Resident Questionnaire Analysis on Disaster Preparedness Awareness for Strategic Resilience Using the Resilience Analysis and Assessment Grid the RAG

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The purpose of this research is to understand the urban characteristics of Tama New Town and develop a disaster-resistant community that aligns with those characteristics. This paper reports on the implementation of a "resident questionnaire on disaster prevention consciousness" among residents around Tama University, based on the Resilience Assessment Grid (RAG) concept used in Resilience Engineering. The RAG defines the four capabilities of a resilient organization as "Resilient Local residents = Anticipating + Watch over (Monitoring) + Preparation (Responding) + Learning." We quantified the resilience potential of the community and found that Preparation (Responding) scored lower than the other items. Our findings can inform the design and management of a disaster-resistant community that is better prepared to anticipate, monitor, respond to, and learn from disasters.

Keywords: Resilience Engineering, Resilience Assessment Grid (the RAG), disaster prevention awareness, questionnaire analysis, community design

INTRODUCTION

This explains the background of Tama New Town located in Tokyo, a community located in Tokyo, Japan. During Japan's Period of Rapid Growth, the population concentrated in the Tokyo metropolitan area, leading to a housing shortage. Tama New Town was built in response to this issue, planned and developed in the Tama Hills, spanning the cities of Tama, Machida, Inagi, and Hachioji in Tokyo. The first residents moved into the Suwa and Nagayama areas in 1971, and the overwhelming majority of residents are baby boomers, with an aging population becoming an issue. Many of the housing complexes and apartment buildings in Tama New Town are mid- to low-rise residences with five or fewer floors, lacking elevators. As residents age, it becomes increasingly physically demanding for them to climb stairs to higher floors. Furthermore, the New Town was planned with environmental considerations in mind, retaining the appearance of the mountains where the land had been cleared. As a result, the terrain is uneven, with many stairs and slopes throughout the town. These factors highlight the challenges that Tama New Town faces as it strives to develop a disaster-resistant community that meets the needs of its aging residents.

There have been a number of major earthquake disasters, including the Indian Ocean Earthquake and Tsunami (2004), the Chilean Earthquake (2010), the Great East Japan Earthquake (2011) and the Turkey-Syria Earthquake (2023). Additionally, rapid urbanization has increased the risk of communities facing other types of disasters, such as typhoons, heavy rain, and heavy snow. As cities become larger and more complex, predicting the magnitude and speed of damage beforehand becomes increasingly challenging. In

the event of a disaster, it can be difficult to obtain a complete understanding of the situation and respond accordingly. The possibility of unexpected events, as discussed following the Great East Japan Earthquake, is growing. These factors demonstrate the need for developing disaster-resistant communities that are capable of anticipating, monitoring, responding to, and learning from disasters.

We outline the objectives of the research, which aims to gain a better understanding of the unique urban characteristics of Tama New Town and develop an appropriate disaster-resistant community that takes these factors into account. The study seeks to collaborate with the residents who live in Tama New Town to create various methods and plans for this purpose. This paper analyzes the results of a questionnaire survey on disaster preparedness conducted among the residents of the Tama Campus of Tama University, which is located in Tama New Town. The survey is based on the concept of the Resilience Assessment Grid (RAG) used in resilience engineering, as discussed in "Resilience Engineering in Practice" by Erik Hollnagel (Erik Hollnagel et al.,2011; Chuang S et al.,2020). The use of the RAG concept provides a framework to evaluate and enhance the community's resilience potential, which can inform the design and management of a disaster-resistant community in Tama New Town.

RESEARCH BACKGROUND

As mentioned in the introduction, the aging of residents in Tama New Town has become a concern. Seisekigaoka, located in the fourth residential area of Tama New Town, was first occupied in 1984 and has a relatively high number of detached houses. The community association has identified several issues, including the fact that residents are aging, children are leaving home, and the number of married-couple-only households is increasing. Additionally, many working people commute to the city center, and some households are only occupied by the elderly during the daytime. In the event of a disaster such as an earthquake, these elderly residents may become isolated and require assistance. The community association has proposed that university students provide support in such situations. On the other hand, if transportation is disrupted and university students are unable to return home, a "mutual aid" system could be created where students could stay overnight in vacant rooms in detached houses. This proposal demonstrates the community association's efforts to address the challenges associated with an aging population and prepare for potential disasters.

