Decision-Making Model Research for the Calculation of the National Disaster Management System's Standard Disaster Prevention Workforce Quota : Based on Local Authorities

SungSu Lee* · Young-Jai Lee**

Abstract

The purpose of this research is to develop a decision-making model for the calculation of the National Disaster Management System's standard prevention workforce quota. The final purpose of such model is to support in arranging a rationally sized prevention workforce for local authorities by providing information about its calculation in order to support an effective and efficient disaster management administration. In other words, it is to establish and develop a model that calculates the standard disaster prevention workforce quota for basic local governments in order to arrange realistically required prevention workforce.

In calculating Korea's prevention workforce, it was found that the prevention investment expenses, number of prevention facilities, frequency of flood damage, number of disaster victims, prevention density, and national disaster recovery costs have positive influence on the dependent variable when the standard prevention workforce was set as the dependent variable. The model based on the regression analysis-which consists of dependent and independent variables-was classified into inland mountainous region, East coast region, Southwest coastal plain region to reflect regional characteristics for the calculation of the prevention workforce.

We anticipate that the decision-making model for the standard prevention workforce quota will aid in arranging an objective and essential prevention workforce for Korea's basic local authorities.

Keywords : Natural Disaster, Prevention Workforce, Local Authorities, Calculation Model for Disaster Prevention Workforce Quota, Regression Analysis

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* Ph.D. candidate, Graduate School, MIS Dept., Dongguk University, e-mail : su_sung@hanmail.net

** Corresponding Author, Professor, MIS Dept. Dongguk University, e-mail : yjlee@dgu.edu

1. Introduction

The recent climate changes due to greenhouse effect and global warming are causing large-scale natural disasters such as typhoon, torrential rain, heat wave, drought, sever cold, and earthquakes to occur all over the world. Active research is being conducted to build an effective prevention and response system against natural disasters, which are characterized by rapid and dynamic changes.

Since the establishment of the Fire Prevention Department on June 1, 2004 and the Basic Rules for Disaster and Safety Management, Korea is actively pursuing the introduction of hi-tech Ubiquitous IT for efficient disaster response in order to strengthen the policies against natural, human-made and societal disasters. Since surpassing the 20,000 dollar per capita GDP mark, the Korean citizens' demand for public safety and disaster management service is continuing to rise [Chung et al., 2008].

Upon the establishment of the Fire Prevention Department, Korea has created and is now implementing a systematic prevention management policy in order to provide an improved disaster management service to meet the demands of the era. Although disaster-related tasks are escalating with the changes in the social environment, the nation is experiencing the strange phenomenon of a reducing prevention workforce [Lee et al., 2009b][1]. It is a fact that the nation currently lacks a systematic research although identifying the reasons for the reduction and calculating and arranging an appropriate prevention workforce is a priority factor in the National Disaster Management System.

Formerly, advance research about disaster management organization and the relevance of information and communication technology (ICT) was focused on areas that support practical business affairs in disaster management, areas centered around administration such as disaster management policy and organizational system, and sociological, administrative, and engineering research for risk management. The nation is now faced with the reality of its need for a research on a model that calculates the quota for disaster management public employees who work on-site at the natural and human-made disaster response regions.

The first step in disaster management is to expand the professional workforce that takes charge of region-based disaster management service [The Ministry of Government Administration and Home Affairs, 2003; Song, 2003; The Board of Audit and Inspection of Korea, 2003]. Calculating the appropriate number of employees is one of its important issues [Lee, 2006]. Investigating the roles and responsibilities of disaster management and a methodology for an effective disaster response are the main research subjects in the research and treatise related to natural disaster at the theoretical stage

1) The regulation on the administrative apparatus and quota standard for local authorities, revised 2004 (Government Newsletter No. 15875, 2004. 12. 18), additionally, the total quota is 2,088 when 9 prevention employees are assigned each to the 232 basic local authorities according regulation, but the number of public prevention employees in the basic local authorities was 1,410 as of December, 2008.

[Kang, 2008; Ryu, 2007; Song, 2003; Yang et al., 2006; Lee, 2002; Lee et al., 2008; Kirschenbaum, 2004].

Up until now, the majority of advance research related to organizational structure and decision-making in the prevention management area was focused on the disaster range, disaster management organizational structure, and disaster management activities, clearly revealing that the primary response organizations are local governments rather than the Central Government [Kim, 2004; Song, 2003; Yang, 2006]. There has even been a research that revealed the fact that the problem in the basic local authorities' disaster situation management is the lack of professional workforce to run the disaster situation management [Kwon, 2003, 2007]. In spite of this, there is still a lack of advance research on determining the appropriate standard prevention workforce for local authorities which is the basis to national disaster management.

The purpose of this research, therefore, is to develop a decision-making model that provides information about the standard prevention workforce quota based on regional characteristics for the calculation of an appropriate target prevention workforce quota in Korea's basic local authorities. A regressive model that supports decision-making for standard prevention workforce quota is established using the analysis about texts related to disaster management ability, ICT, and prevention workforce, interviews with public prevention employees, factor analysis on the model's independent variables, and regressive analysis statistical method. The scope of this research was limited to the local public employees who take charge of the natural disaster tasks in basic local authorities- in other words, to the appropriate prevention workforce quota for local authorities. The disaster types were limited to natural disasters. In particular, the purpose of this paper is to derive a decision-making model to calculate the standard prevention workforce quota, signifying the appropriate future prevention workforce quota classified under city, county, and district.

2. Advance Research about the Results, IT, and Workforce Related to Disaster Management

2.1 Factors influencing Disaster Management Results

Various researches have been conducted about the factors that influence disaster management results [Kang, 2007; Lee, 2007; Choi, 2005; Chae 2009]. The empirical research centered around the three influential factors of the Ubiquitous Technology that affected the effectiveness of disaster management and the 15 items that explain these factors [Chae, 2009] emphasize that UIT factors (level of recognition, utility, appropriateness, facility of information acquisition, usage intent), organization and management factors (governor's interest and support, education and training, communication, budget, legal system) and governance factors (citizens' support, cooperation by related organizations, NGO network, voluntary service, voluntary fire brigade) affect the attainment of goals in disaster management.

In the study about the factors that affect the effectiveness of disaster management system for advance preparation in local authorities, the independent variables were classified into environmental factors and the organization's internal factors as the basis to secure the effectiveness of disaster management. Environmental factors signify the degree of influence by external organizations, and evaluate whether the external organizations' orders and intervention, the level of regulation and control, political leadership, and the level of demand about disaster tasks by ordinary residents affect the organization's internal factors. For organization's internal factors, the top management level's leadership, the professionalism of the employees in charge, the level of disaster management system, and the cooperation among disaster management systems were selected. The professionalism of prevention workforce is mentioned, but here too, the examination about the appropriate size of the workforce is lacking.

