A STUDY ON A COOPERATIVE RELATIONSHIP TO THE IMPROVEMENT OF THE REGIONAL FIRE FIGHTING VALIDITY -Case Study in Bangkok, Thailand-

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Generally, in order to improve some regional fire fighting validity, indispensable strategies are not only a reinforcement of the governmental fire fighting ability, but also a strengthening of the cooperative relationship between governmental and non-governmental fire fighting ability. However, for practical purposes, the effective strategy should be different depending on the actual situation in the subject area. So, in this study, we grasp the actual state and background of the problems that need to be solved for the improvement of the regional fire fighting validity in Bangkok as a case study, and examine the appropriate solution focusing on the relationship between official and voluntary fire fighting.

Through some practicable activities such as interviews, investigations, and making the regional fire fighting validity map, it became clear that the problems of uncooperative relationship and the lack of trust between stakeholders should be solved first and foremost.

Key Words : fire fighting, volunteers, cooperative relationship, risk communication

1. INTRODUCTION

Generally, in order to improve some regional fire fighting validity, indispensable strategies are not only a reinforcement of the governmental fire fighting ability, but also a strengthening of the cooperative relationship between governmental and non-governmental fire fighting ability. However, for practical purposes, the effective strategy should be different depending on the actual situation in the subject area. As a matter of course, there is no guarantee that some strategies or countermeasures based on the common-sense values of Japanese situation will be of universal application for other regions like our study area, Bangkok. Accordingly, it seems that the process to make clear about what the fundamental problems are in the subject area is essential for examination of such solutions as above.

If we outline the recent Japanese situation from the above point of view, we can find the highly developed fire fighting system which can extinguish a fire immediately except for a large number of simultaneous fires in a major earthquake. It can be considered that there is an effect of a smooth cooperative relationship between governmental and non-governmental fire fighting. In. the Japanese

				Tokyo	Bangkok			
			Area (km ²)	1,750	1,568			
			Population (thousands)	12,989	5,702			
	The	number of fi	re stations	387	46			
		(governmen	t)	289	35 (main), 11 (sub*)			
		(voluntary)		98	-unidentified-			
		allocation	Area (km ² /station)	4.522	34.087			
Fire		anocation	Population (thousands of people /stations)	33.563	123.957			
Stations	The	e number of fi	re officers	44,445	1,500			
		(governmen	t)	17,967	1,500			
		(voluntary)		26,478	-unidentified-			
		allocation	Area (km ² /officer)	0.039	1.045			
			Population (thousands of people /officers)	0.292	3.801			

 Table 1 Information of Tokyo and Bangkok Official Fire Stations^{2), 3),4)}.

*note: sub stations just only like a parking on the streets without full-time officers

system, it is worth specially mentioning that the voluntary fire fighting plays a part in the official fire fighting on a legal basis.

On the other hand, it is unusual for some developing countries to have such a highly-developed fire fighting system even Bangkok which is our study area, the biggest city with a large population. So, as urban function advances, the improvement of the regional fire fighting validity becomes one of the most crucial topics today.

In this study, starting with the basic recognition as above, we grasp the actual state and background of the problems that need to be solved for the im-provement of the regional fire fighting validity in Bangkok, and examine the appropriate solution fo-cusing on the relationship between official and vol-untary fire fighting. Furthermore, we try to make and propose the Regional Fire Fighting Validity Map on a trial basis as a practical tool for risk communica-tion.

In the past, indeed there were some researches¹⁾ about volunteers activities in Thailand, but it is dif-ficult to find other studies about solutions for the improvement of the regional fire fighting validity, especially, studies focusing on the relationship between official and voluntary fire fighting.

2. THE STATE OF FIRE FIGHTING SYS-TEM IN BANGKOK

In this chapter, first of all, we give an outline of the state of fire fighting system in Bangkok, mainly based on some information obtained from the inter-views with the Bangkok Fire and Rescue Department and the relevant.

(1) Outline of the interviews

The interview with 15 executives of the Bangkok

Fire and Rescue Department was carried out in January 2010. The summary of the process for this interview is shown below.

At an early stage before some interviews, as one of the authors comes from Bangkok, we could have a rough impression of the state of fire fighting system in Bangkok which are discussed in the following paragraphs. However, thorough some interviews with some acquaintances in various circles who lived in Bangkok including general public and fire fighters, we could recognized that such impression was not simply our personal consideration but was an almost common knowledge. Additionally, we also get the impression that practical and effective solu-tions for the improvement of the regional fire fight-ing validity were not found out yet at the actual lo-cation. After such preliminary investigations, thor-ough the good offices of the fire fighters who sym-pathized with our opinion, we could get an opportu-nity to have an above-mentioned meeting in January 2010. The information obtained from these interviews is described in the paragraphs that follow.

(2) Background of a delay of governmental fire fighting

It can be considered that the most fundamental problem is a fatal delay for governmental fire fight-ing to arrive at the fire scene. Consequently, at pre-sent, enough spraying water by governmental fire fighting cannot be in anticipation.

