A study on Potential of River Navigation in Japan

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ABSTRACT: The function of river navigation is being reconsidered from the viewpoints of environment-friendly and energy-efficient, easing traffic congestion, emergency transport in disaster, and supporting tourism and recreation activities, etc.
The purpose of this study is to identify current trends and problems of river navigation in Japan and indicate the role that river navigation should play in future and the directionality of development. This study focused on disaster prevention function with especially high importance degree in metropolitan area from among various functions of river navigation, and showed potential of river navigation corresponding to stranded commuter who is examined as a serious problem in government.

1 INTRODUCTION

In Japan, water transport was important transport mode of person and freight before. Edo period (17C-19C) was when water transport was developed significantly, and waterway network supported Edo (present Tokyo), where boasted of the world's largest population at that time. But, river navigation had declined by development of land transport links since beginning of 20C.
In recent years, we are confronted with various problems as pollution of city environment, global warming, and energy resource dryness, etc because of the expansion of land transport. On the other hand, in Hanshin-Awaji (Kobe) Earthquake of 1995, the importance of water transport as effective mode of disaster relief transport to substitute land transport damaged. Under such the background, revival of river navigation is requested from the viewpoints of environment-friendly and energy-efficient, easing traffic congestion, emergency transport function in disaster, and supporting tourism and recreation activities, etc.
The purpose of this study is to identify current trends and problems of river navigation in Japan and indicate the

role that river navigation should play in future and the directionality of development.

2 HISTORY AND TODAY OF RIVER NAVIGATION IN JAPAN

2.1 History of river navigation in Japan

Water transport has supported the civilization as one of the oldest transport mode through the world. In Japan, where is surrounded by the sea, we have the history which technology, culture, and religion, etc. were transmitted from continent by ship. We are not rich in the condition which is appropriate for river navigation because there are a lot of mountainous districts of the inland and the river is shorter and steeper than that of continent's river, in addition, the discharge change is large because of peculiar characteristics of rainfall to the monsoon region. However, in old time, river navigation developed by cooperation with marine transport, because land transport was prevented from mountainous district and water transport was more suitable for mass transport than land transport.

The origin of river navigation in Japan is called 'Marukibune' which was made by large tree hollowed, and those made about 5,000 years ago have been discovered. The prosperity of city was closely related to river navigation, and we had advanced city planning in consideration of the accessibility of river navigation. Then, Edo period (17C-19C) was when water transport was developed significantly, and the system of canal and river port called 'Kashi' were maintained in region centered on Edo (present Tokyo), and a lot of ships went and passed. Edo formed the biggest city in the world where the population exceeded one million at that time because of support of river navigation. Afterwards, the transport capacity of river navigation had increased rapidly by appearance of steam ship, but river navigation had declined by development of land transport links since beginning of 20C. Fig.1 shows decrease of river boat according to development of the railway and automobile.

