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Building an Integrated Governance Model and Finding Management Measures for Nonpoint Source Pollution in Watershed Management of Korea

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Abstract

This study intended to develop an integrated governance model and find measures to manage nonpoint source (NPS) pollutions in watershed management. To reach this goal, this study has analyzed NPS pollution management policies in Korea and has employed statistical methods such as expert Delphi survey, analysis of variance, and factor analysis. As a result, this study has found that the favored basic organization form was a private-public cooperative council. The necessary governance-based NPS pollution management measures determined through this study are as follows: to build collaboration mechanisms including those related to motivation provision, trust building, capacity building, and making optimal regulations; to employ financial resources based on principles such as 'polluter-pays', 'recipient-pays', and 'general-tax-source'; and to develop several programs, including system improvement, pilot and management projects, and publicity.

Keywords: Analysis of variance, Factor analysis, Governance model, Nonpoint source pollution management, Watershed management

1. Introduction

1.1. Backgrounds and Purposes

Though efforts to reduce emissions from point sources have been made for decades, pollution from nonpoint sources is now the largest source of pollution in waterways [1, 2]. Nonpoint source (NPS) pollution may deteriorate the water quality of rivers and lakes, as well as residents' health, property values, and the entire ecosystem [3]. The development of effective measures to control diffuse pollution has emerged as a major priority with respect to the improvement of water quality [4]. In Korea, the Ministry of Environment surveyed nonpoint sources throughout the country in 1995, confirming that nonpoint sources constituted from 30% to 70% of existing water pollution sources. Thus, to prevent NPS pollution in Korea, each local government is required to make a progress plan for system improvement and NPS pollution reduction based on the "General Management Measures of Four Major Rivers' Nonpoint Source Pollution (2004–2020)" [5]. In the early stages, the measures were designed to enhance the system. However, these measures have been implemented unilaterally by the central government. In addition, some projects that needed inter-governmental cooperation were undertaken without appropriate communication. To manage NPSs and to implement the management policies effectively, it is necessary to ensure an intimate cooperation among the stakeholders. NPS pollution is usually caused by numerous small sources, and addressing these sources requires coordination and cooperation among stakeholders [6]. Thus a governance system is needed in watershed management to encourage coordination and cooperation between various stakeholders. Governance for effective watershed management includes a range of political, social, economic, and administrative systems for regulating the development and management of water resources and the provision of water services throughout the various demands within society [7]. In particular, collaborative management is suggested as an alternative to regulation for solving nonpoint source pollution from urban and agricultural runoff, and also habitat loss [8]. The literature related to NPS pollution management through governance has focused on analyzing case studies in many countries [2, 4, 9-13]. Thus, this study aims to build an integrated governance model, and to find governance-based measures to manage NPS pollution of watershed management in Korea.

1.2. NPS Pollution and Governance

NPS pollution has been the most critical problem to manage watersheds with effectiveness. The emergence of NPS pollution

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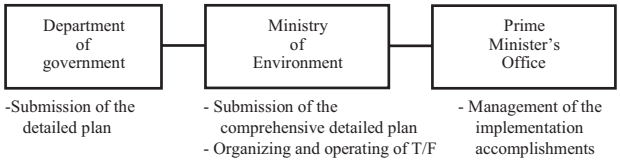


Fig. 1. Management process of nonpoint source pollution in Korea.

as a primary contributor to environmental degradation has led many people to conclude that centralized, federally controlled efforts are insufficient to solve many environmental problems [14-16]. In the environmental arena, growing concerns over NPS pollution have led governments working with non-profit organizations rather than relying on traditional regulatory approaches [17]. Because poor governance according to a rule-based approach has resulted in many problems associated with managing water resources [18].

Governance is more effective than, and normatively superior to, centralized state control [19, 20]. Many collaborative efforts have been initiated to address various water management issues at the watershed level [11, 21]. Watershed management solutions can and should be developed with the participation of watershed stakeholders, which includes anyone who can influence or who is influenced by water quality in the watershed [11]. Therefore, among the fastest growing types of collaboration are groups dedicated to watershed management [22].

