Urban Environmental Problems in Taiwan and Fujian: A Comparison from Historical Perspective*

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Abstract

This paper attempts to investigate urban environmental problems in Taiwan and Fujian situating along the southeast coast of mainland China. Taiwan is an island and Fujian is located in the west side of the Taiwan Strait. Geographically, both Taiwan and Fujian feature hilly topography with small flat area along the coast. Historically, Taiwan was a destination of the people migrated from Fujian since the seventeenth century and it was under Fujian's provincial jurisdiction from 1683 to 1885 when Taiwan was established as a province under the Qing rule. However, Taiwan was ceded to Japan in 1895 after the Sino-Japanese War and thus under the Japanese colonial rule until 1945. And since 1949 Taiwan was politically separated from Mainland China. These were important factors affecting urban development across the Taiwan Straits. With this geographical and historical background, this paper will trace the urban development in Taiwan and Fujian since the late nineteenth century and discuss the urban environmental problems such as water supply and pollutions emerged with industrialization since the late twentieth century.

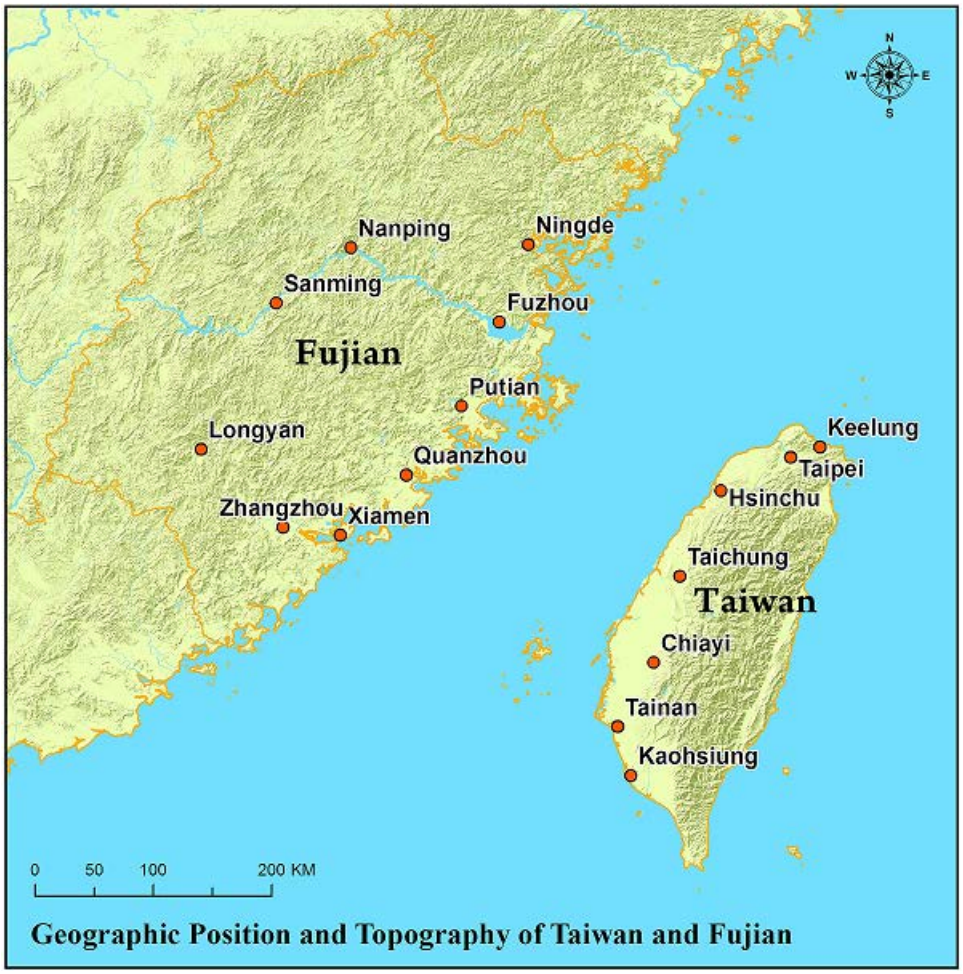
1. Geographical and Historical Background of Taiwan and Fujian

Geographically, Taiwan and Fujian are separated by the Taiwan Strait lying between them with the longest distance being 200 km and the shortest distance being 130 km across the Strait. Both Taiwan and Fujian feature mountainous topography with numerous rivers flowing into the sea. Map 1 shows the relative geographic position and the topography of Taiwan and Fujian.

On the east side of the Taiwan Strait, the Island of Taiwan with 21 offshore islands and the Penghu (澎湖) Archipelago (the Pescadores) consisting 64 small islands are located at north latitude 21°53' ~ 25°18' and east longitude 119°18' ~ 121°59' with a total land area around 36,000 square kilometers. The shape of Island of Taiwan

*This paper was first presented at the WCEH2014, 8-12 July 2014, Guimaräes, Portugal. It was also delivered at the AASSRC 21st Biennial General Conference, 28 April 2015, held at Academia Sinica. This is a revised version.

appears like a spindle or a sweet potato. From north to south, the longest distance is 394 kilometers and east to west the widest distance is 144 kilometers. In the central part of the Island of Taiwan, there are six mountain ranges extending from north to south with more than 100 mountains higher than 3,000 meters. Available statistics show that of the total land area in Taiwan, the areas below altitude of 100 meters are 28.4 percent, those between 100 and 1,000 meters are 38.8 percent, those between 1,000 and 1,500 meters are 11.8 percent, and those above 1,500 meters are 21 percent.[1]



Map 1: Geographic Position and Topography of Taiwan and Fujian

Note: This map is drawn by Miss Yu-ting Li of the GIS Center of Academia Sinica. Her contribution is well acknowledged.

On the Island of Taiwan, there are 24 rivers administered by the central government, 92 rivers administered by the county governments, and 2 rivers administered by

[1] The Agriculture and Forest Division, Taiwan Provincial Government (ed.), *Preliminary planning of slope-land development in Taiwan* [臺灣省山坡地農牧發展初步規劃], Report on Survey of Slope-land Area, No. 3 (1979), p. 3.

trans-county and city governments. The total length of these 118 rivers is 3,432.61 kilometers; but only six of them have a length more than 100 kilometers and the longest one, the Zhuoshuixi (濁水溪) River, being 186.6 kilometers.[2] Most human settlements were established earlier on plains and basins along the west coast facing the Taiwan Strait, but the mountainous topography in the east coast facing the Pacific Ocean constrains number of settlements there.

On the west side of the Taiwan Strait, Fujian province is located along southeast coast of the Chinese Mainland at north latitude 23°32' ~ 28°19' and east longitude 115°50' ~ 120°43' with a total land area around of 121,100 kilometers in a rectangular shape. The east part of Fujian is along the coast, while in the west and central parts there are two parallel mountain ranges extending from north to south with an average altitude around 1,000 meters. The mountainous areas count for 90 percent of the total land area in Fujian. There are 24 river systems originated from the mountains in Fujian with a total number of 663 rivers making up a total length of 12,850 kilometers and the density of river networks is quite unique among provinces in China. Most rivers flow into the ocean from Fujian province except for the Tingjiang (汀江) River, which flows into the sea from Guangdong province. In the inland area of Fujian, there are series of small plains between mountains and rivers; while along the coast, there are four larger plains located in Fuzhou (福州), Xinghua (興化), Quanzhou (泉州) and Zhangzhou (漳州). In the western and central parts of Fujian, cities and towns are mostly located at basins with altitudes of 100-200 meters.[3]

Historical records revealed that by the end of the twelfth century, there were Han (漢) people settled at Penghu but the Han people came to Taiwan at latest in the mid-sixteenth century. Besides the aborigines, the settlements on Taiwan were mostly established by the Han migrants from Fujian since the late sixteenth century and from Guangdong since the eighteenth century. During 1683-1884, Taiwan was a prefecture of Fujian province and in 1885 Taiwan was established as a province under the Qing rule until 1895 when it was ceded to Japan after the Sino-Japanese War. Regardless changes in the jurisdiction, migrants from Fujian to Taiwan continued during the eighteenth and the nineteenth centuries. An investigation of the local policing system (Baojia 保甲) in 1811 reported that there were 1,944,737 persons in Taiwan and this could be taken as a comparatively reliable number of the Han population. During 1895-1945, Taiwan was under the Japanese colonial rule and some people moved back to Mainland China.[4] After the World War II, Taiwan was returned to the

[2] See Tables 16, 17 and 18 in the 2012 Water Resource Statistics compiled by Water Resource Agency, Ministry of Economic Affairs, available at http://www.wra.gov.tw.

[3] Ling Xing, *Urban Development and Social Change: A Study on Urban Modernization in Fujian with a Focus on Fuzhou and Xiamen,1843-1949* (Tianjin: Tianjin Guji chubanshe, 2009), pp. 16-18.

[4] For details see, Liu Ts'ui-jung, "Han Migration and the Settlement of Taiwan: The Onset of Environmental Change," in Mark Elvin and Liu Ts'ui-jung (eds.), *Sediment of Time: Environment*

Republic of China in 1945 and migrants came to Taiwan were not limited to Fujian and Guangdong. After 1949, Taiwan and Mainland China was separated politically and thus the migrations of people were interrupted.

For an overall observation of the population condition, the statistics of population density in Taiwan, Fujian, and China during 1951-2012 are illustrated in Figure 1. Thus, we can see since 1951, both Taiwan and Fujian have higher population density than China as a whole and the population density in Taiwan is more than double of that in Fujian.

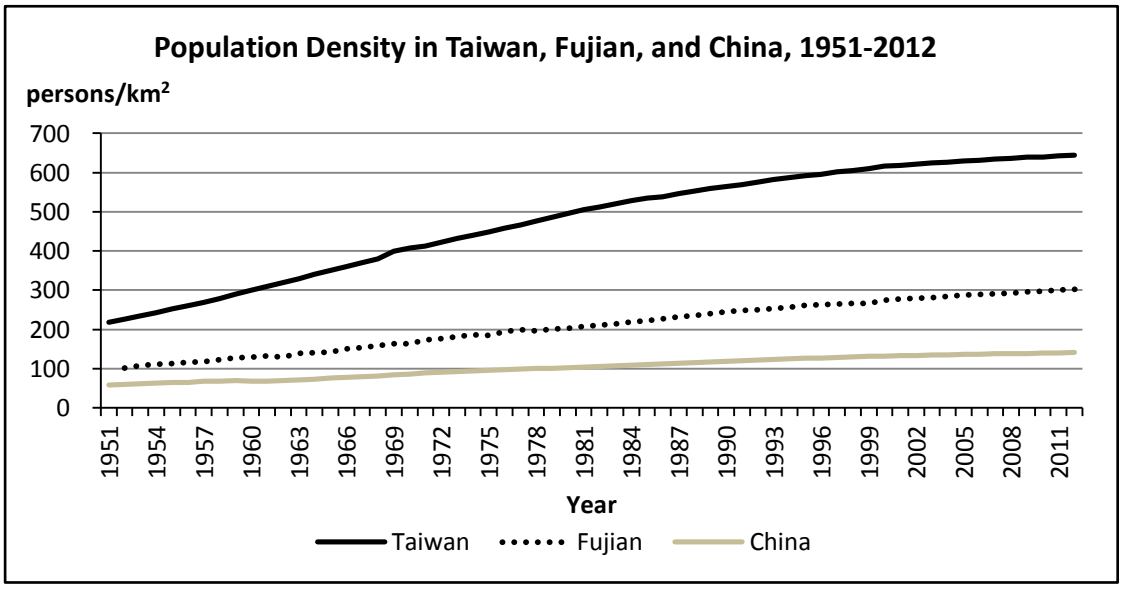


Figure 1: Population Density in Taiwan, Fujian and China, 1951-2012

Source:

Taiwan: For 1952-1962, see Directorate-General of Budgets, Accounts and Statistics, Executive Yuan (ed.), *Statistical Abstract of the Republic of China* 1963 Table 7; for 1963-1979, see *Statistical Abstract of the Republic of China* 1979 Table 14; for other years, see Ministry of Interior (ed.), *Statistical Yearbook of Interior*, available at http://www.moi.gov.tw/stat/year/list.htm.

Fujian: Fujian Statistical Bureau (ed.), *Fujian Statistical Yearbook 1994* (Beijing, 1994), Table 2-1; and *Fujian Statistical Yearbook 2013*, Table 13-1, available at www.stats-fj.gov.cn/tongjinianjian/dz2013/index-cn.htm.

China: National Bureau of Statistics, *China Statistical Yearbook, 2013*, Table 3-1.

Note: In this figure, the population of Taiwan do not include that of Kinmen (金門) and Matsu (馬祖) Islands located along the coast of Fujian but under the jurisdiction of Republic of China. The population density in Kinmen was 313 persons/sq.km and in Matsu 210 persons/sq.km in 1996 and 796 and 422 persons/sq.km respectively in 2013. See *Statistical Yearbook of Interior*.

For an overview of economic condition, here the per capita GDP (Gross Domestic Product) is taken as an indicator. The index of GDP (calculated with previous year = 100) is illustrated in Figure 2. We can see all three curves fluctuated during 1952-2012. The curves of Fujian and China fluctuate almost in the same direction

and Society in Chinese History (New York: Cambridge University Press, 1998), pp. 165-199.

throughout this period; while the curve of Taiwan shows a steady increasing trend in 1955-1970 and then reaches a peak in 1974. It is also notable that both the curves of Fujian and China reach a peak in 1994. After 2000, the curves of Fujian and China are very close to each other while that of Taiwan appears to be lower.

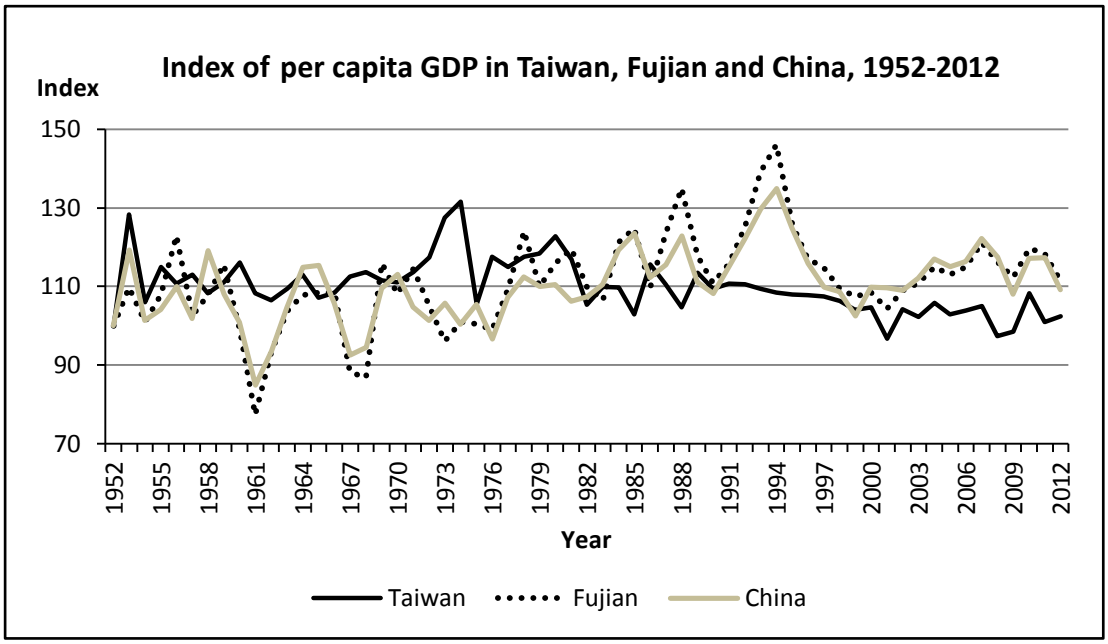


Figure 2: Index of per capita GDP in Taiwan, Fujian, and China
(calculated with previous year =100)

Source:

Taiwan: Directorate-General of Budget, Accounting and Statistics, Executive Yuan, National Statistics, available at: http://ebas1.ebas.gov.tw/pxweb/Dialog/varval.asp?ma= ….

Fujian: Department of Comprehensive Statistics of National Bureau of Statistics (ed.), *China Compendium of Statistics 1949-2004* (Beijing: China Statistics Press, 2005), Table 14-5, p. 507; *Fujian Statistical Yearbook 2013*, available at: www.stats-fj.gov.cn/tongjinianjian/dz2013/index-cn.htm.

China: Department of Comprehensive Statistics of National Bureau of Statistics (ed.), *China Compendium of Statistics 1949-2004*], (Beijing: China Statistics Press, 2005), Table 1-6: Gross Domestic Product; and Table 14-5: Gross Regional Product of Fujian.
National Bureau of Statistics, *Statistical Yearbook of China* 2006, Table 3-9; 2007, Table 3-13; 2008 -2011, Table 2-15; 2013, Table 2-1.

