An Optimal Investment Policy to Control the Land-based Water Pollutant into the Sea of Japan

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Abstract In Asia, comprehensive problems like the climate change and global warming occur in recent years. Northeast Asia countries around the Sea of Japan area have to cooperate in economic and environmental policies. The Sea of Japan area consists of Japan, South Korea, China, and Far East Russia in Northeast Asia, and the countries have to join forces in order to control the ocean environment and attain the sustainable development in the regions. In this study, we try to evaluate an investment policy to reduce the land-based water pollutant from coastal area into the Sea of Japan by a system simulation approach. The system simulation model is formulated by an objective function, the structure of water pollutant inflow and the socio-economic system of the target countries and regions in coastal areas of the Sea of Japan. We present an optimal international investment for water environment taking account of economic situations and environmental influences of this area over a certain period of time through the dynamic simulation.

1. Introduction

The Sea of Japan area consists of some countries, which are Japan, South Korea, China, and Far East Russia in Northeast Asia. In connection with remarkable economic development of these local countries and regions, the corruption load substance which flows into the Sea of Japan has increased in recent years. Furthermore, since the Sea of Japan is the closed ocean area and has the deep basin to its surface area, it has weak structure against contamination. It is expected that the water pollution problem of the Sea of Japan will become more serious due to the above-mentioned factors in the near future.Though Northeast Asia countries around the Sea of Japan area have many differences in the national system one another, they should cooperate in environmental policies, respectively. We also have to present some execution programs of environmental policy options concretely. The countries and regions around the closed ocean have to cooperate with one another in order

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to improve the seawater environment and attain the sustainable development.

Although we have some activities of international cooperation to preserve the closed ocean area and improve the water quality, e.g. NOWPAP (Northwest Pacific Action Plan), it will be taken much more time to attain the ideal targets because of many problems in fact. It is very difficult to build the systems of environment monitoring, marine environment protection databases and information management for target ocean regions, and to assess and manage the water pollutant load by land-based activities in each area.

In this study, we build a system simulation model, which describes a structure of the land-based water pollutant inflow and a socio-economic system of the target countries and regions with an international investment policy for reduction of the pollutant emission from coastal area of the Sea of Japan. Next, we try to present an optimal investment policy to control the land-based water pollutant taking account of economic situations and environmental influences of this area over a certain period of time by dynamic simulation analysis.

2. Outline of regional activity “NOWPAP”

Now, the UNEP (United Nations Environment Programme) is promoting 14 local action plans all over the world. The NOWPAP is internationally promoted by the UNEP, which is one of the local sea action plans to preserve the ocean environment for the coastal countries and regions around the Sea of Japan. Four countries which are Japan, South Korea, China, and Russia adopted this plan in September 1994, and established seven concrete projects such as construction of the database about ocean environment, an environmental monitoring program, and local activity center for various fields related ocean and coastal environment. However, the efforts of these projects cannot bear fruit immediately, and will be taken more time.

In Table 1, it is the general feature of each region in the coastal area of the Sea of Japan.

Table 2 shows seven projects for comprehensive environmental policy measures by NOWPAP to improve the water environment of the Sea of Japan. It is shown the structure of an actual executive organization for NOWPAP by figure 1.

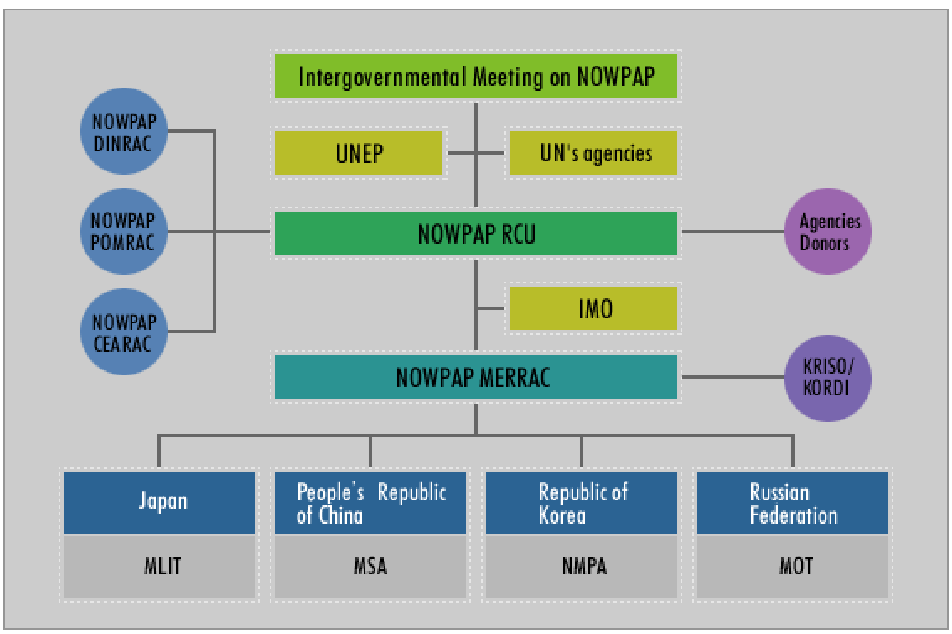
Table 1 Comparison of each region in the Sea of Japan area