In the analysis of factors that influence disaster management in local authorities [Kang, 2007], the independent variables include the level of interest, scope, satisfaction, cooperation, and professionalism, and the dependent variable includes effectiveness. The analysis subjects were each divided into public sector, related organizations, and private sector. According to the research results, the effectiveness of disaster management is affected by the level of cooperation, professionalism, and interest in the successional order. Although the size of the prevention workforce was assumed as the independent variable in the research for an effective disaster management, prevention workforce was converted into a 5-point Likert scale to measure only the appropriateness of the size, and little interest was given in calculating the appropriate prevention workforce quota. Despite this, the fact that the interest level for prevention tasks in local authorities was selected as the independent variable and presented as being influential on the effectiveness of disaster management is largely significant.

2.2 Disaster Management and IT

The National Disaster Management Standard [The Ministry of Public Administration and Security, 2010] that serve as the basic principles in implementing disaster management to implement various disaster management tasks presents the introduction and use of Disaster Health Monitoring using a hi-tech sensor. For the management of disaster situation, a system that prevents damage in advance was established with the introduction of hi-tech Ubiquitous IT sensor technology by collecting and efficiently analyzing the data from sensors that detect signs of disaster in real time to recognize scientific and rational disaster warning data, propagate the situation systematically, and publicize about the disaster. A principle that establishes a Disaster Integrity Monitoring System that enables an expedited disaster response was presented for the central government, local authorities, as well as disaster management agencies, the majority of which are public organizations.

The Geographic Information System (GIS)

clearinghouse established and operated by the Federal Emergency Management Agency (FEMA) at Lousiana State University presents a prime example of GIS and disaster management application [Jacqueline et al., 2008] in regards to the rising importance of geographic data in disaster-related information and prevention workforce arrangement since the occurrence of Hurricane Katrina and Rita in 2005. In particular, the research treatise and government report in disaster response area were used in the Louisiana Recovery activities. Moreover, the clearinghouse provided vast information needed in the region's future disaster preparation and reduction activities.

There have been various discussions that strengthened the disaster preparation capacity in local authorities through IT [Douglas et al., 2007]. Non-profit organizations such as Miami University in Florida and the Red Cross have conducted pilot projects to strengthen disaster response capacity by using ICT. According to an investigation made in 2006 since Hurricane Katrina, 42% of the websites in the Florida region have no information related to disaster. In order to solve this problem and to utilize them in disaster response, the local resource database of the supplier that provides information and human resource is a core factor in disaster preparation in local community bases.

2.3 Disaster Management and Human Resource Management

The theoretical classification about disaster administration is divided into two levels-tool perspective and process perspective. Disaster administration theory is classified into decision-making theory, economic theory, administration theory, and social theory. Decision-making theory deals with policy, standard operating procedure, GIS, and rational approach; economic theory deals with resource distribution and level of economic influence; social theory deals with post-modernism, approach according to gender, vulnerable person in society, etc; and lastly, administrative theory deals with leadership, management, and moral administrative responsibility. In the disaster process aspect, economics and decision-making are core issues at the beginning stage, but with time, the focus shifts to social and administrative management areas. This research focuses on deducing the variables that affect human resource in the natural disaster administrative system aspect and explaining its need.

This research takes on the human resource management perspective in order to establish a prevention workforce plan as a part of the strategic project to strengthen the prevention capacity in local authorities.

Human resource is the most important asset of an organization [Jumara, 2005]. More than any other work such as planning, facilities and equipment management, and accounting, failure in establishing plans for an appropriate human resource management for the future can have an irreversible negative impact on the lives of the organization's members, and the organization must therefore secure at least the appropriate forecasted capacity. The four different levels that attempt planned organizational change are human resource, technological capacity, functional resource, and organizational capacity. These four areas of change are mutually dependent and it is impossible to change one without changing the others.

Unlike many other reforms, strategic project is accepted and established based on the characteristics of political decision-making process, and therefore serves as a tool for sustained leadership and management reform [Bryson, 2004a]. Selecting and solving important issues are at the core of political decision-making and strategic planning. As a tool that benefits an organization, its related parties, and the social community, strategic planning supports in rational rather than simple political decision-making by selecting and solving important issues.

Calculating the prevention workforce quota for local authorities can also be seen as a part of such strategic planning. The calculation and recruitment of a rational and scientific prevention workforce leads to the activation of prevention tasks in local authorities and contribute in achieving a political disaster management policy to build a safer society.

2.4 Calculation Model for Public Employee Quota in Local Authorities

Following the delegation of the right of employee management to the leaders of local authorities upon the introduction of the Total Payroll Costs System implemented in January of 2007, the establishment of a strategic prevention workforce planning is direly needed in order to bring out decision-making by requesting the local authority leaders for the arrangement of appropriate prevention workforce through a rational and objective method. In other words, there is a need for a research about a strategic decision-making tool that establishes an objective standard about the standard prevention workforce quota.

There have been partial studies conducted on standard quota according to classification by function that reflected the opinions of basic local authority employees [Chang, 1999; Koh, 2008a, 2008b; Koh et al., 2005; Kim, 2005] but prevention research is generally centered upon the US and Japan and there is little research about the standard quota professional workforce-or prevention workforce-for natural disasters [Lee et al., 2009a].

(1) Prevention Workforce Calculation Model

In order to explore the calculation model for natural disaster prevention workforce [Lee et al., 2009b], independent variables that affect the calculation of various prevention workforce quota were derived by modifying the research model by using a grounded theory. In the standard prevention workforce quota calculation-in other words, when the appropriate prevention workforce was set as the dependent variable- the number of special weather reports, the number of disaster victims, the scale of damage of the natural disaster, the area of the local authority, local authority population, the number of prevention facilities, the length of the prevention facilities, prevention investment rate, the organization governor's leadership, and natural disaster recovery cost were presented to have significant influence.

This research emphasizes the establishment of a reliable calculation model for the standard prevention workforce through a dummy variable called area type and by increasing the number of samples to at least 100 local authorities as the future research direction in calculating the appropriate prevention workforce, since the consideration about dependent variables and prevention workforce differ according to regional characteristics.

The reason for operating the standard quota system for local employees is to enhance administrative efficiency by enforcing an appropriate level of workforce management for the local authorities. A standard quota system was introduced in 1995 in order to supplement the shortcomings of the existing total quota system which could not effectively reflect the region-specific variables of the local authorities [Kim, 2005].

The independent variables of the standard quota system are population size, the area of the administration region, the number of affiliated organizations, and the account size. Deriving a simple regression model based on these gives : "local authorities employees quota = F (population size, area of the administration region, number of affiliated organizations, account size)."

Chang [1999] presented a Public Employee Quota Management Model according to Function as an alternative plan to improve the standard quota system, which was formerly the local authorities employees quota management system.