With the above geographic, historic, and economic background, the next section will trace urban development in Taiwan and Fujian since the late nineteenth century.

2. Urban Development in Taiwan and Fujian since the Late Nineteenth Century

2.1 Urban Development in Taiwan

In 1895 when Taiwan was ceded to Japan by the Qing government, there was no city with a population above 50,000 persons. In 1899, there were eight urban places (in

Japanese, *shigaichi* 市街地) with the population above 10,000 persons and the largest one, Tainan (臺南), had 42,455 persons. But if the two urban places which later became parts of Taipei (臺北) City were combined together, then there were 52,825 persons.[5] In 1897-1899, the 44 localities with population above 2,000 persons together had 326,036 persons which counted for 12.37 percent of the total population. This rate was higher than the 10.6 percent estimated by G. William Skinner for the Lower Yangtze region in 1893.[6] In 1913, the 24 urban places in Taiwan with population above 5,000 persons together had 397,212 persons which counted for 11.62 percent of the total population.[7]

As scholars tended to adopt different criteria in estimating the urbanization rate in Taiwan, for an observation through time it seems applicable to use the available statistics of population in each city and town.[8] In terms of administration, Taiwan Area consists of national-level city (yüan-xia-shi 院轄市 or zhi-xia-shi 直轄市), provincial-level city (sheng-xia-shi 省轄市) and county (xian 縣); under the national and provincial level cities, there are districts (qü區); and under the county, there are county-level city (xian-xia-shi 縣轄市), urban township (zhen鎮) and rural township (xiang 鄉). Here, the population in cities of various levels and urban townships is considered as urban population.[9] It should be noted that at the end of 2010, a major change was made by establishing four new national-level cities in addition to Taipei City. They are established in the following way: New Taipei City is a conversion from Taipei County; Taichung City, Tainan City and Kaohsiung City are respectively a combination of the original city and county. For a comparison through time, the data of the population in Taichung City, Tainan City and Kaohsiung City in 2011 are calculated only with the original city districts; and for other districts under the municipal jurisdiction, only those belonging to original county-level cities and urban townships are included.

The results of statistics regarding the percentage of urban population in cities and towns in Taiwan classified by different ranges of population are illustrated in Figure 3. It is quite obvious that since the 1950s, Taiwan has more people living in cities than in towns. At the city level, in most years under observation, range D cities have the largest shares except in 1971 when a range B city (Taipei) emerged. The share of

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[5] Liu Ts'ui-jung, "Taiwan's Urban Development in the Past Eighty Years," in the Symposium Editorial Committee (ed.), *Symposium for the Eightieth Anniversary of the Republic of China* (Taipei: Modern China Publisher, 1991), Vol. 4, p. 528.

[6] Chang Ying-hwa, "Taiwan's Urban System—From the Qing to Japanese Rule," in Tsai Yung-mei and Chang Ying-hwa (eds.), *Taiwan's Urban Society* (Taipei: Chuliu Books Company, 1997), pp. 37-39.

[7] Taiwan Sōtokufu (ed.), *Taiwan Statistical Summary 1913* (Tokyo, 1915), pp. 102-103.

[8] See Liu Ts'ui-jung, "Taiwan's Urban Development in the Past Eighty Years," pp. 528-529.

[9] Three cities, Taipei, Kaohsiung, and Hsinchu had increased their areas in 1967, 1979 and 1982 respectively, for details see Liu Ts'ui-jung, "Taiwan's Urban Development in the Past Eighty Years," note 3.

Range D cities increased from 9.68 percent in 1956 to 12.50 percent in 1961 and again from 13.98 percent in 1981 to 22.73 percent in 2011. Range C cities had the second largest share of 7.97 percent in 1956 and 8.40 percent in 1961; and afterwards, their ranks fluctuated and the share once reached 10.10 percent in 2001 but declined to 5.75 percent in 2011. It is notable that in 1971, the single range B city, Taipei, had the second largest share of 12.16 percent and since 1981 it became a range A city and its share was kept as the second largest until 2011. Moreover, in 2011 the three mega cities (with population above 1 million persons), Taipei (range A), Kaohsiung and Taichung (range B), together had a share of 22.79 percent which was about the same as that of range D cities mentioned above. At the town level, range F and range G have larger shares of population: the share of range F towns increased from 6.03 percent in 1956 to 14.78 percent in 1971 and then decreased to 7.32 percent in 2011; while the share of range G towns counted for 23.20 percent in 1956 and 17.17 percent in 1961 but decreased to 4.4 percent in 2011.

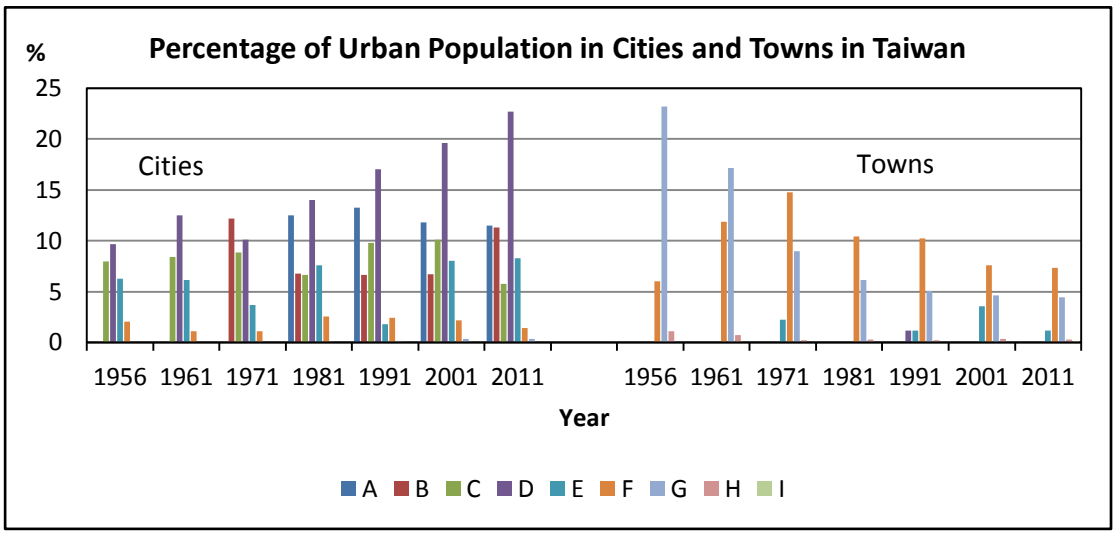

Figure 3: Percentage of Urban Population in Cities and Towns in Taiwan

Ranges of Population (persons):
A: Above 2,000,000 persons; B: 1,000,000-1,999,999; C: 500,000-999,999; D: 200,000-499,999; E: 100,000-199,999; F: 50,000-99,999; G: 20,000-49,999; H: 10,000-19,999; I: Below 10,000.
Source:
Year 1956: Civil Affairs Bureau of Taiwan Provincial Government (ed.), *Household Statistics Yearbooks of Taiwan Province, 1946-1958*, (1959), pp. 278-283.
Year 1961: Civil Affairs Bureau of Taiwan Provincial Government (ed.) *Household Statistics Yearbooks of Taiwan Province, 1959-1961*, (1962), pp. 314-323.
Year 1971: Ministry of Interior (ed.), *Population Statistics of Taiwan, Republic of China, 1961*, (1962), pp. 254-298.
Year 1981: Ministry of Interior (ed.), *Population Statistics of Taiwan and Fujian Areas, Republic of China, 1981*, (1982), pp. 54-400; 220-278; 542-545.
Year 1991: Ministry of Interior (ed.), *Population Statistics of Taiwan and Fujian Areas, Republic of China, 1991*, (1992), pp. 54-102；230-290；570-573.
Year 2001 and 2011: Table 1.7 Population for Township and District in *Statistical Yearbook of Interior*, available at the website of Ministry of Interior, http://www.moi.gov.tw/stat/year/list.htm.

Another way to understand the progress of urbanization in Taiwan is to trace the changes in urban planning districts. In 1936, the Taiwan Governor-General issued the "Taiwan City Planning Order" and by the end of the Japanese colonial period there were 74 urban planning districts in Taiwan. In 1964, the "Urban Planning Law" of the Republic of China was first revised and since then the urban planning districts were established all over Taiwan and there were 438 districts in 2012.[10]

With available statistics regarding urban planning districts in Taiwan, a comparison of urban planning districts with entire Taiwan Area in respect to population, land area and population density are illustrated in Figure 4.

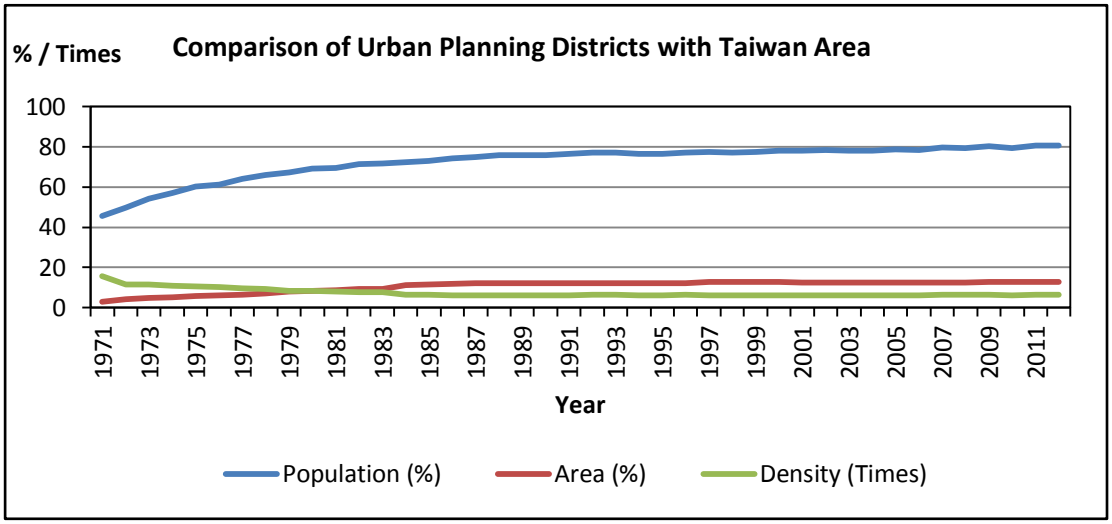

Figure 4: Comparison of Urban Planning Districts with Taiwan Area, 1971-2012

Source:

Statistical Abstract of Interior of the Republic of China, 1981, Table 12, p. 34; Table 140, p. 283.
Statistical Abstract of Interior of the Republic of China, 1985, Table 140, p. 297.
Statistical Abstract of Interior of the Republic of China, 1990, Table 111, p. 275.
Statistical Abstract of Interior of the Republic of China, 1991, Table 14, pp. 48-49.
Statistical Yearbook of Interior of the Republic of China, 1995, Table 14, pp. 52-53. Table 117, p. 339; Table 118, p. 341.
Statistical Yearbook of Interior of the Republic of China, 2000, Table 14, pp. 52-53; Table 142, p. 395; Table 143, pp. 397.
For 2001-2012, see *Statistical Yearbook of Interior of the Republic of China*, available at: http://sowf.moi.gov.tw/stat/year/list.htm.

Thus, we can see during 1971-2012, the share of population in urban planning districts increased from 45.6 percent to 80.5 percent, the share of land area increased from 2.9 percent to 12.7 percent, and the population density decreased from 15.6 times to 6.3 times. In other words, the present situation is that about 80 percent of

[10] For "Taiwan City Planning Order" see, *Encyclopedia of Taiwan*, available at: http://taiwanpedia.culture.tw/web/content?ID=4878. For "Urban Planning Law" see Ministry of Justice (法務部), Law & Regulation Database of the Republic of China, available at: http://law.moj.gov.tw/LawClass/LawHistory.aspx?PCode=D0070001.

Taiwan's total population is residing in 13 percent of the land area with more than 6 times of density.

It should be noted that the urban planning districts in Taiwan are classified in three categories: city (town), rural-settlement, and special district.[11] The first category refers to districts in cities and towns, the second one refers to those in rural townships, and the third one refers to those at industrial zones, scenery places, and other special objectives such as the interchange of freeway. With available statistics of these three categories, their shares of land area are illustrated in Figure 5. It is notable that on average, during 1997-2012, the districts of cities and towns shared 38.2 percent, rural-settlements shared 14.5 percent, and special districts shared 47.3 percent, In other words, human settlements in Taiwan shared about 50 percent of the land area in urban planning districts, while industry, scenery, transportation and other objectives shared another 50 percent.

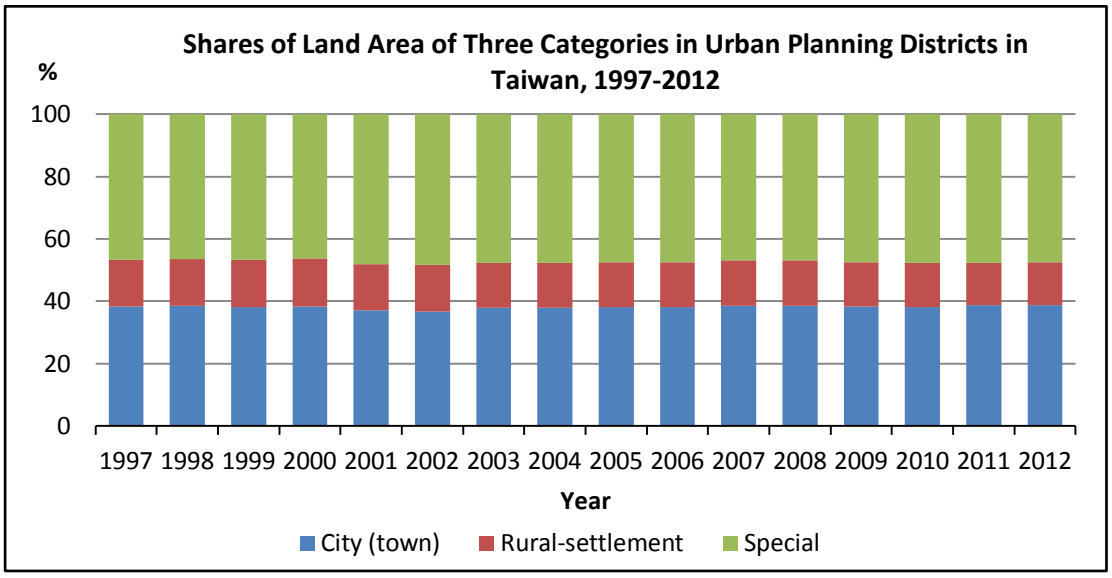

Figure 5: Shares of Land Area in three Categories of Urban Planning Districts in Taiwan
Source: Statistical Yearbook of Interior of the Republic of China, available at: http://sowf.moi.gov.tw/stat/year/list.htm.
Note: The land area is originally recorded as hectare; here it is converted to square kilometer.

In short, since the 1950s the urban population in Taiwan is distributed more in cities and towns than in rural townships. In recent years, about 80 percent of Taiwan's residents are living in urban planning districts which share about 13 percent of Taiwan's total land area and the density is more than 6 times of Taiwan's average.

2.2 Urban Development in Fujian

[11] For the definition of three categories, see articles 10, 11, and 12 of "Urban Planning Law". Available at: http://law.moj.gov.tw/LawClass/LawHistory.aspx?PCode=D0070001.

The urban development in Fujian can be highlighted by the two largest cities, Fuzhou and Xiamen (廈門), after the end of the Opium War in 1842.