Region	Area (10,000 sq. km)	Population (10,000)	GNP (100 million dollars)
Three ministries of China northeasts	79	10,364	830
Far East Russia	622	742	213
Japan	38	12,586	45,993
South Korea	10	4,555	5,202

North Korea	12	2,168	214
Total	761	30,415	52,452
World (The ratio occupied in the world)	13,560 (5.6%)	576,800 (5.3%)	286,549 (18%)

Table 2 NOWPAP projects

NOWPAP1	Development of Marine Environment Protection Detabase and Information Management System for Target Ocean Regions
NOWPAP2	Study into Laws Related to Marine Environment Protection in Related Nations
NOWPAP3	Production of Environment Monitoring Program for Target Ocean Regions
NOWPAP4	Regional Cooperation on Ocean Pollution (action in case of oil pollution incidents, etc.)
NOWPAP5	Designation of Regional Activity Centers to Become Centers of Activity in Respective Areas
NOWPAP6	Public Awareness Raising on the Marine, Coastal and Associated Freshwater Environment
NOWPAP7	Assessment and Management of Land-based Activities



Note:

DINRAC: Data and Information Network Regional Activity Centre (established in People's Republic of China)

POMRAC: Pollution Monitoring Regional Activity Centre (established in Russian Federation)

CEARAC: Special Monitoring and Coastal Environmental Assessment Regional Activity Centre (established in Japan)

MLIT: Ministry of Land, Infrastructure and Transport, Japan

MSA: Maritime Safety Administration, People's Republic of China

NMPA: National Maritime Police Agency, Republic of Korea

MOT: Ministry of Transport, Russian Federation

Figure 1 Organization of NOWPAP activity

3. Purpose

First, we clarify the structure of land-based water pollutant emission from coastal area of the Sea of Japan and economic situation of target regions.

Secondly, we build a dynamic simulation model linked water pollutant load flowing into the Sea of Japan and socio-economic activities around the Sea of Japan area.

Lastly, we try to present an optimal international investment policy for water pollutant reduction to control emission of land-based water pollutant from human activity from coastal area of the Sea of Japan by dynamic simulation analysis. Simulation results will be contributed to decision-making for improvement of water environment and social economic policy in the coastal area of the Sea of Japan.

4. The Model

4.1 Study area

In this study, we focus on the Sea of Japan (or the Japan Sea), which is a sea area located along the northeastern part of the Asian continent. It is separated from the North Pacific Ocean by the Japanese Archipelago and Sakhalin. Figure 2 shows the location of the Sea of Japan and the surrounding countries and regions.

Figure 2 Map of the Sea of Japan

4.2 The framework of the model

Figure 3 shows the framework of our simulation model, which are linked socio-economic activities with water environment of the Sea of Japan and international investment among the countries of the area.

We build the ecosystem model with consideration to the transportation structure of the contaminant in the ring Sea of Japan area, mainly consider the seawater quality and environment as maximum restrictions and aim at the purpose of maximizing the sum of the GDP of all regions. Our simulation model of the water pollution management policy in the Sea of Japan includes an international development assistance policy, and we can analyze the optimal allocation of each country budget.

