AN ANALYSIS OF POPULATION MIGRATION AND ITS ENVIRONMENTAL IMPLICATIONS IN CHINA: APPLICATION TO DOMESTIC WATER USE

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This paper studies China's population migration and its environmental implications taking domestic water use as an example. Firstly, mechanisms of population migration between provinces and between rural and urban areas are analyzed by regression models. Secondly, future scenarios integrating economic development, population migration and urbanization up until 2020 are developed. Finally, the implication of population migration for domestic water use is examined.

The major findings are as follows: a) income gap, migration stock and distance are main determinants of inter-provincial migration; b) In 2020, population migration will cause domestic water use increase by 7.2% in Eastern Region, and decrease by 5.5% and 4.9% in Middle and Western Regions respectively.

Key Words: Environmental issues in China, Domestic water use, Population migration, Urbanization

1. INTRODUCTION

Since the start of economic reform in 1978, China has been experiencing a dramatic transition from a planned economy to a market economy. Uneven regional economic development has created a massive population migration in the past two decades. As a result, urbanization in China is taking place rapidly because of the large flow of rural to urban migration. From 1978 to 2000, China's urbanization level in terms of the ratio of urban population to the total one grew from 18% to 36%, while the total urban population increased from about 170 million to 460 million people. During the period of 1995 to 2000, the total migration amounted to 128 million people[1)]. What do this timing and magnitude of urbanization imply? What is the mechanism of population migration? And more importantly, what the regional environment change will take place due to the population migration and urbanization in China? Although the environmental implications caused by population migration cover many aspects, such as water use, energy consumption, land use change and environmental pollution, this paper just emphasizes on domestic water use as an example, because among the total water use, domestic water use is always given the top priority in water supply and planning, it is directly linked to the public health and regarded as one of the important premises for urban and economic development.

Regarding China's population migration issue, many studies have been conducted in the last decade. As a macro-level study, Wu *et al.* (1996) surveyed the literature on China's rural-to-urban labor migration[2)]. Wang *et al.* (1999) pointed out that huge urban-rural income gap and massive rural surplus labor were the main drivers of the rapid increase of immigrants in cities[3)]. Seeborg *et al.* (2000) adopted sociological theories to

supplement the neoclassical explanation of rural-urban migration in China[4]. Wu *et al.* (2003) established an economic model to explain rural-urban migration theoretically and tested it with empirical data[5]. Yan (2004a) used national census data and examined the driving forces of inter-provincial migration by using a regression model[1]. IIASA (2003a, b) summarized the historical characteristics of China's demographic changes and projected their future development[6], [7]. In the micro-level studies, Zhao (1999) used questionnaires on migrants from rural to urban areas to analyze the motivation of individual migrants[8]. Liang (2004) analyzed the patterns and social characteristics of temporary migrants[9]. Yan (2004b) modeled the choice and schedule of individual migrant with different age and living condition[10]. These studies provide a useful insight into the actual situation. However, most of them focused on the whole China, and the regional disparities of population migration and environmental implications caused by migration have not yet been analyzed.

Water resource issues in China have been paid much attention nationally and internationally. Chinese Academy of Engineering (2001) evaluated the current water resource issues and analyzed the future trend of water supply and demand[11]. World Bank (2001) focused on water resource and demand management issue in north China[12]. Japan Bank for International Cooperation (2004) studied the water supply and demand balance in China's Yellow River Basin[13]. All of these studies analyzed water resource in China comprehensively. However, while evaluating the socio-economic development, especially the population growth, most of the studies just extrapolate the historical trend, neglecting population migration under specific socio-economic development.

In order to overcome the shortcomings of previous studies, this paper uses the works of previous studies as a baseline, and explores particular socio-economic scenarios to consider population migration (as shown in Fig. 1). It attempts to a) characterize the population migration and urbanization phenomena in China; b) analyze the mechanism of population migration by using both nationwide time-series data and 2000 census data; c) formulate scenarios of economic development, population migration and urbanization in China toward the year 2020 by considering possible socio-economic development in the future; d) evaluate the implication of population migration for domestic wateruse.