The independent variable for the model to calculate the employee quota of the disaster risk management function were population density, population, the number of disaster management facilities, and the number of civil defense facilities. The disaster management employee quota formula derived by implementing a regression analysis based on such data was "disaster risk management employee quota = 10.307534+ 0.000165*population density+0.000011197*population+0.001777*number of disaster management facilities+0.0019*number of civil defense facilities."

(2) Calculation Method for the Standard Quota for Korea's and Japanese Local Authorities

As the essential nature of local government is the competition among local authorities, it is appropriate to apply a macro-approach method that makes mutual comparisons among the local authority groups, and a quantitative analysis using the regression analysis can be a useful method in calculating the standard quota for the local authorities. According to the remarks on standard quota, the local authorities employee standard quota model can be expressed by the basic population size that represents the administrative demands, area, the number of current employees, the number of affiliated organizations in county/district/dong, and ordinary total settled accounts [The Ministry of Government Administration and Home Affairs, 1999]. The employee quota for basic local authorities was calculated by using these in the regression analysis model.

Japan's local public employee quota model expresses the mutual relationship with the indexes related to administrative demands such as population and area through a regression formula by using the multiple regression analysis. For the independent variables in this model, several independent variable candidates judged to express the administrative demands well according to the size of each local authority were collected. A statistical analysis was conducted on these and the independent variables with the greatest mutual relationship with the number of employees were selected.

3. Standard Prevention Workforce Quota Calculation Model for Local Authorities

The research procedure for the prevention workforce quota calculation model for local authorities in this research is as follows :

1) Interview investigation on the public employees in charge of prevention in 23 local authorities about the factors presumed to decide the size of prevention workforce in local authorities,

2) The dependent variable is the appropriate prevention workforce quota for local authorities,

3) The independent variables are derived from factors that have high influence on the prevention workforce quota,

4) Advance research and interview investigation about the quantification of independent and dependent variables,

5) Collection of quantification data according to dependent and independent variable items,

6) Factor analysis and reliability analysis of the independent variables to analyze soundness,

7) Implementation of a regression analysis by entering independent and dependent variable data

8) Derivation of a calculation model for prevention workforce quota

9) Derivation of a predictor variable verified by statistical significance.

The regression analysis statistical method used in this research is a technique that predicts what is most influential upon the organization's future workforce demand by calculating the degree of influence of various factors that affect the organization's workforce demand decision. In order to enhance the effectiveness of the prevention organization, it is very important both scholastically and practically to derive an appropriate prevention workforce.

3.1 Interview Investigation of Public Employees in Charge of Prevention in Basic Local Authorities

23 local authorities were selected according to socio-statistical classification and visited for interviews with local public employees in charge of prevention. Population size was classified into over 500,000, 300,000~500,000, 100,000~300,000, and less than 100,000 in accordance with the most commonly used classification system in social scientific investigation. 23 local authorities were selected according to such classification system that maximally reflects prevention characteristics according to region. The local authorities thus selected were visited for in-depth interviews through the cooperation of

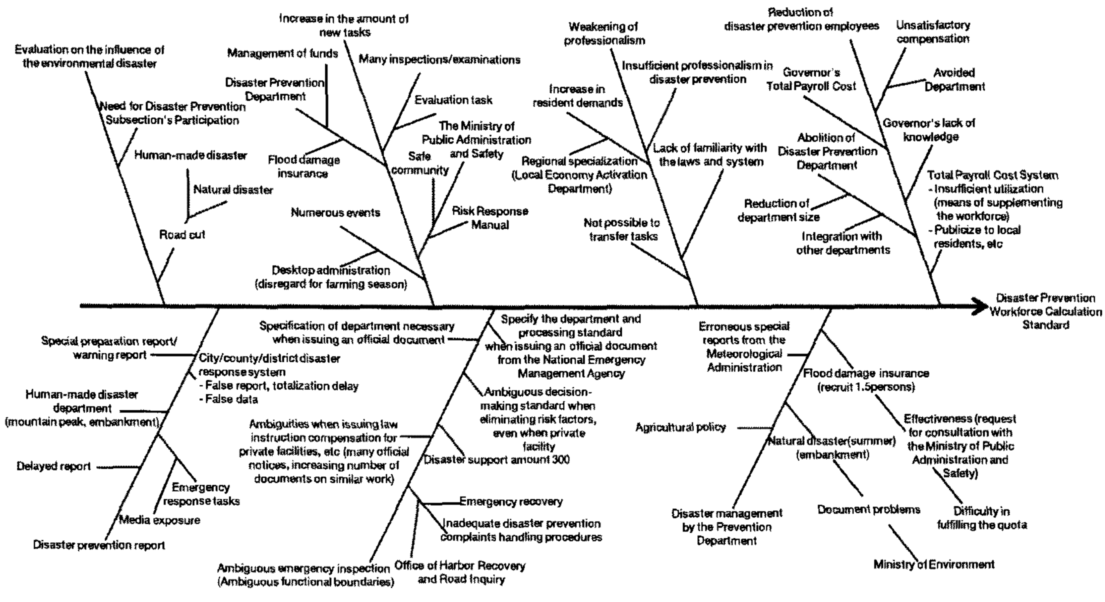
their prevention employees.

The investigation period for the prevention work was from July to August of 2009. The local authorities subject to the investigation were located in 23 cities, counties, and districts, and classified into 4 regions. The Kyoung-Sang region includes Jin-gu in Busan Kwangyuk-shi, Dalsuh-gu in Daegu, Jinju, Youngju, Sancheong, and Haman; the Jeolla region includes Jeonju, Mokpo, Namwon, Naju, and Wando. The Choong-Cheong region includes Cheongju, Seo-gu in Daejeon, Jecheon, Danyang, Kumsan, and Taean; the Kangwon and Metropolitan regions include Sokcho, Wonju, Songpa-gu in Seoul, Euiwang, Kwacheon, and Bupyeong in Incheon.

After two months of interviews with the local authorities prevention employees(<Figure 1>), it was found that proper prevention work cannot be implemented due to the lack of prevention employees in contrast to the increasing amount of new prevention tasks.

<Figure 1> shows the current situation and problems in prevention work. The main point of the diagram is that the workforce in charge of prevention-related work is decreasing in contrast to the rising amount of work, and that there is a great difficulty in cooperating with related departments due to the low perceived status of the prevention department. Frequent emergency shifts, poor work environment, etc have caused an unpopular image of the prevention department as a department that has many responsibilities and little authority. Moreover, the employees' morale and the organization leader's interest level are low compared to the heavy workload.

The prevention employees in the local authorities presented several opinions in order to solve such problems, and the opinions related to prevention workforce are as follows : First, it is



<Figure 1> Problem Analysis related to Disaster Prevention based on Fishborn Diagram

desirable to calculate the prevention workforce by supplementing the workforce recruitment method related to the Total Payroll Costs System and through close cooperation with HR-related organizations. Second, an establishment of a system that can secure workforce that has received specialized prevention training is needed in order to process prevention work smoothly. Third, the supplementation of the lack in prevention workforce and the reduction of the surplus workforce must be induced by arranging a securing policy or standard for a rational prevention workforce.