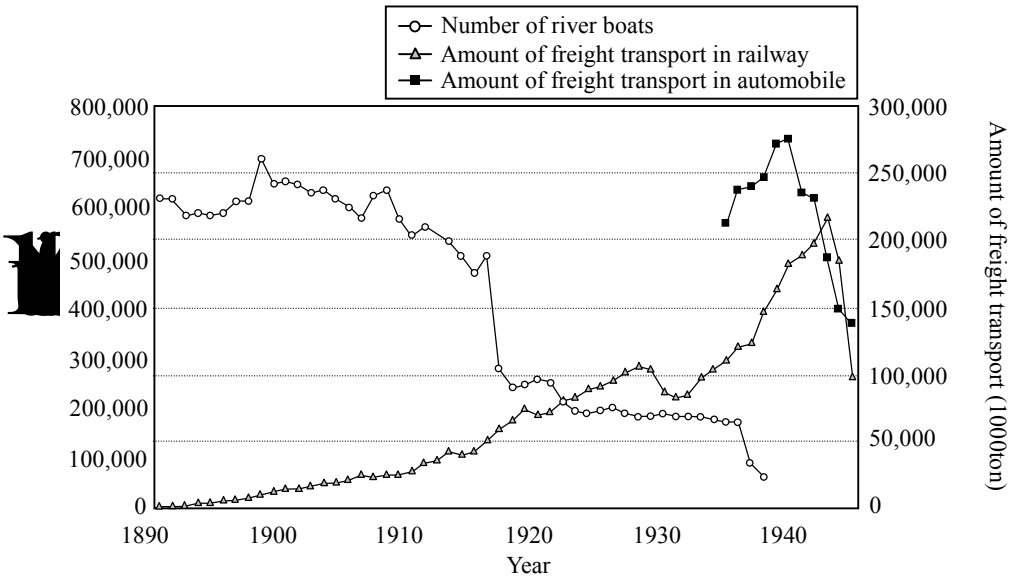


Fig.1. Historical trend of number of river boats and Amount of land transport

2.2 Today's river navigation in Japan

In recent years, though river navigation doesn't bear a traffic main axis, it is used in various forms all over Japan. Table 1 shows the number of execution places of each use form of river navigation. River navigation is seen in 76 water systems of 109 water systems of the main river, and it is used for sightseeing and recreation such as water bus, excursion ship and pleasure boat in 260 places. River distribution is slightly seen partially of municipal river for oil, steel material, and waste, etc which there is constant transport needs, and transport speed is not demanded. On the other hand, the civic groups such as NPO are doing activities of sailing investigation and event cruise, etc aiming at revival of river navigation.

Table 1. Number of execution places of each use form of river navigation in Japan (Research in 1997)

Region / Use form	Hokkaido	Tohoku	Kanto	Hokuriku	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Total
Water Bus		2	7	1		1	3		2	16
Excursion ship		9	22	2	11	10	9	7	9	79
Pleasure Boat	3	26	46	11	19	5	33	6	16	165
Cargo Ship		1	17	5	2	1	25	8	12	71
Tanker			8	1			2	4	1	16
Others	5	12	18	1	12	4	17	1	20	90
Total	8	50	118	21	44	21	89	26	60	437

Note: Research object was 109 main rivers managed by Ministry of Land, Infrastructure and Transport.

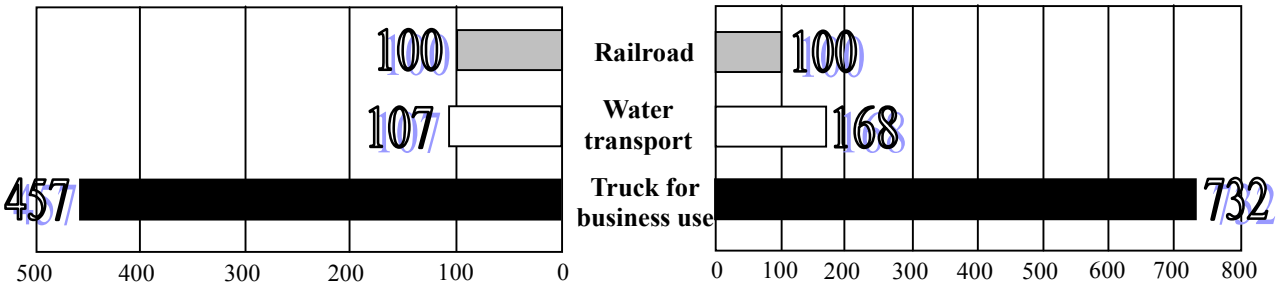
3 ROLE THAT RIVER NAVIGATION SHOULD PLAY IN JAPAN

3.1 Environment-friendly transport system

According to Quality of the Environment in Japan (Ministry of the Environment 2007), transport section accounts for 19.9% of CO_2 emissions in Japan, and about 87.7% of that is an amount of the exhaust of automobile transport. In the background of the targeted reduction regulations of greenhouse gas by Kyoto Protocol etc, approach to review the transport system is advanced by various organizations related to the transport section aiming at the reduction of CO_2 emissions.

River navigation is Environment-friendly transport mode. As shown in Fig.2 and Fig.3, energy consumed and CO_2 emissions of river navigation are the about same as the railway per ton-km of Freight, and about 1/4 of the tracks. Moreover, river navigation is suitable for mass transport, and contributes to reduction of traffic jam by converting a part of trucking.

A modal shift from trucking to river navigation is requested in consideration of gas price rise and environmental control of urban traffic, etc in future.