1.3. NPS Pollution Management Policies in Korea

The number of NPS pollution sources increase every year, despite the fact that the policies are focused mainly on the treatment of NPS pollution. This focus has made it difficult to manage the improvement of the water quality in a ground-breaking way. Given this situation, a management system for NPS pollution was adopted by the Ministry of Environment in 1998, but because the control policies were applied only by the Ministry of Environment, they were inadequate for the efficient management of water quality. Therefore, comprehensive countermeasures that encompass the four major rivers in Korea were established through joint participation cooperation of the following departments: the Ministry of Environment; the Ministry of Land, Transport, and, Maritime Affairs; the Ministry of Food, Agriculture, Forestry and Fisheries; and other related institutions in 2004. In spite of these new attempts, the policies still involve problems such as a lack of understanding of the characteristics of land and rivers, indiscriminate adaptation of foreign policies, and weak cooperation between the government institutions. In March 2005, the Water Quality and Ecosystem Conservation Act was modified to control NPS pollution. The Act implemented a reporting system for the establishment of NPS sources, as well as a designation system of NPS source control district, in 2006. In Korea, the management procedures of NPS pollution are as follows: department of government make the detailed plans. Based on these detailed plans, Ministry of Environment establishes the comprehensive detailed plan, organizing and operating a task force. The Prime Minister's Office manages the implementation accomplishments. NPS pollution governance in Korea is a government-led hierarchy structure as Fig. 1. In this respect, the governance structure lacks both stakeholder participation and cooperation.

In Korea, the largest portion of the population and the major facilities are mostly located from the midstream to the downstream of each of the four major rivers, so that there are limits that the current regulation based on concentration levels could achieve the water quality standards. To resolve these issues, the national government has adopted a regulation called "Total Maximum Daily Load (TMDL)" to keep the total load of the pollution sources under some degree of control in order to maintain the water quality which is close to the assigned goal. If local governments succeed in reducing the actual displacement of the pollution sources, the national government awards them with incentives. To the contrary, if they exceed the pollution displacement standards, the responsible local governments are penalized. Point pollution source management alone is limited to achieve the target levels of water quality. Thus, it is necessary to prepare for the measures of NPS pollution management. It is a fundamental call for finding measures to reduce NPS on blind spots of water pollution. While point pollution source discharge facilities have been controlled well, NPS discharge facilities have not. It is also difficult to quantitatively evaluate NPS pollution. Thus, it is very hard to optimally manage NPSs through TMDL. TMDL is one of the prevention measures to manage NPS pollution. At the time of planning the TMDL-based strategy, it was inevitable to promote appropriate NPS management projects for achieving the target levels of water quality.

2. Materials and Methods

2.1. Conceptual Framework and the Factors of a Governance Model

This study made a conceptual framework of a governance model and deduced the various factors in the context of that model regarding the concepts and characteristics of governance.

Governance refers to the means for achieving direction, control, and coordination of individuals and organizations with varying degrees of autonomy to advance joint objectives [23-25]. Mukherji and Shah [26] describe it as meaning "de-centering and diversification of the state into a number of levels that stretch horizontally from civil society and market organizations on the one hand and vertically from the transnational to local self-government institutions on the other." Based on these concepts, governance constitutes participation and relationship of stakeholders. The participation and relationship of stakeholders could be realized through appropriate organizations.

To influence governance, stakeholders should participate in organizations or issues and make mutual diverse relationships among them to achieve objectives. So, this study looked into the participatory and relational characteristics of governance. In governance, the elements of participation and relationship include network and collaboration.

Governance involves the identification of who is responsible for specific decisions, how the organization is to be managed, how objectives are identified and met, how performance is managed, and who bears the general oversight of management [27, 28]. Hence, governmental institutions including agencies, programs, and policies and actors, such as agency personnel and elected officials, typically influence the environmental and social outcomes of collaborative environmental management partnerships [25].