3.2 Dependent Variables in the Standard Prevention Workforce Quota Model

The concept of standard prevention workforce quota-which is considered as a dependent variable-is defined as the number of prevention employees required by local authorities to provide prevention administration services. The prevention administration services employees must realize what and how to provide to the regional residents in order to derive the standard prevention workforce quota. In other words, an objective and quantitative model is needed for the local authorities to determine the total amount of prevention administration services. Despite such a need for a public choice model for prevention administration services, no established theory has been agreed upon as yet.

Dependent variable data is needed in order to derive the standard prevention workforce quota by using the regression model. The investigative research by Lee et al. [2009b] revealed the limitations of the research by using the number of current prevention employees as the value for the dependent variable. In this research, a structural survey was developed and distributed to 30 prevention work managers in the National Emergency Management Agency in order to create dependent variable data. This was used as the basic data to calculate the appropriate size of prevention workforce for the local authorities.

The survey consisted of data such as the population size, area, frequency of flood damage, number of victims, size of disaster damage, prevention investment rate, and the current number of prevention employees in the 105 local authorities. Based on such status data, employees stationed above the deputy director post who have been in charge of prevention work for a long time at the Central Administrative Agency recorded in the survey what the appropriate number of workforce should be for each local authority. The standard prevention workforce quota for each local authority-or the value of the dependent variable-was deduced from the average value of the results collected from 30 prevention specialists.

3.3 Independent Variables in the Standard Prevention Workforce Quota Calculation Model

The variable items to be used in the calculation model for the standard prevention workforce quota of local authorities are derived by using Chang's Local Public Employee Quota Calculation Model according to Function, Kim's

Local Public Employee Standard Quota Model, Lee et al's Investigative Standard Prevention Workforce Calculation Model, The Ministry of Government Administration and Home Affairs' Standard Quota Calculation Method, and in-depth interviews with the US and the National Emergency Management Agency' prevention specialists. Data for measuring each item is then collected to implement a statistical analysis and a final research model is established by selecting significant items.

The independent variables presented in the research model [Chang, 1999] for the calculation of the employee quota with disaster risk management function has the limitation of including all disasters such as natural and human-made disasters, civil defense, and military to be directly applied to the scope of this research. Kim [2005] and The Ministry of Government Administration and Home Affairs [1999] presented the population size, area of the administration region, number of subsidiary organizations, and the account size as independent variables, but even these were inadequate to be used as the core variables to calculate the size of the prevention workforce quota.

The variables derived from the interviews with the prevention employees working in the Fairfax County local government (US)[2] were IT skills, the frequency of natural disaster occurrence, the scale of disaster damage, financial capacity, regional characteristics, the number of prevention facilities, and local governor leadership. Such variables are generally considered in calculating the prevention workforce quota in the US.

The final variable items were selected by exchanging opinions over ten times with the prevention employees working in The National Emergency Management Agency's Prevention Management Department,[3] which centered around the variables that were derived based on text research and on the interviews with prevention managers in the local government in the US, and the items and data that measure those variables. <Table 1> organizes the variables that affect the standard prevention workforce and shows the reasons why the variables were selected or rejected by the National Emergency Management Agency's public employees.

The selected research variables are prevention investment rate, number of prevention facilities, length of prevention facilities, number of special weather reports, the frequency of flood damage occurrence, scale of disaster damage, number of victims, natural disaster recovery cost, and prevention density-which divides the area by the current prevention workforce-and regional characteristics. Such variable items can be explained by being classified into prevention work factors, natural disaster damage factors, and prevention administration factors. In this way, a research model which is affected by the prevention administration variable which

2) These are the results obtained from the telephone interviews and in-depth interviews by visiting the Fairfax County's Disaster Management Department in Virginia, US in August, 2009.

3) In-depth interviews were conducted on the variable items that affect the calculation of the standard prevention workforce 2~3 times every month from September to December, 2009.

〈Table 1〉 Variables that Affect the Standard Prevention Workforce

Research Variable	Eun-Joo Chang [1999]	The Ministry of Gov't Administration and Home Affairs [1999]	Tae-Young Kim [2005]	Chang-Won Lee [2009]	US Disaster Management Public Employee Interview [2009]	Variable Selection by the National Emergency Management Agency's Prevention Management Public Employees [2009]
Number of affiliated organizations		o	o			Rejected for the limitation of local authorities
Number of special weather reports				o		Number of special weather reports
IT skills					o	Rejected for being a qualitative variables
Frequency of natural disaster occurrence				o	o	Changed into the number of flood damage
Scale of natural disaster damage				o	o	Scale of disaster damage
Number of disaster victims				o		Number of disaster victims
The account size		o	o			Reflected in the prevention investment rate
Financial capacity					o	
Natural disaster recovery cost				o		Natural disaster recovery cost
Number of disaster management facilities	o					Substituted by prevention facilities
Number of prevention facilities				o	o	Number of prevention facilities
Number of civil defense facilities	o					Rejected for being a civil defense tasks
Length of prevention facilities				o		Length of prevention facilities
Number of population	o	o	o			Substituted by prevention density
Population density	o					
Prevention density				o		Prevention density(area/prevention workforce)
Area of administration region		o	o			Reflected in the prevention density
Region type					o	The calculation model was presented after dividing the region into 5 types
Natural disaster hotspot maintenance cost				o		Rejected for being a nationally supported project
Small river maintenance cost				o		
Prevention investment rate				o		Substituted by prevention investment rate
Local governor leadership					o	
Local governor's interest level on prevention task				o		
Number of current employees		o				Required number of prevention employees(dependent variable)

explains the prevention work, scale of disaster damage, and the governor's interest level in the given cities/counties/districts is established for the calculation of the prevention workforce quota for the local authorities. In other words, there are largely three factor variables that are used in the calculation of the prevention workforce quota calculation for local authorities.