Note: Comparison on the basis of the Railroad value"100"

Fig.2. Consumed Energy per ton-km of Freight according to transport mode

Fig.3. CO_2 Emission per ton-km of Freight according to transport mode

3.2 Regional development from waterside

Japanese have come to demand rest and relief in the background of the lifestyle change and the increase of leisure time. In Japan, there is an aspect "365 days of the river", we have come to attach importance to creation of place where can touch waterside through four seasons.

Promotion of waterside use by river navigation activates attractiveness and economy in the region, and contributes to community building which combines with waterside. River navigation is used for recreation etc. in various places, and scenery of waterside with ship is established now. Moreover, river navigation is built into the activity program by civic group, and plays the role to create the occasion which the citizens are familiar with the history, the culture, and the environment, etc.

3.3 Emergency transport in disaster

Japan is called an earthquake-prone archipelago, where is located in the vicinity of the boundary of four plates (Pacific Plate, Philippine Sea Plate, Eurasian Plate, and North American Plate), so has frequently suffered earthquake damage. When a large earthquake occurs in metropolitan area, the paralysis of urban function by collapse of building and road is not avoided. On the other hand, it is thought that prompt transport by ship is possible because obstacle of river and canal is fewer than that of road. In addition, various use forms of river navigation such as fire fighting and medical support, etc. are expected, and the disaster prevention system-making by cooperation of related organization and facilities is requested.

In Hanshin-Awaji (Kobe) Earthquake of 1995, water transport contributed to the rescue operation to substitute land transport damaged. After this earthquake, disaster management jetties were constructed in various rivers and water transport came to be recognized as an emergency transport means in the regional disaster prevention plan. Moreover, the disaster drill using river navigation and disaster management jetty is executed in “Disaster Preparedness Day”.

3.4 Role that river navigation should play in Japan

In Japan, though river navigation had declined once, the function is being reconsidered as not only transport mode but also from various viewpoints of regional development and disaster management, etc again. The role of river navigation will become indispensable for correspondence to global environmental concerns and sustainable development in future. Though a matter geographical feature of Japan is not suitable for river navigation, we can find the possibility of river navigation use which is appropriate for each regional environment and social circumstances by maintaining related infrastructure and improving the accessibility and the convenience.
The role that river navigation should play is shown below.

1) Establishment of water disaster prevention network based on river navigation in emergency
We establish the disaster prevention network which effectively uses waterway links with river and canal. River navigation supports transport of rescue supplies and victims, etc until land transport links are restored, and allot transport of earthquake toles and pebbles for the city revival.
2) Construction of infrastructure related to river navigation which combines with city planning, and promotion of the profit use in normal time
We build construction of infrastructure related to river navigation where function as an interface of the citizens and waterside into the city planning to promote for regional development. In addition, we establish efficient management system of the jetty etc, and effectively use them in normal time.
3) Revival of water distribution system for easing negative environmental impact of city
We revive distribution system of environment-friendly type based on river navigation aiming at the improvement of traffic in city, considering history which the world's biggest city 'Edo' was supported by water transport. We create the opportunity which river navigation is recommended such as an introduction of energy conservation preferential treatment to urban traffic, and maintain hard and soft infrastructure such as a loading facilities along river and a related law, etc.

4 THE DIRECTIONALITY OF DEVELOPMENT OF RIVER NAVIGATION IN JAPAN

In this chapter, we focus on disaster prevention with especially high importance degree in metropolitan area from among various roles of river navigation, and show the directionality of development about it in future.

4.1 Estimation of damage of capital inland earthquake

While imminence of capital inland earthquake generation is pointed out in metropolitan area where population, property and central management function in Japan concentrate, Central Disaster Prevention Council in Japan has reported the forecast result of damage estimated by earthquake. Table 2 shows a part of the forecast result.