Adams and Gray [29] determined that the establishment

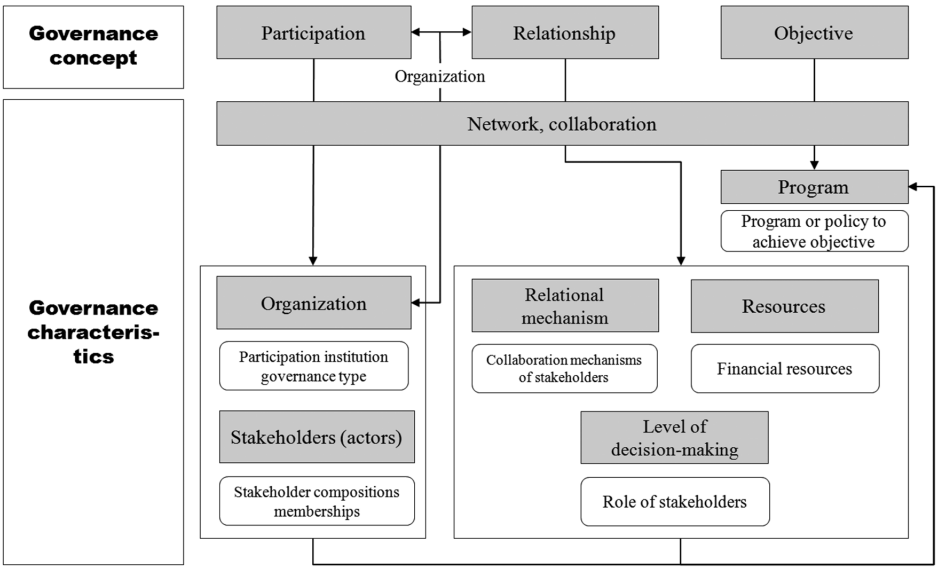


Fig. 2. Relationship between conceptual framework and the factors of a governance model.

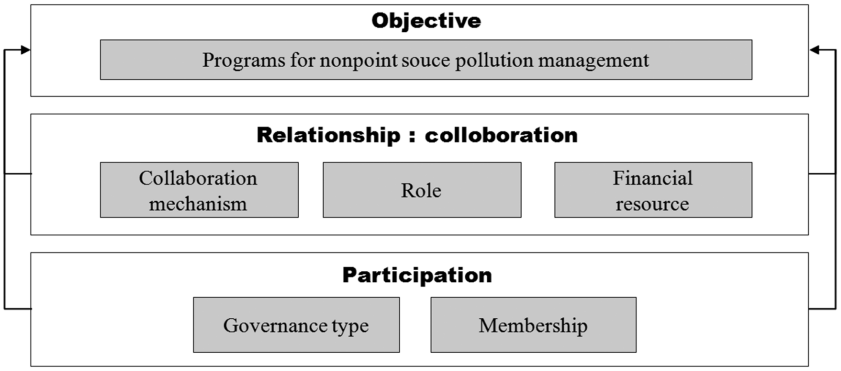


Fig. 3. Conceptual framework and the factors of a governance model.

of ground rules and stakeholder compositions are procedural characteristics for successful watershed governance [11]. Governance, which is accomplished through social and institutional networks, can facilitate a more equitable distribution of power and decision-making [20]. Levels of decision or participation are classified according to shared information, consultation with stakeholders, and advisory or managerial participation in the planning process [30]. Such governance would need to include enabling statutes, organizational and financial resources, programmatic structures, and administrative rules and routines [23, 24, 31, 32]. Koontz et al. [33] determined the pathways to governance outcomes as issue definition resources, and decision-making processes.

Public managers often use collaboration as a strategy to improve the governance of inter-organizational networks [32]. Collaboration represents a process whereby entities share information, resources, and responsibilities to jointly plan, implement, and evaluate activity programs to achieve a common or compatible goal [34]. Collaborative strategies emphasize the inclusion of diverse stakeholders in planning. Virtually all common property systems are enmeshed in complex institutional networks which include regional and national governmental organizations and private corporations and individuals, in addition to one or more local, common property institutions [1, 5, 20, 21, 34]. The collaboration mechanisms of stakeholders in governance are trust and respect [16, 34-38], clarity or definition of the issue, resources [11, 33, 35, 37, 39] motivation [2], legislation, and policy and programs [20, 40].

Governance types may be assessed based on competitiveness, hierarchy or bureaucracy based on command and control, and network based on trust.

Based on these characteristics of governance, organization, stakeholders, relational mechanism, resources, level of decision-making, and program could be typical factors of governance model. Brief meanings of each factor are described in Fig. 2. Using these factors and meanings, this study makes a framework and factors of a governance model for NPS pollution management, as shown in Fig. 3.

2.2. Research Methods

A general governance model was derived through a literature review related to watershed management governance. The components of the governance model include governance and partnership types, membership, role, principles of the economic instrument, a collaboration mechanism, and a program. In addition, this study has derived management plans for NPS pollution from the policy directions, central agendas, and sectional measures included in "General Management Measures of Four Major Rivers," the comprehensive measures for managing NPS pollution according to Ministry of Environment [17], Cooperation of Relevant Authorities [41], and Korea Environmental Institute [5].