We describe the Tama University Collaboration Group, which was established in 2015 by the Faculty of Management and Information Sciences and the Renkoji-Seigaoka Community Welfare Promotion Committee. The group aims to create a foundation for "mutual aid" to emerge during times of emergency by learning about the local community and interacting with local people during normal times. The collaboration group aims to study a new model for disaster prevention collaboration, which involves Tama University in cooperation and collaboration during a disaster. A questionnaire survey was conducted among local residents to measure their disaster awareness and to utilize the results for future disaster-resilient community development. The questionnaire items were based on the Hamura City Citizen Questionnaire Report on Disaster Prevention. Through this collaboration, the group hopes to contribute to the development of disaster-resilient communities in the Tama New Town area (Hiroyuki MASUDA,2021).

The survey was conducted between October 2016 and February 2017, during which a total of 344 questionnaires were collected, with 301 valid and 43 invalid responses. The questionnaires were distributed at various events, including joint disaster drills held at Hijirigaoka Junior High School and Hijirigaoka Elementary School in October 2016, as well as at Renkoji Elementary School in February 2017. Additionally, the questionnaires were distributed to two neighborhood associations, Keio Ichinomiya Neighborhood Association and Renkoji Mukonooka Neighborhood Association, in February. The age and gender breakdown of the respondents revealed a significant absence of elderly residents in their 60s and 70s or older, which is likely due to the aging population of the target areas and the uneven distribution of age groups that actively participate in disaster drills. Nonetheless, there were no significant differences between the responses of male and female residents.

TABLE 1
GENDER OF SURVEY RESPONDENTS

	Frequency	Percentage
male	172	57.1
female	129	42.9
total amount	301	100.0

TABLE 2
AGE GROUPS OF SURVEY RESPONDENTS

age	frequency	percentage
Under 10 years old	6	2.0
20s.	3	1.0
30s.	15	5.0
40s.	31	10.3
50s.	35	11.6
60s.	100	33.2
Over 70 years old	111	36.9
total amount	301	100.0

RESILIENCE ENGINEERING

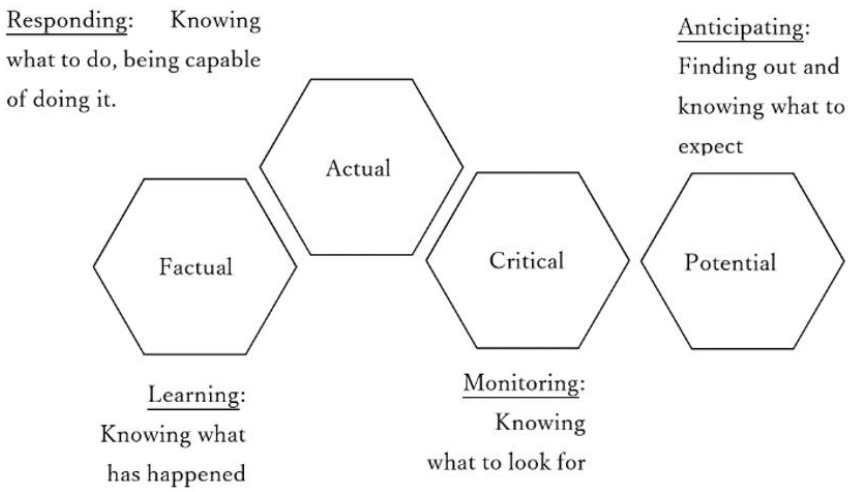
Resilience is a concept that refers to the ability to flexibly recover from a temporary loss of functionality in the face of major changes in the environment, and is a term that has attracted widespread attention as a risk response capability in safety ergonomics and social systems theory (Erik. Hollnagel et al.,2006; Erik. Hollnagel et al.,2008; Erik. Hollnagel et al.,2009; Erik. Hollnagel et al.,2014; Erik. Hollnagel et al.,2017; James Reason,2008). In particular, the term "resilience" has been used in Japan since the Great East Japan Earthquake that occurred on March 11, 2011, and the subsequent accident at the TEPCO's Fukushima Daiichi Nuclear Power Station8).