Needless to say, the fundamental solution is to establish more fire stations. However, it is difficult to realize the solution in a short period for the reason that the procurement of a revenue source and a building lot are difficult. Therefore, in fact, it is considered that the improvement of its potential abilities is badly needed.

Table 1 shows the basic information of Tokyo andBangkok fire stations, and **Fig.1** shows the dis-



Fig.1 Distribution of official fire stations in Bangkok⁴).

tribu-tion of fire stations in Bangkok. As seen from **Table 1** and **Fig.1**, compared with similar areas in both regions, the number of official fire stations in Bangkok is much fewer than that of in Tokyo. As for Bangkok official fire fighting, as a result of a small number of the official fire stations and the long dis-tance from fire stations to the sites of fire, it becomes more difficult for the fire fighter to be well aware of the regional road networks in every corner. Actually, the government fire-trucks, which are turning back or losing way, can frequently be seen. From the actual situation above, as a logical consequence, the time required from the official fire stations to the scenes of fire extends.

To make matters worse, the confirmed traffic congestion in arterial roads and the parking on the local streets also mean delay of the government fire-trucks arrival to the site of fire.

Additionally, the following matters often lead to the delay of starting time for spraying water when the fire fighters arrive at the site of fire. For example, frequently, it is difficult for fire fighters to find any fire hydrants for the reason that the stalls items sometimes cover and hide the fire hydrant. More-over, the lack of governmental fire officers' knowl-edge also leads to delay. With a background of the lack of knowledge, we have to point out that there was a major reorganization which moved the duty of fire protection from the police authority to the Bangkok Metropolitan Administration (BMA) in November 1, 2003⁵⁾. For that reason, the new fire fighters whose knowledge and experiences are not enough account for almost 70 percent of all current governmental fire fighters (BMA).

With these states as background, the delay of the government fire fighting returns to normal, and the fact is that the residents cannot expect enough water discharged only by official fire-fighting when a fire occurs.

(3) Non-governmental fire fighting activity

As mentioned above, it seems that it is difficult for governmental fire fighters to gain confidence from residents. As a result, in Bangkok, a while before the governmental fire fighters arrive at the site of fire, a voluntary fire fighting groups in the region play a very important role. Unlike the governmental fire fighters, as members of voluntary fire fighting groups are the residents, the advantage of a voluntary fire fighting groups is the speed of action after all. However, we should pay attention to some points of difference between Japanese voluntary fire fighting groups and Bangkok ones.

In Japanese case, as mentioned above, the volun-tary fire fighting groups take part in the official fire fighting together with the governmental fire fighting based on a legal basis. On the other hand, in Bangkok case, voluntary fire fighting group does not have such an official role, and is no more than a sponta-neous activity by residents. The qualities of the ac-tivity and equipment of each voluntary fire fighting group are not at the same level depending on its ef-fort, determination, and economic conditions. Moreover, there are not any periodical training and officially disposition of equipment by municipality. As matters stand, the fact is that we can see only a few highly-developed voluntary fire fighting groups which are not at all inferior to the governmental fire fighting while many voluntary groups still have in-ferior knowledge, skills and activity.

For example, the following cases which are capa-ble of leading the residents' distrust of the inferior voluntary groups can be seen frequently. Firstly, the crowds of the volunteers' cars frequently obstruct the governmental fire fighting activity at a site of fire. Secondly, there are thieves at a site of fire pretending to be voluntary fire fighters. Thirdly, for the reason that they can receive a reward according to the number of the injured bodies which are carried by them to hospitals, some volunteers concentrate on just only scrambling for injured bodies without any first aid and fire extinguishing. Another point is about some volunteers' cars with fake sirens ringing to dodge through some traffic congestion.

Moreover, in actual state, it is difficult for gov-ernmental fire fighters and residents to distinguish between the sensible volunteers and inferior ones, between voluntary fire fighters and governmental fire fighters, or between volunteers and residents, for the reason that some volunteers wear the imitation of the governmental uniforms and some volunteers wear ordinary clothes. As a result, it seems that such an actual state makes building up reliance on various voluntary fire fighting groups much more difficult.

3. THE FEASIBILITY OF AN ESTAB-LISHMENT OF THE COOPERATIVE RELATIONSHIP

(1) Summarizing the investigation design

As the mentioned-above, in order to improve the regional fire fighting validity, it is considered that the smooth relationship between the governmental fire fighting and the voluntary is very important. Fur-thermore, it is necessary for each group to win an-other's confidence.

Certainly, on some basic laws⁶⁾ in Thailand, we can find some descriptions on the establishment of the cooperative relationship between government and volunteers for not only the fire event but also the whole disasters. However, through the above inter-views, at least for the fire event, we also have an impressions that any essential and effective practices for the establishment of the cooperative relationship between them have never been done successfully. Practically, it can be said that such an cooperative relationship does not exist at all.