Based on the management plans and the components of the general governance model, questionnaires were developed to ask experts to evaluate the suitability of each section of both the management plans and the governance model, using a 5-point Likert scale [42]. These experts have been working in such fields as NPS pollution management, watershed management, governance, and environmental planning. The response rate was about 55% (25 out of 45).

This study employs one-way analysis of variance (ANOVA) to determine the most statistically significant alternative among such aspects as governance type, council type, alternative financial resources, and relational mechanism of participants, all of which were the operational components of the governance system except for the role of participants. As for the specifics of statistical analysis, this study verified the statistical significance using one-way ANOVA with 95% confidence levels, and tested differences among groups using the Tukey method of post-hoc analysis [43]. As mentioned above, the levels of the various participants' roles were determined through suitability verification. To elicit the measures for NPS pollution management, the factor analysis was employed following the central agenda of the "General Management Measures of Four Major Rivers." The results of the factor analysis were that a plan having greater than the eigenvalue of one was chosen as a category of NPS pollution management measures. The governance model shown in Table 1 is an integrated system composed of both governance characteristics and NPS pollution management programs.

Table 1. Integrated governance model showing the characteristics of nonpoint source (NPS) management programs

Program	General management measures of four major rivers			
	Policy direction	Central agenda	Sectional measure	KEI 2008 [5]
Vesting management obligation to central government, local authorities, enterprisers and residents		•		
Establishing of NPS management system				•
Preparing comprehensive coordination functions				•
Reflecting measures of NPS from stage for making all sorts of development planning		•		
Preparing plan, guidance and regulation for managing and reducing NPS in construction and redevelopment projects		•	•	
Investing and installing sectional reduction facilities for city, rural community, forest, road, river and place of business		•		•
Strengthening ability for NPS management in flood prevention facilities within city, urban parks, and urban infrastructure			•	
Preventing earth and sand erosion in the fields; management through precaution to spray fertilizer and agrichemicals			•	
Preventing outflow of earth and sand in the forest; emission reduction of NPS by road and forest fire			•	
Managing and utilizing of land facing river			•	
Reducing and treatment after inflowing to public water	•			
Monitoring precaution and treatment projects				•
Monitoring water quality				•
Monitoring river restoration				•
Making basic research and developing watershed management model		•		
Developing NPS outflow model and reduction facilities			•	
Establishing guidelines for NPS management			•	
Implementing research on the actual condition of NPS and building NPS data				•
Spreading awareness of NPS through national education and publicity		•	•	
Promoting residents' participation			•	
Supporting special business for NPS facilities				•
Linking with superordinate plan		Addition		
Monitoring regulation, plan, and policy		Addition		

KEI: Korea Environmental Institute.

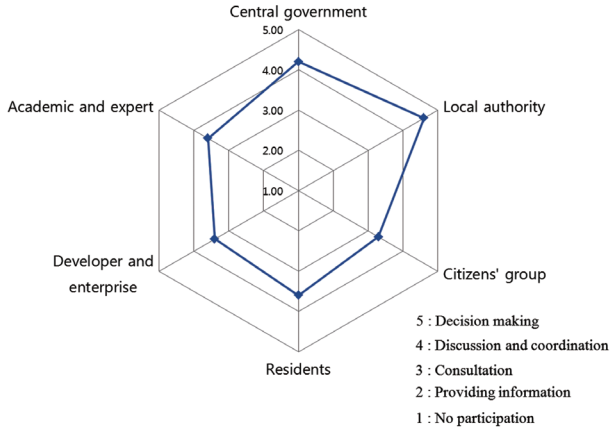


Fig. 4. Importance of various stakeholders in the decision-making process.

3. Results and Discussions

Table 2 shows the results concerning governance alternatives, such as types of governance institutions, financial sources, and collaboration mechanisms. With regard to the governance institution aspect, council (4.08) was the highest concern, followed by local authority driven (3.29) and cooperation of relevant authorities in central government (3.17). Private-public partnership had the highest overall mean, followed by government driven (3.00) and private driven (2.79). The polluter-pays principle (3.96) was the most popular choice as an economic instrument, followed by the recipient-pays principle (3.28), the general-tax-sources principle (3.20), and the victim-pays principle (1.92). Regarding the collaboration mechanism, motivation (4.28) was the highest concern, followed by empowerment (4.16), trust building, and appropriate regulations (4.08). Fig. 4 shows that the mean of the decision-making level for the local authority that was responsive was the highest, followed by the central government, residents, academics and experts, developers and enterprise, and citizens' groups.