Table 2. Forecast result of damage of capital inland earthquake(M7.3)

Item	Forecast result	Note
Complete destruction and fire burnt down of building	About 850,000 houses	Eight times Hanshin-Awaji Earthquake (about 110,000 houses)
Death toll	About 11,000 people	Twice Hanshin-Awaji Earthquake (6,433 people)
Toles and pebbles	About 96 million tons	Five times Hanshin-Awaji Earthquake (about 20 million tons)
Injured person	About 210,000 people	Five times Hanshin-Awaji Earthquake (43,792 people)
Stranded commuter	About 6.5 million people in Tokyo and three adjacent prefectures (Saitama, Chiba and Kanagawa)	Situation at noon About 3.9 million people in Tokyo

Note1: The hypocenter is a Tokyo Bay northern part and the scale of earthquake is M7.3.
Note2: It is assumed that the earthquake occurred at 18 in winter. (except estimation of stranded commuter)

4.2 Potential of river navigation use corresponding to capital inland earthquake

4.2.1 Disaster prevention use of river navigation

Metropolitan area's river such as Ara River and Sumida River, etc and disaster management jetties are defined as emergency transport route and facilities in the regional disaster prevention plan. Especially, the importance degree of disaster management jetties where are constructed near the disaster base hospital is high, and they are expected to function to medical support. In addition, Arakawa lock gate where the time required passing ship is the shortest in Japan was constructed in 2005 shown in Fig.4, and Onagi River which flows in Tokyo connecting Ara River to Sumida River through Arakawa lock gate has potential to function as a part of water disaster prevention network.

To use river navigation in emergency, it is necessary to procure ships and crews. For example, a lot of houseboats exist in Tokyo and the crews are well informed of sailing situation in the regional river. Moreover, because houseboats have equipments such as drinking water, foods and dynamos, etc, they can expect activity as not only stranded commuter transport means but also issuance of rations and hotel ship, etc.

Source: Ministry of Land, Infrastructure and Transport

Fig.4. Arakawa rock gate

4.2.2 Potential of river navigation corresponding to capital inland earthquake

We selected main forms of river navigation use corresponding to capital inland earthquake considering of past studies, the regional disaster prevention plan, and the site situation, etc in Table 3. Main forms of river navigation use with high necessity include transport of stranded commuter, rescue supply, earthquake toles and pebbles, and medical support. About stranded commuter measures, the past study is a few, and the examination is being advanced in Central Disaster Prevention Council now, so it is hoped to be recognized the river navigation as one of the measures by proving the effect.

Table 3. Main forms of river navigation use corresponding to capital inland earthquake