Resilience engineering is a concept of system safety that was first proposed by Hollnagel et al. in 2004(Erik Hollnagel et al.,2006). The concept applies the idea of Complex Adaptive Systems in systems theory to system safety. Unlike the conventional methodology of Safety-I, which focuses on eliminating failures and faults, this methodology is designed to improve safety by exploring the reasons why a system continues to operate despite being affected by various disturbances and uncertainties. This resilience engineering approach is a theory of self-organized safety enhancement through the search for reasons why a system survives and continues to operate despite various disturbances and uncertainties, known as Safety-II. The concept of resilience engineering was originally developed to quantitatively evaluate the safety of industrial organizations and is now being applied in various fields. Hollnagel defines resilience as "the intrinsic ability of a system to adjust its own functions before, during, or after a change in conditions or disturbance in order to continue required behavior under expected and unexpected conditions."

From this perspective, resilient organizations must be able to:

- Respond to normal and unusual fluctuations, disturbances and opportunities (Responding).
- Monitor what happens and be able to recognize when something occurs that may affect the organization's ability to conduct current operations (Monitoring).
- They must be able to learn appropriate lessons from appropriate experiences (Learning).
- Anticipating events that may occur in the future that are beyond the scope of the current mode of operation（Anticipating）.

FIGURE 1
THE FOUR MAIN CAPABILITIES OF A RESILIENT SYSTEM



The following four capabilities are necessary for a resilient organization5).

(1) Factual: To understand what has occurred (to correctly learn what was the cause from past events)
(2) Potential: To be able to judge what is likely to happen and to know what is likely to happen.
(3) Critical: To know what to keep an eye on
(4) Actual: Know what to do and have the ability to respond (to respond effectively and flexibly to changes in normal or unusual situations).

With reference to the above, this paper expands the concept to determine the disaster preparedness of community safety by extending the organization to be handled to local residents, and thus defines "resilient residents = foresight + watch and patrol (monitoring) + preparedness (coping) + learning."

RESILIENCE ASSESSMENT GRID (RAG) AND QUESTIONNAIRE ITEMS

The Resilience Assessment Grid (RAG) has been proposed by Hollnagel as a method for assessing resilient organizations2 (Erik Hollnagel, 2014; Erik Hollnagel. 2017; Chuang S, 2020). To evaluate the resilience of an organization, it is necessary to develop a set of questionnaire questions to weigh and evaluate the four characteristics of the organization (see Fig. 1). The specific items of the questionnaire administered in Section 2 were categorized as follows.

Questions to Measure Learning Ability

- What do you know about earthquakes in the Tokyo metropolitan area?
- When was your house built? If your house has been extended or remodeled, please indicate the year of construction of the main part.
- Have you ever had your house inspected for earthquake resistance?
- Do you know of any temporary gathering places, evacuation sites, or shelters in the area where you live in case of a disaster?

Question to Measure Foresight

- What is the probability of a major earthquake occurring in Tama City?

Questions to Measure Preparedness (Coping) Ability

- How many days do you think you can live with the food you keep in your house for daily meals?
- How many days' worth of food do you think you can live with the food you keep in stock at home for daily meals?
- How many days' worth of drinking water do you have stockpiled for a disaster?
- Please calculate 3 liters per family member per day. As a rule of thumb, a large PET bottle contains 2 liters.