As for the role of participants in the decision-making process, local authority (4.60) was the highest concern, followed by central government (4.20), residents (3.60), academics and experts (3.60), developers and enterprises (3.40), and citizens' groups (3.30). The role of participants was divided into 5 levels: decision-making (5), discussion and coordination (4), consultation (3), providing information (2), and no participation (1). The higher the number, the more critical the role of participants in decision-making process is.

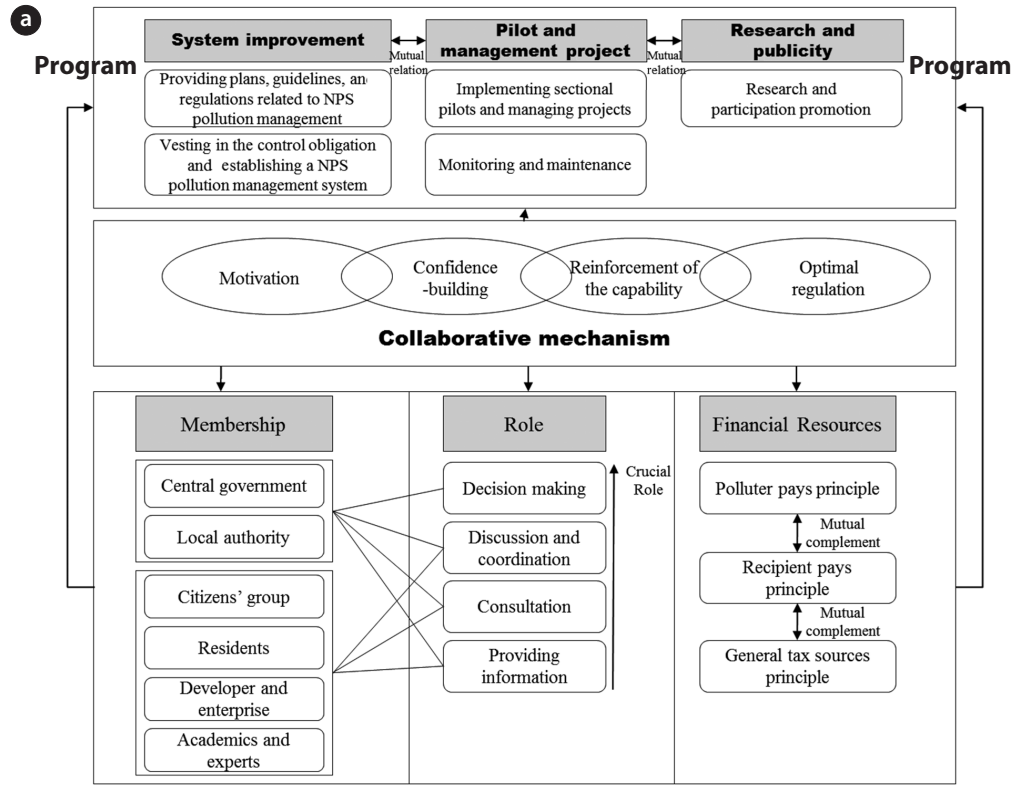
Table 3 shows that there existed significant differences among experts' preferences in one-way ANOVA, as follows: institutional forms, $F(2, 70) = 4.70$ and $p < 0.05$; partnership types, $F(2, 70) = 7.64$ and $p < 0.05$; and financial resources, $F(3, 96) = 16.13$ and $p < 0.05$. The institutional forms perceived by the private-public council were significantly higher than others. In addition, the polluter-pays, beneficiary-pays, and general-tax-sources principles were significantly higher than the victim-pays principle in terms of financial resources. However, there was no statistically significant group difference in terms of a collaboration mechanism.