Therefore, in order to investigate the feasibility of an establishment of the cooperative relationship between governmental and voluntary fire fighters, we carried out the questionnaire survey. As shown in Table 2, Bang Khae District is selected as the main subject area of 50 districts in Bangkok. The subjects of this investigation are the governmental fire fight-ers in Bang Khae fire station, the voluntary fire fighters and the general public in this area. Bang Khae District is located in the western of central Bangkok; its area is almost 46.55 km2. Its population is Bangkok's highest rank, approximately 193,448 $people^{7}$. The population density is 4,156 people per km2. It is difficult to completely grasp the number of voluntary fire fighting groups and voluntary fire fighters. The summary of the process for this ques-tionnaire survey is shown below.

Generally, it can be said that it becomes very hard to do such a questionnaire survey in some developing countries. However, it seems that the reasons why these questionnaires were carried out smoothly for the most part were as follows. First, when we de-cided to select Bang Khae District as the main sub-ject area, we could get some quite helpful sugges-tions from the above fire fighter who were like a mediator for the meeting in January 2010. Second, at the meeting in January 2010, we could get a per-mission of directors to distribute the questionnaire survey sheets among the fire fighters in Bang Khae fire station. Third, when we selected one voluntary fire fighting group as a subject, we also could get an opportunity to become acquainted with the liaison person of this voluntary group with an introduction from the above fire fighter. Even if it was

 Table 2 Summary of the Questionnaire Survey Design.

	Governmental Fire Fighter	Voluntary Fire Fighter	People
Date	Febr	010	
Area	Bangkol	vistrict)	
Distribution	handing the q	Interview and	
Return	picking	Recording	
Sample 101		108	80

unsuc-cessful at first, after four or five times contacts by phone from Japan, it was successful in obtaining the liaison's consent to distribute the questionnaire survey sheets among the voluntary fire fighters in this group finally. Fourth, as it can be said that the questionnaire has not really taken root in developing countries, for the general public part of this ques-tionnaire survey, we desided to switch the way to the interview method which was carried out on the roadside.

According to the actual situation mentioned in above chapter, in order to investigate the feasibility of an establishment of the cooperative relationship between governmental and voluntary fire fighters, it is considered that it becomes important to investigate the following points of issue: how each groups rec-ognize the own and the another side's ability for fire fighting, each groups' attitudes toward sharing common ideas to one another, and whether each groups hold in common the quite fundamental pur-pose of "saving Life" in the first place or not. These points of issue are discused in the following para-graphs.

(2) Abilities

The first point of issue is concerned with the ability of the governmental fire fighter and the voluntary one. On this point, it is considered that there are two sides; they are "the rapidity of reaching the site of fire" and "the fire fighting ability at the site of fire". According to the information mentioned in above chapter, at present, it is assumed that "the rapidity of reaching the site of fire" is higher for the voluntary fire fighting groups than for the government. On the other hand, "the fire fighting ability at the site of fire" is higher for the governmental fire fighting than the voluntary groups. These conjecture almost can be confirmed in **Fig.2(1)**.

Fig.2(1)a) shows the survey result concerned with "the rapidity of reaching the site of fire" for the both sides of the governmental fire fighters and the voluntary one. According to these results, it can be said that there is significant difference between the both recognitions (p=0.000)^[1]. Therefore, it is clear that the recognition which the voluntary group is superior

(1)	Results for the Ability of the Governmental and the Voluntary Fire Fighting	0%	20%	409	% 60	0% 80)% 100)%
	[fire fighters] Can you reach the event before volunteers come	? 2.0	30.0			60.0	8.0	n=100
a)	[volunteers] Can you reach the event before fire fighters come	?	26.9		46.3		25.9 0	9n=108
b)	[fire fighters] Do you have enough tools when you go to the event	?	43.6		24.8	8	29.7	9 n=101
	[volunteers] Do you have enough tools when you go to the event	?	34.6		25.2	39	9.3 0	9n=107
c)	[fire fighters] Do you think your organization is more effective than the voluntary groups	?	5().7		34.3	11.9 3.	0 n=67
	[volunteers] Do you think your organization is more effective than the fire department	? 8.2	31	.8		47.1	12.9	n=85
	[people] Do you think the fire department can efficiently help people when disaster occurs	?	25.3		49.4		19.0 6.3	n=79
d)	[people] Do you think the voluntary groups can efficiently help people when disaster occurs	?	25.0		47.5		18.8 8.8	n=80
(2)	Result for the Attitudes toward Sharing Common Ideas	- 1						
	[fire fighters] Do you want to coodinate and share information with the voluntary groups	?	31.7		31.7	3	4.7 2	0 n=101
a)	[volunteers] Do you want to coodinate and share information with the fire fighters	?	34.6		20.6	35.5	9.3	n=107
	[fire fighters] Do you want to follow what the voluntary groups inform you	? 3.0	25.0		62	2.0	10.0	n=101
	[volunteers] Do you want to follow what the fire officers inform you	?	20.4	39	.8	33.	3 6.5	n=108
	[fire fighters] Do you think the voluntary groups will follow your command	? [0 1]	1.9		51.4		25.7	n=101
c)	[volunteers] Do you think the fire officers will follow your instruction	? 10.	2 24.1		38.9		26.9	n=108
(3)	Result for the Fundamental Purpose							
a)	[fire fighters] Do you want to help people when disaster occurs	?		77.2	2		18.8 31	0n=101
	[volunteers] Do you want to help people when disaster occurs	?		65.7			.9.6 4.0	0n=108
b)	[fire fighters] Can you collaborate with the volunteers	?	39.1		35.	9	23.9 1	1n=108
	[volunteers] Can you collaborate with the fire fighters	?	42.2	<u> </u>	3	4.3	22.5	0n=102
	Note: [square brackets] mean the subject type of the investigation	n.	ye	s 🗖 ra	ther yes	rather n	io 🗖 no	

