅲ	Ⅲ	N	Above Helong Town: SS, COD
	Biyan	Ⅲ	Ⅱ	N	Helong – Bajiazi: SS, COD, BOD_5, NH_3-N
	Dongsheng Bridge	Ⅴ	– Ⅴ	Y	Bajiazi – Toudao: SS, COD Toudao – Longjing (above): SS, COD
	Helong	Ⅴ	– Ⅴ	Y	Longjing(above) – Longjing(below): SS, COD, BOD_5, NH_3-N Longjing(below) – Burhatong River: No obvious pollution
Burhatong River	Below Antu	Ⅲ	Ⅳ	Y	Above Mingyue Town: no obvious pollution source
	Yushuchuan	Ⅲ	Ⅱ	N	Mingyue Town – Yushunchuan: SS, COD, BOD_5, NH_3-N, Pb
	Laotougou	Ⅲ	Ⅲ	N	Yushuchuan – Laotougou: SS
	Above Yanji	Ⅴ	Ⅱ	N	Laotougou – Chaoyangchuan: SS, COD, Pb
	Below Yanji	Ⅴ	Ⅳ	N	Chaoyangchun – Yanji(above): SS, COD
	Mopanshan	Ⅳ	Ⅲ	N	Yanji(above) – Yanji(below): SS, COD, BOD_5, NH_3-N
		Ⅳ	– Ⅴ	Y	Yanji(below) – Estuary: no obvious pollution
Wangqing River	Daxian				Headstream-Wangqing: no bovious pollution source Wangqwing-River mouth: SS, BOD_5, NH_3-N, Ar-OH

Note: This assessment is operated by Jilin Provincial Monitoring Center Station of Environmental Projection according to comparative method with five grades in "Surface Water Environment Quality Criteria" as the reference. "– Ⅴ" indicates that the water quality is lower than grade Ⅴ. As there is no SS in national standard, this pollutant is not included in the assessment, although it is one of main contaminants of the Tumen River. However, in order to make the contents clear, SS is listed in the column of Major pollutants.

Major pollution sources are Mushan Iron Mine (DPRK), Awudi Chemical Works (DPRK), Jilin Yasong Industrial Ltd, industrial and municipal wastewater from Tumen City and the pollutants for the Gaya River and the Hunchun River. In the Hunchun River, which is less polluted, the differences in pollution degree are insignificant. Main pollutants are SS and COD. For the Gaya River the most heavily polluted section is the Baye Bridge in the lower reaches. Key contaminants are SS, COD and BOD_5. Major pollution source is Yanbian Shixian Bailu Paper Ltd. Along the course of the Buerhatong River the most seriously polluted sections are below Antu and below Yanji. The pollution is mainly caused by NH_3. Major pollution sources are municipal sewage from Antu, Yanji and Yushuchuan Electric Power Plant. For the Hailan River the most heavily polluted sections are Dongsheng and Helong, where the dominant contaminants are COD_{Mn} and BOD_5. For the Wangqing River, main pollutants are COD_{Mn} and BOD_5 from municipal sewage and a few enterprises.

From Table 8 we can see that during 1991 – 1995, pollutants in each section had increased, with SS content rising dramatically in some sections, COD content rising gradually. During 1996 – 1999, nearly all pollutants content had decreased to the level lower than 1991. It illustrates that the situation of environmental pollution has been changed to some extent. Large-scale city development in TRB began at the end of 1980. The rapid development of urbanization in this area is caused by exterior forces. TRB lies in the center of northeast Asia, close to five countries: China, Russia, ROK, DPRK and Japan. Based on such superior geographical conditions, Chinese government lists TRB as one of the important areas to be developed. With supports from national government, TRB enjoys a great number of preference policies. At the beginning of last decade, this region attracted large amount of investment from outside. A great number of industrial enterprises and