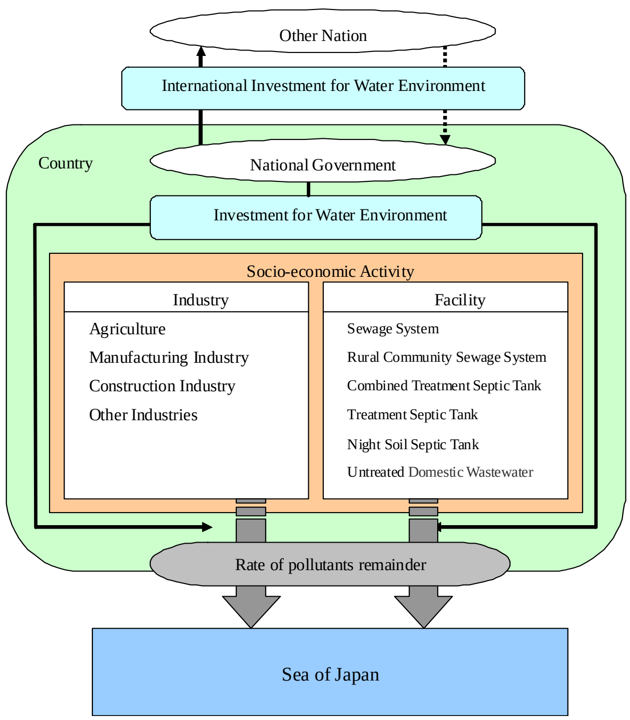


Figure 3 Framework of the model

As shown in Table 3, the pollutant index measured in this study is only COD (Chemical Oxygen Demand), because it is too difficult to get other pollutant data depending on areas.

Table 4 shows the classification of the target area, which is distinguished by administrative districts like prefectures in each country.

First, based on past data, we can guess the total amount of contaminant discharge and its coefficient of the region. Secondly, we build the multi-area and multi-section regional economic model in the ring Sea of Japan area. The socio-economic model describes the social and economic activities in each region and how the pollutant is originated by production, household wastewater, and other industries. Table 5 and Table 6 show the categories of industries and classification of household wastewater disposal system in each area. In Table 5, “Others” emits no water pollutants.

Table 3 Target pollutant

Index	Pollutant
1	COD (Chemical Oxygen Demand)

Table 4 Classification of the study area

Country	Index	Prefecture	Area ($10^4 km^2$)	Population (1,000) (1995)	GRP(billion dollars) (1995)
Japan	1	Hokkaido	7.8	5,719	208.9
	2	Aomori, Akita, Yamagata	3.1	4,000	129.5
	3	Niigata, Nagano, Toyama	3	5,820	229.1
	4	Ishikawa, Fukui, Gifu	1.9	4,108	155.8
	5	Kyoto, Hyogo	1.3	7,960	318.6
	6	Yamaguchi, Shimane, Tottori	1.6	2,957	105.6
	7	Fukuoka, Saga, Nagasaki	1.1	7,345	260.1
		(Others)	(18)	(87,660)	(3,729.8)
South Korea	8	Kangwon-do, Gyeongsangbuk-do	3.6	4,308	4.4
	9	Busan, Gyeongsangnam-do	1.1	7,843	8.7
China	10	Ji Lin	18.7	25,920	13.5
	11	Heilongjiang	45.5	37,010	24.1
Russia	12	Khabarovsk Krai	82.4	*1,608	4.3
	13	Primorsky Krai	16.6	*2,287	3.5
	14	Sakhalinskaya Oblast	8.7	*699	1.7

Table 5 Classification of industry

Index	Industry
1	Agriculture
2	Manufacturing Industry
3	Construction Industry
4	Communication and Transportation
5	Commerce and Services
6	Others

Table 6 Classification of household wastewater disposal system (1,000 person, 1995)

Index	Treatment Facility	Japan	South Korea	China	Russia
1	Sewage System	24,819	4,637	12,598	689
2	Rural Community Sewage System	1,115	0	0	0
3	Combined Treatment Septic Tank	3,231	0	0	0
4	Treatment Septic Tank	8,496	0	0	0
5	Night Soil Septic Tank	248	0	0	0
6	Untreated Domestic Wastewater	0	6,403	50,332	3,905
Total		37,909	11,040	62,930	4,594

5. Simulation Model

5.1 Total Amount of pollutant flowing into the Sea of Japan

The total amount of pollutant (COD) into the Sea of Japan is shown by eq. (1).

$$Q(t) = \sum_{j=1}^{14} q_j(t) \tag{1}$$

$Q(t)$: Total amount of pollutant flowing into the Sea of Japan

$q_j(t)$: Pollutant flowing into the Sea of Japan from zone j

5.2 Amount of pollutant from each zone

The amount of pollutant emission from each zone consists of household and industry sector, and it can be reduced by investment for water pollution control.