Fig.2 Results of the Questionnaire Survey.

in the rapidity is in common among the both sides. On the other hand, Fig.2(1)b) shows the survey result concerned with "the fire fighting ability at the site of fire". The questions are in self-awareness form, not relative comparison form. According to these results, for each group, the percentage of respondents who recognize that own tool is enough is less than 50 percent. Therefore, it can be said that the expansion of each group's facilities becomes an important issue for the present. Additionally, it can be seen that such a tendency is slightly remarkable in the voluntary group more than in the governmental group, although it cannot be said that there is a significant difference between them $(p=0.167)^{[1]}$. Moreover, according to Fig.2(1)c), it can be said with a statistical significance $(p=0.000)^{[1]}$ that the recognition which the own organization is more effective than the other side is lower in the voluntary group than that of the governmental group. From the above, it can be said that the following matters are confirmed. The both groups recognize that the voluntary group is superior to the government one in "the rapidity", and also recognize that the government group is superior to the voluntary one in "the fire fighting ability".

Additionally, we have shown the survey result from the viewpoint of the general public about an overall expectation of the ability for each sides in **Fig.2(1)d**). According to this result, the general public can put their hope on neither the voluntary group nor the government one, rather than have great expectation on only one side of the two groups (There is no significant difference between them at a level of 5% $(p=0.784)^{[2]}$.).

(3) Attitudes toward sharing common ideas

The second point of issue is concerned with the each groups' attitudes toward sharing common ideas to one another. According to the information mentioned in above chapter, it is assumed that the greater part of governmental fire fighters and voluntary ones may not necessarily have positive attitudes towards sharing common ideas. This conjecture almost can be confirmed in **Fig.2(2)**.

According to Fig.2(2)a), it can be said that the percentage of approval opinions about sharing information in common is not so high on each groups (There is no significant difference between them at a level of 5% $(p=0.407)^{[1]}$.). Especially, according to Fig.2(2)b), the percentage of approval opinions about following the information of another group is very low (There is a significant difference between them at a level of 5% $(p=0.000)^{[1]}$, but the fact that the approval opinions is a small minority is basically common.). Additionally, according to Fig.2(2)c), from the opposite viewpoint, the percentage of approval opinions about the prospect of another group's following a command or instruction from my own organization is also very low (There is a significant difference between them at a level of 5% $(p=0.032)^{[1]}$, but the fact that the approval opinions is a small minority is basically common.).

From the above, for an establishment of the cooperative relationship such as sharing common information, it can be said that both groups' opinions are mostly negative. Namely, it also seems that it can be assumed as if such a negative attitude toward sharing common ideas is caused by an overwhelming lack of confidence.

(4) Fundamental purpose

The third point of issue is concerned with the quite fundamental purpose of "Saving Life" in the first place.

According to the above results, it must be considered that it is difficult to establish the cooperative relationship between each group in the present circumstances. However, granting the expectation of ability and the attitudes toward sharing common ideas are negative among each other, if the each groups hold in common the quite fundamental purpose of "Saving Life" in the first place, it still can be considered that it is possible for each groups to establish a smooth cooperative relationship from a long term viewpoint.

From this point of view, according to **Fig.2(3)a**), it is clear that both groups are active for the quite fundamental purpose of 'Saving Life'. Namely, it is easy to be confirmed that the quite fundamental purpose of each group is identical (There is no significant difference between them at a level of 5% $(p=0.078)^{[1]}$.).

However, from **Fig.2(3)b**), it is also confirmed that the percentage of approval opinions about the establishment of the cooperative relationship is not so high on each group (There is no significant difference between them at a level of 5% (p=0.684)^{[11}.). Namely, it is considered that these results should be explained as follows: There are plenty of problems that need to be solved at present. Still more, the most serious problem is the recent situation that neither of each group recognize the other's opinions correctly. It is, therefore, exceedingly important that each group recognizes that their fundamental purpose is identical.

4. THE REGIONAL FIRE FIGHTING VA-LIDITY MAP

(1) Basic stance

According to the above, at present, it seems that there is very little feasibility of an establishment of a cooperative relationship between the governmental fire fighters and voluntary ones. On the other hand, it is also confirmed that the fundamental purpose of fire fighting activity is the same for both groups. In this sense, it can be said that there is a glimmer of hope.