Table 8 Water quality of the Tumen River system in 1991, 1995 and 1999

River	Monitoring section	SS(mg/L)			COD_{Mn}(mg/L)			Ar-OH(μg/l)		
		1991	1995	1999	1991	1995	1999	1991	1995	1999
Tumen River	Nanping	872.0	786.1	115.0	8.7	9.03	4.7	1.6	1.2	1.1
	Tumen	553.0	317.7	89.0	44.2	40.5	43.4	8.2	9.2	16.7
	Hedong	490.0	1936.0	18.0	33.9	35.5	53.1	11.0	8.5	24.9
	Quanhe	281.0	349.3	32.0	19.8	28.1	21.4	4.2	6.1	7.0
Burhatong River	Yushuchuan	69.0	327.0	6.0	4.3	4.7	3.0	1.0	1.4	1.6
	Above Yanji	50.0	310.8	10.0	4.0	4.4	3.2	1.4	2.0	1.8
	Below Yanji	69.0	36.0	12.8	6.9	8.0	4.4	2.4	4.3	2.6
Wangqing River	Daxian	52.0	33.7	21.0	13.7	9.9	43.6	4.7	6.9	15.2
Gaya River	Tuanjie	2.0	79.0	13.0	5.9	8.0	6.0	2.1	0.4	0.3
	Baye Bridge	127.0	159.9	51.0	33.2	47.0	88.1	9.4	12.0	23.8
Hailan River	Guanmen	162.0	115.5	19.0	18.5	8.9	5.0	3.4	3.7	3.3
	Dongsheng Bridge	37.0	35.2	28.0	24.6	21.4	6.8	12.2	9.3	3.8
	Hunchun Bridge	90.0	24.0	33.0	5.9	2.6	2.5	0.9	1.2	0.6
Hunchun River	Xiweizi	93.0	36.5	38.0	7.6	3.9	3.0	1.4	1.7	0.9

Note: The data are from Jilin Provincial Mornitoring Center Station of Environmental Projection.

residential buildings were built. The pace of urbanization was sped up greatly. The period of 1990 – 1995 was the initial stage of urbanization in this region with rapid increase of urban population and industrial enterprises. However, these new plants and buildings are constructed on insufficient municipal infrastructures that cannot meet the requirements of environmental protection. This is an important factor contributing to the decrease of water quality. In addition, in the early stage of urbanization, citizens' environmental awareness was weak and there was no perfect publication and education system for environment(ZHU *et al.*, 1996).

The period of 1996 – 2000 was the stable stage of urbanization. Environmental problems have become obvious and attracted the attention of the government and citizens in the last few years. Many methods are adopted to control environmental pollution. Due to human intervention, such situations have been changed to some extent. That is to say, urbanization is developing toward a new era.

However, it should be pointed out that municipal sewage has become one of the major pollutions sources. According to the statistics for 232 industrial pollution sources at the end of 2000, there have been 173 sources being harnessed to the discharge standard, except Kaishantun Chemical Fiber Pulp Plant, Shixian Paper Mill and Yanbian Aluminum Plant. The government has closed 59 sources. Standard discharge rate reaches 98.7%. At present, municipal sewage discharged volume has accounted for 50% of the total. With population growth and the enlargement of cities, the burden of domestic pollution has correspondingly increased.

In terms of urbanization, the basic reason for water pollution of the Tumen River system is that infrastructure construction doesn't match with the requirements of city development. City development demands certain infrastructure for the existence, such as wastewater treatment plant. But in TRB, there is only simple municipal facilities in some enterprises are either backward or too simple, far from meeting the requirements of normal city life. Another reason is insufficient city supervision on industrial wastewater discharge. The third is that city development doesn't conform to the standard of sustainable development. Highly polluted enterprises should be transformed or modern technologies should be introduced to such plants. Future benefits cannot be sacrificed.