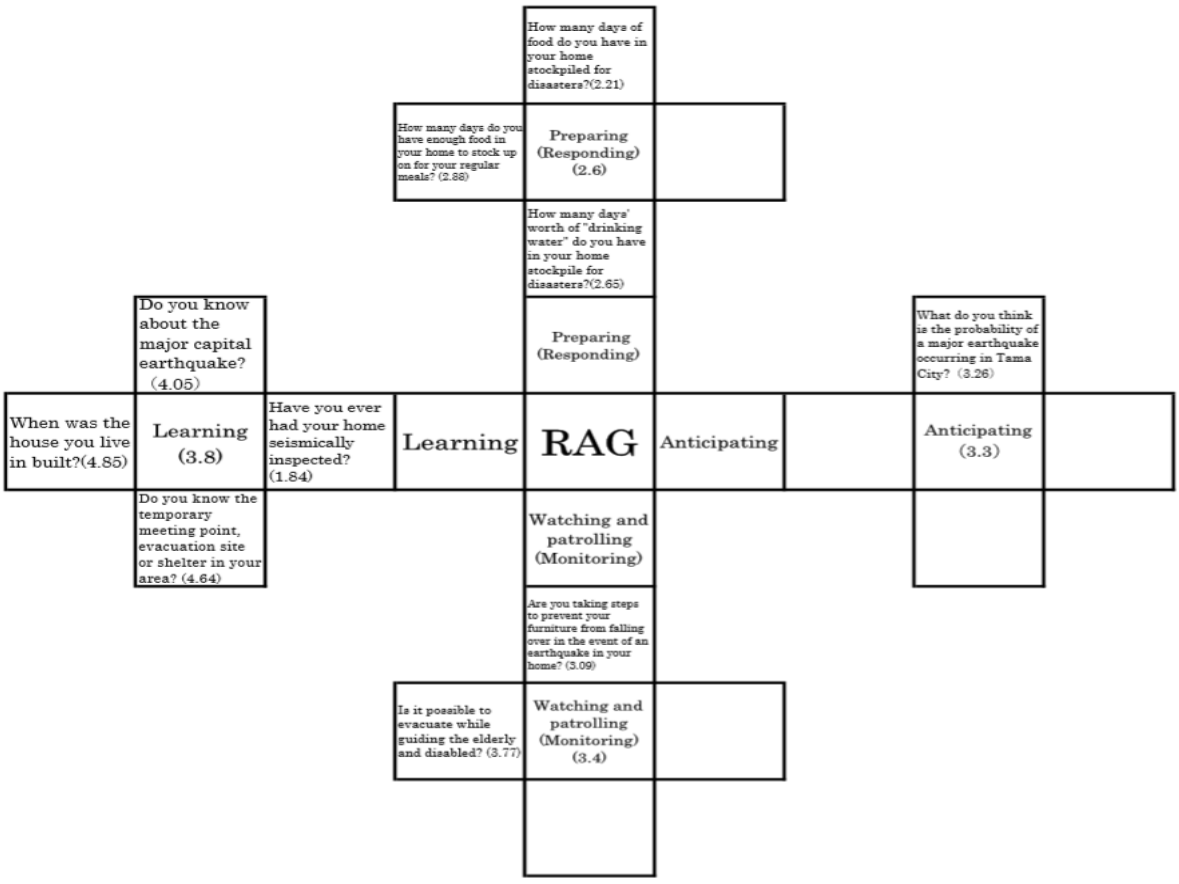
Questions to Gauge Your Ability to Watch Over and Patrol (Monitor)

- Do you take measures to prevent furniture from falling over in your home?
- Do you think you would be able to evacuate while guiding elderly or disabled neighbors when evacuating in the event of a disaster?

QUANTIFICATION OF EACH QUESTIONNAIRE ITEM

The questionnaire items presented in section 4 were structured (see Fig. 2) and quantified using a 5-point scale, with the average of the surrounding values represented by the number in the center of each of the four characteristics. This display enables a quick understanding of the scores of each question, facilitating the identification of areas in which the resilience potential of the organization can be improved.

FIGURE 2
RAG CLASSIFICATION OF QUESTIONNAIRE ITEMS



Among the items in this survey, those that could be rated on a 5-point scale were selected, and specific examples of calculations used for quantification are shown below. These numerical values are entered in Fig. 2.

Q1: Do you know about earthquakes directly under the Tokyo metropolitan area?

1. well informed 2. somewhat informed 3. not very well informed 4. not at all informed

For each of the above questions, 5 points were given for "I know much about it," 4 points for "I know some about it," 2 points for "I don't know much about it," and 1 point for "I don't know much about it at all." These were multiplied by the number of respondents to the questionnaire (Tab. 3), and the arithmetic mean was calculated.

$$(73 \times 5 + 199 \times 4 + 27 \times 2 + 1 \times 1) / 300 = 4.05$$

TABLE 3
FREQUENCY DISTRIBUTION TABLE FOR Q1 "DO YOU KNOW ABOUT EARTHQUAKES DIRECTLY UNDER THE TOKYO METROPOLITAN AREA?"

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I know a lot about it	73	24.3	24.3	24.3
	Somewhat familiar	199	66.1	66.3	90.7
	Do not know much about it	27	9.0	9.0	99.7
	Do not know at all	1	.3	.3	100.0
	Total	300	99.7	100.0	
Missing value		1	.3		
Total		301	100.0		

Q2: What do you think is the probability of a major earthquake occurring in Tama City?