$$q_j(t) = f_1^j E \cdot z_j^u(t) + f_2^j \left[P x_j(t) - R k_j^A(t) \right] \tag{2}$$

f_1^j: Rate of remainder pollutants from household wastewater disposal system in zone j

f_2^j: Rate of remainder pollutants from industries in zone j

E: Coefficient of pollutant from household wastewater disposal system

z_j^u: Population using each household waste water disposal system in zone j

P: Coefficient of pollutant from industries

$x_j(t)$: Industrial production vector in zone j

R: Abatement coefficient of investment

$k_j^A(t)$: Capital accumulation of abatement for industry emission in zone j

($u=1$:Sewage system, $u=2$: Rural community sewage system, $u=3$: Combined treatment septic tank, $u=4$: Treatment septic tank, $u=5$: Night soil septic tank, $u=6$: Untreated domestic wastewater)

5.3 Capital accumulation of abatement

The capital accumulation of abatement for industries in each zone is as follows:

$$k_j^A(t+1) = k_j^A(t) + i_j^A(t) - \delta_j^A \cdot k_j^A(t) \quad (3)$$

$k_j^A(t+1)$: Capital accumulation of abatement for industries in zone j in term of t+1

$i_j^A(t)$: Investment of abatement for industries

δ_j^A: Depreciation rate

5.4 Investment for abatement of water pollutant

$$i_j^C(t) = i_j^A(t) + i_j^S(t) \quad (4)$$

$$i_j^S(t) = \sum_{u=1}^{6} i_j^u(t) \quad (5)$$

$i_j^C(t)$: Total investment for abatement of water pollutant

$i_j^S(t)$: Investment for household wastewater disposal system

$i_j^u(t)$: Investment for construction of abatement facilities

5.5 Population

Population in each zone is as follows:

$$z_j(t+1) = z_j(t) + \Delta z_j(t) \quad (6)$$

$$\Delta z_j(t) = \lambda_j z_j(t) \quad (7)$$

$z_j(t)$: Total population in zone j

$\Delta z_j(t)$: Change of population in zone j

λ_j: Rate of population change in zone j

5.6 User population of each household wastewater disposal system

User population of each household wastewater disposal system is as follows:

$$z_j(t) = \sum_{u=1}^{6} z_j^u(t) \quad (8)$$

$$z_j^u(t+1) = z_j^u(t) + \Delta z_j^u(t) \tag{9}$$

$$\Delta z_j^u(t) = \Gamma_j^u i_j^u(t) \tag{10}$$

Γ_j^u: Parameter

In case of u=3, the change of combined treatment septic tank is defined as follows:

$$z_j^3(t+1) = z_j^3(t) + \Delta z_j^3(t) \tag{11}$$

$$\Delta z_j^3(t) = \frac{i_j^3}{\Phi} \tag{12}$$

Φ: Setting cost for combined treatment septic tank per person

5.7 Flow conditions of production market

5.7.1 Japan side ($j \le 7$)

$$x_j(t) \ge Ax_j(t) + c_j(t) + Di_j^C(t) + i_j^p(t) + y_j(t) + EX_j(t) - IM_j(t) \tag{13}$$

A: Input coefficient matrix

$c_j(t)$: consumption vector in zone j

D: Input coefficient vector for investment of abatement

$i_j^p(t)$: Total production investment vector

$y_j(t)$: International investment vector for abatement received by zone j

$EX_j(t)$: export in zone j

$IM_j(t)$: import in zone j

5.7.2 Other countries ($j \ge 8$)

$$x_j(t) + y_j(t) \ge Ax_j(t) + c_j(t) + Di_j^C(t) + i_j^p(t) + EX_j(t) - IM_j(t) \tag{14}$$

International investment for abatement of water pollutant received by zone j is less than equal to the sum of total investment for abatement in each zone.

$$i_j^C(t) \ge y_j(t) \tag{15}$$

5.8 Production function

The amount of production is dependent on capital accumulation of production.

$$x_j(t) \le \omega_j k_j^p(t) \tag{16}$$

ω_j : Proportion coefficient of production to capital stock

$k_j^p(t)$: Capital accumulation of industrial production

5.9 Capital accumulation

Capital accumulation of production in zone j is determined by production investment and consumption of fixed capital in each zone.