Therefore, in order to increase this feasibility, as a first step, it can be said that it is important for both to understand the validity of the establishment of the cooperative relationship after understanding the strong and weak points of both. However, it seems that it is difficult to understand how much the seemingly slight difference such as the establishment of the cooperative relationship has an influence on an improvement of the regional fire fighting validity. Accordingly, it can be said that some countermeasures which can lead the well understanding for the above influences are needed. In this chapter, "The Regional Fire Fighting Validity Map" will be made on a trial basis and proposed as a practical tool for risk communication in order to improve each group's understanding about the effect of the establishment of the cooperative relationship. According to the aims of this mapping, it seems that this mapping can be called 'the Solution-Oriented Mapping'.

(2) Fundamental conditions in mapping

Basically, in Tokyo, there is a high potential risk of spreading fire by reason of high density of wooden houses. Moreover, Japan is subject to frequent earthquakes. Accordingly, the target of typical measurements against fire disasters is always spreading fire risk caused by large earthquake. In fact, at present, all so-called 'fire hazard map' in Japan is made under conditions such as the above two kinds of risks.

In contrast, in Bangkok, except for slum areas, the density of wooden houses is not so high, and the spreading of fire risk is not so serious. Therefore, it can be said that the safety in the region is settled by "the causing fire risk itself" and "the regional fire fighting validity". Among these factors, the former has a quite considerable uncertainty. Consequently, this mapping assumes that "the causing fire risk itself" is constant and can be neglected. Therefore, only the latter "the regional fire fighting validity" is considered in this mapping.

To evaluate the regional fire fighting validity, we set a [cumulative spraying water amount] as an evaluation index. This amount is defined as the total amount of water supplied by both the governmental fire fighting and the voluntary fire fighting at a given time T_V .

The governmental fire fighters always turn out from each fire station with the prescribed equipment when they receive an emergency call. In Bang Khae district, there is just only one fire station. However, if a fire occurs in Bang Khae district, some support fire engines will come from neighboring 6 main fire stations and 1 sub fire station.

On the other hand, the voluntary fire fighters'