1. very high 2. high 3. not very high 4. low 5. don't know

The probability of a major earthquake occurring in Tama City is: 5 points for "very high," 4 points for "high," 3 points for "not very high," 2 points for "low," and 1 point for "don't know." These were multiplied by the number of respondents to the questionnaire (Tab. 4), and the arithmetic mean was calculated.

$$(19 \times 5 + 144 \times 4 + 82 \times 3 + 9 \times 2 + 47 \times 1) / 301 = 3.26$$

TABLE 4
WHAT DO YOU THINK IS THE PROBABILITY OF A MAJOR EARTHQUAKE OCCURRING IN TAMA CITY?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very high	19	6.3	6.3	6.3
	High	144	47.8	47.8	54.2
	Not very high	82	27.2	27.2	81.4
	Low	9	3.0	3.0	84.4
	Don't Know	47	15.6	15.6	100.0
	Total	301	100.0	100.0	

Q3: How many days do you think you can live on the food you keep in your house for daily meals?

We gave 5 points for "8 days or more," 4 points for "6 to 7 days," 3 points for "3 to 5 days," 2 points for "1 to 2 days," and 1 point for "0 days." These were multiplied by the number of respondents to the questionnaire (Tab. 5), and the arithmetic mean was calculated.

$$(10 \times 5 + 47 \times 4 + 155 \times 3 + 49 \times 2 + 27 \times 1) / 288 = 2.88$$

TABLE 5
HOW MANY DAYS DO YOU THINK YOU CAN LIVE ON THE FOOD YOU KEEP IN YOUR HOUSE FOR DAILY MEALS?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	27	9.0	9.4	9.4
	1	12	4.0	4.2	13.5
	2	37	12.3	12.8	26.4
	3	103	34.2	35.8	62.2
	4	13	4.3	4.5	66.7
	5	39	13.0	13.5	80.2
	6	4	1.3	1.4	81.6
	7	43	14.3	14.9	96.5
	10	9	3.0	3.1	99.7
	15	1	.3	.3	100.0
	Total	288	95.7	100.0	
Missing value	99	13	4.3		
Total		301	100.0		

Q4. How many days' worth of food uncooked food, dried bread, alpha rice, etc.) do you keep in stock at home for disasters?

The score was 5 for "more than 8 days," 4 for "6 to 7 days," 3 for "3 to 5 days," 2 for "1 to 2 days," and 1 for "0 days." These were multiplied by the number of respondents to the questionnaire (Tab. 6), and the arithmetic mean was calculated.

$$(3 \times 5 + 17 \times 4 + 101 \times 3 + 81 \times 2 + 85 \times 1) / 287 = 2.21$$

TABLE 6
HOW MANY DAYS' WORTH OF FOOD UNCOOKED FOOD, DRIED BREAD, ALPHA RICE, ETC.) DO YOU KEEP IN STOCK AT HOME FOR DISASTERS?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	85	28.2	29.6	29.6
	1	32	10.6	11.1	40.8
	2	49	16.3	17.1	57.8
	3	83	27.6	28.9	86.8
	4	3	1.0	1.0	87.8
	5	15	5.0	5.2	93.0
	7	17	5.6	5.9	99.0
	10	2	.7	.7	99.7

	30	1	.3	.3	100.0
	Total	287	95.3	100.0	
Missing value	99	14	4.7		
Total		301	100.0		

Q5. How many days worth of drinking water do you have stockpiled at home for disasters?

Five points were given for "8 days or more," four points for "6 to 7 days," three points for "3 to 5 days," two points for "1 to 2 days," and one point for "0 days." These were multiplied by the number of respondents to the questionnaire (Tab. 7), and the arithmetic mean was calculated.

$$16\times5+31\times4+128\times3+77\times2+45\times1) \div 297 = 2.65$$

TABLE 7
HOW MANY DAYS WORTH OF DRINKING WATER DO YOU HAVE STOCKPILED AT HOME FOR DISASTERS?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	45	15.0	15.2	15.2
	1	25	8.3	8.4	23.6
	2	52	17.3	17.5	41.1
	3	90	29.9	30.3	71.4
	4	13	4.3	4.4	75.8
	5	25	8.3	8.4	84.2
	6	12	4.0	4.0	88.2
	7	19	6.3	6.4	94.6
	8	3	1.0	1.0	95.6
	10	11	3.7	3.7	99.3
	30	2	.7	.7	100.0
	Total	297	98.7	100.0	
Missing value	99	4	1.3		
Total		301	100.0		

Q6. Do you have measures in place to prevent furniture from falling over in your home?