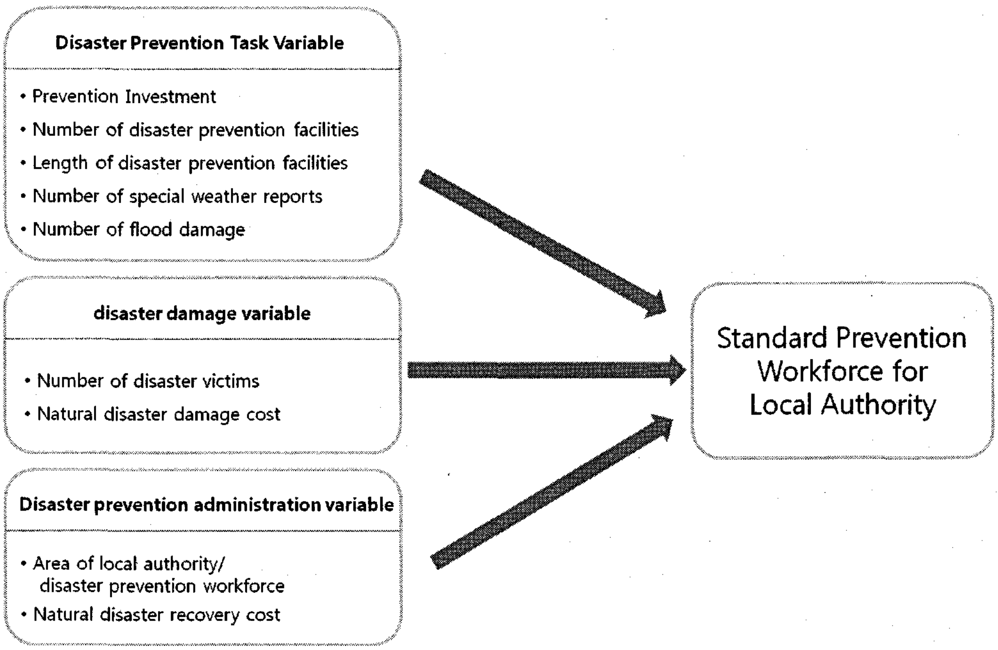
Second, natural disaster damage factors can be explained as the number of disaster victims, which signifies the loss of human lives and assets due to the disaster- and the size of disaster damage, which signifies natural disaster damage cost. These items were explained by the number of victims in the given local authorities over the last ten years and the average value of the natural disaster damage cost, in order to reflect the natural disaster characteristics that do not repeat year after year.

Third is the prevention administration factor, which is the area of local authorities divided by the number of current prevention workforce employees, and the natural disaster recovery cost, which is the average value of the local authorities' recovery cost over the last three years. The local authorities' discretionary authority in regards to the prevention organization and workforce is guaranteed according to the Total Payroll System introduced in January, 2007. There have been various discussions on how to reflect the governor's interest level in the prevention work-which, according to the results of the investigation visit to the local authorities, was deduced as being the biggest factor in arranging prevention workforce- but finally the number of current workforce assigned in prevention work was selected as the standard value in measuring the governor's interest level in the prevention work. Also, as a part of natural disaster recovery cost is covered by the local authorities' own budget to supplement the central support amount, it was selected as an item that explains the prevention administration factor.

3.4 Decision-Making Model for the Standard Prevention Workforce Quota

The variables that influence the calculation of the standard prevention workforce in local authorities are prevention work, disaster damage variable, and prevention administration, as shown in <Figure 2>. Prevention work variables that consider city/county/district regional characteristics consist of 5 items, which are prevention investment expenses, the number and length of prevention facilities, the number of special weather reports, and the number of flood damage occurrence. As such, city/county/district prevention work can be explained as activities that manage prevention facilities according to the prevention budget and prevent against disaster damage in accordance to the special weather reports. Moreover, regional characteristics are classified into East coast region, South coast region, West coast region, inland mountainous region, and inland plain region.

City/county/district disaster damage variable consists of the number of disaster victims-which signify the loss of human life-and the damage cost due to natural disaster. The scale of disaster damage affects the calculation of the pre-



〈Figure 2〉 Standard Prevention Workforce Quota Research Model

vention workforce, and the number of disaster victims and natural disaster damage cost were used in order to measure this value.

It was considered possible to measure the items included in the city/county/district prevention administration variable by the prevention density which divides the area of the given local authority by the prevention workforce, and the investment scale of the recovery budget.

The calculation model for the standard prevention workforce quota provides a logical concept about the prevention employee demand for each local authority. Moreover, by presenting the number of public employees required to implement the prevention administration services, it suppresses inefficiency during the production stages of the services, and provides the opportunity to overcome the limitations that the local authorities cannot solve on their own.

In order to support the effective decision-making of the governors of the local authorities, this research deduces variable items based on prevention-related duties, verifies the prevention workforce quota calculation model for the local authorities by collecting quantitative data and implementing a regression analysis, and carries out an empirical analysis of the model.

Despite this, the research results for the model established in Lee's advance research are rather inadequate to be generalized as there is incomplete analysis about the soundness and reliability of the independent variables deduced in the research, and also due to the limitation of the research being restricted to 27 local authorities. This research supplements these shortcomings in order to contribute in establishing a strategic decision-making model for a more reliable prevention workforce quota calculation for the local authorities.

In other words, it presents a strategic decision-making tool model that implements the budget efficiently and strengthens the disaster preparation capacity by creating and administrating a minimum standard prevention workforce calculation model that go with the characteristics of the 232 basic local authorities.

(1) Independent Variables for the Standard Prevention Workforce Quota

In order to develop the standard prevention workforce calculation model, a statistical analysis about the research model needs to be conducted first. Therefore, quantitative data about the 9 variables excluding regional characteristic-which is an independent variable in the research model-is required. As the purpose of the analysis is to develop a model for the prevention employee quota for local authorities, the data on the variables were limited to the data related to the local authorities.

The samples used in the research model were selected from 105 out of the 232 cities/counties/districts in Korea according to the facts stated in the investigative research by Lee et al. Also, as the research samples need to reflect regional characteristics, they were divided into East coast region, South coast region, West coast region, inland mountainous region, and inland plain region according to the opinions collected from the National Emergency Management Agency's prevention management public employees. 11 local authorities-Pohang, Sokcho, Samcheok, Wuljin, Youngduk, etc-were included in the East coast region. 22 local authorities including Goheung, Tongyeong, Gangjin, and Jeju were selected in the South coast region. The South coast region consists of 23 local authorities including Mooan, Shinan, Taean, Seocheon, and Hwasung. 24 local authorities including Bonghwa, Andong, Mungyeong, and Sancheong were selected as the research samples in the inland mountainous region. Lastly, the inland plain region consists of 25 local authorities including Dalseo-gu Daegu, Bupeyong-gu Incheon, Jinan, and Namwon.

The origins of data for independent variables related to the 105 local authorities are as follows : The number of special weather reports was collected from the readings from the Meteorolocal Bureau homepage over 3 years since 2006. The 2008 data from the National Emergency Management Agency and the Korea Rural Community Corporation were used for the frequency of flood damage occurrence, and the number and length of prevention facilities (m).

For the number of victims and scale of natural disaster damage-which are disaster damage variables-the averages of the data collected over 10 years since 1998 from the Annual Disaster Report provided by the National Emergency Management Agency were used. For the data on the area per prevention workforce- which is used to measure prevention administration variable-the area of local authorities was taken from the National Statistical Office homepage, and the current number of prevention employees in local authorities was collected from the local authorities' homepages. For the prevention investment expenses-which signify the local authorities' disaster prevention expenses-2008 data were used. Natural disaster recovery cost also uses data collected over 3 years since 2006 by the National Emergency Management Agency. <Table 2> shows the content and origin of the collected research variable data.