$$k_j^p(t+1) = k_j^p(t) + i_j^p(t) - \delta_j^p \cdot k_j^p(t) \tag{17}$$

δ_j^p : Depreciation rate

5.10 Restriction of consumption

Consumption in zone j is determined by population in each zone.

$$c_j(t) \le k_j z_j(t) \tag{18}$$

k_j : Consumption coefficient vector

5.11 GRP (Regional GDP)

GRP in zone j is determined by the rate of added value and the amount of production in each zone.

$$GRP_j(t) = V_j x_j(t) \tag{19}$$

$GRP_j(t)$: Regional GDP in zone j

V_j : Vector of added value rate

5.12 Total GDP

Total amount of GDP is the sum of GRP that in each zone.

$$GDP(t) = \sum_{j=1}^{14} GRP_j(t) \tag{20}$$

$GDP(t)$: Gross domestic product in target area

5.13 International assistance investment for abatement of water pollutant

Total amount of international assistance investment for abatement of water pollutant is as follows:

$$y_J^T(t) \le \gamma GDP_J^T(t) \quad (21)$$

$y_J^T(t)$: Total international assistance investment for abatement of water pollutant in Japan

γ: Parameter

$GDP_J^T(t)$: Total GDP in Japan

5.14 Fund for assistance raised in Japan

The sum of investment for abatement of water pollutant in zone j is equal to total international assistance investment for abatement in Japan.

$$y_J^T(t) = \sum_{j=1}^{14} y_j(t) \quad (22)$$

5.15 Accumulated debt of each zone

The accumulated debt of each zone is taken as total of the debt in each zone in each term, and accumulated debt in each zone in term t carries out to less than the fixed ratio of the t term GDP in each zone.

$$DB_j(t) = \sum_{t=1}^{t} y_j(t) \quad (23)$$

$$DB_j(t) \le \sigma_j GRP_j(t) \quad (24)$$

$DB_j(t)$: Accumulated debt in zone j

σ: Rate of debt

5.16 Objective function

The objective function is the sum of water pollutant (COD) flowing into the Sea of Japan from all zones, and minimizing it in the last term with restriction of the GDP.

$$\min Q(t) \quad (25)$$

$$\text{subject to} \quad GDP(t) \ge GDP^*(t) \quad (26)$$

$$Q(t+1) \le Q(t) \quad (27)$$

$GDP^*(t)$: Constraint value of GDP

6. Simulation

6.1 Simulation cases

We establish the simulation cases shown as Table 7, and the running period is set from 1995 to 2007 in the calculation because it is based on scientific data in 1995. For example, Case00 is the basic case minimizing total amount of land-based water pollutant inflow from coastal area of the Sea of Japan in term t=6 with restriction of 0% GDP growth rate.

In Table 8, it shows estimation results of the total emission and inflow of household and industry sector in each zone of the Sea of Japan area from scientific data in 1995 referring World bank[11] and Wada[10] through the simulation model. It is clear that the emission from household wastewater is higher than industry sector. It is higher emission from household in two zones of China comparing with others.

Table 9 shows total GDP of each zone in the Sea of Japan area in the first period.

Table 7 Simulation cases

Case	Case00	Case05	Case10	Case15	Case20	Case24
GDP growth rate	0%	5%	10%	15%	20%	24%

Table 8 Estimate of total COD emission and inflow of each zone in the Sea of Japan area

(ton/year)

Zone	Household wastewater	Industry wastewater	Total emission	Total inflow
1	5,882	6,209	12,092	8,732
2	13,048	3,849	16,897	11,430
3	18,694	6,812	25,506	17,414
4	13,635	4,632	18,267	12,432
5	12,021	9,472	21,493	15,271
6	8,971	3,140	12,111	8,254
7	12,316	7,732	20,047	14,067
Total in Japan	84,568	41,846	126,413	87,600
8	26,572	2,577	29,149	14,816
9	27,393	4,841	32,234	17,021
Total in South Korea	53,965	7,418	61,383	31,838
10	207,620	453	208,074	33,582
11	296,455	809	297,264	48,080
Total in China	504,075	1,262	505,337	81,662
12	13,660	498	14,158	5,862
13	19,425	602	20,028	8,252
14	6,970	269	7,240	3,004
Total in Russia	40,055	1,370	41,425	17,118
Total in the Sea of Japan area	682,662	51,895	734,560	218,217

Table 9 Estimate of total GDP of each zone in the ring Sea of Japan

(million dollars)

Zone	1	2	3	4	5	6	7
GRP	208,860	129,458	229,126	155,803	318,599	105,606	260,052

Zone	8	9	10	11	12	13	14
GRP	44,025	86,718	13,523	24,126	8,099	9,790	4,378
Total GDP in the Sea of Japan area			1,598,163				

6.2 Simulation results

6.2.1 Objective value

Table 10 and Figure 4 show the changes of objective value (total COD inflow into the Sea of Japan) from 1997 to 2007, which are the solutions derived by optimization.