Five points were given for "all furniture is fixed," four points for "most furniture is fixed," three points for "some furniture is fixed," two points for "I am thinking of fixing furniture but have not yet done so," and one point for "I am not thinking of fixing furniture at present." These were multiplied by the number of respondents to the questionnaire (Tab. 8), and the arithmetic mean was calculated.

$$(12\times5+93\times4+117\times3+60\times2+15\times1) \div 297 = 3.09$$

TABLE 8
DO YOU HAVE MEASURES IN PLACE TO PREVENT FURNITURE FROM FALLING OVER IN YOUR HOME?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All furniture fixed.	12	4.0	4.0	4.0
	Fixed most of the furniture.	93	30.9	31.3	35.4
	Some furniture fixed.	117	38.9	39.4	74.7
	I'm thinking of fixing the furniture, but haven't done it yet.	60	19.9	20.2	94.9
	I'm not thinking about fixing furniture at this point.	15	5.0	5.1	100.0
	Total	297	98.7	100.0	
Missing value	99	4	1.3		
Total		301	100.0		

Q7. When was your residence built?

Five points were given for "before May 1981 or after June 1981" and one point for "don't know." These were multiplied by the number of respondents to the questionnaire (Tab. 9), and the arithmetic mean was calculated.

$$(286\times5+11\times1)\ /297 \quad = \quad 4.85$$

TABLE 9
WHEN WAS YOUR RESIDENCE BUILT?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Before May 1981	59	19.6	19.9	19.9
	After June 1981	227	75.4	76.4	96.3
	I don't know.	11	3.7	3.7	100.0
	Total	297	98.7	100.0	
Missing value	99	4	1.3		
Total		301	100.0		

Q8. Have you ever had your home's seismic evaluation?

Five points were given for "Yes" and one point for "No" or "Don't know." These were multiplied by the number of respondents to the questionnaire (Tab. 10), and the arithmetic mean was calculated.

$$(62\times5+234\times1)\ /296 \quad = \quad 1.84$$

TABLE 10
HAVE YOU EVER HAD YOUR HOME'S SEISMIC EVALUATION?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	62	20.6	20.9	20.9
	No	211	70.1	71.3	92.2
	I don't know.	23	7.6	7.8	100.0
	Total	296	98.3	100.0	
Missing value	99	5	1.7		
Total		301	100.0		

Q9. If you evacuate in the event of a disaster, do you know the temporary gathering place, evacuation site, or shelter in the area where you live?

Five points were given for "know," and one point for "don't know or don't know." These were multiplied by the number of respondents to the questionnaire (Tab. 11), and the arithmetic mean was calculated.

$$(270\times5+27\times1)\ /297 \quad = \quad 4.6$$

TABLE 11
IF YOU EVACUATE IN THE EVENT OF A DISASTER, DO YOU KNOW THE TEMPORARY GATHERING PLACE, EVACUATION SITE, OR SHELTER IN THE AREA WHERE YOU LIVE?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I know	270	89.7	90.9	90.9
	Don't know	27	9.0	9.1	100.0
	Total	297	98.7	100.0	
	99	4	1.3		
Missing value	301	100.0			

Q10. When evacuating in the event of a disaster, if there are elderly or disabled neighbors, do you think you would be able to guide them while evacuating?

The score was 5 for "I think I can do it," 4 for "I think I can do it if I am with others or if I am called upon," 2 for "I am too busy evacuating myself and my family to help others," and 1 for "I cannot help regardless of the situation or I don't know." These were multiplied by the number of respondents to the questionnaire (Tab. 12), and the arithmetic mean was calculated.