3.3 Wetland Decreasing

The major wetlands in TRB include three linked and ecologically inter-related wetlands: the very extensive Tumen River coastal wetlands on the coastal plain to the north and south of the mouth of the river; the Tumen River itself and the immediately adjacent wetlands, including the Jingxin wetlands in China part; the shallow coastal waters, including much of Possiet Bay and waters around offshore seabird island(CHEN, 1987).

The threats from urbanization are mainly as follows:

(1) Water pollution of local water sources and of the Tumen River and nearby marine environment. Most importantly for the wetlands of Possiet Bay, pollution of the partly closed bays, or of the streams flowing into

them, will be likely to accumulate in the ecosystem. Pollution is almost certainly being carried into the Possiet Bay wetlands from the Tumen River (and possibly the Rajin-Sonbong area) by a north-flowing current.

(2) Sand extraction near the mouth of the Tumen River is reported to occurr on a large scale and threatens the habitat and the hydrology of the area(LANG, 1998).

(3) Land reclamation by enclosure and packing river for farm. As the increasing pressure from population, marsh is reclaimed for farmland in succession. For instance, since the 1970s most of the herbaceous wetlands have been cultivated into paddy fields in Jingxin Wetlands. There were more than 2000ha wetlands remained up at the end of 1980 and mainly distributed in Liudao pond and Jiudao pond, and became the only useful and valuable habitat for the migration and reproduction waterfowls. However, 1/4 or 1/5 marshland of this area had been reclaimed for paddy field by the beginning of 1998. Jingxin wetland will never exist at such reclamation speed.

(4) Tourism development.

(5) Economic development.

3.4 Effluent Irrigation and Water Losses and Soil Erosion

According to statistics, in 1998, the Tumen River mainstream and its tributaries, the Gaya River, the Hailan River, the Hailan River and the Burhatong River received 10 730t of effluent, and the effluent irrigated 28 879ha of cultivated land. Details can be referred to Table 9. So the effluent irrigation area in TRB is quite large, and the irrigating water quality is poor. If no effective measures are taken to intensify treatment, it will affect this region's soil and result in eco-environment worsening in farm fields.

With the population increase, forest deterioration and reclamation, the forest area has decreased and the waste mountains and lands have increased year after year. All those activities lead to serious water losses and soil erosion.

Most of the soil in TRB is granite-based gray-brown soil and dark brown soil. It is rather light and weak in resisting erosion. Water and soil erosion is common when its vegetation is destroyed. In recent years, with sharp population increase and irrational production activities, including over-cutting of trees, mining, quarrying, extracting sand, blind opening up land, etc, the water and soil erosion has become more serious. According to statistics, in 2000 the water and soil erosion area in the Tumen River valley was 370 463 ha, accounting for 12.05% of the total area.

4 PERSPECTIVE AND RECOMMENDATIONS

4.1 Forecasting on the Future Development of Urbanization in TRB

Many factors can influence the trend of urbanization development in TRB, including many undetermined ones such as political situation. Consequently, it is still difficult to predict long-tem trend. However, short-term trend is clear(LITVINENKO, 1982).

Because of economy depression, urbanization process in DPRK part will not develop greatly. In Russia part, there is a trend of economy recovery, and urban capacity and vitality will be improved. However, due to small population, large area, and present high urbanization level, there won't be great changes in short-term. In China part, with a series of favorable policies such as the development of town and township enterprises, tourism development, infrastructure construction, and business and capital invitation, urbanization will develop rapidly.

Table 9 Wastewater irrigation area in the Tumen River valley

Irrigation area	Irrigated area(ha)	River
Dehua, Guangkai, Bailong, Liangshui irrigation, Quanhe pumping, Mingdong electric power irrigation	6032	Tumen River mainstream
Tumen	993	Gaya River
Helong, Bajiazi, Toudaolongjing, Hailan, Guangxi irrigation areas	11647	Hailan River
Shimen, Chaoyang, Changbai, Xiaoying irrigation areas	10207	Burhatong River

There is an optimistic prospect of cooperative development of China, Russia, DPRK, ROK and Mongolia. Urbanization in the areas where ROK, Mongolia, Japan, USA and European countries invest will develop most rapidly(ROSE and SCTT, 1994).