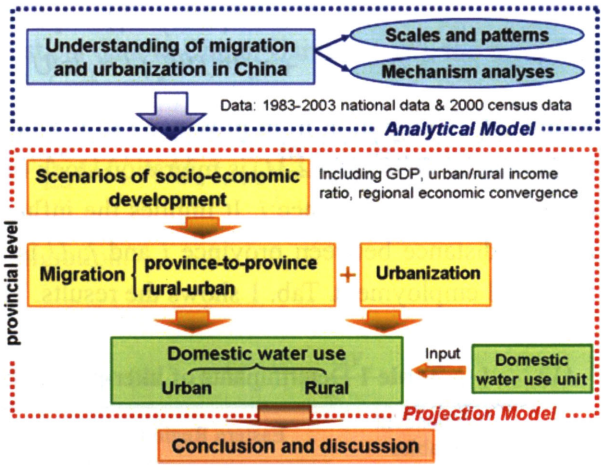
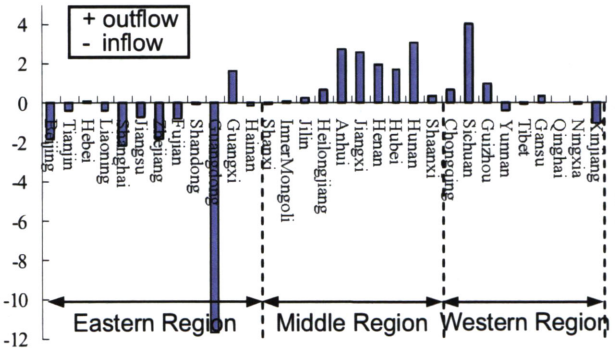


Figure 1 Flow chart of this study

2. POPULATION MIGRATION AND URBANIZATION IN CHINA

(1) Scales and contribution of rural-to-urban migration to urbanization 1983-2003

According to the 5th National Census in 2000, within the total 128 million migrants, 73% were identified as the intra-provincial migrants, while 27% belonged to inter-provincial migration.As showed in Fig. 2 and 3, the migration was primarily from the middle and western regions toward the eastern region. Guangdong, Shanghai, Zhejiang and Beijing became the concentrated centers. While Sichuan, Hunan, Anhui, Jiangxi were the largest senders of emigrants.



Notes: Eastern Region includes: Beijing, Tianjing, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan. Middle Region includes: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Shannxi. The rest belong to Western Region.

Figure 2 Provincial-level net in and out population migration (Unit: million)

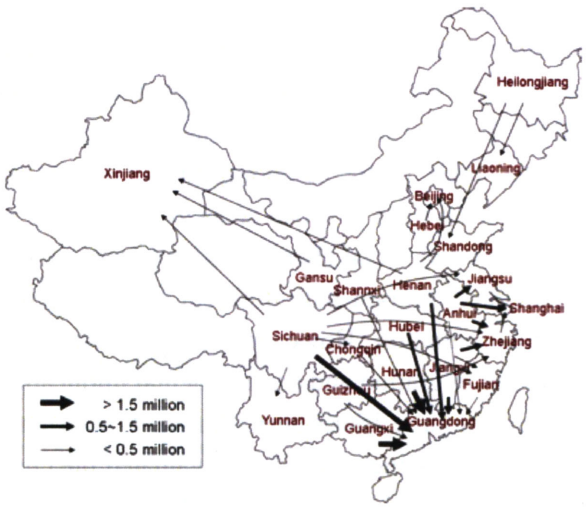


Figure 3 The 31 largest inter-provincial migration flow in 1995-2000 in China

(2) Empirical analyses of the mechanism of population migration

In order to further describe the patterns and mechanisms of population migration, an analytical model is established based on the cross-section data of 2000 Census.