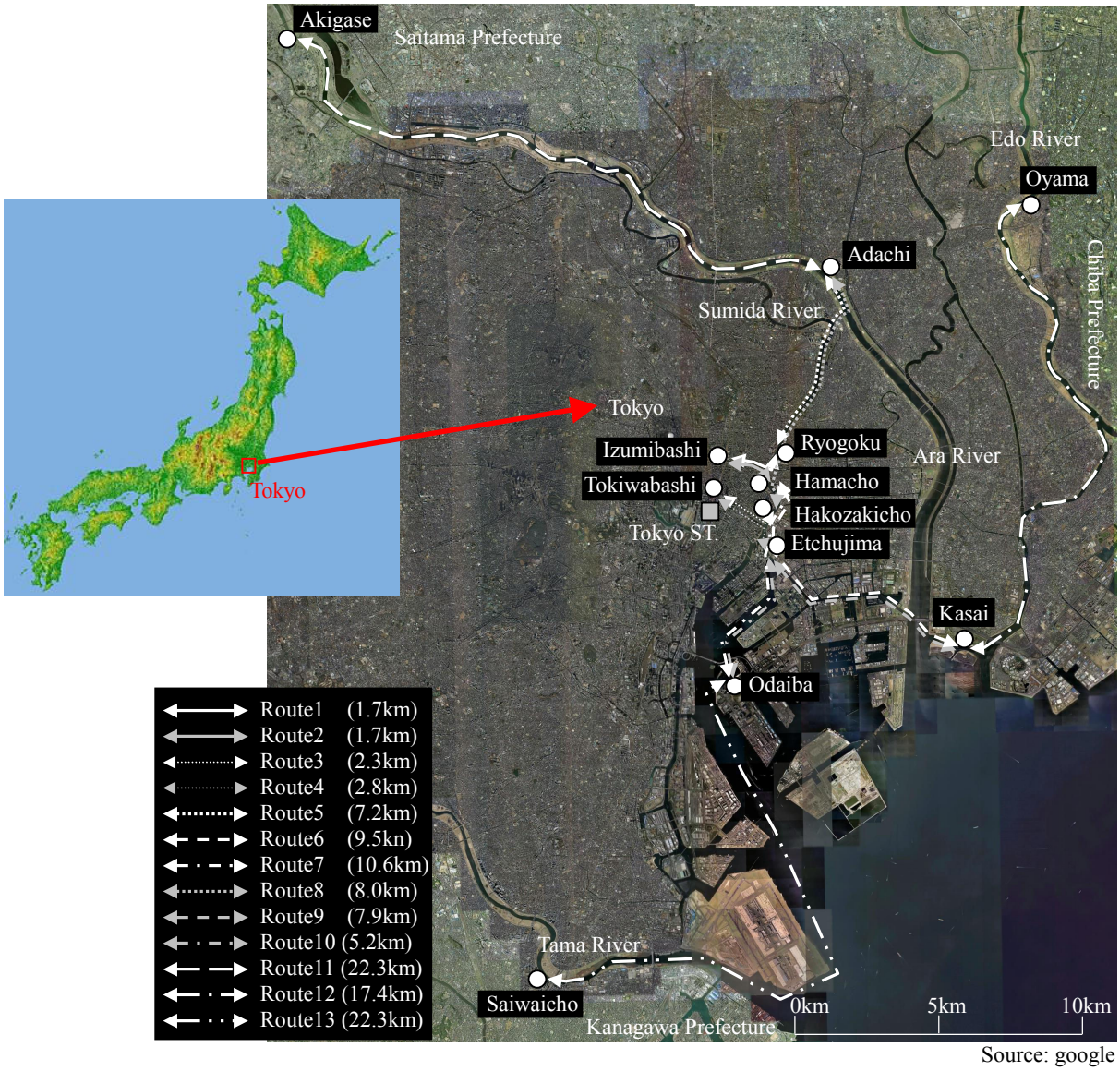
Use form	Characteristic
Transport of stranded commuter	・In metropolitan area where daytime population concentrates, it is clear to generate a lot of stranded commuter because of function stop of land transport, therefore it is necessary to clarify the measures at early stage. ・Heavy equipment, etc are unnecessary in disaster management jetty, so the possibility to be able to execute in current facility is high. However, the adjustment strategy is necessary in the jetty, because generation of victim's congestion is expected. ・Houseboat and water bus, etc have the possibility of functioning smoothly because of usual sailing results.
Transport of rescue supply	・The demand for rescue supply is the highest until restoration of city from occurrence of earthquake. ・Effective results are estimated in past studies, but there is a problem of preparation of unloading facilities, etc to achieve enough effect.
Transport of earthquake toles and pebbles	・River navigation is very suitable for transport of toles and pebbles generated along river at the restoration period. ・The emergency degree is lower than transport of victim and rescue supply related to the life. ・The decision of the earthquake waste management plan to locate temporary places and the final disposal dump of toles and pebbles is remaining issue.
Medical support	・The activity of extent in which land medical services are supported can be expected by effectively using disaster management jetties constructed near the hospital. ・The medical support person's procurement is problem. ・The ship for medical treatment is developing.

4.2.3 Potential of river navigation corresponding to stranded commuter

We thought that the necessity and the feasibility of stranded commuter transport are high for capital inland earthquake, and examined the case study which assumed transport by river navigation from some jetties where had been constructed on the side of the main station in Tokyo to adjacent prefectures, 'Saitama', 'Chiba' and 'Kanagawa'. In this case study, we assumed to take the form transferred to ships of scale which is appropriate for each river in relay jetties, because there are parts where depth is shallow and clearance under bridge digit is not enough, etc in metropolitan area's river.

Fig.5 shows the transport route in the case study, and Table 4 shows the result. Number of people who can be transported from central area of Tokyo is about 14,000 people a day, and Number of people who can be

transported from Tokyo to adjacent prefectures is about 22,000 people a day, using ships of a realistic number. As a calculation condition, assuming that only one ship can be come alongside the pier at the same time in each jetty is a critical restriction of frequency can be transported. However, jetties used are increased to extent to which ships don't become complicated in the river, and there is potential that amount of transport can be increased in proportion to them. Though it is difficult for river navigation to become the main measures compared with the forecast number of stranded commuter, it is possible to contribute to easing road congestion expected which it becomes a dangerous situation by victim's complication. Then, it is hoped to execute proof experiment on the site to do verification with higher accuracy, because the idea of this case study contains some assumption.