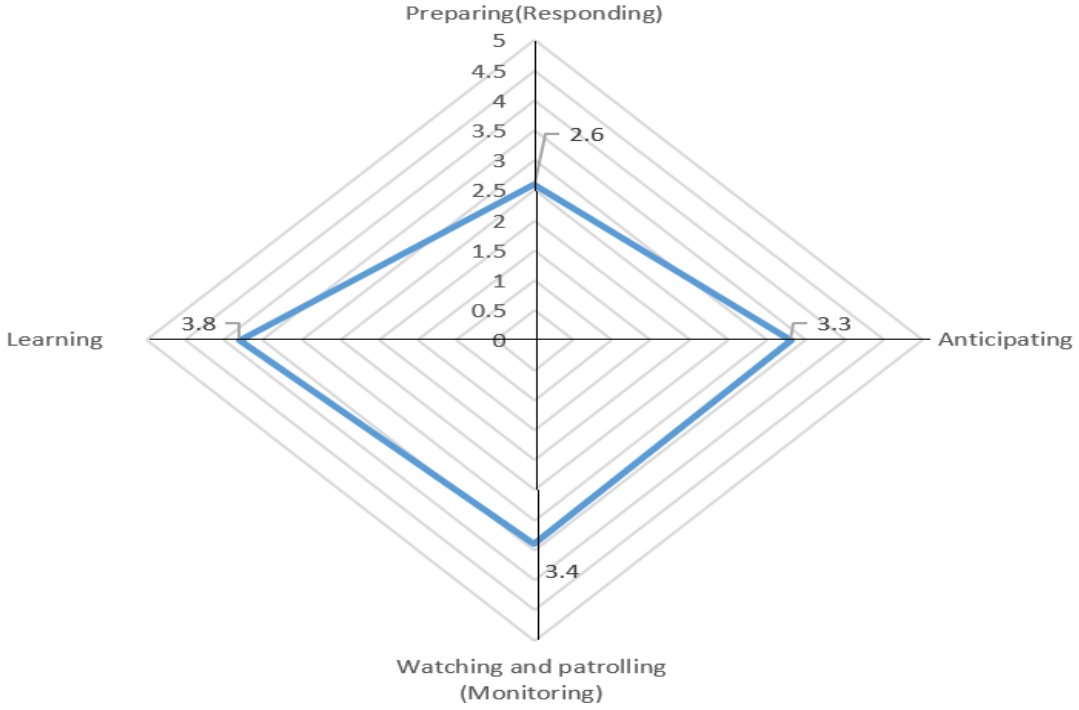
$$(52\times5+179\times4+35\times2+16\times1)\ /282 \quad = \quad 3.77$$

TABLE 12
WHEN EVACUATING IN THE EVENT OF A DISASTER, IF THERE ARE ELDERLY OR DISABLED NEIGHBORS, DO YOU THINK YOU WOULD BE ABLE TO GUIDE THEM WHILE EVACUATING?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I think I can do it	52	17.3	18.4	18.4
	I think I can do it if I am with others	121	40.2	42.9	61.3
	I think I can do it if I am called upon	58	19.3	20.6	81.9
	I am too busy evacuating myself and my family to help others	35	11.6	12.4	94.3
	I cannot help regardless of the situation	2	.7	.7	95.0
	I don't know	14	4.7	5.0	100.0
	Total	282	93.7	100.0	
Missing value	99	19	6.3		
Total		301	100.0		

Fig. 3 shows the results of the RAG aggregation star diagram. In this paper, "resilient residents = foresight + watch and patrol (monitoring) + preparedness (coping) + learning" was defined as follows: 3.3 for foresight, 3.4 for watch and patrol (monitoring), 2.6 for preparedness (coping), and 3.8 for learning.

FIGURE 3
THE AGGREGATED STAR DIAGRAM



CONSIDERATIONS AND FUTURE ISSUES

This paper examines the outcomes of the "Resident Questionnaire on Disaster Preparedness" conducted with residents who live near Tama University, based on the RAG concept used in resilience engineering. The results indicate that the preparedness (coping) score was lower at 2.6 compared to the other items. To make Tama New Town a resilient city, with the ability to anticipate, withstand, and overcome disasters, it is essential to enhance the awareness of residents on this item. For instance, when implementing a "mutual aid" system, in which university students are requested to stay overnight in a vacant room in a detached house when they face difficulties in returning home, it is crucial to consider preparedness. In the future, there will be a need to establish learning organizations (Peter M. Senge, 2006; Peter M. Senge et al., 2000). with universities at the center to enhance the community's resilience towards disasters.

The following issues are considered for the future. In this study, a group of questionnaire questions was created to determine resilience potential, and the average of the numerical values for each group of questions was further averaged. In addition, this questionnaire did not include questions on the treatment of pets in evacuation centers and communal living with foreigners, both of which have recently been considered problems, but we believe that the questionnaire should be revised to take these issues into account in the next questionnaire. Activities to improve resilience potential are long-term. The questionnaire should be administered on a regular basis to observe and record the changes in the resilience potential of the residents of the area.

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