The favored form of governance to manage NPS pollution efficiently was a type of council, based on private-public cooperative. As shown in Fig. 5, membership of the council included central government, local authority, citizens' groups, residents,

Table 2. Types of governance alternatives according to preference

Governance alternatives	No.	Mean	SD
Type of governance institution			
Cooperation of relevant authorities in central government	24	3.17	1.13
Local authority driven	24	3.30	1.04
Councils	25	4.08	1.22
Total	73	3.52	1.19
Partnership type			
Government driven	24	3.00	1.47
Private-public partnership	25	4.04	1.10
Private driven	24	2.79	0.98
Total	73	3.29	1.31
Principles of alternative financial resources			
Polluter-pays principle	25	3.96	1.14
Recipient-pays principle	25	3.28	0.98
Victim-pays principle	25	1.92	1.04
General-tax-sources principle	25	3.20	1.08
Total	100	3.09	1.28
Collaboration mechanism			
Motivation	25	4.28	0.74
Confidence building	25	4.08	0.81
Optimal regulation	25	4.08	0.86
Reinforcement of capacity	25	4.16	0.80
Total	100	4.15	0.80

SD: standard deviation.



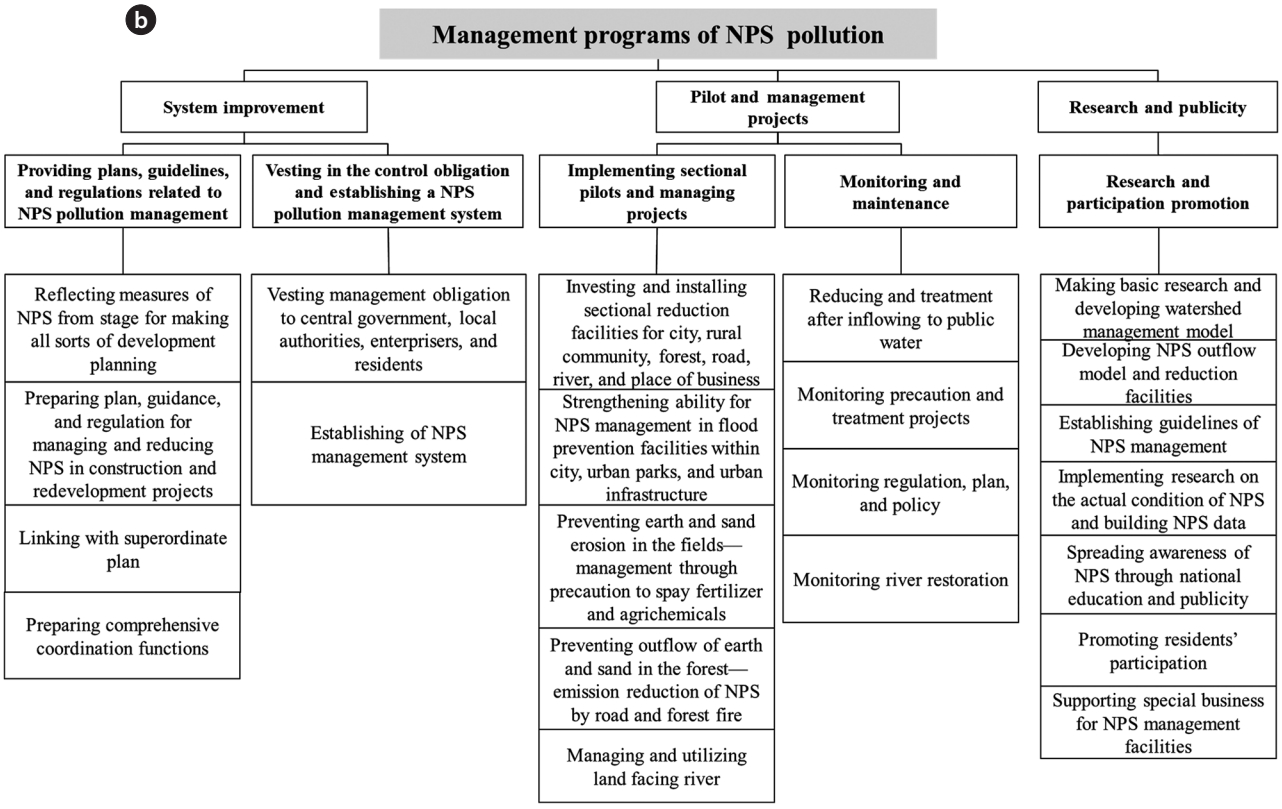


Fig. 5. An integrated governance model and measures to manage nonpoint source (NPS) pollution: (a) structure and process of an integrated governance model and (b) management programs of NPS pollution.

developers and enterprises, and experts. Authority groups, central government and local authorities, play a decision-making role, and non-authority groups, citizens' groups, residents, developers and enterprises, and experts play the role of discussion and coordination. There were such principles of financial resource as polluter-pays, recipient-pays, and general-tax-sources principles. Collaboration mechanisms we found were motivation, confidence-building, capacity building, and optimal regulations.