Fuzhou was opened up as a treaty port in 1844 and from then on, the urban and socio-economic development in Fuzhou was summarized in four characteristics as follows: (1) The maritime defense construction was a starting point of urban modernization and industrialization in Fuzhou; (2) Essentially, Fuzhou was a port with export surplus; (3) The merchant capitals of Fuzhou were used not only in buying and selling local resources, transportation, manufacturing, and exports, but also invested in urban constructions and public enterprises; and (4) The Christian church played an important role in the cultural, educational, medical and public health developments and thus promoted the transmission of Western cultural and technological knowledge in Fuzhou.[12]

Xiamen had already become a center of maritime trade for more than 200 years before the Opium War. However, most areas of the Xiamen Island still dotted with small villages and the city area was limited only at the southwestern corner of the Island. In 1843, Xiamen was opened up as a treaty port and thus trade and migration became two major driving forces for the city's modern development. Moreover, overseas and foreign capital investments played an important role in commercial and industrial development as well as urban construction in Xiamen.[13]

In the nineteenth century, in addition to overseas migrations, people moving into Fujian were mostly from the neighboring provinces such as Guangdong, Zhejiang, Anhui and Jiangxi. As for within Fujian province, people moved mostly from the coastal area to the mountain area in northwestern Fujian where some migrants engaged in trade and some in handicrafts or in producing cash crops. Thus, urban development in northwestern Fujian was quite remarkable in the nineteenth century.[14]

According to the statistics in 1937, Fujian had 69 county cities, 3,026 rural and urban townships, and 30,626 villages. The urban system in Fujian was classified in five categories: (1) Provincial center cities such as Fuzhou and Xiamen; (2) Regional center cities such as Sanduao (三都澳), Jianou (建甌), Nanping (南平) and Hanjiang (涵江) in the north; Quanzhou, Zhangzhou, Changting (長汀) and Longyan (龍岩) in the south; (3) There are some regional secondary center cities serving as connecting knots between center cities and various townships; (4) Most county cities are the political, economic and cultural centers of the counties; and (5) Small urban and rural townships were the basis of the urban network.[15]

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[12] Zhang Zhong-li (ed.), *Cities along the Southeast Coast and China's Modernization*, (Shanghai: People's Press, 1996), pp. 129-170.

[13] Zhang Zhong-li (ed.), *Cities along the Southeast Coast and China's Modernization*, pp. 172-224.

[14] Dai Yi-feng , "Population Migration and Urbanization in Modern Fujian," *Journal of Chinese Economic History*, No. 2 (1989): 95-105.

[15] Ling Xing, *Urban Development and Social Change*, pp. 246-247.

As for the rate of urbanization in Fujian since the 1950s, available time series of China and Fujian are illustrated in Figure 6 for a comparison.

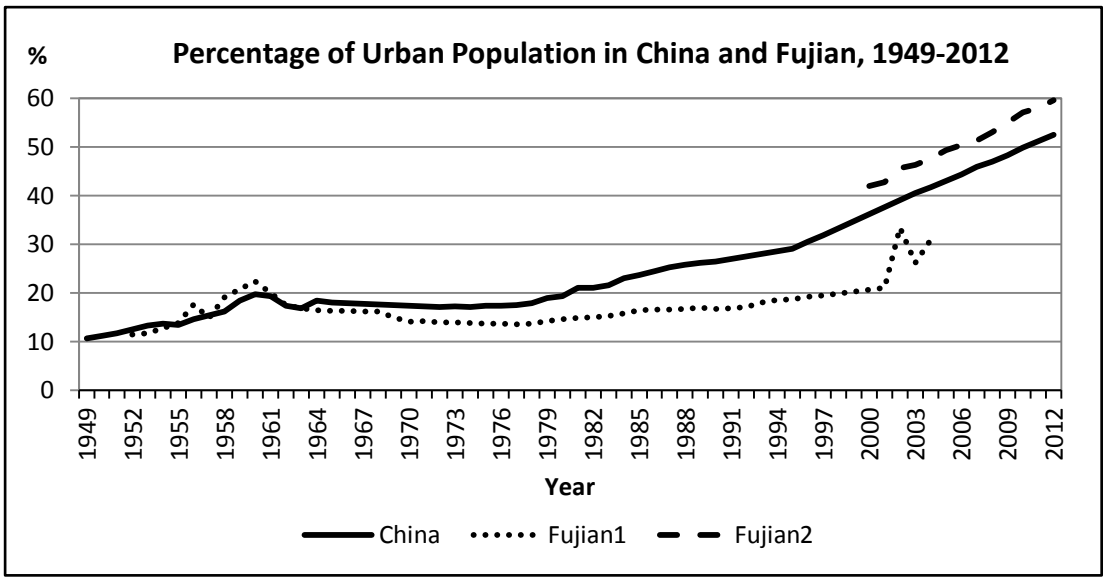

Figure 6: Percentage of Urban Population in China and Fujian, 1949-2012

Source:

Department of Comprehensive Statistics of National Bureau of Statistics 國家統計局國民經濟綜合統計司 (ed.), *China Compendium of Statistics 1949-2004*, (Beijing: China Statistics Press, 2005), for China, Table 1-3; for Fujian, Table 14-2.

National Bureau of Statistics of China (ed.), *China Statistical Yearbook 2012* (Beijing: China Statistics Press, 2013), Table 3-1.

Fujian Provincial Bureau of Statistics (ed.), *Fujian Statistical Yearbook 2013*, available at http://www.stats-fj.gov.cn/tongjinianjian/dz2013/index-cn.htm.

It should be noted first, the curves of China and Fujian1 during 1949-2004 are based on the data taken from the same source and can be considered as using the same criterion in estimating the percentage of urban population.[16] Thus, we can see the curve of Fujian1 was lower than that of China throughout most years under observation except in 1956 and 1958-1960. The rate of China increased from 10.64 percent in 1949 to 19.75 percent in 1960, then decreased before reaching 20.16 percent in 1981 and then increased steadily to 41.78 percent in 2004. The rate of Fujian1 increased from 11.48 percent in 1952 to 22.38 percent in 1960 and then declined before recovered slowly to 21.10 percent in 2001 and then suddenly reached a peak of 33.46 percent in 2003 and declined slightly again. However, the curve of Fujian2 shows that since 2000 the rate in Fujian was higher than that in China. Because it is difficult to obtain consistent series of urban population from various

[16] For a discussion on problems of estimated rates of urbanization in China, see Aimin Chen, "Urbanization in China and the Case of Fujian Province," *Modern China* Vol. 32, No.1 (Jan.1006), pp. 99-130; available at: URL: http://www.jstor.org/stable/20062630, accessed April 24, 2014.

editions of the *Fujian Statistical Yearbook*, the data available in the 2013 edition as shown in the curve of Fujian2 can be taken for a reference here. As for the fact that since the opening up of China in 1978, Fujian had lagged behind the national level in the progress of urbanization, many studies have discussed the problems and crucial factors related to this situation.[17]

In administrative terms, Fujian Province consists of nine regions and each region has one prefectural-level city (di-ji-shi 地級市), several county-level cities (xian-ji-shi 縣級市) and counties (xian 縣); while each city and county consists of urban townships (zhen 鎮) and rural townships (xiang 鄉).[18] In 2000, of the 23 cities in Fujian, 9 were prefectural-level cities and 14 county-level cities; but 5 of the latter did not have districts (qű 區) and thus had no population of city districts but only populations in towns. With this in mind, for calculating urban unit and population in Fujian, both prefectural and county level cities with districts are listed under the city level and all urban townships are listed under the town level.

Due to the fact that the data of individual townships are not available in the *Fujian Statistical Yearbook*, the data of cities of towns are reorganized from a collection based on the 2000 census. The result shows that there were 18 cities and 643 towns in 2000.[19] These cities and towns shared respectively 15.05 percent and 76.18 percent of Fijian's total population. This implies that on 1 November 2000 when the census took place, cities and towns together had 91.23 percent of the registered permanent population (chang-zhu ren-kou 常住人口) in Fujian.[20] Apparently, this rate is much higher than that illustrated in Figure 6, but it is comparable to 81.3-85.9 percent based on the household records for 1993-2001 in the 2002 edition of *Fujian Statistical Yearbook*.[21]

According to the census criteria, the permanent population also includes the people living at a locality for more than half a year but whose household registrations were not in that locality. These people are mostly peasant laborers (nong-min-gong 農民工) who left rural area to work in towns and cities and were waiting for obtaining

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[17] Tang Xing-xia, "Proposal and Strategy for Speeding up Process of Urbanization in Fujian," *Fujian Tribune, Social Science Education Edition*, No. 2 (1993):47-48. Huang Jian-qing, "Fujian Province Lagging behind in Urbanization: Causes and Countermeasures," *Journal of Fujian Normal University* (*Philosophy and Social Sciences Edition*), No. 4 (2003): 37-41. Qiu Rong-ji, Wang Song-liang, and Zhu Chao-zhi, "On Urbanization of Fujian Province," *Journal of Southwest Agricultural University* (*Social Science Edition*), Vol. 3, No. 4 (December 2005): 68. Lin Feng-feng, Wei Yuan-zhu, and Xieh Chi-zhong, "Empirical Study on Urbanization and Upgrading the Income of Peasants in Fujian," *Fujian Forum* (*Humanities and Social Sciences Edition*), No. 1 (2006): 116-117.

[18] For the administration division in Fujian, see Table 1-1 in yearly editions of *Fujian Statistical Yearbook*.

[19] Of these 643 towns, 18 were supposition towns (xu-ni-zhen 虛擬鎮).

[20] See editorial explanations in *China Population by Township*.

[21] See *Fujian Statistical Yearbook 2002*, Table 3-2.

formal household registration in the locality they worked.[22] This is the key issue for understanding different rates of urban population available in different records.

In regard to regional variation, the reorganized statistics based on *China Population by Township* obtained the following results.[23] At the city level, the rate of urban population varied in the following order: Fuzhou 3.78 percent, Xiamen 2.83 percent, Quanzhou 2.40 percent, Nanping 1.30 percent, Longyan 1.21 percent, Sanming 1.18 percent, Ningde 0.93 percent, Zhangzhou 0.85 percent, and Putian 0.58 percent. At the town level, the rates were in the order of Quanzhou 18.13 percent, Zhangzhou 15.61 percent, Fuzhou 12.9 prcent, Putian 6.70 percent, Ningde 5.28 percent, Nanping 5.26 percent, Sanming 4.56 percent, Longyan 4.44 percent, and Xiamen 3.19 percent. Putting the rates of cities and towns together, the regions on top —Fuzhou, Xiamen, Quanzhou, and Zhangzhou—are located along the southeast coast of Fujian. Some studies have proposed that in the process of urbanization it is appropriate to construct urban-belt (cheng-shi-dai 城市帶) or urban-group (cheng-shi-qün 城市群) in this area.[24]

The regional variations of urban population in Fujian classified by ranges of population are illustrated in Figure 7. Obviously, a larger proportion of Fujian's population was distributed in towns and there was not yet a city with population above one million by the end of 2000. At the city level, only 4 prefectural-level cities had the rate of urban population above 1 percent; they were Fuzhou (range B, 3.51 percent), Xiamen (range C, 2.83 percent), Quanzhou (range D, 1.92 percent), and Longyan (range D, 1.02 percent). At the town level, the top three regions were: Quanzhou (114 towns, 18.13 percent), Zhangzhou (98 towns, 15.61 percent), and Fuzhou (109 towns, 12.99 percent). In Quanzhou region, the order was: range F (45 towns, 8.95 percent), range G (37 towns, 4.10 percent), and range E (8 towns, 3.53

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[22] For studies on the issue of peasant laborer, see Liu Ping and Xu Jin-ju, "A Preliminary Discussion on the Transfer of Rural Labor in Fujian during 30 years since the Reform and Opening-up," *Journal of Fujian finance and Accounting Administrator College*, No. 4 (2008): 1-4. Song Guo-kai, "In-migrating Population and the development of urbanization: The Case of Jinjiang, Fujian," *Gansu social Sciences*, No. 6 (2008): 2-25. Shen Wen-feng, "Report on Peasant Laborers and the Interaction of Urban Cultural concepts : A case Analysis of Quanzhou, Fujian," *Southeast Communication*, No. 12 (2008): 17-19. Song Chun-ming, "Investigation on the Issue of Transferring Surplus Labor from Agriculture in Fujian," *Southern Tribune*, No. 3 (2009): 38-41. Zhou Xiao-gang and Chen Dong-you, "Theory Explanation and Policy Choice of Population Urbanization in China: Let Peasant Laborers become Residents of Cities," *Jiangxi Social Sciences*, No. 12 (2009): 142-148.

[23] Department of Population, Social, Science and Technology Statistics, National Bureau of Statistics 國家統計局人口和社會科技統計司 (ed.), *China Population by Township* [中國鄉鎮街道人口資料], (Beijing: China Statistics Press, 2002), Fujian Province, pp. 330-350.

[24] Yan Zheng 嚴正, "Speeding up the Construction of Urban-belt in Southeastern Fujian (加快閩東南城鎮帶的建設)," *Journal of Fujian Normal University (Philosophy and Social Sciences Edition)* [福建師範大學報(哲學社會科學版)], No. 1 (1996): 9-13. Lin Hui-ling 林惠玲, "Analysis on the Advantage of Establishing Urban Group of Xian-Zhang-Quan Region in Southern Fujian (厦漳泉地区构建闽南城市群的优势分析)," *Journal of Hubei University of Education* [湖北第二师范学院学报], Vol. 27, No. 1 (January 2010): 90-93.

percent). In Zhangzhou region, the order was: range G (26 towns, 5.06 percent), range H (49 towns, 5.06 percent), and range F (2 towns, 4.70 percent). In Fuzhou region, the order was: range F (27 towns, 5.54 percent) and range G (54 towns, 5.32 percent). In other six regions, two had the highest shares in towns of range F: Xiamen (8 towns, 1.65 percent), Putian (17 towns, 3.63 percent); and four had the highest rate in towns of range G: Sanming (23 towns, 2.00 percent), Nanping (37 towns, 3.17 percent), Longyan (34 towns, 3.08 percent), and Ningde (46 towns, 4.30 percent). In other words, most towns in Fujian were small-scale with population below 50,000 persons.

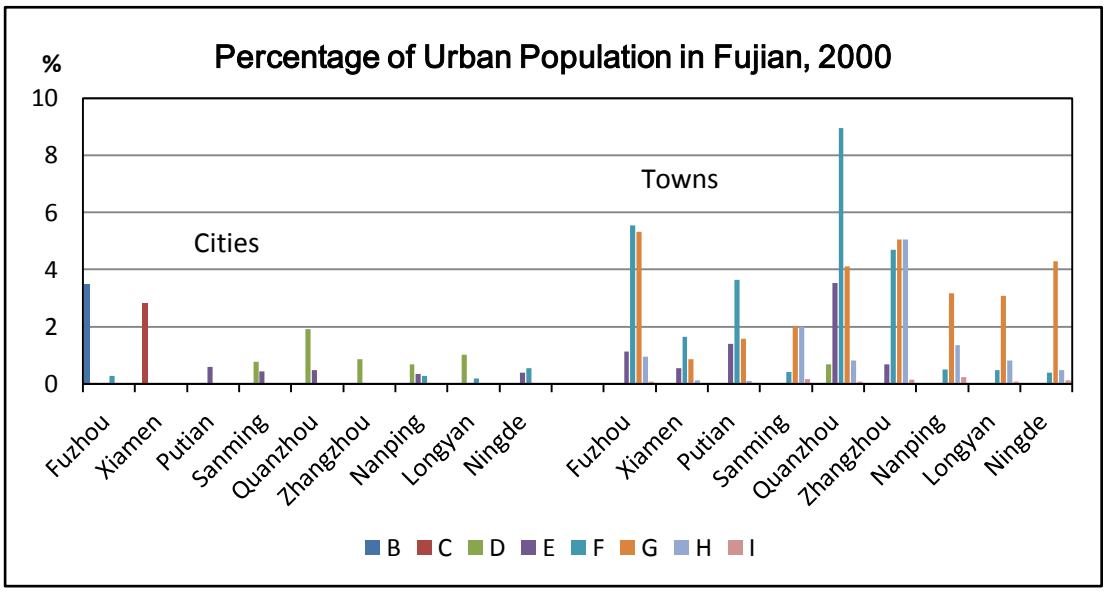

Figure 7: Percentage of Urban Population in Regions of Fujian, 2000

Ranges of population (persons):
B: 1,000,000-1,999,999; C: 500,000-999,999; D: 200,000-499,999; E: 100,000-199,999;
F: 50,000-99,999; G: 20,000-49,999; H: 10,000-19,999; I: Below 10,000.
Source: Department of Population, Social, Science and Technology Statistics, National Bureau of Statistics 國家統計局人口和社會科技統計司 (ed.), *China Population by Township* (中國鄉鎮街道人口資料), (Beijing: China Statistics Press, 2002), Fujian Province, pp. 330-350.