$$\ln M_{ij} = C + \alpha_1 \ln(Y_j / Y_i) + \alpha_2 \ln(GDPR_j / GDPR_i) + \alpha_3 \ln(M_{ij} / \sum M_{ij}) + \alpha_4 \ln(DIS_{ij}) + \alpha_5 \ln(U_j / U_i) + \alpha_6 \ln(S_j / S_i) \quad (2)$$

where, M_{ij} is migration from province i to j; Y is provincial per capita income; $GDPR$ is annual growth rate of provincial GDP; $M_{ij}/\Sigma M_{ij}$ is migration stock (measured by the proportion of emigrants from province i to each immigration province j. It implies the influence of old migrants on new migrants who plan to move); DIS_{ij} is distance between province i and j; U is urban unemployment rate; S is share of the 2nd and 3rd industrial employment. Tab. 1 shows the results. The major findings are as follows.

Table 1 Determinants of inter-provincial migration in China (with stepwise estimation)

Independent variables	Eastern Region		Middle Region		Western Region		Whole China	
	Coefficients	*t* statistic	Coefficients	*t* statistic	Coefficients	*t* statistic	Coefficients	*t* statistic
Y	0.84***	10.58			0.43**	2.39	0.62***	9.53
GDPR					2.90***	7.17		
Mstock	0.77***	20.84	0.72***	21.52	0.66***	12.55	0.64***	23.89
DIS	-0.28***	-3.42	-0.42***	-5.00	-1.13***	-7.96	-0.83***	-13.17
Unemploy								
S			0.92***	6.59				
Constant	5.25***	9.98	6.69***	11.81	10.50***	11.63	8.74***	20.56
Adjusted R^2	0.77		0.82		0.61		0.65	
F statistic	385.06***		433.87***		107.40***		567.27***	

*Level of significance: 10%; **Level of significance: 5%; ***Level of significance: 1%.

In whole China, income gap and migration stock have significant and positive effects on migration, while distance has a significant and negative effect on migration. In sum, the most important determinants of inter-provincial migration are income gap, migration stock and distance. Income gap and migration stock encourage migration while the distance discourages migration.

3. SCENARIOS OF POPULATION MIGRATION AND IMPACT ON DOMESTIC WATER USE

(1) Projection of population migration

This projection starts from Lowry's migration model and substitutes some variables for more readily available data.

$$M_{ij} = k\frac{U_i}{U_j} \times \frac{y_j}{y_i} \times \frac{P_i P_j}{D_{ij}} \tag{3}$$

Where, M_{ij} is migration from province i to j; U is the unemployment rate; y is average provincial per capita income; P is provincial population; D_{ij} is the distance between province i and j; k is a constant. Suppose the new income in province i after the migration can be expressed like $y_i^{'} = y_i + \Delta y_i$ then to first order,

$$\Delta(\frac{y_j}{y_i}) \approx (\frac{y_j}{y_i}) \cdot (\frac{\Delta y_j}{y_j} - \frac{\Delta y_i}{y_i}) \tag{4}$$

Ignoring the second-order effect of changes in population due to migration and changes in unemployment associated with income change, we obtain

$$\Delta M_{ij} \approx M_{ij,t-1}(\frac{\Delta y_j}{y_{j,t-1}} - \frac{\Delta y_i}{y_{i,t-1}}) \tag{5}$$

In this exercise, the relative unemployment UE_i/UE_j is neglected, because the unemployment rate in provinces are quite similar according to the published statistical data in China. Using Eq. (5), the net inflow migrants to province i is

$$\mathrm{NETM}_{i,t} = \sum_{j \neq i}(M_{ji} - M_{ij})_t = \mathrm{NETM}_{i,t-1} + \sum_{j \neq i}(M_{ji} + M_{ij})_{t-1}(\frac{\Delta y_i}{y_{i,t-1}} - \frac{\Delta y_j}{y_{j,t-1}}) \tag{6}$$

Here, Eq. (6) is used for the projection of inter-provincial migration.

Similar to Eq. (6), the net inflow of migrants to urban is

$$\mathrm{NETM}_{u,t} = -\mathrm{NETM}_{r,t} = (M_{ru} - M_{ur})_t = \mathrm{NETM}_{u,t-1} + (M_{ru} + M_{ur})_{t-1}(\frac{\Delta y_u}{y_{u,t-1}} - \frac{\Delta y_r}{y_{r,t-1}}) \tag{7}$$

Eq. (7) is used for the projection of rural-urban migration.

