PROBLEMS OF POST-TSUNAMI DISASTER HOUSING RELOCATION IN SANRIKU FISHERY VILLAGES, NORTHEAST JAPAN

Keisuke Hisamoto
Department of Civil Engineering and Architecture
Saga University, Saga, Japan
+81-952-28-8954, Email: 12577023@edu.cc.saga-u.ac.jp

Pegy Merlyn Ivanna Besouw
Department of Civil Engineering and Architecture[1]
Saga University, Saga, Japan
Manado City Government-Town Planning Division[2]
Manado, Indonesia
+81-952-28-8954, Email: 12587003@edu.cc.saga-u.ac.jp

Ryutaro Goto
Department of Civil Engineering and Architecture
Saga University, Saga, Japan
+81-952-28-8954, Email: rgoto@saga-u.ac.jp

Abstract

The great earthquake in East Japan caused a tsunami that created extensive damage in urban areas, as well as in villages situated near those areas. In this report, we propose an appropriate management and reconstruction method for village housing that addresses the following points: (1) residents' daily activities (e.g. fishing, and son) and the development of defenses against unpredictable emergency situations (e.g., tsunami disasters), and (2) community sustainability in the village. We measured actual damage levels for 122 villages located on the Sanriku Coast that were affected by the tsunami disaster. We created a damage map of the selected villages that suffered the effects of the tsunami disaster. Then, we divided the villages into sections based on damage levels. In particular, we classified villages based on how well they maintained their original forms. We also analyzed factors that might reduce the risk of potential disasters (e.g., locating settlements in highlands or near dikes). We compared the features of several existing systems (Group Relocation for Disaster Mitigation, and so on) with the Japanese government's system. We also examined the shortage of large-scale maintenance applications. With respect to tsunami defense measures, a multiplex defense does not solely depend on tide embankments. It also requires resettlement on higher ground, development of evacuation routes, and so on. Large-scale side maintenance can be effective for a village that suffers serious damage. However, large-scale side maintenance may not be appropriate for a village that suffers medium-level damage. For a village that sustained medium-level damage, we propose the use of a plural reconstruction method that involves five houses, maintains geographical and village forms, and helps maintain the community.

Keywords: Damage map; Tsunami; Disaster mitigation; Housing relocation; Village based planning

1. INTRODUCTION

When the Great East Japan Earthquake occurred on March 11, 2011, some parts of Japan suffered significant damage. This included damage to housing and community infrastructure. Currently, measures to ensure quick housing reconstruction and increased housing supply for disaster victims are underway. The damage from the Great East Japan Earthquake and Tsunami is concentrated on the towns and villages in the area along the shoreline. The regional economy of these villages is greatly based on their fisheries industry. In short, these small village communities may collapse because both their settlement and their employment suffered destructive damage.

This paper examines a situation that developed on the Sanriku coast. Many villages located in Sanriku District have suffered repeated tsunami damage over the years (Meiji Sanriku Tsunami, 1896; Syowa Sanriku Tsunami, 1933, and so on). Whenever a tsunami hazard occurs, the local government and villagers undertake measures to deal with the situation, such as the relocation of the village at a height. However, some houses are still located in lowlands near beaches, and they have suffered damage again. Thus, ensuring the safety of the place of residence is a significant part of Sanriku District’s recovery program, so that it is well prepared for any tsunami disaster that may occur in the future. This is an important step to ensure that not only their lives but also their livelihoods—such as fishery—are protected.

1.1. Objectives

In this study, we target the Sanriku coast villages (fishery villages that contained 500 houses or fewer, and others) and focus on those that have rolled out successful disaster mitigation plans to deal with the housing damage that occurred as a result of the disaster. We inspect the present situation and the problems faced in residence coexistence of tsunami disaster prevention and an occupation by clearly land use or space structure in disaster mitigation villages. To achieve this end, we employ the following research methods.

1) First, we create damage maps of every village in Sanriku coast to further our understanding of the actual disaster conditions. Then we organize and analysis these data. We focus on the villages that have mitigated disaster with regard to housing, and we arrange the disaster mitigation elements (the presence of a seawall or forest, planning higher residence, residential arrangement, etc.) through a field survey. We organize the data by disaster mitigation patterns and consider the land use and space structure in each pattern.

2) We identify problems with the existing recovery programs by the local governments, and we arrange the problems of the housing relocation which was based on the village community

1.2. Method Used to Create the Damage Map

To gain a better understanding of the actual disaster conditions that affected the Sanriku coast, the authors created a map of a village damaged by the tsunami based on observational data. We relied on several map sources including housing maps developed by ZENRIN Co., aerial photos taken from Google Earth Pro, and so on. We selected disaster areas based on these map sources.

Classifications of damage condition criteria	Classifications of four types of building criteria
Red: outflow buildings	housings
Orange: flooded buildings	housing that includes shops/ offices
Green: undamaged buildings	buildings that did not contain housing (e.g.,shops,offices, and schools)
	other types of buildings (e.g.,warehouses, parking facilities)

Figure 1: Judgment criteria for building damage and building use

In Figure 1, the left column contains classifications of damage condition criteria. Red represents outflow buildings, orange represents flooded buildings, and green represents undamaged buildings. The right column contains classifications of four types of building criteria: housing, housing that includes shops/offices, buildings that did not contain housing (e.g., shops, offices, and schools), and other types of buildings (e.g., warehouses, parking facilities).

The damage maps on A3 size are created through these processes. In order to compare the damage situation of the villages, the number of damage classifications for each building criteria is counted. Using these counting result, "Housing outflow rates" and "Building outflow rates" can be calculated as measure of comparison. Housing outflow rates means the number of damages houses in comparison with all houses located in the village.