As the process of urbanization moved slowly, scholars have pointed out the problems of urbanization in Fujian in six aspects: (1) The level of urbanization was quite uneven spatially; (2) The number of center cities is too small and the scale of these cities is not big enough to play the role of radiation; (3) The progress of industrial development has been constrained by that of urbanization; (4) There are too many small-scale county-level cities and towns; (5) The institution regarding rural-urban migration is not well operated; and (6) The urban infrastructures are relatively backwards and there are serious environmental problems.[25]

[25] Qiu Rong-ji 邱容机, Wang Song-liang 王松良, and Zhu Chao-zhi 朱朝枝, "On Urbanization of Fujian Province (福建城市化现状、问题与统筹城乡发展对策)," *Journal of Southwest Agricultural*

In the beginning of the twenty-first century, scholars have proposed many strategies for promoting urbanization in Fujian. A study in 2001 emphasized the necessity of narrowing down the gap between the mountain area and the coastal area by developing green industry in the mountain area and establishing "city with hills and rivers" (Shan-shui-cheng-shi 山水城市).[26] Similarly, a study in 2002 pointed out that the development of small cities and towns should not fallow a uniform pattern but adopt one that is most suitable for local conditions.[27]

In 2003, Huang Jia-hua (黃家骅), a professor of economics, suggested that urbanization in Fujian should take a route of establishing "clusters" (cu-qűn-hua 簇群化) of cities and towns. In each cluster, the large center city should function as a core and around it layers are formed by other medium and small cities and towns, and thus to facilitate interactions among each other. He pointed out that it was possible to create three "clusters" in Fujian with Fuzhou, Quanzhou, and Xiamen as center cities.[28] Similarly, a doctoral student of economics also suggested that large and medium cities should have a priority in urban development.[29] At a forum of urban development in Fujian held in 2003, Huang Jia-hua criticized the strategy proposed by the government—"Control strictly the scale of large cities, develop rationally the medium-sized cities, promote positively the small cities, and develop forcefully the small towns (嚴格控制大城市規模, 合理發展中等城市, 積極發展小城市, 大力發展小城鎮),"—had led to cities being small and scattered in Fujian. He elaborated further his idea of creating "clusters". However, another economist proposed a strategy of developing cities with population below one million, particularly small cities and towns with population below 100,000 persons.[30] It is notable that Aimin Chen criticized the "Small City Strategy" for it was a deterrent to population

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University(Social Science Edition) [西南农业大学学报(社会科学版)], Vol. 3, No. 4 (December 2005): 68-70. For interaction between urbanization and industrialization in Fujian, see Li Ji 李霁, "On Interactive Development of urbanization and Industrialization in Fujian (论福建城市化和工业化的互动发展)," *Times Finance* [時代金融], No. 418 (June 2010): 115-117.

[26] Wang Yu-qiong 王玉琼 and Huang Jun 黃骏, "To Fulfill Speed-up in Characterizing Development: on the Problem of Urbanization in the Mountain Area of Fujian (在個性化發展中實現騰飛—論福建山區的城市化問題)," *Urban and Rural Development* [城鄉建設], No. 9 (2001): 24-25.

[27] Lin Er-kai 林尔凯, "The Pattern and Strategy for Developing Small Cities and Towns in Fujian (福建小城镇建设的发展模式与對策)," *Urban and Rural Development* [城鄉建設], No. 6 (2002): 20.

[28] Huang Jia-hua 黃家骅, "On the Cluster Pattern of Urbanization Development (论簇群式城市化发展路径)," *Southeast Academic Research* [東南學術], No. 4 (2003): 334-340.

[29] Huang Jian-qing 黄建清, "Fujian Province Lagging behind in Urbanization: Causes and Countermeasures (福建省城市化发展滞后原因分析及对策措施)," *Journal of Fujian Normal University* (*Philosophy and Social Sciences Edition*)[福建師範大學學報(哲學社會科學版)], No. 4 (2003): 37-39.

[30] See report of Chen Rong-sheng 陳榕生, "Choosing the Route of Urban Development in Fujian: 'Grape String' or 'Radish Hole' (福建省城市化發展道路的選擇—'葡萄串'還是'蘿蔔坑')," *Newsletter of Urban Design* [城市規劃通訊], No. 12 (2003): 10.

mobility.[31]

In 2004, Fujian Provincial Government proposed to establish an "Economic Zone at West Coast of the Strait (海峡西岸经济区)" by including cities and towns in Xiamen, Quanzhou, and Zhangzhou regions into a city combination for strengthening the area's economic capacity.[32] In 2005, the central government proposed in the draft of the "Eleventh Five-year Plan" that the "West Coast of the Strait" was included as a "conditional region" for developing city-group. Thus in 2006, Fujian proposed to construct the "City-group at West Coast of the Strait (海峡西岸城市群)". In this city-group, Fuzhou and Xiamen will function as center cities for constructing an urban system with rational division of labor among cities and towns and to fulfill the goal of urban-rural integration (cheng-xiang i-ti-hua 城乡一体化). It has also been pointed out that in constructing the "City-group at West Coast of the Strait", there are four problems should be solved: (1) The relationships between center cities should be well managed; (2) The strategic resources of the center cities should be well managed; (3) The relationships between city-group, harbor-group, and industrial-group should be well coordinated; and (4) The promotion of urban-rural integration should be speeding up.[33] In 2009, the State Council announced its support for constructing the "Economic Zone at West Coast of the Strait" and in March 2011 the plan was formally approved. In a global perspective, the "Economic Zone at West Coast of the Strait" is expected to follow the Yangtze River Delta, the Pearl River Delta, and the Bohai (渤海) Coastal Zone to become a new pole of growth (zeng-zhang-ji 增長極) in China. Moreover, this zone is strategically important for re-opening the cross-strait communication between China and Taiwan.[34]

In addition to the development of city-group at the top regions, it is also notable that in recent years some studies have focused on less developed regions. For instance,

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[31] Aimin Chen, "Urbanization in China and the Case of Fujian Province," pp. 119-120.

[32] Shi Zheng-fang 石正方, "On the Significance and the Developing Orientation of Xia-Quan-Zhang City Combination (厦泉漳城市联盟发展的意义及取向探析)," *Taiwan Research Quarterly* [台湾研究集刊], No. 3 (2005): 19-24. For the competitive capability of cities in this area see, Wang Fang 王芳 and Liu Wei-hong 刘伟宏, "Research on Economic Competitiveness of the Cities—Evidences from Fujian province (城市经济竞争力研究—来自福建省的证据)," *Science Technology and Industry* [科技和产业], Vol. 11, No. 9 (Sept. 2011): 106-110. Li Mei-ju 李美茹, "Investigation on taking the Strategy of Urban-rural Integration for the Promotion of Regional Competitiveness—The Case of Xia-Zhang-Quan Integration (城乡一体化战略提升区域竞争力探索—以"厦漳泉一体化"为例)," *Journal of Simao Teachers'College* [思茅师范高等专科学校学报], Vol. 28, No. 2 (April 2012): 26-28.

[33] Wang Qing-hua 王庆华, "A Study on Important Problems in the Construction of City Group at the West Coast of the Strait (建设海峡西岸城市群若干重大问题研究)," *Journal of Fujian Party School* [中共福建省委党校学报], No. 1 (2008): 65-69.

[34] Yuan Huai-yu 袁怀宇, "Development of Urban Agglomerations—Study on City-group of Fujian in the West Coast Economic Zone (福建海峡西岸经济区城市群发展对策)," *Economic Geography* [经济地理], Vol. 32, No. 2 (February 2012): 66-70. Lin Hui-ling 林惠玲, "Analysis on the Advantage of Establishing Urban Group of Xian-Zhang-Quan Region in Southern Fujian," p. 92.

regression analysis models are applied to study Nanping and Ningde and the data of remote sensing and field-work investigation are used to study Putian.[35]

3. Urban Environmental Problems in Taiwan and Fujian

Urban environmental problems discussed below will include clean water supply and waste water treatment, solid waste disposal, air pollution, environmental noise, as well as availability of green area.

3.1 Taiwan

3.1.1 Tape water supply

In respect to clean water supply, the construction of the first tap-water plant in Taiwan was completed in 1899 and in 1974 there were 128 plants organized under the Taiwan Provincial Water Company which was reorganized into Taiwan Water Corporation in 2007 for providing water supply service in Taiwan Area except for Taipei City where the Taipei Water Department was established in 1977.[36]

The percentage of total population (not just the urban population) served by tap-water supply in Taiwan was illustrated in Figure 8. Thus we can see in Taiwan, the population served by tap-water was 9.2 percent in 1930 and 14.6 percent in 1940 before the outburst of the Pacific War. After the World War II, the percentage increased from 16.26 percent in 1950 to 38.97 percent in 1970, to 83.62 percent in 1990, to 90.48 percent in 2000, and reached 92.72 percent in 2012.

Although the percentage of population served by tap-water was increasing steadily since the 1950s, the distribution was not even between urban and rural area. With the percentage of population served by tap-water at each city, town, and rural township available for the year 2012, the data are organized by regions and the results are illustrated in Figure 9.

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[35] JI Gui-zhen 姬桂珍, Wu Cheng-zheng 吴承祯, and Hong Wei 洪伟, "Study on the Driving Force of Urbanization at Nanping City (南平市城市化驱动力研究)," *Territory & Natural Resources Study* [国土与自然资源研究], No. 2 (2012): 38-39. Liu Feng 劉峰, "Some Thought for Speeding up Development of Urbanization in Medium and Small Cities—The Case of Ningde, Fujian (加快中小城市城镇化发展的思考—以福建宁德为例)," *Journal of Hubei University of Economics* (*Humanities and Social Sciences*) [湖北经济学院学报(人文社会科学版)], Vol. 9, No. 12 (December 2012): 15-17. Zhang Min 张敏, Zhen Feng 甄峰, and Zhang Xiao-ming 张晓明, "Characteristics and Mechanisms of the Peri-urbanization in China's Less Developed Coastal Areas: A Case Study of Putian, Fujian Province (中国沿海欠发达地区半城市化特征与机制—以福建莆田为例)," *Geographical Research* [地理研究], Vol. 27, No. 4 (July 2008): 927-936.

[36] For details, see Liu Ts'ui-jung 劉翠溶 and Liu Shi-yung 劉士永, "Water Supply and Water Drainage: A Study on the History of Environment in Taiwan (淨水之供給與污水之排放: 臺灣聚落環境史研究之一)," *Academia Economic Papers* [經濟論文], Vol. 20, No. 2 (Sept. 1992): 459-504. Taiwan Water Corporation includes 12 branches, for details, see www.water.gov.tw. For history of Taipei Water Department, see http://www.twd.gov.tw/np.asp?ctNode=48103&mp=114001.

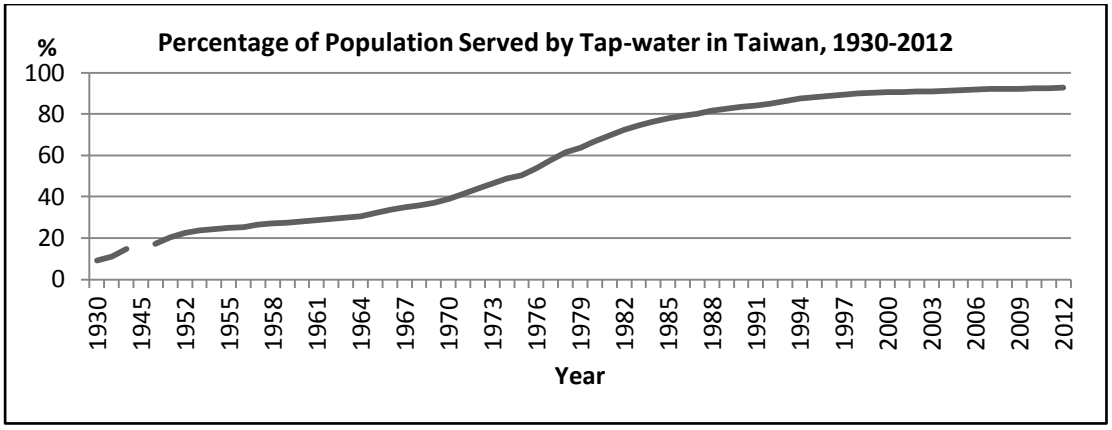

Figure 8: Percentage of Population Served by Tap-water in Taiwan, 1930-2012

Source:

For the data of 1930-1990 see, Liu Ts'ui-jung 劉翠溶 and Liu Shi-yung 劉士永, "Water Supply and Water Drainage: A Study on the History of Environment in Taiwan," *Academia Economic Papers* [經濟論文], Vol. 20, No. 2 (September 1992), Table 1 and Table 3.

The data of 1990-2012 are obtained by combining the statistics of Taiwan Water Corporation and Taipei Water Department. See, *Statistical Yearbook of Taiwan Water Corporation 2012* [臺灣自來水公司 101 年統計年報], available at: http://www.water.gov.tw/02results/res_d_main.asp?bull_id=7376; *Taipei Water Department Statistical Yearbook, 2001* [臺北自來水事業九十年統計年報], available at: http://www.twd.gov.tw/public/Attachment/032912305130.pdf, Table 6-1; *Taipei Water Department Statistical Yearbook, 2012* [臺北自來水事業統計年報: 中華民國 101 年], available at: http://www.twd.gov.tw/public/Attachment/36316401792.pdf, Table 27.

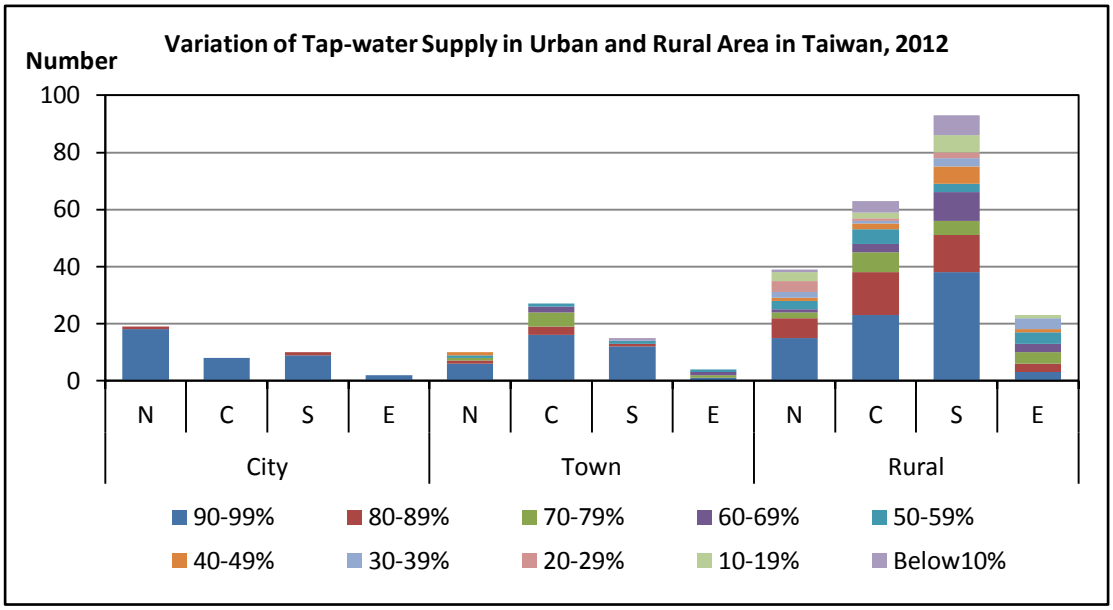

Figure 9: Variation of Tap-water Supply in Urban and Rural Area in Taiwan, 2012

Note: N, C, S, E indicate the north, central, south and east region respectively.

Source: *Taiwan Water Corporation Statistical Yearbook 2012*, available at: http://www.water.gov.tw/02results/res_d_main.asp?bull_id=7376

Taipei Water Department Statistical Yearbook 2012, available at: http://www.twd.gov.tw/public/Attachment/36316401792.pdf

Obviously, the variation was most remarkable among rural townships. At the city level, only Yangmei (楊梅, 89.83 percent) in north region and Pingtung (屏東, 79.23

percent) in south region had the rate below 90 percent. At the town level, the north region had 4 of the 10 towns below 90 percent and the lowest rate was found at Guanxi (關西, 46.27%); the central region had 11 of the 27 towns below 90 percent and the lowest rate was found at Yuanli (苑裡, 50.22 percent); the south region had 3 of the 15 towns below 90 percent and the lowest rate was found at Chaojhou (潮州, 3.25 percent); the east region had 3 of the 4 towns below 90 percent and the lowest rate was found at Yuli (玉里, 56.24 percent).

In the rural area, the four regions had respectively 38 percent (15/39), 37 percent (24/64), 41 percent (38/93), and 13 percent (3/23) of the rural townships where the population served by tap-water was over 90 percent. In general, rural townships located at hilly and mountain area had lower rates and the lowest rate in the four regions was found respectively at Jianshih (尖石, 9.09 percent), Taian (泰安, 2.22 percent), Jiouru (九如, 0 percent), and Zhuoxi (卓溪, 14.23 percent). It is notable that besides Jiouru, another five exceptional low rates in south region are all in Pingtung County; they are Yanpu (鹽埔, 1.74 percent), Wanluan (萬巒, 1.43 percent), Ligang (里港, 1.38 percent), Linluo (麟洛, 1.27 percent), and Jhutian (竹田, 1.15 percent).