In Case24, it can be obtained the feasible solution, however, we can derive no feasible solution in case of 25% GDP growth rate.

Comparing Case00 and Case05, though objective value in the last period of Case00 is smaller than that of Case05, total amount of COD inflow in Case05 through the simulation period is smallest in all cases. It shows that economic activity has important role to invest for abatement of water pollutant.

Table 10 Change of objective value (total COD inflow into the Sea of Japan)

(ton/year)

Year	Case00	Case05	Case10	Case15	Case20	Case24
1997	218,217	218,217	218,217	215,632	218,217	218,217
1999	218,217	204,502	210,310	211,510	213,599	217,339
2001	218,217	204,502	210,310	209,575	213,599	217,339
2003	207,152	204,502	210,310	209,575	213,599	217,339
2005	201,798	203,545	206,212	209,575	213,599	217,339
2007	201,798	203,545	206,212	209,575	213,599	217,339
Total	1,265,399	1,238,812	1,261,570	1,265,440	1,286,212	1,304,913
Average	210,900	206,469	210,262	210,907	214,369	217,486
Reduction rate in the last term	7.5%	6.7%	5.5%	2.8%	2.1%	0.4%

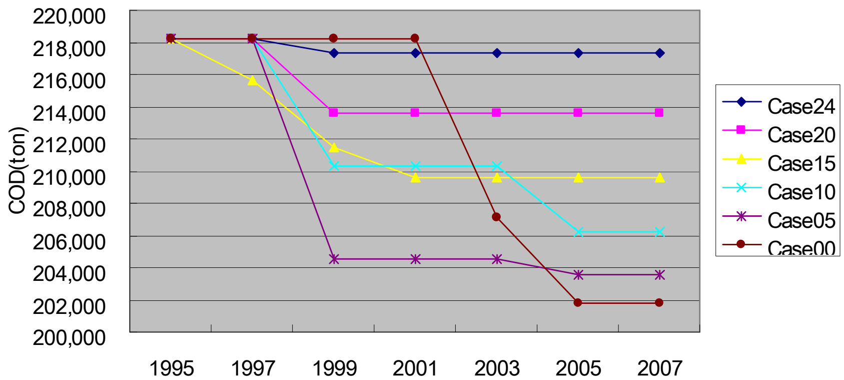


Figure 4 Change of total COD inflow into the Sea of Japan

6.2.2 GDP

Table 11 shows the change of total GDP in coastal area of the Sea of Japan. These GDP values are the restriction in the system simulation model, for instance, the GDP growth rate is 5% in each term in Case05. In this study, it is shown that the maximum growth rate is 24% in each term.

Table 11 Change of total GDP of the Sea of Japan area

(billion dollars)

Year	Case00	Case05	Case10	Case15	Case20	Case24
1997	1,598	1,598	1,598	1,598	1,598	1,598
1999	1,598	1,678	1,758	1,838	1,918	1,982
2001	1,598	1,762	1,934	2,114	2,301	2,457
2003	1,598	1,850	2,127	2,431	2,762	3,047
2005	1,598	1,943	2,340	2,795	3,314	3,778
2007	1,598	2,040	2,574	3,214	3,977	4,685
Total	9,589	10,871	12,331	13,990	15,870	17,548
Average	1,598	1,812	2,055	2,332	2,645	2,925

6.2.3 International assistance investment for abatement of water pollutant

(1) Change of total international investment from Japan to other countries

In this study, we assume a policy of international assistance investment for abatement of water pollutant emission from industrial activity in coastal area of the Sea of Japan. Table 2 shows the change of total amount of international assistance investment for abatement from Japan to other three countries, which are South Korea, Chine, and Russia. In case of higher GDP growth rate, it is invested for abatement of water pollutant much more and in earlier term from Japan to other countries.