Source: google

Fig.5. Transport route in case study

Table 4. Result of case study

Route	Starting point	Terminal	Number of necessary ships	Number of people can be transported a day	
1	Izumibashi	Ryogoku	Electric boat (For 10 person) : 21	7,200 people	Number of people can be transported from central area of Tokyo 14,400 people
2		Hamacho			
3	Tokiwabashi	Hakozakicho	Electric boat (For 10 person) : 30	7,200 people	
4		Etyujima			
5	Ryogoku	Adachi	Houseboat (For 80 person) : 3	3,600 people	Number of people can be transported from Tokyo to adjacent prefectures 21,600 people
6	Hamacho	Kasai	Houseboat (For 80 person) : 6	7,200 people	
7		Odaiba			
8	Hakozakicho	Adachi	Houseboat (For 80 person) : 3	3,600 people	
9	Etchujima	Kasai	Houseboat (For 80 person) : 4	7,200 people	
10		Odaiba			
11	Adachi	Akigase	Water bus (For 400 person) : 3	7,200 people	Ditto
12	Kasai	Oyama	Water bus (For 400 person) : 3	7,200 people	
13	Odaiba	Saiwaicho	Water bus (For 400 person) : 3	7,200 people	

Note1: The sailing speed of Electric boat is 3 knots (5.6 km/h), and the time required to get on and off is 2 minute / 10 people.
Note2: The sailing speed of Houseboat is 10 knots (18.5 km/h), and the time required to get on and off is 10 minute / 80 people.
Note3: The sailing speed of Water bus is 10 knots (18.5 km/h), and the time required to get on and off is 30 minute / 400 people.
Note4: Only one ship can be come alongside the pier at the same time in each jetty.
Note5: Sailing for 24 hours.

4.3 Effective use of disaster management jetty

Using disaster management jetty usually effectively is enabled to do rescue operation smoothly by river navigation in emergency. Actually, the jetty where is opened and used positively in normal time is a few. The following problems are assumed.

1) Anxiety to management wound when accident occurs
2) Anxiety to management load such as residing of manager
3) Anxiety to occurrence of trouble to river management such as unlawful occupation of ships

It is difficult for river administrator to always manage jetties on the site, so it is necessary to establish the mechanism that civil organizations etc. can be involved in jetties' management. For example, it is preferable that river administrator consigns civil organization such as a NPO jetties' management and the consignment manager operates them adapting oneself, while confirming their use needs and management loads.

4.4 Problem for disaster prevention use of river navigation

The problem for achievement of disaster prevention use of river navigation is shown.

1) We examine the operation system of river navigation, and clarify concrete use in the regional disaster prevention plan, etc.
2) We improve arrangement, the scale, and the function of disaster management jetty to correspond to the use of river navigation assumed.
3) We provide the priority level and the rule of facilities use to evade complication of ships and victims around disaster management jetties in emergency.

4) We execute making of facilities concerned including disaster management jetties earthquake-proof, measures to dropping of bridge, maintenance of river and canal where can be used as sailing route, and promotion of informationization concerning sailing, etc
5) We advance the conclusion of the agreement of disaster prevention with ship groups such as water buses and houseboats, and prepare the information report system by wireless, etc.
6) We confirm the coming alongside the pier situation to disaster management jetty, the state of the sailing route, and problem in the site, etc. through the disaster drill. Moreover, we inform the citizens of the jetty's existence and role by using them in normal time.

5 CONCLUSION

In this study, we identified current trends and problems of river navigation in Japan and indicated the role that river navigation should play in future and the directionality of development. We focused on disaster prevention function with especially high importance degree in metropolitan area from among various functions of river navigation, and showed the potential corresponding to stranded commuter who is examined as a serious problem in government.

As a next step, it is necessary that we examine effective use of disaster management jetty including normal time use to function the river navigation smoothly in emergency.

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