3.1.2 Waste water discharge

In respect to waste water discharge, historical records revealed that in the late nineteenth century, some ditches were constructed and dredged in Tainan, the largest city at that time. During the Japanese colonial period, the first sewer system was planned in 1896 in Taipei City and completed in 1901. Moreover, the city planning order was applied to other cities in 1910. Available statistics showed that by 1915, the total length of sewer system was 357,154 meters in 11 cities. After the War World II, the government drew up new urban planning and sewer system was one of the public works; gradually, in addition to the storm sewer system, the sanitary sewer system was constructed for preventing water pollution.[37]

With consistent statistics of storm sewer completed in urban planning districts of cities and counties during 1998-2012, the data of length completed and regional shares are illustrated in Figure 10. The total length of storm sewer system completed in Taiwan Area increased from 3,158 kilometers to 4,611 kilometers during 1998-2012 and the shares in north, central, south, and east regions are respectively on average 36 percent, 22 percent, 36 percent, and 6 percent.

With the background of regional variation, the statistics of five municipalities (Taipei City, New Taipei City, Taichung City, Tainan City and Kaohsiung City), three provincial-level cities (Keelung, Hsinchu, and Chia-I), the average of counties in four regions, as well as the grand average of Taiwan Area during 1998-2012 are illustrated

[37] See Liu Ts'ui-jung and Liu Shi-yung, "Water Supply and Water Drainage," pp. 482-485.

in Figure 11. Taking the rate in 2012 as a guide, Figure 11 illustrates the rate from the highest to the lowest.

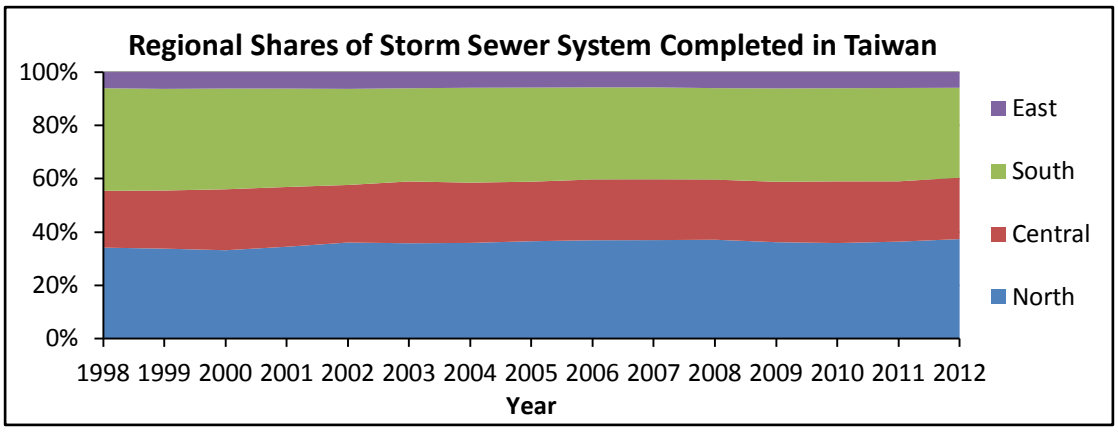

Figure 10: Regional Shares of Storm Sewer System Completed in Taiwan, 1998-2012
Source: Table 09-13, Statistical Yearbook of Interior of the Republic of China, available at: http://sowf.moi.gov.tw/stat/year/list.htm.

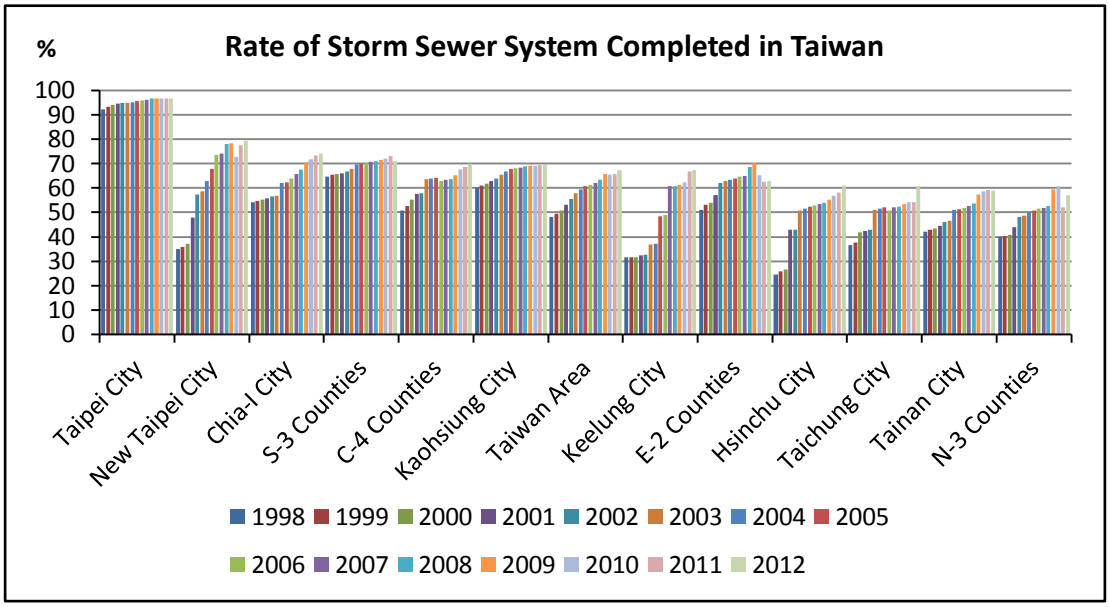

Figure 11: Rate of Storm Sewer System Completed in Taiwan, 1998-2012
Source: Same as Figure 10.
Note: For years 1998-2010, the data of New Taipei City are those of Taipei County; the data of Taichung City, Tainan City, and Kaoshiung City are respectively the sum of original City and County.

In 2012, the rate was in the order of 96.7 percent in Taipei City, 79.4 percent in New Taipei City, 74.2 percent in Chia-I City, 70.9 percent in three counties of south region, 69.9 percent in four counties of central region, 69.5 percent in Kaohsiung City, 67.3 percent in Taiwan Area, 67.2 percent in Keelung City, 63.0 percent in two counties of east region, 61.1 percent in Hsinchu City, 60.7 percent of Taichung City, 59.1 percent of Tainan city, and 57.1 percent of three counties of north region. Even

though the changing of rates varied among places, a trend of increasing can be discerned. It is notable that among the five municipalities, Taichung and Tainan are relatively backward in constructing storm sewer system. Moreover, in the north region, the rates of Taipei City and New Taipei City were on the top while the average of three counties was at the bottom.

The sources of waste water discharged in Taiwan are classified in three categories: municipal (i.e., daily life), industrial, and agricultural (mainly from husbandry). In 1987, the shares of three categories were respectively 25 percent, 54 percent, and 21 percent. But the averages of 1999-2005 were 72.90 percent, 7.45 percent, and 19.65 percent respectively. The reduction of industrial waste water was due to implementation of regulations.[38] Here, the focus is on treatment of municipal waste water. During 2003-2012, the cumulative length of sanitary sewer completed increased from 2,593.3 kilometers to 6,702.5 kilometers. The shares of four regions are illustrated in Figure 12.

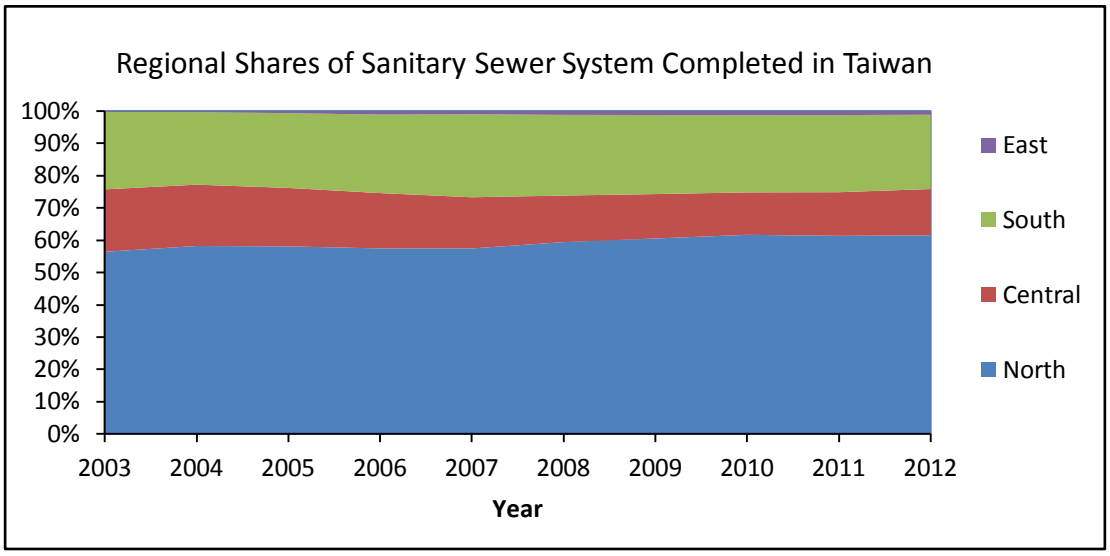

Figure 12: Regional Shares of Sanitary Sewer System Completed in Taiwan, 2003-2012
Source: Table 09-12, Statistical Yearbook of Interior of the Republic of China, available at: http://sowf.moi.gov.tw/stat/year/list.htm.

Moreover, the percentages of population served by sanitary sewer system during 2000-2012 are illustrated in Figure 13 with the rates arranged from the highest one (Taipei City) to the lowest one (the average of East-2 County). It should be noted that due to the method of calculating the rate, Taipei City had its rate above 100 percent

[38] See Ts'ui-jung Liu, "Water Pollution control along Rivers in Taiwan during 1986-2006 (近二十年來(1986-2006)臺灣河川污染防治)," in Fu-shan Huang 黃富三 (ed.), *Ocean, River and the Transformation of Settlements in Taiwan: A Comparative Perspective* [海、河與臺灣聚落變遷：比較觀點], (Taipei: Institute of Taiwan History, Academia Sinica, 2009), pp. 236-237; 250-271.

since 2009 and New Taipei city had its rate above 100 percent in 2012. With the rate of 2012 as a guideline, it can be seen that there are five cities above the grand average of Taiwan Area; of them four were in north region (Taipei City, New Taipei City, Keelung City and Hsinchu City) and one in south region (Kaohsiung City). But in 2003, only Taipei City and New Taipei City had the rate above the grand average. This reveals that the construction of sanitary sewer has been speeding up recently and it is most remarkable that Keelung City has an abrupt increase in 2012.

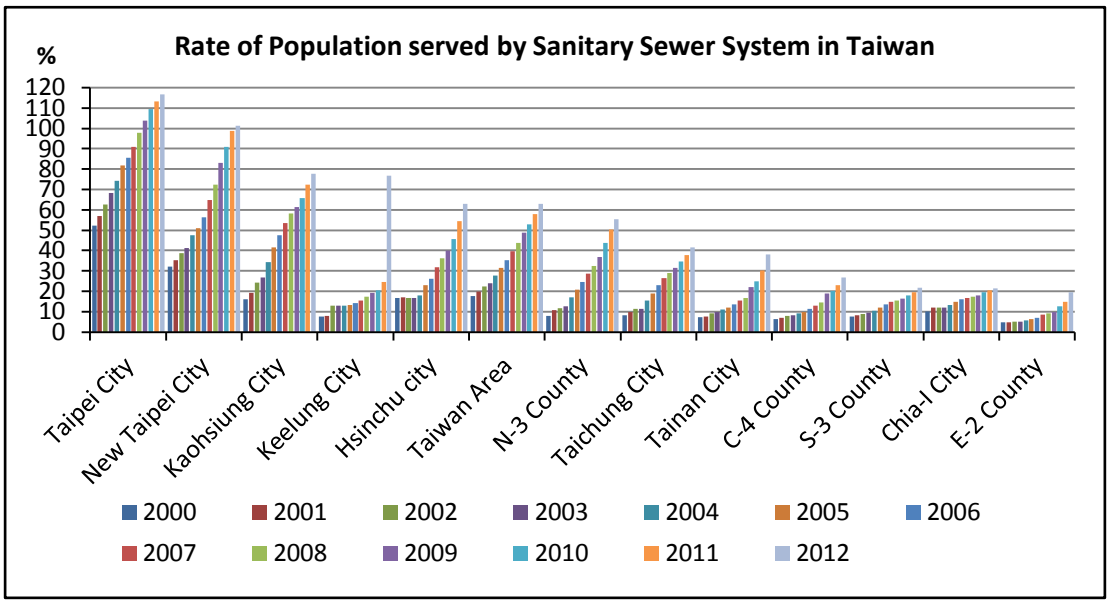

Figure 13: Rate of Population Served by Sanitary Sewer System in Taiwan, 2000-2012

Source: Same as Figure 12.

Note: Rate of population served by sanitary sewer system is calculated by:
Total number of household served / Total number of household times 4, thus, it can be over 100 percent in some cases.

3.1.3 Solid waste (garbage) clearance and recycle

In regard to municipal solid waste (garbage) clearance and recycle, the shares of treatment by different methods are illustrated in Figure 14. It is notable that among five methods of garbage clearance, the share of incineration increased while that of sanitary landfill, general landfill, dumping, and others, decreased since 1996, and general landfill and dumping were no longer in practice since 2007 while others were negligible. Moreover, since 1998, the practice of recycling steadily increased until 2012, the three items of recycled solid waste together shared 54.76 percent while clearance reduced to 45.24 percent.

In regard to night soil, Figure 15 shows the percentages of disposal to different destinations during 2003-2012. It is obvious that disposal of night soil to the sewage treatment plants increased largely after 2006, while those to the night soil treatment

plants and to other destinations had declined, disposal to the compost treatment plants ceased after 2005, and disposal to the landfill treatment plants decreased until 2008 and then increased slightly again.

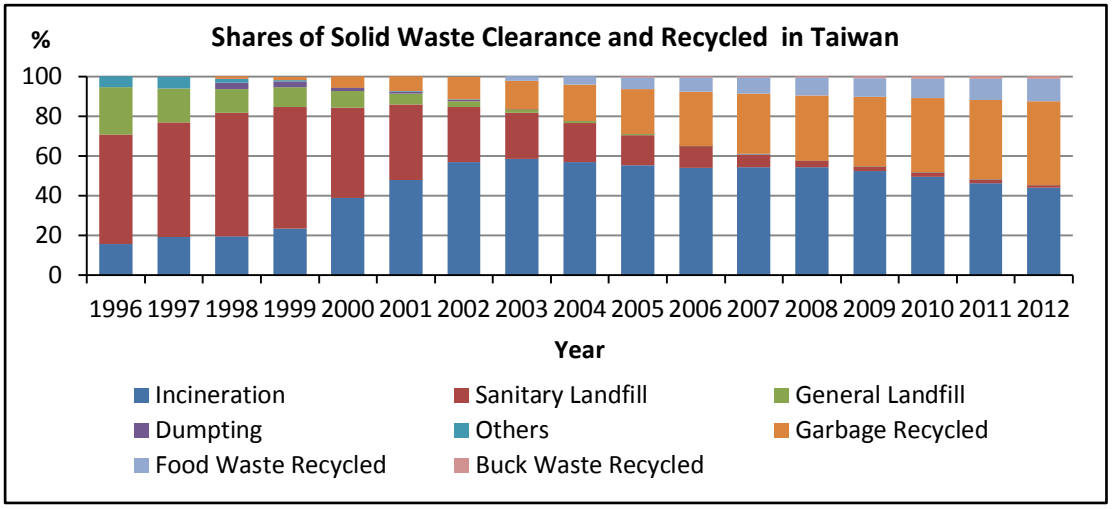

Figure 14: Shares of Solid Waste Clearance and Recycled in Taiwan, 1996-2012
Source: Environmental Protection Administration, Executive Yuan 行政院環境保護署, *Yearbook of Environmental Protection Statistics, Republic of China, 2013* [環境保護統計年報 102 年版], Table 4-1, available at: http://www.epa.gov.tw/ch/SitePath.aspx?busin=4177&path=4327&list=4327.