Subject		Process		Note									
People		Emer-	After an	After an outbreak of fire, time required to emergency call is indicated as ' t_{p1} (sec.)'. (t_{p1} =300, as a									
		gency call	default)	default)									
Governmental		l Turning	After red	After receiving an emergency call, time required to turning out is indicated as t_{g1} (sec.)'. $(t_{g1}=180,$									
fire fighting		out	as a defa	as a default)									
		Approach	After tu	After turning out, time required to arrive at a site of fire is indicated as t_{g2} (sec.)'. The approach									
			routes an	routes are chosen by the shortest distance within the utilizable roads limited by a fire engine's width,									
			an obstr	an obstruction by parking on local streets occurs at a rate p_1 and an obstruction by crowds of the									
			voluntee	ers' cars. T	he moving o	listance is	s indicated as	' <i>x</i> (km)'. T	The prescri	ibed proper	ties of fi	re	
			stations	and fire en	gines are as	follows:						1	
	T	Cars (per one o	event, per or	e fire sta.)	Loadage	Width	Capacity	Warming	Sp	eed (v: km/l		-	
	Type	Bang Khae	neighbor	fire sta.	(liter)	(m)	(liter per min)	up	Arteri	al road	Local		
	T	2	(main)*	(sub)**	10.000	2.5	500	(sec)	normal	crowded	street	-	
	Large	2	2	0	5,000	2.5	590	300	40	5	20		
	Small	2	1	1	5,000	2.5	590 500	300	40	5	20		
	Sillali				1,300		390 	1. 1 1 (*)	* . 1 10		1 21 1	-	
	[*note: 6 ma	in fire stations, Bang	Accordi	Dao Ka Nhôn ngly $(t, 2)$ i	g, Bang Knun N	$\frac{1}{2}$	$\Omega * \mathbf{r} / \mathbf{v}'$	alingenanj [**	(n	0.3 as a det	g Knaemj	l	
		Prepara-	After ar	rival time	required to	research	the condition	s is indicat	$\frac{\sqrt{1-1}}{2}$	$(sec)^{\prime}$ $(t = 1)^{\prime}$	-120 as	9	
		tion	default)	iivai, tiine	lequirea to	researen	the condition	s is maleat	eu as igs	(Sec.) . (<i>igs</i>	-120, d3	a	
		lion	After an	rival, time i	equired to c	onnect so	me hoses is in	dicated as '	t_4 (sec.)'.	This value	depends of	on	
			the nece	ssarv numb	er 'v' of hos	es. The 'v	' is divided by	the distanc	e between	the fire eng	ine and th	he	
			site of fi	re. Time re	equired to co	onnect one	e hose is fixed	as 8 secon	ds. The let	ngth of one	hose is 2	20	
			meters.	meters. Accordingly, $t_{\sigma4}$ ' is expressed as $t_{\sigma4}=8*v'$. (an upper limit of 'v' is set as 10)									
			After ar	rival, at fir	st, try to fin	d the near	est available	hydrant. Bı	it, actually	, some wro	ng matte	ers	
			happen	at a consta	nt rate ' p_2 ',	for exam	ple, breakdow	vn, fail to f	ind becaus	se of items	hiding th	he	
			hydrant,	ydrant, and so on. Granting that the finding is success, moreover, if there is no cooperative rela-									
			tionship	onship, volunteers often keep the hydrant to themselves and the governmental fire fighters can not									
			connect	connect it. The possibility of such an obstruction case is defined as $'p_3'$. In any case, if not suc-									
			cessful to connect to the nearest hydrant, try the next nearest hydrant. ($p_2=0.2$, $p_3=0.4$, as a default) After research conditions and connecting hoses, spraying water starts using the loaders water										
Sprayin			After research conditions and connecting hoses, spraying water starts using the loadage water. Therefore, the time required since the outbreak fire to starting spray water is as follows:										
		water	Therefor	Therefore, the time required since the outbreak fire to starting spray water is as follows: 4 + 4 + 10 + 100 +									
			I_{p1}	$-\iota_{g1}+\iota_{g2}+MI$	$AX(I_{g3}, I_{g4})$	amount	hu ono firo on	aina ia avni	accad as fo	llowe			
			So, [cuil	nacity•MIN	$T = \{t \} + t$	a = 100 m	$X(t \circ t \cdot)$	gine is expi	anacity]	JIIOWS.			
			After empty the loadage water, if already finished the connecting to the nearest hydrully, spraying water can be continued. But if not successful, the fire engine has to								est hydrant success-		
											ry the ne	ext	
			nearest l	nydrant.				, , , ,	0		J		
V	oluntary fire	Turning	After su	cceeding in	an intercept	tion, time	required for tu	Irning out i	s indicated	as ' $t_{\nu 1}$ (sec	.)'. $(t_{\nu 1} = 6$	<i>i</i> 0,	
fighting out			as a default)										
		Approach	After tur	rning out, t	ime required	l to arrive	at a site of fin	re is indicat	ted as $t_{\nu 2}$ ((sec.)'. The	behavior	al	
			rules in	rules in approach is the same as the government one, except for some properties as follows: Type:									
pick			pick-up	pick-up truck with a small pump, Cars: 2 cars per each base, Loadage: none, Width: 2.0 meters,									
Capacity: 350 liters per sec., Speed: the same as the governmental one.													
Prepara- After arrival, time required t				equired to re	red to research the conditions is indicated as ' $t_{\nu3}$ (sec.)'. ($t_{\nu3}$ =60, as a default)						lt)		
		tion	After an	rival, time 1	required to co	onnect so	ne hoses is ind	licated as '	$t_{\nu 4} (\text{sec.})'.$	The behavio	oral rules	is	
the same as the government one, except for some properties as follows: 1)Ther					ere are not	obstructio	on						
		C	matters.	2) an uppe	r limit of 'y'	1s set as 4	+. Januar			···· 41 4	·	1	
Spraying After research and c				and connecting to the hydrant, spraying water starts. Therefore, the time required									
water			since the outbreak file to starting spray water is as follows: t + t + t + MAX(t - t +)										
			$p_1 + p_1 + p_2 \pm p_1 \pm p_2 \pm p_1 \pm p_2 \pm p_1 \pm p_2 $										
			So, [cumulative spraying water amount] by one voluntary file fluck is as follows. $Canacity \left[T_{-} \{t_{1}+t_{2}+t_{3}+MAX(t_{2},t_{4})\}\right]$										
			Ca	such y [I v	(<i>vp1</i> + <i>vv1</i> + <i>vv2</i> -	1712 121 (ly	5) *V4 / J]						

Table 3 Expression of fire fighting activity process in this mapping.

whereabouts are exactly unknown. However, it is true that the voluntary fire fighters exist at a fixed

rate. And it is also fact that they turn out from some bases which are dotted about the region (refer to



Fig.3 Location of hydrants and voluntary groups' bases in Bang Khae District.

Fig.3) or each of their homes. Among them, the former volunteers from some bases go by one or two pick-up trucks with a fire pump, but the latter volunteers come directly from each of their homes do not have any effective extinguishers. Therefore, the spraying water by voluntary fire fighters starts as soon as the fire pump arrives. Consequently, in case of the evaluation on [cumulative spraying water amount], it is enough to consider only the former volunteer's activity. Incidentally, the departure timing is divided depending on the timing of the interception of a radio message among the governmental fire fighters.

The details of the parameters which express the governmental fire fighting ability and the voluntary one are shown in **Table 3**. Some settings of values in **Table 3** are based on some information obtained from the above interviews. Moreover, as there are some stochastic factors, the Monte Carlo method is adopted in this mapping in order to stably obtain the value of [cumulative spraying water amount].

(3) Obstructive factors and improved scenario

Referring to the above, if we rearrange the parameters affecting the [cumulative spraying water amount] as obstructive factors, the list is as shown in **Table 4**. Among them, it can be said that the factors which can be influenced by the establishment of the cooperative relationship are the 5 factors from (e) to (i). Therefore, as a first step, it is important for each groups to understand how much the improvement of these 5 factors have an influence on the regional fire fighting validity.