(2) Reliability and Soundness Analysis of Independent Variables

The reliability and soundness of the research model's concept used in this research were verified prior to the verification of the hypothesis. The soundness of the concept was verified by implementing a factor analysis of the independent variables, and through this analysis, its reliability was measured by obtaining the Cronbach' α coefficient of the measurement items which consist of identical factors.

The principal components analysis was used as the factor extrication method in the analysis, and varimax rotation was used to rotate the factors in order to enhance the clarity of their classification. Also, factors with original value of 1 or higher were appointed for extrication. Factor loading was composed of factors that were 0.6 or higher, and variables under this value were eliminated.

The analysis result is presented in <Table 3>, although the independent variables were reduced to 3 factors-prevention work, disaster damage, and prevention administration-the pre-

〈Table 2〉 Research Variable Data Collection Status

Research Variable	Data	Data	Origin
Prevention Task	Number of special weather reports	2006, 2007, 2008. 3 year data	Meteorological Administration
	Frequency of flood damage occurrences	1998~2007 10 year data	Annual Disaster Report/National Emergency Management Agency
	Number of prevention facilities	2008	Local Authorities, National Emergency Management Agency
	Length of prevention facilities	2008	Korea Rural Community Corporation, National Emergency Management Agency
	Prevention Investment Rate	2008	Local Authorities
Disaster Damage	Scale of disaster damage	1998~2007 10 year data	Annual Disaster Report/National Emergency Management Agency
	Number of disaster victims	1998~2007 10 year data	Annual Disaster Report/National Emergency Management Agency
Prevention Administration	Area of local authority	2008	National Statistical Office
	Number of current prevention employees	October, 2009	Local Authorities
	Natural disaster recovery cost	2006, 2007, 2008. 3 year data	National Emergency Management Agency
Standard prevention workforce quota	Average value of the survey investigation result	Survey on 30 employees	National Emergency Management Agency prevention middle manager

vention work variable was shown as Cronbach' α coefficient 0.546, which is below 0.6-the value recognized by organizations and agencies. In particular, when the number of special weather reports from the statistical analysis result was included, the resulting value was too low and was thus rejected.

All of the factor loading of the variables that compose each factor are over 0.6, and when the Cronbach' α coefficient of each of the factors is over 0.6 (<Table 4>), it can be generally stated that the soundness of the concept among the constituent items has been secured by satisfying the factor loading conditions.

In other words, the soundness of the concept of the constituent items used in this research was recognized in light of the consideration that there is a high correlation between the variables and the constituent items, as the factor loading without counting the length of pre-

〈Table 3〉 Reliability and Soundness Analysis Results of the Independent Variables and Measurement Items

Name of Variable	Measurement Item	Factor Loading			Cronbach' α
		Factor 1	Factor 2	Factor 3	
Prevention Work	Prevention investment expenses	.677	.136	-.205	.546
	No. of prevention facilities	.825	-.067	.109	
	No. of flood damage occurrences	.642	.285	.365	
	Length of prevention facilities	.342	-.218	.101	
Disaster Damage	No. of disaster victims	.001	.933	-.066	.852
	Scale of disaster damage	.070	.869	.408	
Prevention Administration	Area/Workforce	.532	-.014	.703	.620
	Recovery cost	-.084	.131	.874	
Original Value		2.598	1.676	1.110	-
Variation		32.473	20.951	13.872	
Total Variation		67.295			

〈Table 4〉 The Reliability and Soundness of the Analysis Results of the Independent Variable and Measurement Items

Factor	Independent Variable	Factor Loading			Cronbach' α
		Factor 1	Factor 2	Factor 3	
Prevention Work	Prevention investment expenses	.718	.078	-.158	.622
	No. of prevention facilities	.824	-.104	.161	
	No. of flood damage occurrence	.637	.265	.397	
Disaster Damage	Length of prevention facilities	.019	.952	-.096	.852
	No. of disaster victims	.081	.877	.390	
Prevention Administration	Scale of disaster damage	.486	-.011	.731	.620
	Area/Workforce	-.115	.143	.869	
Original Value		2.579	1.611	1.110	-
Variation		36.839	23.019	15.852	
Total Variation		75.711			

vention facilities is more than 0.6 [Bagozzi and Yi, 1988; Challangalla and Shervani, 1996; Singh and Rhoads, 1991]. Also, the reliability of the independent variables is at a satisfactory level in light of the standard which states that reliability can be considered as being high when the Cronbach' α coefficient of the measurement items is more than 0.6 [Nunnally, 1967].

The independent variables and their finally selected items through the reliability and soundness analysis are as follows : Prevention work variable consists of prevention investment expenses, the number of prevention facilities, and the number of flood disaster occurrence. Disaster damage variable consists of the number of victims and natural disaster damage cost, and prevention administration variable consists of the prevention density-which is the area of the local authority divided by the current prevention workforce quota-and natural disaster recovery cost.

(3) Statistical Analysis of the Standard Prevention Workforce Quota Decision-Making Model

The research hypothesis of this model is to set the factors that affect the calculation of the local authorities prevention workforce quota as prevention work, disaster damage, and prevention administration factors. The data of each of the 7 items are used in order to measure the three independent variables and the results of the survey conducted on employees above the deputy director post in the National Emergency Management Agency is used for the standard prevention workforce quota-which is a dependent variable.

A statistical analysis is conducted on the data related to the 105 local authorities in order to verify this hypothesis model. The analysis checks whether all 11 of the item data including the local authorities' prevention investment expenses, the number of flood damage occurrence, natural disaster damage cost, the number of disaster victims, the number of prevention facilities, natural disaster recovery cost, prevention density, and data about regional characteristics classified under East Coast, West Coast, South Coast, and inland region(mountainous region)-can statistically form a causal relationship with the dependent variable called standard prevention workforce quota. The research model was selected as the model's explanatory power was 46.4% and the F-value significant according to the result of the statistical analysis when the 11 constituent item data related to the 105 local authorities were entered into the SPSS statistical program (<Table 5>). The number of prevention facilities, number of disaster victims, size of disaster damage, and the regional characteristics of West Coast and South Coast, however, were rejected in 95% of the confidence interval.