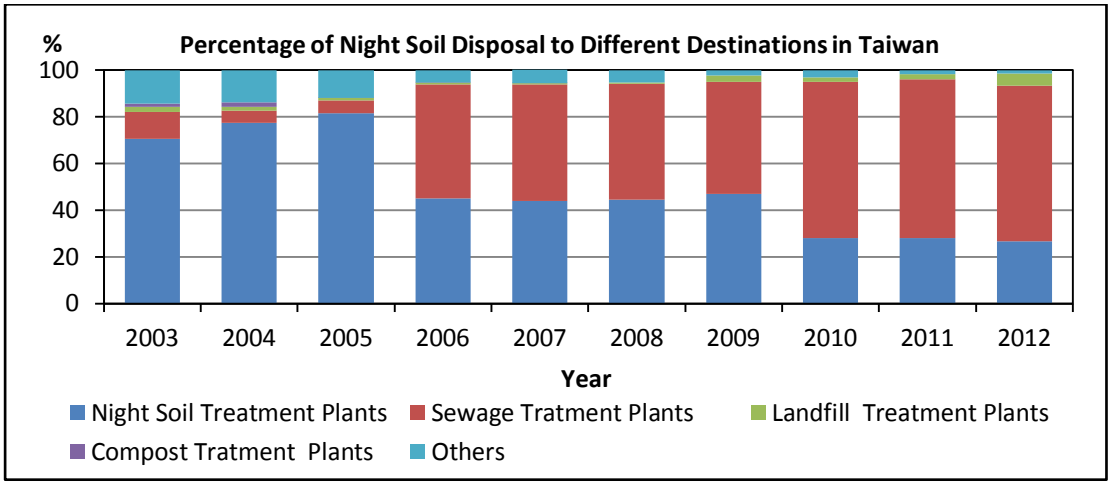

Figure 15: Percentage of Night Soil Disposal to Different Destinations in Taiwan, 2003-2012
Source: *Yearbook of Environmental Protection Statistics, Republic of China, 2013*, Table 4-7, available at: http://www.epa.gov.tw/ch/SitePath.aspx?busin=4177&path=4327&list=4327.

3.1.4 Air pollution

In regard to air pollution in Taiwan, The available statistics of pollutant standard index (PSI) during 1992-2012 showed that the PSI levels in Taiwan was mostly good (PSI=0~50) and moderate (PSI=51~100) with the rate of good increased from 15 percent to 48 percent and that of moderate decreased from 73 percent to 51 percent; while the rate of unhealthy (PSI=101~200) decrease from 11 percent to 1 percent and

the rates of very unhealthy and hazardous were all below 1 percent. Here, the statistics PSI at seven air basins in 2012 and the shares of different PSI levels are illustrated in Figures 16a and 16b. In 2012, the monitoring records at seven air basins showed that four had unhealthy records (Kao-Ping 2.68 percent, Yun-chia-Nan 0.85 percent, Central 0.70 percent, and North 0.59 percent) and one had very unhealthy records (Kao-Ping 0.03 percent).

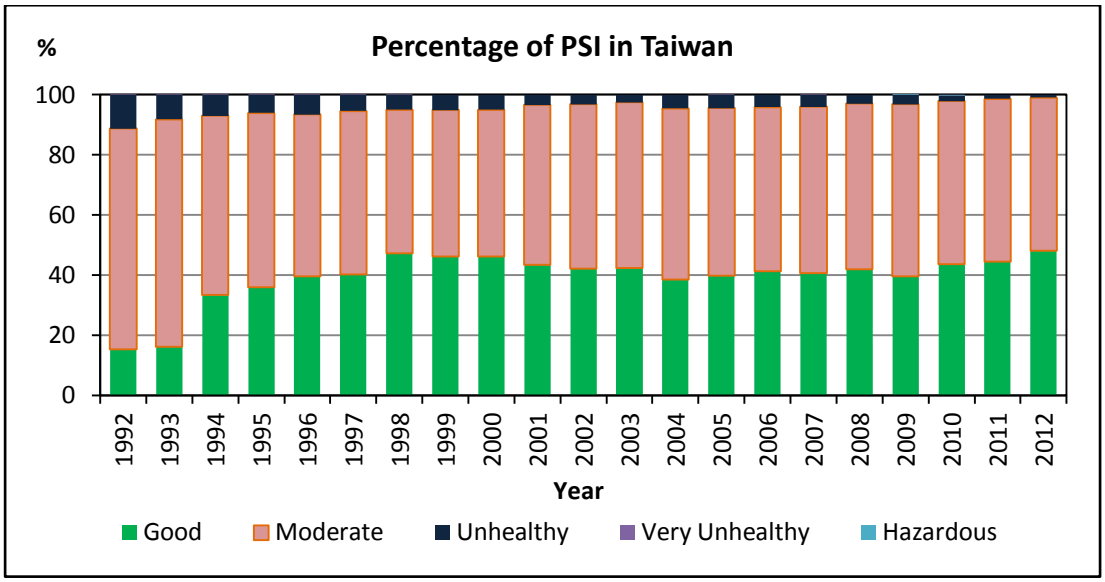

Figure 16a: Percentage of PSI in Taiwan, 1992-2012

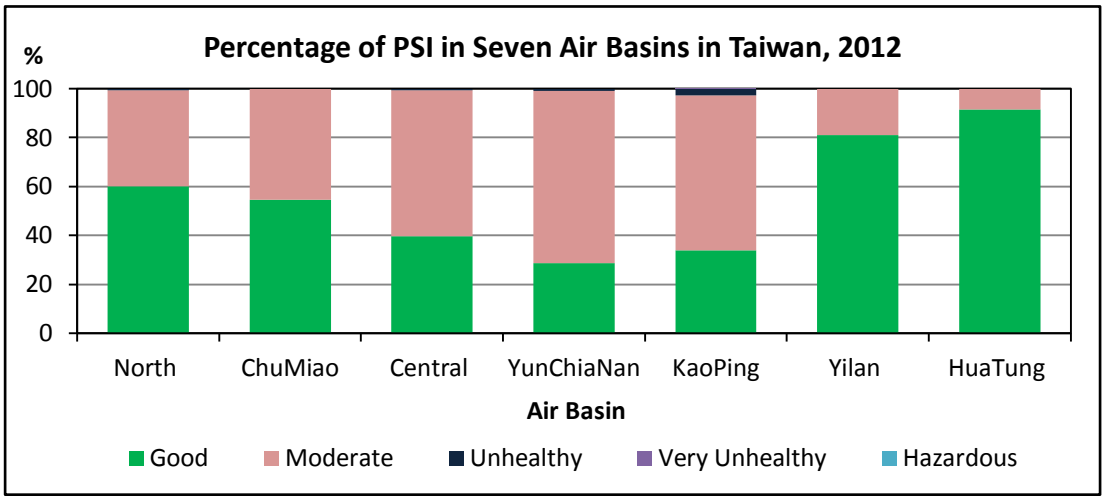

Figure 16b: Percentage of PSI in Seven Air Basins in Taiwan, 2012

Source: *Yearbook of Environmental Protection Statistics, Republic of China, 2013*, Table 1-1, available at: http://www.epa.gov.tw/ch/SitePath.aspx?busin=4177&path=4327&list=4327.

In regard to incident of acid rain in Taiwan, available statistics of the pH value of acid rain obtained from 15 monitoring stations during 2002-2012 are illustrated in Figure 17. The variation of these stations arranging from north to south and to east.

We can see that most stations had pH values around 4.5-5.5; the values below 4.5 were found at Yangming and Wanli, the two stations nearby Taipei City, and at Kuanyin, the station nearby the industrial zone in Taoyuan County; while the highest value of 6.07 was at Lunpei station in 2011 and this station together with Nantou in Central Taiwan had higher value in years under observation.[39] The overall situation is that the pH value of acid rain has been improved but not even among regions.

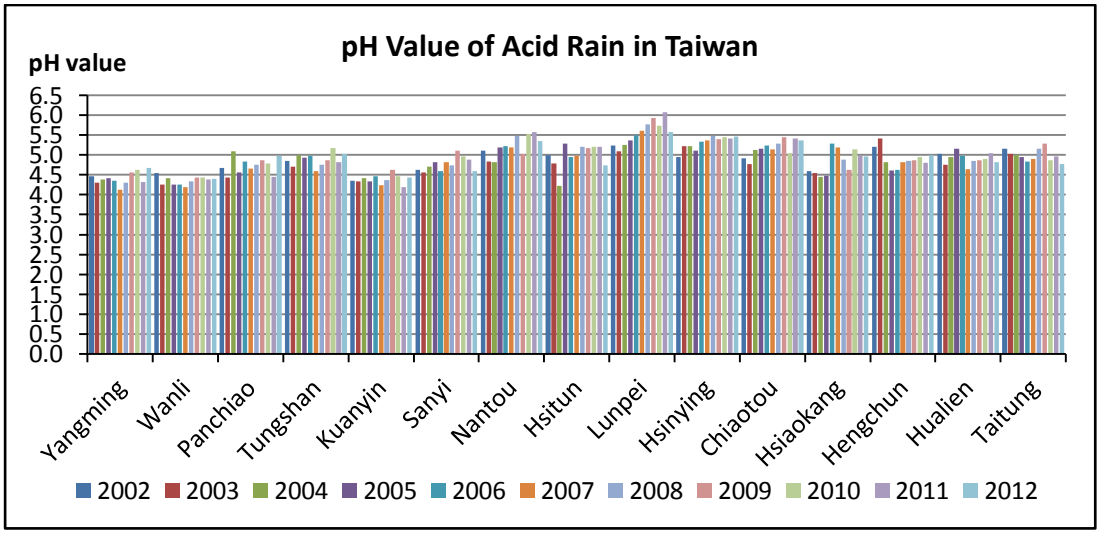

Figure 17: pH Value of Acid Rain in Taiwan, 2002-2012

Source: *Yearbook of Environmental Protection Statistics, Republic of China, 2013*, Table 1-10, available at: http://www.epa.gov.tw/ch/SitePath.aspx?busin=4177&path=4327&list=4327.

3.1.5 Environmental noise

In regard to environmental noise, the statistics of over-standard time frame are illustrated in Figure 18.

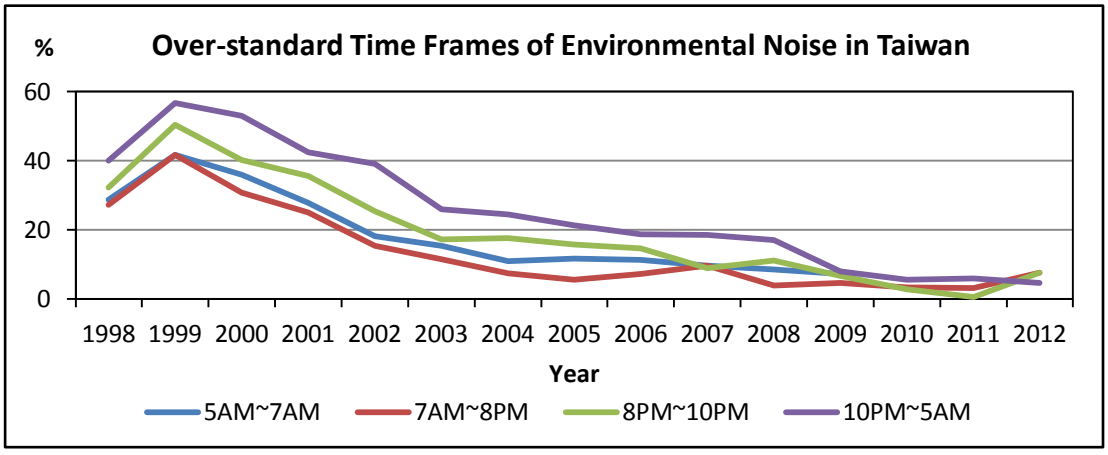

Figure 18: Over-standard Time Frames of Environmental Noise in Taiwan, 1998-2012

Source: Source: *Yearbook of Environmental Protection Statistics, Republic of China, 2013*, Table 2-1, available at: http://www.epa.gov.tw/ch/SitePath.aspx?busin=4177&path=4327&list=4327.

[39] For more details of acid rain in Taiwan since 1990, see http://acidrain.epa.gov.tw/now/04.htm.

Thus, we can see at four time frames, the percentage of over-standard environmental noise declined from the peak of 40-50 percent after 1999 and reduced to less than 10 percent after 2009.

3.1.6 Park and green areas in urban planning districts

In regard to availability of park and green area in urban planning districts in Taiwan, Statistics are available for the total and per capita data in 1992-2012 as well as data of five municipal cities, three provincial level cities, the average of counties in four regions, and the grand average of Taiwan Area in 2012. Figure 19 illustrates the per capita area in 2012.

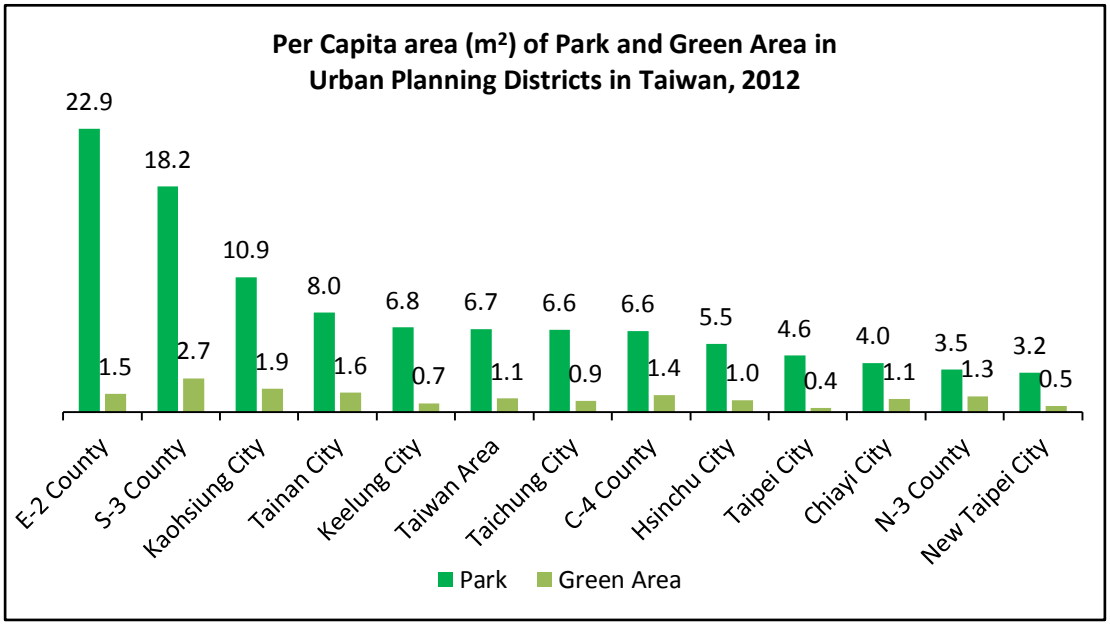

Figure 19: Per Capita area (m^2) of Park and Green Area in Urban Planning Districts in Taiwan, 2012

Source: Table 09-04, Statistical Yearbook of Interior of the Republic of China, available at: http://sowf.moi.gov.tw/stat/year/list.htm.

Thus, we can see in 2012, the per capita area of park ranged from the largest 22.9 square meter in E-2 County to the smallest 3.2 square meter in New Taipei City; and the per capita green area ranged from 2.7 square meter in S-3 County to 0.4 square meter in Taipei City. On the average, the people of urban planning districts in Taiwan had 6.7 square meter of park and 1.1 square meter of green land. Generally speaking, the people living in east and south regions have larger shares of park and green area and those in north region have smaller shares, while those in central region are in between.

3.1.7 Promoting green building

Finally, for sustainable development of cities, it is notable that Taiwan began to adopt the EEWH (Ecology, Energy saving, Waste reduction, and Health) green building certification system in 1999, next only to UK, USA, and Canada, and the evaluation system set up in Taiwan was the first one suitable for tropical and sub-tropical area. In 2001, the Executive Yuan approved the "Plan for promoting green building (綠建築推動方案)" for seven years and up to 2008, there were 1,953 buildings obtained the certificate in Taiwan. In 2008, the Executive Yuan further approved the "Plan for promoting ecological city green building (生態城市綠建築推動方案)" with a goal of reducing yearly carbon dioxide emission of 270 million kg by 2011.[40] Thus, Taipei City had its plan of ecological city initiated in 2004; Tainan City had its plan drawn in 2008; and Taichung City had its evaluation system designed in 2011 with three main categories: social progress, economic development, and environmental protection.[41] It is also notable that Kaohsiung City was cited as an example of "Renewable Energy City" for its plan in 2009 and an example of "Sustainable Transport City" for its implementation of C-Bike system in the same year.[42]

3.2 Fujian

In 1997, Yang Jin-sheng (楊錦生), Deputy Director of Environmental Protection Department of Fujian Province, pointed out the following urban environmental problems in Fujian: (1) The waste water of cities has been discharged into rivers without treatment thus water pollution extended along the rivers and affected the sources of drinking water. (2) Factories nearby cities were located at places off the wind and thus caused air pollution in cities. (3) The statistics of 22 cities revealed that 50% of urban noise comes from social and daily life. (4) The rate of industrial solid waste recycled was very low and the rate of sanitary treatment of urban garbage was also very low and thus caused secondary pollution. (5) The "heat island effect" has accelerated and caused the problem of urban ecology. (6) The environmental law and

[40] Ho Ming-chin 何明錦 and Chen Po-hsun 陳伯勳, "Ecological City: The Plan and Mechanism for Promoting Green Building (生態城市：綠建築推動方案與行動機制)," *Civil Engineering and Water Control* [土木水利], Vol. 36, No. 2 (April 2009): 27-37.