Table 4 also shows the setting values which were used in the calculations for the drawing the Regional Fire Fighting Map. The following paragraphs give additional explanations of the above factors. Incidentally, these setting values include some real values based on the survey for the actual situation and some values as an assumption. These values should be used as sensitivity analyses in order to express the effects of the improvement of the above 5 factors related to cooperative relationship.

a) Time loss from the misunderstanding of the emergency telephone number

In Bangkok, almost seven years ago, the emergency telephone number "191" for a fire station was the same number as for a police station. Until November 1, 2003, with the reorganization which moved the duty of fire prevention from the police authority to BMA, the emergency telephone number was then separated into "191 (police)" and "199 (fire station)". However, at present, without the announcement of this change, there is a tendency for most people to dial "191" when a fire breaks out. As a result of this harmful vertical division, when the police are informed of fire, it takes much more time for the nearest fire brigades to get the information and reach the site of fire. In this mapping, the value of t_{p1} which indicates the time loss by the people's misunderstanding of the emergency telephone number is assumed as 300 seconds.

Incidentally, as this factor is not concerned with the establishment of the cooperative relationship, it is assumed that this value of ' t_{p1} ' does not change under the improved scenario.

b) Traffic congestion on arterial roads

The traffic congestion on arterial roads has a strong influence on the rapidity of reaching the site of fire, and the traffic congestion improvement is, actually, quite difficult. So, in both scenarios, the value of 'v' which indicates the speed of fire engines is assumed as 5 km per hour.

c) Obstruction by parking on local streets

The fire engines frequently cannot go through some local streets, and sometimes has to turn back because of the obstruction of parking. So, in this mapping, the value of p_1 which indicates the incidence of such obstruction of parking is assumed as 0.3.

Incidentally, as this factor is not concerned with the establishment of the cooperative relationship, it is assumed that this value of p_1 does not change under the improved scenario.

d) Time loss by failure to find the available hydrants

When governmental fire fighters try to set their

		in actual situation	in improved scenario
(a)	Time loss by misunderstanding of the emergency telephone number	t_{p1} =300 sec.	·
(b)	Traffic congestion on arterial roads	v = 5 km/h.	
(c)	Obstruction by parking on local streets	p ₁ =0.30	
(d)	Time loss by failure to find the available hydrants	p ₂ =0.20	
(e)*	Lack of cooperation on the scene of connecting to hydrant	p ₃ =0.40	p ₃ =0.00
(f)*	Lack of volunteers' equipment (Num. of fire engines with tank)	none	1 (type: small)
(g)*	Obstruction by crowds of the volunteers' cars	Obstruction	Moving aside, making it possible for the gov- ernmental fire engines to access
(h)*	Time loss for gathering information at the site of fire	$t_{g3}=120$ sec.	$t_{g3}=30$ sec.
(i)*	Loss of human resource for watching out for stealing fire fighting equipment	Loss of 2 or 3 human resource from the gov- ernmental team. So, t_{g3} and t_{g4} increase one-and- a half times.	No loss of human re- source, and the gov- ernmental team can concentrate on the fundamental activity.

Table 4 Summary of actual and improved scenarios.

*: factors which can be influenced by the establishment of the cooperative relationship

equipment, some obstructing matters often occur, for example, breakdown of hydrant, fail to find the hydrant because of hiding it by some items, and so on. Accordingly, in this mapping, the value of p_2 which indicates the failure incidence of finding the nearest available hydrants is assumed as 0.2.

Incidentally, as this factor is not concerned with the establishment of the cooperative relationship, it is assumed that this value of p_2 does not change under the improved scenario.

e) Lack of cooperation on the scene of connecting to hydrant

When governmental fire fighters try to connect their equipment to the available hydrant, voluntary fire fighters who came earlier than governmental one frequently keep the hydrant to themselves. Therefore, the governmental fire fighters can not connect it. In this mapping, the value of ' p_2 ' which indicates the incidence of such an obstacle is assumed as 0.4.

Needless to say, as this factor is concerned with the establishment of the cooperative relationship, it is assumed that the value of ' p_3 ' is reduced to 0.0 under the improved scenario.

f) Lack of volunteers' equipment

The volunteers' equipment for fire extinguishing is hardly enough. Especially, when there are not any hydrants available, then most volunteers have nothing to do with the fire extinguishing. Therefore, in this mapping, the number of fire engines with water tank in each voluntary base is assumed as zero. On the other hand, it can be said that it is possible to increase the fire engines with water tank in each voluntary base with efforts in the future. So, it is assumed that this number is increased to one under the improved scenario. This assumption means complete integration with governmental fire fighting and the voluntary one.

g) Obstruction of the crowds of volunteers' cars

If the greater part of governmental fire fighters and voluntary ones have positive attitudes towards sharing common ideas to one another, it can be said that the obstructing incidence of the crowds of volunteers' cars will be reduced. So, under the improved scenario, it is assumed that such an obstruction will not occur.

h) Time loss for gathering information at the site of fire

When arriving at a site of fire, firstly, the fire fighters spends time researching conditions and gathering information. However, if governmental fire fighters can get such information immediately from the volunteers who can reach the site of fire earlier, it seems that it is possible to shorten the time required.