(2) Projection of economic development

In order to achieve the target of sustainable development of whole nation, regional convergence must be considered as an important policy focus in the model. The model is based on the following hypotheses: Firstly, if other things being equal, per capita GDP growth rate is higher for regions with lower per capita GDP. Secondly, per capita income is a constant proportion of per capita GDP. Over the whole scenario, they share the same growth rate. Each province converges in the following way.

$$r = r_0 - \chi\lambda \ln(y / y_0) \tag{7}$$

Where, r is the growth rate of the provincial per capita income y; r_0 is the growth rate of per capita income y_0 in the reference region; λ is the coefficient, set as 2.5% (Barro and Martin, 2003); X is the economic convergence parameter of each province.

As for the urban/rural income ratio, provinces within the region converge toward the target over scenario at a convergence rate. Since there are no data that directly give an estimate for this rate. There are only data for the change of urban/rural income ratio. Between 1978 and 2003, the national ratio varied between -5% and 5% annually. Based on the historical performance, a convergence rate of 5% per year is assumed. We set

the national target that urban/rural income ratio will decrease at the rate of 0.4% per year.

(3) Projection of domestic water use

In this model, provincial domestic water use (PW) can be calculated as:

PW= urban pop. × urban domestic water use unit+ rural pop. × rural domestic water use unit (8)

Where, domestic water use unit in rural and urban areas are estimated according to the research result of Chinese Academy of Engineering (Liu and Chen, 2001). In scenario analyses, urban domestic water use unit will increase to 209 L/(person•d) in 2020. And the rural unit will increase to 105 L/(person•d) in 2020.

(4) Model results

Tab. 2 shows some major results of socio-economic development. Fig. 4 shows two different methods in evaluating domestic water use. Method A considers the effect of population migration and urbanization by using the projection models stated above. Method B just bases on the observation of historical patterns, and then extrapolates the domestic water use.

Table 2 Selected outputs from projection models

	Regions	2000	2005	2010	2015	2020
GDP (trillion yuan)	China	9.72	13.74	19.27	26.52	36.32
	Eastern	5.77	8.14	11.38	15.63	21.38
	Middle	2.79	3.94	5.52	7.57	10.33
	Western	1.15	1.66	2.37	3.31	4.61
Population (million)	China	1,242	1,282	1,321	1,359	1,398
	Eastern	528	553	579	607	636
	Middle	468	476	484	490	496
	Western	247	253	258	262	267
Urbanization (%)	China	35.96	39.30	44.44	49.64	54.74
	Eastern	44.96	48.06	54.55	60.85	66.72
	Middle	31.38	35.34	39.54	43.90	48.36
	Western	24.50	27.60	30.92	34.42	38.07

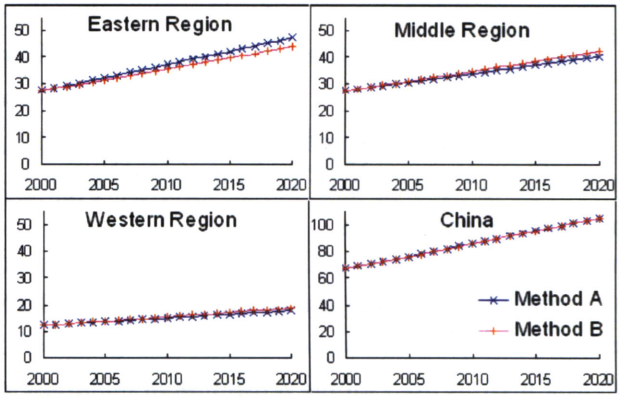


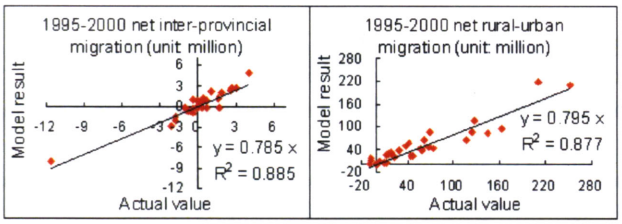
Figure 4 Regional domestic water use (unit: billion m^3)