[41] Ho Y. F. 何友鋒, Wang H. L. 王小璘, Wu Y. Y. 吳怡彥, and Wu C. I. 吳靜宜, "The Policy of Sustainable Building: From Green Building to Ecological City (從綠建築邁入生態城市的全方位永續營建政策)," *Civil Engineering and Water Control* [土木水利], Vol. 36, No. 2 (April 2009): 58-70. Wang H. L. 王小璘, Ho Y. F. 何友鋒, Huang Y. C. 黃晏淨, and Wu C. I. 吳靜宜, "The Evaluation Framework of Eco-city – A Case Study in Taichung City (生態城市評估指標體系之研究--以台中市為例)," *Journal of Architecture*, No. 75 (March 2011): 115-134.

[42] Peter Newman and Anne Matan, *Green Urbanism in Asia: The Emerging Green Tigers* (Singapore: World Scientific Publishing Co., 2013), pp. 40-45, 203-204.

regulations are not well implemented, the managerial personnel are insufficient, and the level of environmental investment was lower than the national level. Since 1995, Fujian had tried to control environmental pollution and to adjust the industrial structure for improving the environmental quality of major cities, such as Fuzhou, Xiamen, Quanzhou, Zhangzhou and Sanming; the goal was to have the environment of all cities in the province largely improved by 2000 and all cities can have good environment by 2010.[43]

With this general perspective, related issues will be discussed in below with data I have collected so far. Because it is rather difficult to obtain from statistical yearbooks the data for reconstructing consistent time series of urban environmental condition in Fujian, the discussion below will focus only on selected years.

3.2.1 The year 1993

For the year 1993, with available statistics of 20 cities in Fujian the rate of population served by tap water is illustrated in Figure 20a and the green area in built district (jian-cheng-qü 建成區) is shown in Figure 20b.

In Figure 20a, the rate of population served by tap-water is arranged from the highest to the lowest; thus, it is obvious that the gap between them is very wide as Fuzhou had 93.42 percent and Nanan had only 3.65 percent. In regard to green area in built district, Figure 20b shows that the largest one was 13.56 square kilometer in Xiamen and the smallest one was 0.18 square kilometer in Ningde.

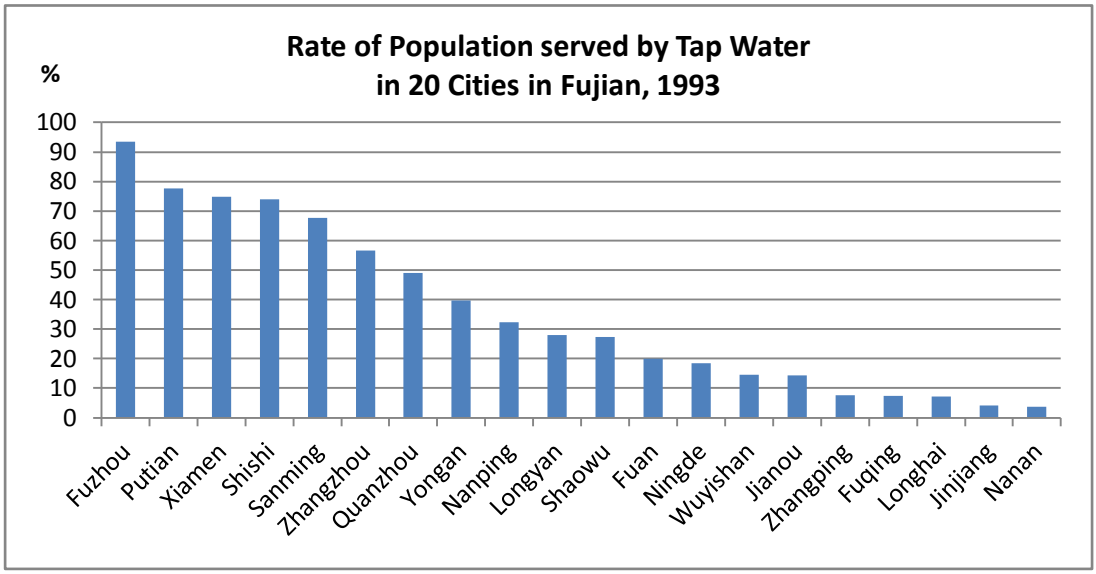

Figure 20a: Rate of Population Served by Tap Water in 20 Cities in Fujian, 1993

Source: *Fujian Statistical Yearbook 1994* [福建統計年鑑 1994], Table 17-1, pp. 373-388.

[43] Yang Jin-sheng 楊錦生, "Fujian's urban environmental problems and counter strategies (福建城市環境的主要問題與對策)," *Development Studies* [發展研究], No. 2 (1997): 17-19.

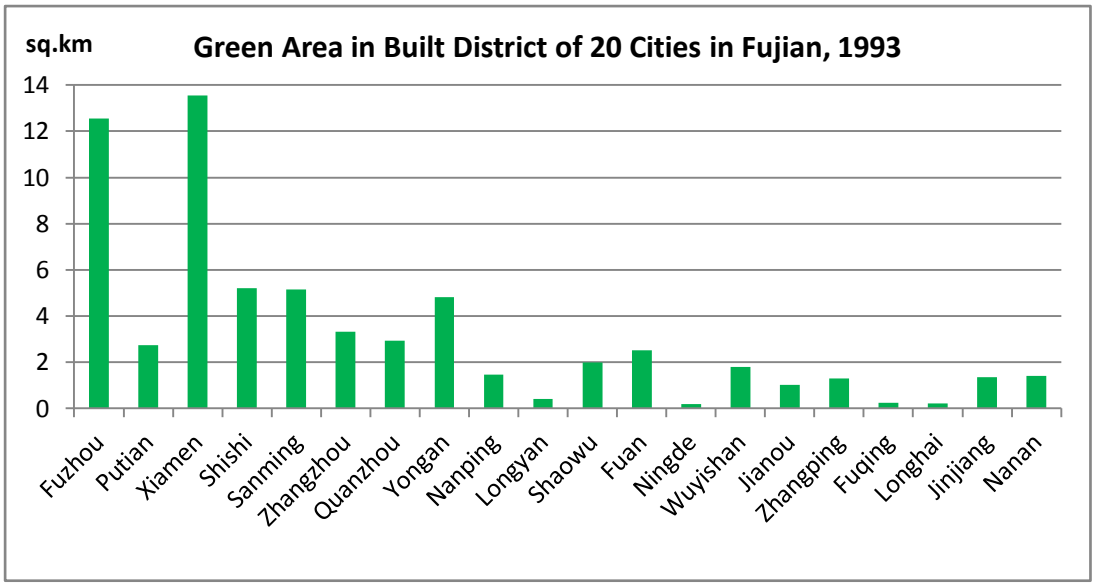

Figure 20b: Green Area in Built District of 20 Cities in Fujian, 1993

Source: Same as Figure 20a.

In addition to tap-water consumption and green area, the data regarding length of sewer (Figure 20c), volume of daily life waste water discharged and industrial waste water treatment (Figure 20d) were also available for 20 cities in 1993. These items, too, were in great variation among cities. In regard to length of sewer, Fuzhou had 599 kilometers while Longhai had only 8 kilometers. In regard to the volume of daily life waste water discharged, Fuzhou had 102,790,000 tons while Nan-an only had 20,000 tons; as for industrial waste water treatment, Sanming had 67,340,000 tons, while Nanan only had 200,000 tons.

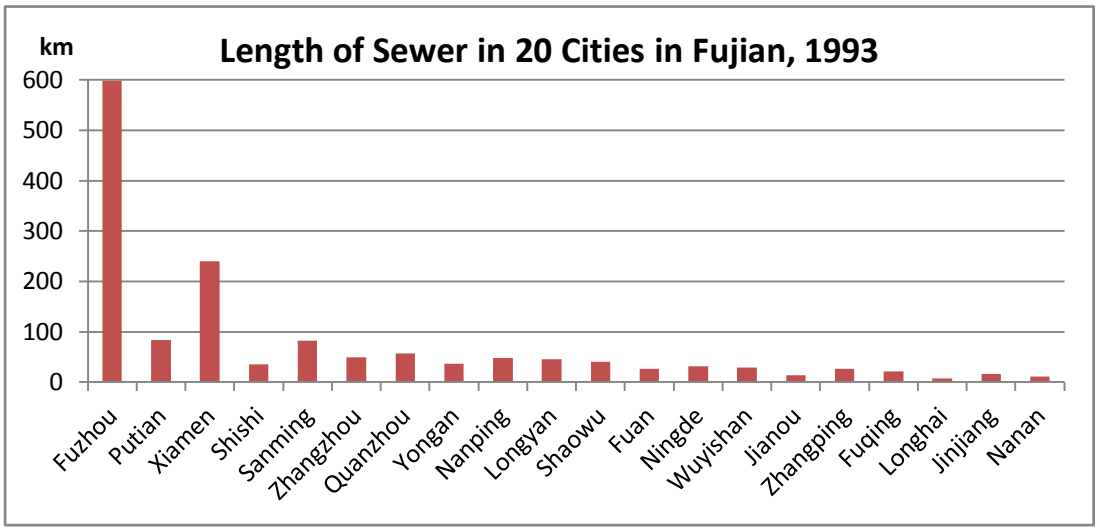

Figure 20c: Length of Sewer in 20 Cities in Fujian, 1993

Source: Same as Figure 20a.

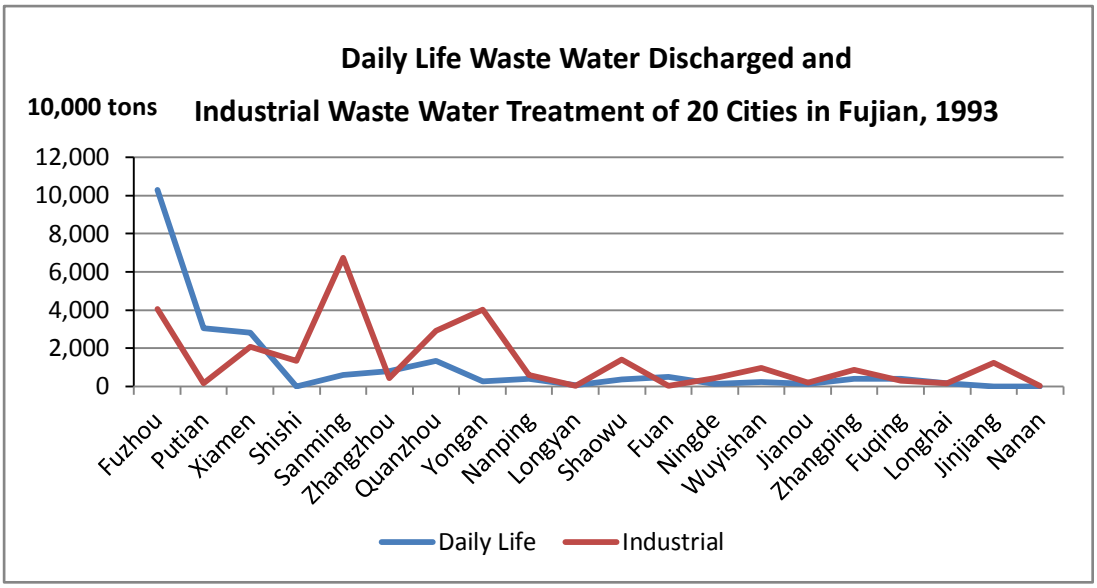

Figure 20d: Daily Life Waste Water Discharged and Industrial Waste Water Treatment of 20 Cities in Fujian, 1993

Source: Same as Figure 20a.

3.2.2 The year 2000

In the year 2000, the data available in statistical yearbook are only for nine prefectural level cities, here the rate of population served by tap water and green area in built district are illustrated in Figures 21.

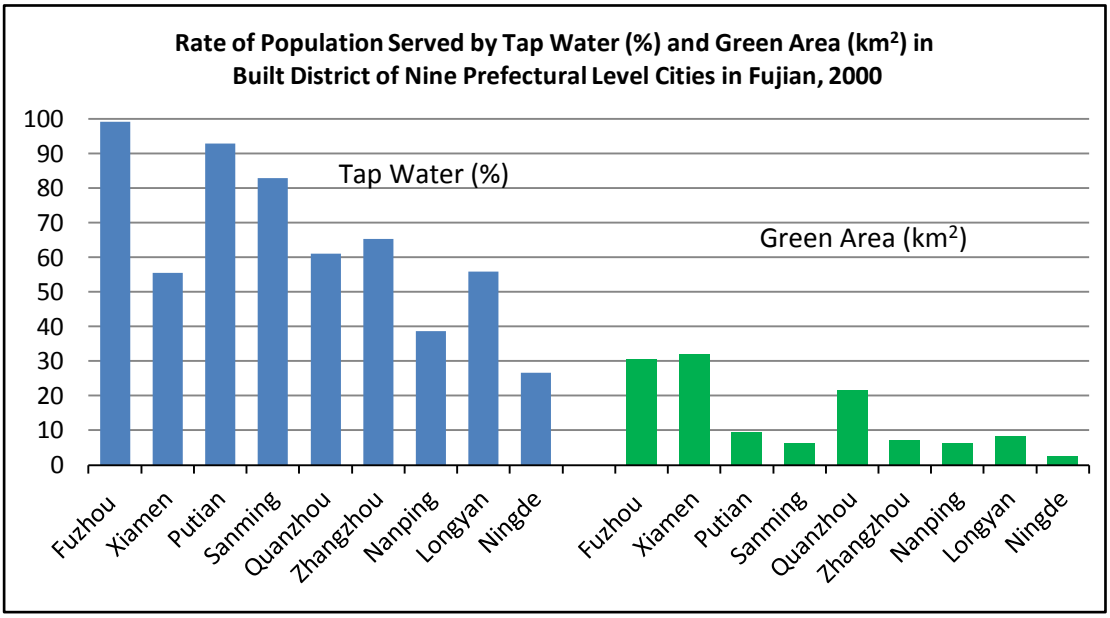

Figure 21: Rate of Population Served by Tap Water and Green Area in Built District of Nine Prefectural Level Cities in Fujian, 2000

Source: *Fujian Statistical Yearbook 2001* [福建統計年鑑 2001], Table 16-1.

The percentages of population served by tap water in 2000 were in the following order: Fuzhou 99.29, Putian 92.84, Sanming 82.98, Zhangzhou 65.31, Quanzhou 61.02, Longyan 55.96, Xiamen 55.51, Nanping 38.60, and Ningde 26.68. As for green area in the built district, the order was as follows: Xiamen 31.87 sq.km, Fuzhou 30.42 sq.km, Quanzhou 17.57 sq.km, Sanming 9.94 sq.km, Putian 9.06 sq.km, Longyan 8.55 sq.km, Zhangzhou 7.10 sq.km, Nanping 5.73 sq.km, and Ningde 2.42 sq.km. The gap between the top and the bottom was still quite wide.

3.2.3 The years 2010 and 2012

For the years 2010 and 2012, data of 23 cities were available. Here, the rate of tap-water supply, the rate of waste water treatment, the rate of garbage clearance, and per capita park and green area are illustrated in Figures 22a, 22b, 22c, and 22d respectively.

Figure 22a shows that the rate of tap-water supply in Xiamen and Shaowu had reached 100 percent in 2010 and Nanping reached the same level in 2012; most cities had reached 99 percent, but a drop from 99.6 percent to 91.5 percent in Nanan is rather peculiar.