The programs, as shown in Tables 4–6, were entered into a factor analysis to identify the primary mechanism of variation relating to neighborhood character. Two factors were generated, accounting for 67.9% of the total variation in the system improvement section, 68.2% in the pilot management projects section, and 83.1% in the research and publicity section. Based on these factor loadings, each factor was interpreted as a dimension of neighborhood character (Tables 4–6).

In the system improvement section, the first component included 1) reflecting measures of NPS from stage for making all sorts of development planning, 2) preparing plan, guidance, and regulation for managing and reducing NPS in construction and redevelopment projects, 3) linking with superordinate plan, and 4) preparing comprehensive coordination functions. The second component is comprised of 1) vesting management obligation to central government, local authorities, enterprisers, and residents, and 2) establishing of NPS management system. Detailed programs in the system improvement section included the following sections: 1) providing plans, guidelines, and regulations related to NPS pollution management and 2) vesting in the control obligation and establishing a NPS pollution management system.

In pilot and management projects section, the first component include 1) investing and installing sectional reduction facilities for city, rural community, forest, road, river, and place of business; 2) strengthening ability for NPS management in flood prevention facilities within city, urban parks, and urban infrastructure; 3) preventing earth and sand erosion in the fields—management through precaution to spay fertilizer and agrichemicals; 4) preventing outflow of earth and sand in the forest—emission reduction of NPS by road and forest fire; and 5) managing and utilizing land facing river. The second component contain 1) reducing and treatment after inflowing to public water, 2) monitoring precaution and treatment projects, 3) monitoring regulation, plan, and policy, and 4) monitoring river restoration. Pilot management projects were divided into 1) implementing sectional pilots and managing projects, and 2) monitoring and maintenance.

Research and publicity section had only one component, research and participation promotion. The component included 1) making basic research and developing watershed manage-

Table 3. The results of the ANOVA

Variable		Sum of squares	df	Mean square	F	Sig.	Difference group
Type of governance institution	Between groups	12.088	2	6.044	4.694	0.012	Cooperation of relevant authority of the central government, local government driven / ***Council***
	Within groups	90.132	70	1.288	-	-	
	Total	102.219	72	-	-	-	
Partnership type	Between groups	22.041	2	11.020	7.644	0.001	Government-led, private sector-led / ***Public-private partnership***
	Within groups	100.918	70	1.442	-	-	
	Total	122.959	72	-	-	-	
Alternative financial resources	Between groups	54.350	3	18.117	16.128	0.000	Polluter-pays principle, beneficiary-pays principle, general-tax-sources principle / ***Victim-pays principle***
	Within groups	107.840	96	1.123	-	-	
	Total	162.190	99	-	-	-	
Collaboration mechanism	Between groups	0.670	3	0.223	0.345	0.793	-
	Within groups	62.080	96	0.647	-	-	
	Total	62.750	99	-	-	-	

Table 4. The results of factor analysis for system improvement section

Variable	Component 1	Component 2
Preparing plan, guidance and regulation for managing and reducing NPS in construction and redevelopment projects	0.823	-0.336
Reflecting measures of NPS from stage for making all sorts of development planning	0.802	-0.343
Preparing comprehensive coordination functions	0.793	0.279
Linking with superordinate plan	0.726	0.025
Establishing of NPS management system	0.150	0.811
Vesting management obligation to central government, local authorities, enterprisers, and residents	-0.300	0.722
Total variance explained (% of variance)	43.13	24.78

ment model, 2) developing NPS outflow model and reduction facilities, 3) establishing guidelines of NPS management, 4) implementing research on the actual condition of NPS and building NPS data, 5) spreading awareness of NPS through national education and publicity, 6) promoting residents' participation, and 7) supporting special business for NPS management facilities.