Methods for selecting significant variables in regression analysis include stepwise selection method, forward selection method, and backward elimination method [Ahn et al, 1993], and the backward elimination method is used as an explanatory process for the research model. The backward elimination method selects only the variables that are finally meaningful by removing the meaningless variables one by one. As shown in <Table 6>, when the backward

〈Table 5〉 Results of the Statistical Analysis of the Prevention Workforce Quota Calculation Concept Model

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance Probability (95% Confidence Interval)
	B	Standard Error	Beta		
(Constant)	8.192	0.446		18.382	**0.000**
Prevention Investment Expenses	0.000	0.000	0.321	3.743	**0.000**
No. of Prevention Facilities	0.001	0.001	0.156	1.669	0.099
No. of Flood Damage Occurrences	0.230	0.058	0.398	3.936	**0.000**
No. of Disaster Victims	0.001	0.001	0.167	1.263	0.210
Scale of Disaster Damage	0.000	0.000	0.096	0.568	0.571
Area/Prevention Workforce	-0.025	0.003	-0.787	-7.736	**0.000**
Recovery Cost	0.000	0.000	0.226	2.291	**0.024**
West Coast	0.137	0.386	0.032	0.354	0.724
South Coast	-0.431	0.410	-0.098	-1.052	0.296
East Coast	-1.213	0.603	-0.207	-2.011	**0.047**
Inland Region(Mountainous Region)	1.232	0.413	0.288	2.986	**0.004**
Total	F-value(significance probability) = 9.170(0.000), R squared = 0.520, Corrected R squared : 0.464				

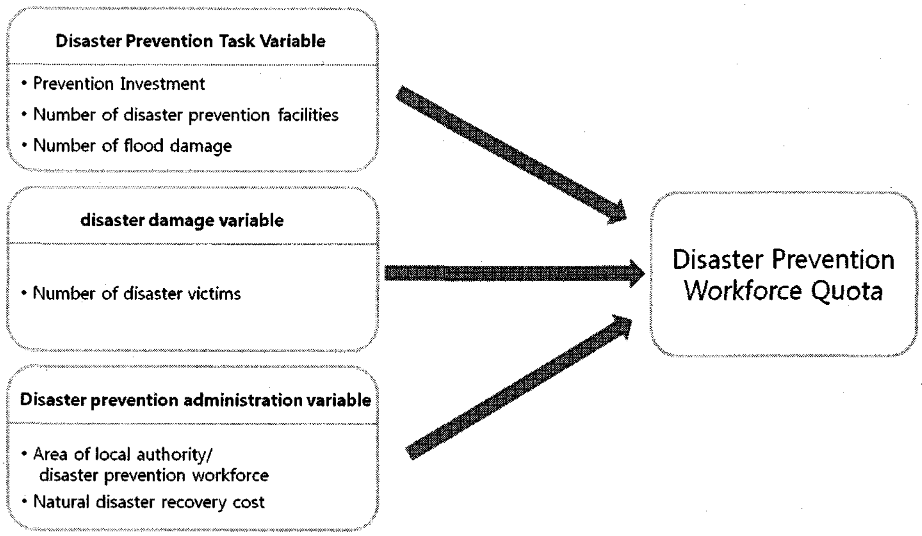
elimination method was implemented 4 times, only the 6 independent variables and East coast and inland mountainous region excluding West coast, the scale of disaster damage, and South coast were selected.

〈Table 6〉 Application Variable Deduction Process for Standard Prevention Workforce

Model	Entered Variables	Eliminated Variables
1	ALL(7)+Region(4)	-
2	7 Variables+3 Regions	West Coast
3	6 Variables+3 Regions	Scale of Disaster Damage
4	6 Variables+2 Regions	South Coast

4. Corrected Decision-Making Model for the Standard Prevention Workforce Quota

The decision-making model to calculate the final prevention workforce quota for the local authorities is shown in <Figure 3>. It shows the policy that was deduced to explain prevention work, disaster damage variable, and the prevention administration variable in order to calculate the standard prevention workforce quota for the local authorities. In other words, the model can explain an appropriate prevention workforce quota for the given local authorities through the prevention work variable- which consists of prevention investment expenses, the number of prevention facilities, and the number of flood damage occurrence-the disaster damage variable-which is measured by the number of disaster victims-and the prevention administration variable-which consists of prevention density, which is the area of the local authority divided by the prevention workforce, and natural disaster recovery cost.



〈Figure 3〉 Decision-Making Model for the Standard Prevention Workforce Quota

4.1 Regression Analysis of the Standard Prevention Workforce Quota

The 3 independent variables applied to the standard calculation model for the prevention workforce quota-in other words, the 6 items and 2 regional variables-serve as direct factors in the calculation of the prevention workforce quota. When a statistical analysis was implemented by entering the 8 item data related to the 105 local authorities in order to prove whether or not to select this hypothesis, the model's explanatory power was 46.9%, the model was significant(0.00), and all the variables were selected in the confidence interval (<Table 7>). The number of prevention facilities and East coast were rejected in 95% of the confidence interval, but the decision whether or not to make the variable selection was made in 90% of the confidence interval as the regional characteristic was only slightly reflected.

First, the regression formula for the standard prevention workforce quota of inland mountainous region =

8.133-8.887279270522 52E-11
*(prevention investment expenses)
+0.00116202030504626
*(no. of prevention facilities)
+-0.0238298675469 44*(prevention density)
+1.77436120750779E-08
*(natural disaster recovery cost)
+1.349*(inland mountainous region);

The regression formula for the standard prevention workforce quota in the East coast region =

8.133-8.88727927052252E-11
*(prevention investment expenses)
+0.00116202030504626
*(no. of prevention facilities)
+0.233688938219831
*(no. of flood damage occurrence)
+0.00132628851087322
*(no. of disaster victims)

〈Table 7〉 Results of the Regression Analysis of Variables that Affect the Standard Prevention Workforce Quota

Model	Unstandardized Coefficient		Standardized Coefficient	t	Significance Probability (90% Confidence Interval)
	B	Standard Error	Beta		
(Constant)	8.133	0.380		21.397	0.000
Prevention Investment Expenses	0.000	0.000	0.288	3.585	0.001
No. of Prevention Facilities	0.001	0.001	0.155	1.680	0.096
No. of Flood Damage Occurrence	0.234	0.055	0.404	4.247	0.000
No. of Disaster Victims	0.001	Z0.000	0.213	2.794	0.006
Area/Workforce	-0.024	0.003	-0.760	-7.663	0.000
Recovery Cost	0.000	0.000	0.238	2.830	0.006
East Coast	-0.920	0.485	-0.157	-1.895	0.061
Inland Region (Mountainous Region)	1.336	0.354	0.313	3.776	0.000
Total	F-Value(Significance probability) = 12.472(0.000), R squared = 0.510, Corrected R squared : 0.469				

+-0.023829867546944*(prevention density)
+1.77436120750779E-08
*(natural disaster recovery cost)
- 0.920*(East coast region);

The regression formula of the standard prevention workforce quota for the Southwest coastal plain region including the South coast, West coast, and inland plain region =

8.133-8.88727927052252E-11
*(prevention investment expenses)
+0.00116202030504626
*(no. of prevention facilities)
+0.233688938219831
*(no. of flood damage occurrence)
+0.00132628851087322
*(no. of disaster victims)
+-0.023829867546944*(prevention density)
+1.77436120750779E-08
*(natural disaster recovery cost).