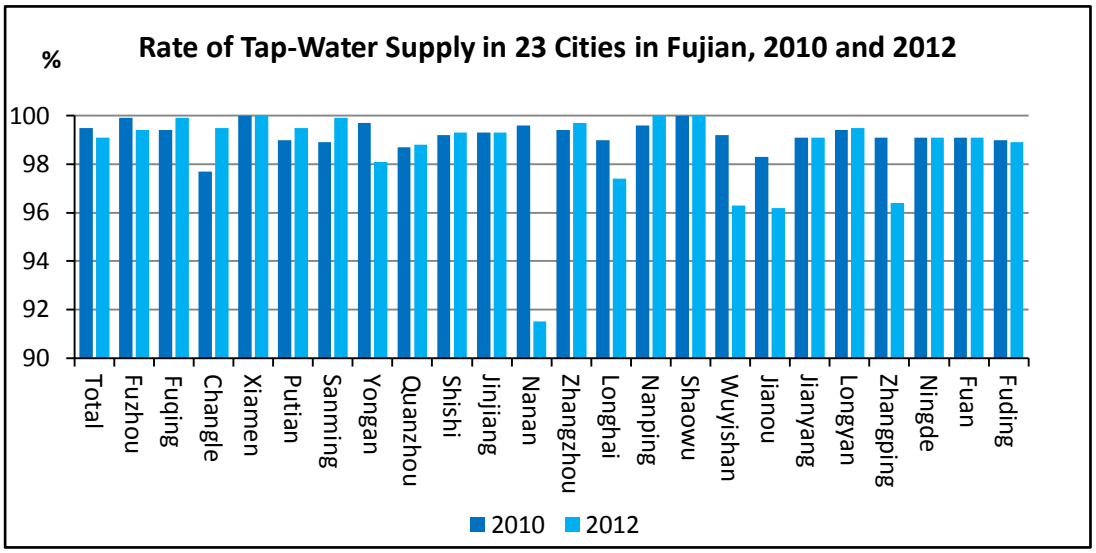

Figure 22a: Rate of Tap-Water Supply in 23 Cities in Fujian, 2010 and 2012

Source: *Fujian Statistical Yearbook 2011* [福建統計年鑑 2011], Tables 9-2 ~ 9-7.
Fujian Statistical Yearbook 2013 [福建統計年鑑 2013], Tables 9-2 ~ 9-7.

Figure 22b shows that the rate of waste water treatment in Xiamen and Longyan had reached around 90 percent, but Yongan and Fuan had around 70 percent, and other cities had rates in between.

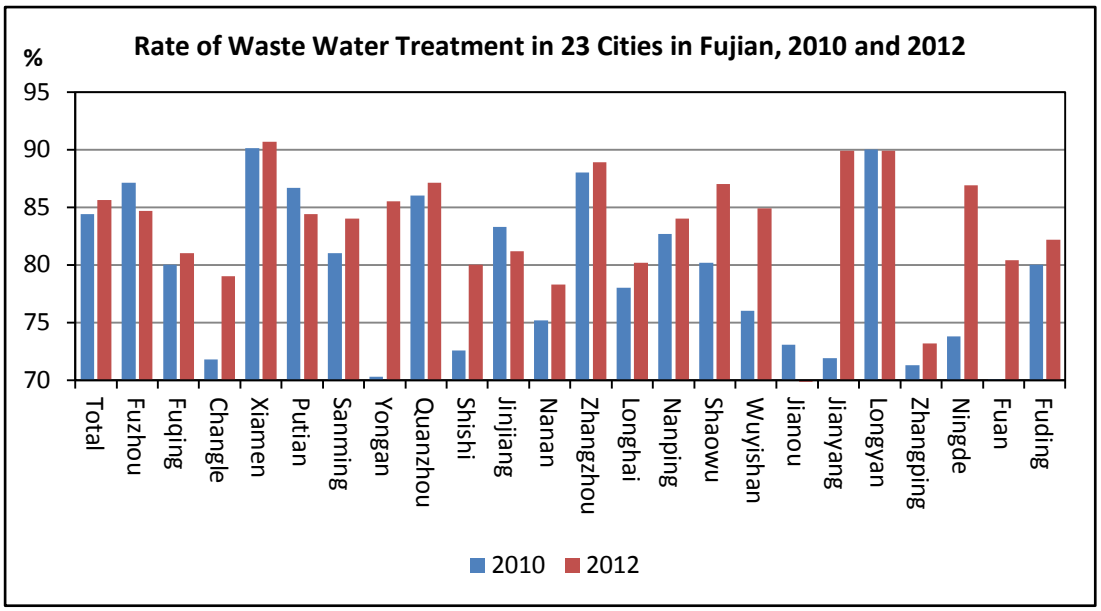

Figure 22b: Rate of Waste Water Treatment in 23 Cities in Fujian, 2010 and 2012

Source: Same as Figure 22a.

Figure 22c shows that the rate of garbage clearance in five cities—Shaowu, Wuyishan, Jianou, Jianyang, and Ningde—was not available in 2010; but in 2012, most cities had the rate above 90 percent, except for four cities—Jianou (27.3 percent), Wuyishan (38.0 percent), Jianyang (41.7 percent), and Ningde (84.0 percent).

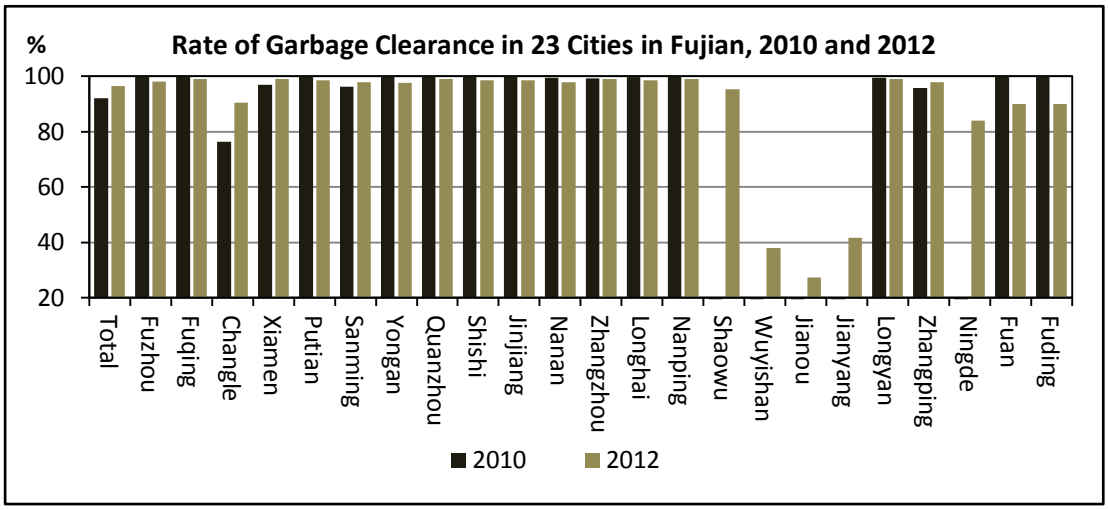

Figure 22c: Rate of Garbage Clearance in 23 Cities in Fujian, 2010 and 2012

Source: Same as figure 22a.

As for per capita area of park and green area, Figure 22d shows that in 2010, Nanan had the smallest 10 square meters and Shaowu had the largest 18.5 square meters; in 2012, Nanan still had the smallest 9.77 square meters and Changle had the largest 16.64 square meters.

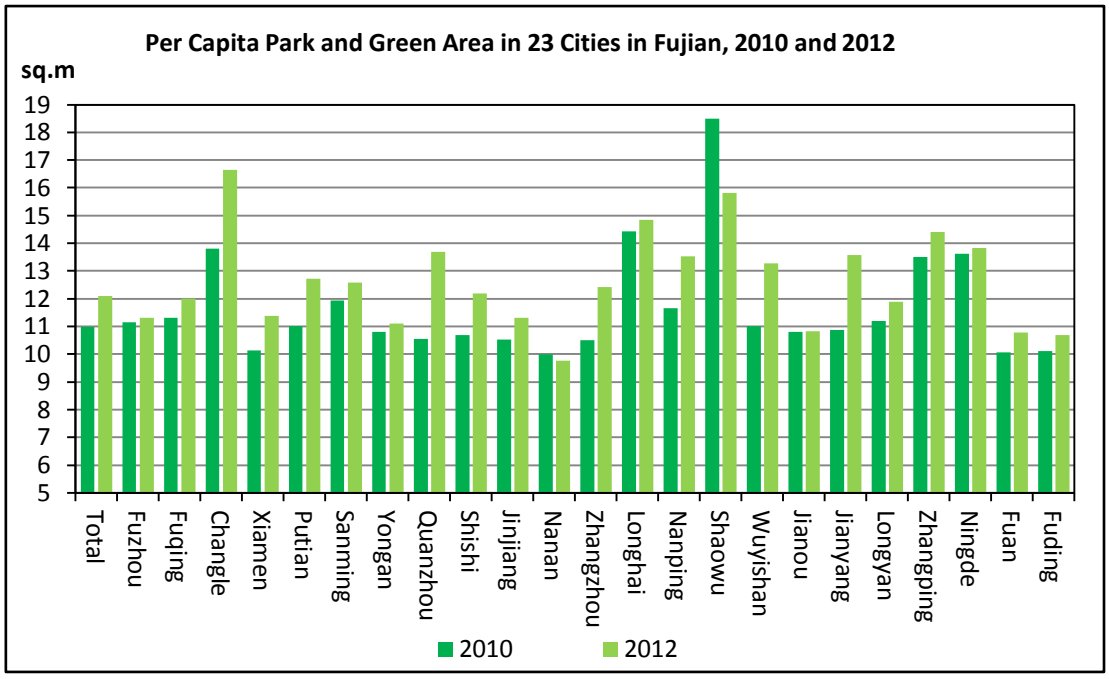

Figure 22d: Per Capita Park and Green Area in 23 Cities in Fujian, 2010 and 2012

Source: See Appendix Table 22.

Moreover, the data of industrial pollution treatment were available in nine prefectural-level cities in 2010 and Figure 23 illustrates the rate of treatment reaching the required standards in five aspects: industrial waste water, sulphur dioxide, dust, waste gas, and solid waste utilized.

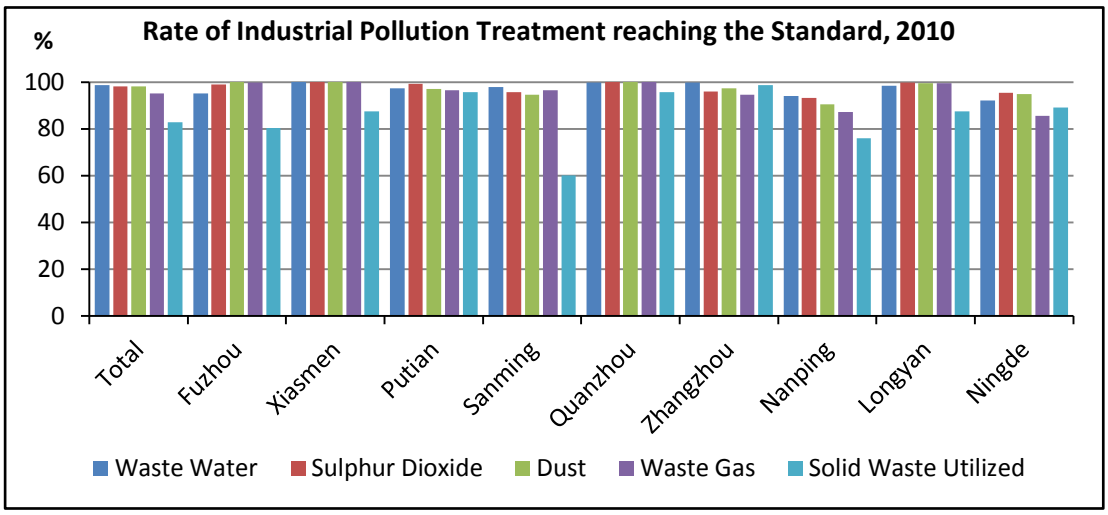

Figure 23: Rate of Industrial Pollution Treatment reaching the Standard in Fujian, 2010

Source: *Fujian Statistical Yearbook 2011*[福建統計年鑑 2011], Table 19-8.

Figure 23 shows that the rates of industrial pollution treatment reaching the required standards were mostly over 90 percent except for solid waste utilized.

Particularly, Xiamen had four items reached 100 percent except for solid waste utilized (87.3 percent); Quanzhou had three items reached 100 percent, except for waste water (99.8 percent) and solid waste utilized (95.6 percent). For other cities, most rates were over 90 percent, but Nanping and Ningde had somehow lower rate in waste gas treatment (87.1 percent and 85.5 percent respectively). It is also notable that the rate of solid waste utilized in Sanming was only 60 percent. Despite these cases of lower rates, these data reflected that industrial pollution treatment in Fujian had been improved remarkably in recent years.[44]

3.2.4 Air quality and environmental noise

Despite the improvement in industrial pollution treatment, the problem of acid rain in Fujian was still rather serious. With available data of air quality during 1992-2005, it is notable that pH values in these years were mostly below 5 and the lowest one was mostly below 4 or even down to 3. Acid rain appeared in most cities in Fujian except for Wuyishan City (武夷山市), a city at scenery mountain area.[45]

As for the environmental noise, the data available during 1992-2005 showed that environmental noise in nine prefectural-level cities in Fujian was quite high as the dB value was mostly above 55 and the transportation noise in cities even above 70.[46]

3.2.5 Construction of ecological city

It is notable that in recent years the promotion of constructing ecological city and low carbon economy was in progress in Fujian. In July 2002, the Fujian Provincial Government announced an environmental protection plan by stressing the construction of ecological cities, communities, towns and villages which will be beneficial for human health and harmony with nature.[47] In practice, a study has pointed out that Fujian should develop energy-saving technology and promote low-carbon consumption life style.[48] Another study has pointed out the achievement of building an ecological city at Fengze (豐澤) District in Quanzhou since 1997 as

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[44] For a discussion on reducing industrial waste, see Huang Yi-sui 黃一綏 and Huang Ling-feng 黃玲芬, "Relationship between urbanization and industrial pollution in Fujian province (福建省城市化與工業污染的關係研究)," *Ecology and Environmental Sciences* [生態環境學報], Vol. 18, No.4 (2009): 1342-1345.

[45] See the data in the appendix of *Environmental Protection Section in Gazetteer of Fujian Province* [福建省志 • 環境保護志], 1992-2000 and 2001-2005 editions.

[46] See the data in the appendix of *Environmental Protection Section in Gazetteer of Fujian Province* [福建省志 • 環境保護志], 1992-2000 and 2001-2005 editions.

[47] See People's Daily News [人民日報˙華東新聞], July 11, 2002, accessed on 2014/02/09 at: http://www.people.com.cn/BIG5/paper40/6689/653652.h.

[48] Feng Bi-mei 冯碧梅, "Strategy for Constructing Low-carbon City in Fujian (福建省构建低碳城市战略)," *Development Studies* [发展研究], No. 1 (2011): 92-94.

well as factors of restrictions.[49] A plan had been drawn up for constructing an ecological city on Pingtan (平潭) Island at the "Economic Zone at West Coast of the Strait".[50] Another plan had been drawn up with the aim of building Zhangzhou into a "pastoral city and eco-city".[51]

4. Concluding Remarks

Situating respectively on the east and west side of the Taiwan Strait, Taiwan and Fujian are rather similar with mountainous topography which no doubt set a precondition for urban development. The political separation after 1895 and again after 1949 was an important factor affecting the social and economic development as well as urbanization in the two sides of the Taiwan Strait.

Up to recent years, a remarkable difference in the progress of urbanization is that in Taiwan there are more people living in cities than in towns; while in Fujian the opposite is true. Similarly, in both Taiwan and Fujian, the process of industrialization brought serious problems of pollution in urban areas but the situation had gradually been improved in the past two decades, although variation among cities are still quite remarkable. Moreover, in response to the global alert of sustainable development, both Taiwan and Fujian had drawn up plans for developing ecological cities and green buildings in recent years, and it is remarkable that Taiwan has designed the first evaluation system of green building which is suitable for tropical and sub-tropical areas.

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[49] Yang Jing-zhong 杨京钟, "Research on Ecological Orientation of the Sustainable Development of Urban Areas—Take Quanzhou, Fujian for Example (生态城区的可持续发展取向研究─以福建泉州丰泽区为例)," *Journal of Jinzhong University* [晋中学院学报], Vol. 27, No. 1 (2010): 68-70.

[50] Huang Bai-fu 黃百富, "A Conceptual Plan of Pingtan Laboratory District: The initiative and realization of an ecological city (平潭綜合實驗區概念性總體規劃: 一座生態城市的發想與體現)," *Chung-hsing Engineering* [中興工程], No. 113 (October 2011): 105-115, available at: http://www.sinotech.org.tw/journal/.

[51] Chen Gang-tie 陈钢铁, "Zhangzhou Pastoral Eco-city Planning and Construction Essentials (漳州田园生态城市规划建设要点)," *Urban and Rural Development* [城鄉規劃], No. 8 (2012): 21-22.