Table 12 International assistance investment for abatement from Japan to other countries

(million dollars)

Year	Case00	Case05	Case10	Case15	Case20	Case24
1995	0	0	0	0	0	0
1997	5,337	10,505	13,504	15,379	15,379	15,379
1999	2,413	4,198	4,763	5,312	5,312	5,312
2001	3,103	4,902	6,277	7,421	7,421	7,421
2003	8,594	12,367	16,028	18,763	18,763	18,763
2005	55,520	60,947	65,775	70,489	70,489	70,489
2007	407,775	525,036	680,707	875,883	886,578	1,366,129
Total	482,743	617,956	787,054	993,249	1,003,944	1,483,495

(2) Change of international assistance investment to South Korea, China, and Russia

Figure 5, 6, and 7 show the change of international assistance investment for abatement of water pollutant to South Korea, China, and Russia, respectively. In case of China, total amount of investment is almost same in every case. It shows that we have to abate COD emission from China as much as we can, because amount of water pollutant emission from China is very large as shown in Table 8.

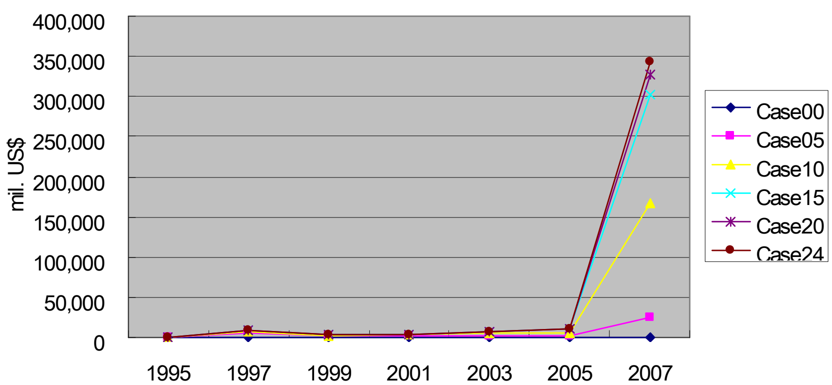


Figure 5 Change of international investment to South Korea

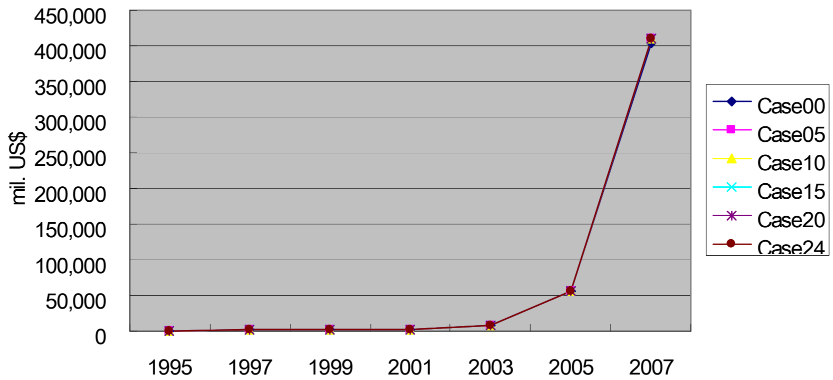


Figure 6 Change of international investment to China

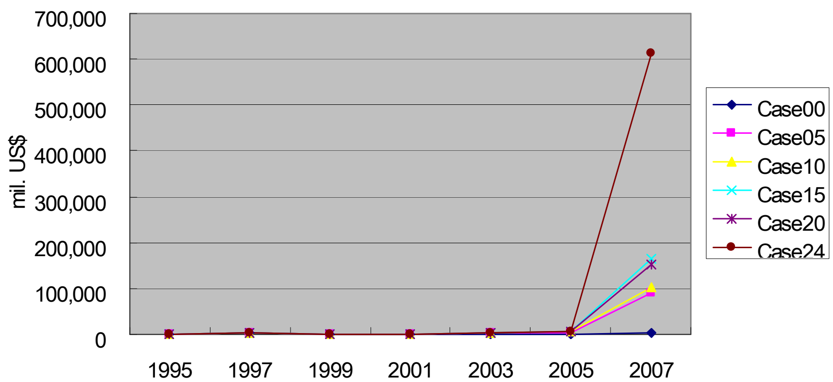


Figure 7 Change of international investment to Russia

7. Conclusion

In this study, we can obtain the feasible solution, which is 7.5% maximum reduction rate of COD inflow in the last term with 0% GDP growth rate in coastal area of the Sea of Japan in Case00. However, Case05 is the best solution from viewpoint of average amount of COD emission and economic development of target area (See Figure 8). It is clear that minimizing environmental impact with sacrifice of economic growth is not always the best solution by simulation result. It is also important for abatement of water pollutant to invest for environmental policy and to promote technologies by industrial and economic development. Furthermore, countries and regions around the Sea of Japan area have to cooperate to manage an international ocean in various fields such as water environment, industrial technology and so on, from integrated ocean management perspective.