An objective regression formula was derived to obtain the prevention workforce quota of the 232 local city/county/district authorities in Korea. This is the development of an objective decision-making tool that derives the appropriate prevention workforce quota for the local authorities by inserting the data values of the independent variable items that match each given region.

4.1 Empirical Comparison between Prevention Workforce Quota in Local Authorities and the Standard Prevention Workforce Quota

105 local authorities were classified into inland mountainous region, East coast, and Southwest coastal plain region using the model, and a comparison was made among the estimated values of prevention workforce derived through the regression formula based on the current prevention workforce quota, the prevention workforce quota according to the survey conducted on the National Emergency Ma-

nagement Agency's prevention employees, and the regression formula based on the research model of the current prevention workforce quota of the local authorities.

A regression formula model with an added compensation coefficient according to regional characteristic was derived only for inland mountainous region. The estimated value obtained through the standard prevention workforce calculation model for inland mountainous region is 241, and shows that the current prevention workforce at 199 is in lack of 42 persons.

The estimated value obtained through the standard prevention workforce calculation model for East coast is 103, and shows that the current prevention workforce at 75 is in lack of 28 persons. The estimated value obtained through the standard prevention workforce calculation model for East coast is 204, and shows that the current prevention workforce at 171 is in lack of 33 persons. The estimated value obtained through the standard prevention workforce calculation model for East coast is 213, and shows that the current prevention workforce at 158 is in lack of 55 persons. The estimated value obtained through the standard prevention workforce calculation model for East coast is 241, and shows that the current prevention workforce at 199 is in lack of 42 persons.

The analysis of the workforce calculation according to the type of region obtained through the standard prevention workforce calculation model showed that the regional prevention workforce was lacking by an average of 38.2 persons when the overall lack of workforce was 191(refer to <Table 8>). The allocation basis of the current prevention workforce in local authorities was shown to differ according to the local authorities, and the result of investigation on realistically needed prevention force showed that the values were similar to the prevention workforce obtained through the regression model.

In particular, the result of comparing the current prevention workforce quota and standard prevention workforce quota showed that the values varied by a minimum 1~2 persons, and by a maximum of 4~5 persons. However, the current prevention workforce quota can be interpreted as being rather lacking considering it from the aspect that such differences in the quota apply to the future prevention workforce

<Table 8> The Calculation Results of the Prevention Workforce of the Local Authorities According to Region Type

Region Classification	(a) Required Prevention Workforce according to Survey	(b) Current Prevention Workforce	(c) Prevention Workforce Quota according to Regression Model	Required Prevention Workforce [(c) - b)]
Inland region (mountainous)	243	199	241	42
West Coast	207	171	204	33
South Coast	207	158	213	55
East Coast	104	75	103	28
Inland region (plain)	223	182	220	33
Total	984	785	981	191

quota and also compared with the amount of prevention management work. This research is significant in that it enables an objective comparison with the prevention workforce quota in other local authorities in the future, and that it derived a solution that can explain the reasons why an appropriate prevention workforce is necessary.

5. Conclusion and Implications

Most of the research conducted in Korea in the natural disaster prevention management field deal with the range of disaster, disaster management organizational structure, disaster management activities, response to climate changes, and international cooperation for disaster management. Also, with the insistence on the importance and necessity of prevention workforce by many researchers, a reasonable amount of research results have been obtained in calculating the number of public employees and the standard fire service workforce, but the research on calculating the appropriate prevention workforce for natural disasters still remains at the level of investigative research.

In this research, we aimed to contribute to establishing a standard decision model in calculating Korea's prevention workforce by presenting a decision-making model to calculate the appropriate prevention workforce based on text research, interviews with prevention employees in local authorities, and interviews with specialists. We presented an objective standard through a standardized information management calculation model for general use in calculating the prevention workforce quota for local authorities. When the appropriate prevention workforce was set as a dependent variable in calculating Korea's prevention workforce, variables including the prevention investment expenses, the number of prevention facilities, the frequency of flood damage occurrence, the number of disaster victims, prevention density, and natural disaster recovery cost were shown to have significant effect on the calculation result. The standard model was classified into inland mountainous region, East coast region, and others to reflect regional characteristic variables and was used in the prevention workforce calculation.

This standard model provides objective information that enable the governors of local authorities to make flexible decisions on prevention workforce according to regional characteristics. The present lack of diverse socio-scientific research to calculate appropriate prevention workforce must be quickly ameliorated. We anticipate that the limitations up to now in trying to explain the necessity of prevention workforce only from disaster recovery-centered perspective will be overcome and that there will be continuous research conducted to present rational and scientific explanatory indexes.

A unique aspect of this research is that it rejected the most basic socio-demographical variables that are selected in standard social science research such as population and area, thus creating the occasion to confirm the special quality of prevention workforce quota and achieving the academic result of deriving new socio-scientific variables such as prevention density.

Although creating an occasion to recognize the importance of the prevention workforce quota for local authorities can be judged as being very meaningful in calculating the governors' interest level in this area by deriving the prevention investment expenses and prevention density items, it presents the need for a research that derives variables that can more precisely measure governor leadership.

This research achieved the result of procuring a base for a more systematic and scientific prevention and workforce arrangement by presenting a strategic decision-making tool that can arrange appropriate prevention workforce according to the regional characteristics and prevention environment for each local authority. It also prepared a basis for calculating an objective prevention workforce quota by collecting and analyzing the accumulated data over the last 10 years related to the prevention tasks, scale of disaster damage, and prevention administration in order to calculate the optimum workforce quota for the local authorities for the present. The reason for utilizing such data, moreover, is because the standard prevention workforce quota has many limitation and problems that are difficult to deduce through a cross-sectional analysis from a random point in time.

We hope that in the future, the standard prevention workforce quota for local authorities will be deduced by mobilizing all four paths of knowledge- in other words, various life experiences, exemplary cases, insight such as generated ideas, a scientific methodology that predicts the future by discovering the causal relationship of a given phenomenon-and thereby contribute to the strengthening of the region's prevention capacity.

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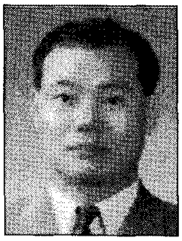
Author Profile



SungSu Lee

SungSu Lee is a doctoral candidate of MIS department on the graduate school of Dongguk University. He is a secretary-general of Association of Business Continuity and Disaster Mitigation. He is concerned with Information Management, Disaster Management, and Business Continuity.

YoungJai Lee

Dr. Youngjai Lee is a professor of MIS at Dongguk University. He is currently president of Association of Business Continuity and Disaster Mitigation. His research interests include Decision-Making, Disaster Management, and Business Continuity.

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