In whole China, the domestic water use estimated by method A and B are nearly the same. But in the eastern region, domestic water use affected by population migration is larger than the value just extrapolated by historical trend. While the situations in the middle and western regions are opposite. Apparently, because of population migration, large amount of people will move to eastern provinces and urban areas, which will definitely cause the disparity of domestic water use among regions. If just estimating the domestic water demand without tying to specific socio-economic and policy influences, the result of projected future domestic water use will deviate largely from the possible amount.

(5) Model verification

In order to verify the validities of equations in projecting population migration, models are modified to start from 1990 by using the 1990 census data to simulate the net inter-provincial and rural-urban migration till 2000 and results are compared with actual migration data in 2000 census. As shown in Fig.6, R^2 in each case is high, proving that models in this paper are acceptable and reasonable for evaluation.

In addition, actual population, urbanization level and GDP of each province in 2004 are compared with model results respectively. As shown in Fig. 7, R^2 in each case is close to 1.0.



(1) Data source: the 1990 census (NBS, 1993); the 2000 census (NBS, 2002).

(2) Data source: China Statistical Yearbook 2005 (NBS, 2006); China Population Statistical Yearbook 2005 (NBS, 2006).

Figure 6 Model verification (1)

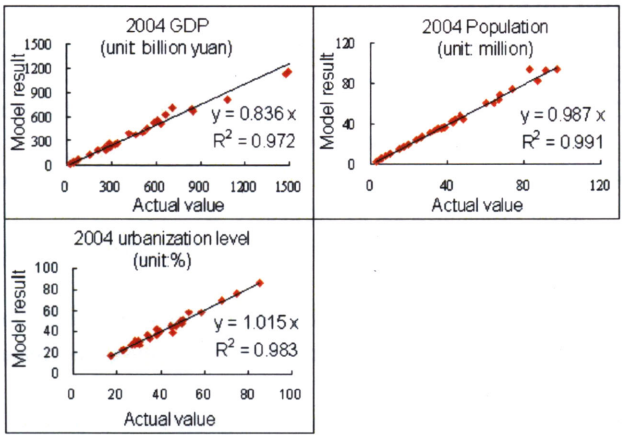


Figure 7 Model verification (2)

4. CONCLUSION AND DISCUSSION

In China, large flows of population migration, rapid urbanization and their environmental implications have been paid wide attentions in recent years. This paper tries to understand the historical trend and mechanism of population migration, and project its implication for domestic water use. The main findings are as follows.

- The main source of China's urbanization in the past two decades is the rural-to-urban migration, which shares about 80% of total urban population growth.
- The most important determinants of inter-provincial migration in China are income gap, migration stock and distance. Income gap and migration stock encourage migration while the distance discourages migration.
- Due to the uneven regional economic development, large amount of people move from Western and Middle Regions to Eastern Region, particularly from rural to urban areas. This also results in the disparity of domestic water use among regions. Comparing with the case neglecting population migration, in 2020, population migration will cause the amount of domestic water use increasing by 7.2% in Eastern Region, while decreasing by 5.5% and 4.9% in Middle and Western Regions respectively.
- This paper integrates specific socio-economic development such as regional economic convergence and population migration, etc. with the implication for domestic water use, which are usually neglected in conventional studies. The validities of model results are high and acceptable.

This paper presents a method to evaluate the future population migration between provinces and between rural and urban areas, together with income distribution, urbanization and etc. in China. By using the results, we can apply them for further studies. For example, by taking into account the regional water supply capacity, regional water balance affected by population migration and urbanization can be evaluated. Moreover, by adding assumptions to the projection models, the authors plan to study environmental implications of population migration and urbanization with respect to urban housing issues, energy consumption issues, land use changing issues and environmental pollution issues, etc. in the future.

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