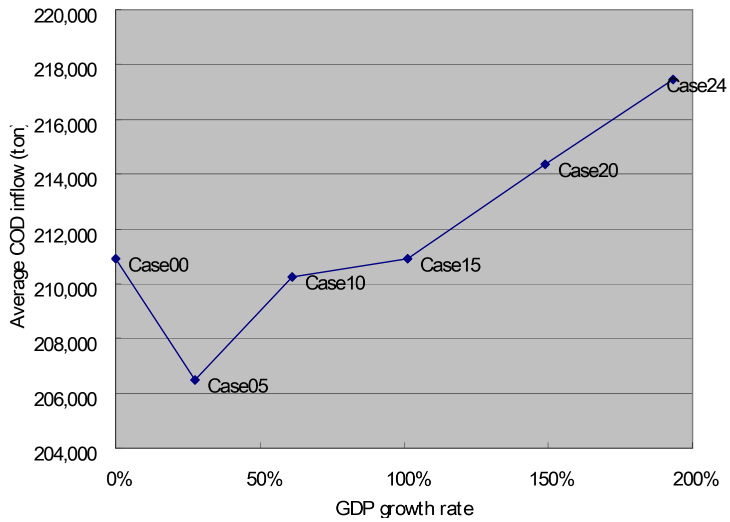


Figure 8 GDP growth rate and average COD inflow

8. Further development

We have to analyze other pollutant indices for water and air environment. And then, it is necessary to collect more precise and new scientific data of our target area. It has to be set more long-run period in the simulation as much as possible.

References

[1] Economic Research Institute, Far Eastern Branch of Russian Academy of Sciences, *Russia Far East economy conspectus*, Toyokeizaishinpo-sha, 1994.

[2] Ebise, S. and Inoue, T, "Estimation on Amount of Water Quality Change during Flowing-Down of a River Joined by Tributaries," *Japan Journal of Water Pollution Research*, Vol.14, No.4, 1991, pp.41-50.

[3] Higano, Yoshiro, *Measurements of the Social Cost of the Metropolitan Express Highway*, The Research Institute of Socio-Economic Engineering, 1988.

[4] Higano, Y and Sawada, T, "The Dynamic Policy to Improve the Water Quality of Lake Kasumigaura," *Studies in Regional Science*, Vol.26, No.1, 1997, pp.75-86.

[5] Hirose, F and Higano, Y., "A Simulation Analysis to Reduce Pollutants from the Catchment Area of Lake Kasumigaura," *Studies in Regional Science*, Vol.30, No.1, 2000, pp.47-63.

[6] Mizunoya, T., Morioka, R. and Higano, Y. "Evaluation of Pollutional Load Abetment Technology and Optimal Environmental Policy to Improve Water Quality of Lake Kasumigaura," 2000 Annual Meeting of Japan Association for Human and Environmental Symbiosis, Oct. 27-28, 2000, University of Nagoya, pp.1-10.

[7] Kondo, Jiro, *Ring Sea of Japan Environmental White Paper*, Northwest Pacific Region Environmental Cooperation Center, 2003.

[8] Sakurai, K., Mizunoya, T. and Higano, Y., “An Integrated River Basin Management Policy Incorporating Residents' Preferences -In Case of Lake Kasumigaura-,” The 40th Annual Meeting of the Japan Section of the RSAI, Okinawa, Japan, Nov.1-2, 2003, pp1-24.

[9] Sakurai, K., Mizunoya, T., Kobayashi, S. and Higano, Y. “A Water Environmental Policy to Improve the Water Quality of Lake Kasumigaura Incorporating Residents' Preferences in the Basin,” *Studies in Regional Science*, Vol.34, No.1, 2004 (now printing).

[10] Wada, Yasuhiko, *Model Analysis on Non-Point Sources of Pollutants*, Giho-do Press, 1990.

[11] World bank, *World Economics and Social Statistics*, Toyo-shorin, 1999.