So, in actual situation, the value of t_{g3} which indicates the time required to gather information at the site of fire is assumed as 120 seconds. On the other hand, under the improved scenario, it is assumed that this value is reduced to 30 seconds.

i) Loss of human resources for watching out for fire fighting equipment theft

In actual situation, the loss of 2 or 3 human resources from the governmental team is unavoidable. So, in this mapping, it is assumed that the value of t_{g3} which indicates the time required to gather information at the site of fire and the value of t_{g4} which indicates the time required to connect hoses are increased one-and-a half times. However, if the greater part of governmental fire fighters and voluntary ones have positive attitudes towards sharing common ideas to one another, it can be said that more efficient allocation of human resources can be put into practice. So, under the improved scenario, it is

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Fig.4 The regional fire fighting validity map under the two scenarios.

assumed that the values of t_{g3} and t_{g4} are not increased.

(4) Mapping examples to show the effects of the establishment of the cooperative relationship

The example of the regional fire fighting validity map in **Fig.4** is to show the effects of the establishment of the cooperative relationship. The upper row shows the mapping under the actual situation and the second row shows the mapping under the improved scenario. In both mapping, the [cumulative spraying water amount] as an evaluation index can be indicated by a shade as shown in the legend. This shade is mapped out by an interpolation based on the 8,527 evaluation points which are dotted on the roads at intervals of 100 meters. Additionally, the lowest row shows the difference between the actual situation and the improved scenario.

Basically, it can clearly be seen that the remarkable betterment of [cumulative spraying water amount] is produced, if it is possible to establish cooperative relationship between the governmental fire fighting and the voluntary fire fighting as shown in **Table 4**.

In details, we can see that the marked betterment occurs at the sites which are close to the governmental fire station, voluntary fire fighting bases and fire hydrants. However, it seems that such a betterment is partially limited since the local road networks are not functionally linked. Of course, it is considered that the heavy traffic congestion on arterial roads also obstructs the spread of the betterment of [cumulative spraying water amount].

At any rate, it can be said that such a regional fire fighting validity map as shown above will be helpful for each stakeholder to understand how effective the establishment of the cooperative relationship is.

5. CONCLUSION AND DISCUSSION

(1) Conclusion

Needless to say, since a certain solution does not apply to every case, it is essential to investigate and make clear what the fundamental problem is in the subject area. Even if in our study area, it became clear that the actual situation about regional fire fighting is totally different between Bangkok and Japan.

Through some practicable activities such as interviews, investigations, considerations and making the regional fire fighting validity map, it became clear that there are many obstructive factors for improving the efficiency of fire extinguishers in Bangkok as follows: a small number of fire stations, heavy traffic congestion, lack of effective fire fighters and volunteers, and so on. Especially, it is considered that the problems of uncooperative relationship and the lack of trust between stakeholders should be solved first and foremost.

Moreover, through making the regional fire fighting validity map, it illustrates how effective the establishment of cooperative relationship between each stakeholder is. It surely seems that it is difficult to establish such a cooperative relationship at the present, but it is also true that each stakeholder hold in common the fundamental purpose of "Saving Life". Therefore, we can say that it is surely possible to establish a smooth cooperative relationship from a long term viewpoint. Accordingly, in order to obtain each stakeholder's understanding of the effectiveness of the cooperative relationship to achieve the fundamental purpose of "Saving Life", it is considered that some practicable activities like a risk communication will hereafter become important more and more. At that time, it seems that some tools such as the regional fire fighting validity map as above will be helpful.

(2) Discussion

The future plan and the prospect are as follows.

Firstly, this is to set some opportunities to discuss the establishment of the cooperative relationship with each stakeholder in the study area. Toward this, in fact, we have already started to contact with some voluntary fire fighting groups in Bang Khae District as mentioned above. According to this approach, it became clear that nobody tried to solve this problem in the past. As a practical matter, it seemed that such a discussion was just unthinkable matter for them before. Therefore, it can be said that our approach is the first contact in Bangkok. After having our purpose of this study explained to the above liaison person and some leaders, most of them changed their attitudes and admired our purpose, although they were almost negative in having any discussions with the governmental fire fighters before. In this sense, there is no guarantee that such a positive change will occur for common members, but it can be also said that there is a glimmer of hope to have some discussion about this matter with the voluntary fire fighters and the governmental fire fighters in the future.

Secondly, if it is successful in Bang Khae District as a case study, we, therefore, propose that it should be necessary to expand such practicable activities into other districts. Moreover, with reference to these results and outcomes, it is important that the strategy which was nothing but an impractical proposition before will be changed into the practical activity.

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NOTE:

- [1] These statistics are the Mann-Whitney U test⁸). It is a non-parametric statistical hypothesis test. It can be applied to the comparison of two independent random samples whose measurement scales is ordinal.
- [2] These statistics are the Wilcoxon signed-rank test⁹⁾. It is a non-parametric statistical hypothesis test. It can be applied to the comparison of a pair of samples whose measurement scales is ordinal.

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