The amount, type, scale and distribution of the investment from UNDP and other international organization will play an important role of guides and impe-

tus.

Each country attaches importance to the development and construction of harbors. Therefore, frontiers export and harbors will become hot spots of urbanization development in TRB, which make trans-boundary city possible.

4.2 Possible Threats on Water Environment from Urbanization

There are great differences in the status of water environment among China, Russia and DPRK. If there is no communications, coordinations, unified goals or activity planning among the three countries, loss of habitats, decrease in types and amounts of plants and animals and water pollution, which are linked with each other, may ocurr.

None of currently China, Russia and DPRK is developed country. In particular, economy in northeast of China, and Far East Area of Russia hasn't been in a prosperous phase in recent years and it is urgent for them to speed up economic development. Economy may develop at the expense of environment, which is harmful to sustainable development.

Urbanization of China has been in a stage with high development speed. It is estimated that urbanization level can get as high as 50% twenty years later, and the consumption of large urban population and the large area of urban construction will bring about huge burdens on water environment.

The problem of environment hasn't been paid enough attention to in DPRK. Their economic activities will increase the press on environment. Especially in the upper reaches of the Tumen River and Changbai Mountains, there will be affected in large area .

The investment of international financial group and transnational corporations on TRB is likely to increase. Some of them are not government activities. And profits may be maximized, while environment quality is neglected.

Tourism has become a promising industry in China. The government of many cities in Changbai Mountain area and the Tumen River area all have planned to develop tourism with emphasis. Therefore, the development of tourism will be one of the factors for water pollution.

At present, several main sources of pollution all contribute a lot to local finance. Activities of enterprises and the protection of local government may impede the application of environmental protection.

4.3 Recommendations

(1) Defining urban development guidelines, which is beneficial to the protection of water environment and sustainable development.

– On the whole, controlling the amount and distribution between cities, so as to decrease pollution on water environment.

– Individually, controlling the extension of urban land, making full use of urban potential and increasing urban capacity, so to alleviate the pressures on eco-environment and water sources.

(2) Formulating scientific and reasonable urban, planning and constructing ecological cities.

– By the reasonabe ways laying out cities, coping with the relation of cities and source of water.

– Replacing the construction materials which are hazardous or can lead to forest decrease, through urban management; meanwhile, specifying the position, amount, and means of digging and filling; treating construction garbage.

(3) Constructing and perfecting urban infrastructures, which are conductive to environmental protection, so to minimize pollution intensity(ZHU *et al.*, 1998).

– Treating industrial waste to harmless standard.

– Constructing urban drainage system which can separate rain and sewage in each city.

– Improving treated rate of industrial and domestic effluents to 100%.

– Classifying, bagging, recovering and harmlessly treating domestic wastes.

(4) Actualization of choosing and restricting system for industrial projects in terms of environment and ecology.

– All new projects and extended projects should meet the requirement of cleanness and saving water.

– Mainly developing ecological tourism, strictly restricting sightseeing places and transport lines in protected areas of source of water.

(5) Harnessing and controlling serious pollutants sources with clear point.

– Restricting or harmlessly replacing pesticides in urban life and grasslands.

– Strictly monitoring and controlling discharged sewage exits.

– Renovating main severe pollution enterprises and towns, emphasis laid on Shixian, Kaishantun of China.

(6) Strengthening government management and administrative methods.

– Formulating policies such as investment policy,

population policy, and industry policy, and establishing environmental protection atmosphere.

– Perfecting laws and systems, such as tourism controlled system, discharged sewage controlled system, controlling constructive material system and protected area system.

(7) Strengthening publication and education of environmental protection and intensifying citizens' consciousness of environment.

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