These analyses favor an integrated governance model for comprehensive management of NPS pollution. The favored type of governance institution was a private-public collaboration council. Membership included central government, local authority, citizens' groups, residents, developers and enterprises, and academics and experts. Collaborative mechanisms between these members were motivation, confidence-building, optimal regulation, and reinforcement of capacity. Decision-making processes related to watershed management in Korea were as follows: 1) central government, such as Ministry of Environment, must establish a plan to manage basin; 2) central government discusses and adjusts the plan with related government departments and committees; and 3) central government issues a plan to municipal governments and local governments. Although local governments were influenced directly and/or indirectly by central government-driven plans, they could hardly participate in decision-making processes. Residents, citizen groups, academics, and experts have played indirect roles such as those of consultancy, or they have been excluded from decision-making processes. In order to improve these problems and manage NPS pollution effectively, the governance organization such as a council is necessary for collaborating the private and the public. Furthermore, it is important to establish cooperative governance, motivation for participation, trust building between the private and the public, capacity building of the private and the public, and optimal regulations related to NPS pollution management. This council should be supported by the financial sources funded by the polluter-pays, recipient-pays, and general-tax-sources principles. Both the polluter pays principle and recipient pays principle have been generally applied to securing financial resources for watershed management. Additionally, a general-tax-sources principle has been considered, because water is public property and affects various stakeholders. All stakeholders have participated in the decision-making process in accordance with their roles. The public participants, such as central government and local authority, could play a role as decision makers. Private and expert groups could act as discussants and coordinators. The council could perform the projects, including system improvement, pilot management projects, and research and publicity. Different roles at decision-making seem closely related to both the characteristics of NPS pollution management programs and the limited finance and capacity for final decision-making by residents, non-governmental organizations (NGOs), academy, and experts to establish the institutional systems and the implementation projects relevant to NPS pollution management. The NPS pollution management measures consist of stages such as initiation, policy development, pilot project development, and institutional development, which ensure the improvement of project efficiency. From now on, in order to enforce NPS pollution management with efficiency, it is recommended that the management scheme ensures the equal participation of stakeholders in decision-making processes, within a council-based governance system.

Table 5. The results of factor analysis for pilot and management projects section

Variable	Component 1	Component 2
Investing and installing sectional reduction facilities for city, rural community, forest, road, river, and place of business	0.844	-0.006
Strengthening ability for NPS management in flood prevention facilities within city, urban parks, and urban infrastructure	0.837	0.231
Preventing earth and sand erosion in the fields; management through precaution to spray fertilizer and agrichemicals	0.799	0.250
Managing and utilizing of land facing river	0.760	0.280
Preventing outflow of earth and sand in the forest; emission reduction of NPS by road and forest fire	0.661	0.292
Reducing and treatment after inflowing to public water	0.255	0.857
Monitoring precaution and treatment projects	-0.033	0.817
Monitoring regulation, plan, and policy	0.467	0.692
Monitoring river restoration	0.446	0.656
Total variance explained (% of variance)	39.43	28.79

Table 6. The results of factor analysis for research and publicity section

Variable	Component 1	Component 2
Developing NPS outflow model and reduction facilities	0.922	0.296
Making basic research and developing watershed management model	0.912	0.270
Implementing research on the actual condition of NPS and building NPS data	0.721	0.451
Spreading awareness of NPS through national education and publicity	0.317	0.884
Promoting residents' participation	0.269	0.879
Supporting special business for NPS facilities	0.561	0.614
Total variance explained (% of variance)	44.79	38.26

4. Conclusions

NPS pollution management is currently the most critical issue in controlling water quality. This study has suggested an integrated governance model to manage NPS pollution effectively in watershed management practiced in Korea. The governance model was derived by analyzing the characteristics of governance and the management plans for NPS pollution. To build an objective model, an expert survey and statistical analyses like ANOVA and factor analysis were employed. The integrated governance model was composed of a council based on private-public partnership, different decision-making levels between stakeholders, and a variety of financial resources, including the polluter-pays, general-tax, and recipient-pays principles. The collaborative mechanism was also a critical factor for operating the other governance factors. The reasonable distribution of membership roles acts as an effective tool for the operation of the program. Furthermore, the economic instrument, guarantees stabilized financial resources for the program.

This study suggested a conceptual governance model, including membership, roles, economic instrument, and a program as components of governance for managing NPS pollution. Research regarding the governance for NPS pollution management has, thus far, been limited to case studies. So, there has been no comprehensive governance model to manage NPS pollution effectively. To overcome the shortcomings of the researches, this study has derived a typical governance model through literature review, and has verified it using expert survey and statistical analysis methods. Thus, this study has suggested a comprehensive governance model for NPS pollution management. But this study needs further researches including the determination of: 1) how the model could be applied to actual NPS management policy cases as a conceptual model; and 2) how these various factors of the governance model related to each other. Thus, further research is needed to analyze the relationships between these components, and should be accompanied with various stakeholders' opinions during the research process.

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