1.3. Selection Method of Object Villages

The method used to select villages was based on the following three points:

(1) The village was located on the shore and one or more buildings were destroyed by the tsunami.

(2) The village contained between 10 and 500 houses.

(3) The village's area was clearly visible on maps.

Figure 2 provides a map of the positions and housing outflow rates in object villages. At the moment,98 damage maps were made on 8 municipalities, Iwate Prefecture. This figure is colored according to the housing outflow rates.

Red represents 75.1%–100% of village damage levels.

Orange represents 50.1%—75% village damage levels.

Yellow represents 25.1%–50% village damage levels.

Blue represents 0.1–25% village damage levels.

Gray is the not object village because there is not consistent object conditions.

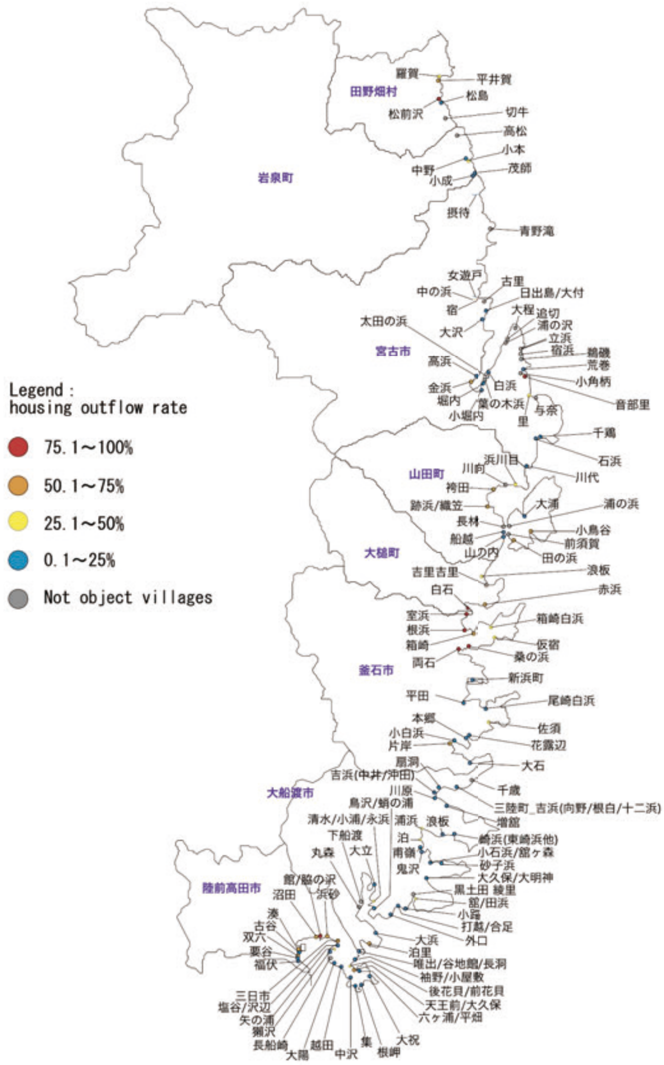

Figure 2: Position and housing outflow rates for object villages.

2. ACTUAL DAMAGE AND DISASTER MITIGATION IN VILLAGES

2.1 Housing Outflow Condition and Tendencies

In this study, we analyze about the actual damage condition and tendency of housings for 98 object villages.

2.1.1 The relationship between housing location heights and housing outflow rates

As shown in Figure 3, we identified village damage levels and classified them based on their land levels. We classified land levels into three zones: lowland (<10 meters above sea level), middle land (10-20 meters above sea level), and highland (>20 meters above sea level). Based on our observations, we determined that many villages were located in two or more zones.

In Figure 3, the x-axis represents the percentage of outflow rate per building and the y-axis represents land levels. The green, yellow, orange, and red bars describe damage levels 0%–25.0%, 25.1%–50.0%, 50.1%–75.0%, 75.1-100%, respectively. The graph shows that

Only lowland (5 villages)

Lowland + middle land (18 villages)

Lowland + middle + highland (44 villages)

Middle land + highland (26 villages)

Only highland (5 villages)

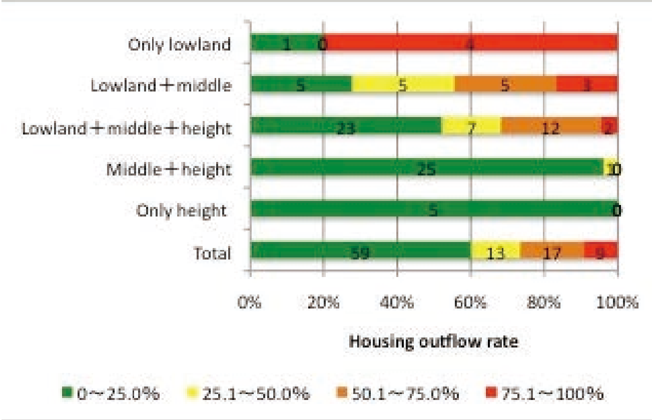

Figure 3. The relationship between housing location heights and housing outflow. rates

four villages located in the lowland area suffered 75-100% damage. One village located in the lowland area suffered 0%–25% damage. All villages located in the highland area suffered 0-25% damage. In contrast, villages located in the middle land area suffered differing damage levels. These results imply that damage levels are influenced by village locations.

2.1.2 The relationship between housing locations' geographical features and housing outflow rates

As shown in Figure 4, we identified village damage levels and classified them based on each location's geographical features. Based on our observations, we classified each location's geographical features into the following four sub-features, as shown below:

In Figure 4, the x-axis represents the percentage outflow rate per building and the y-axis represents each location's geographical features. The green, yellow, orange, and red bars show damage levels of 0%–25.0%, 25.1%–50.0%, 50.1%–75.0%, and 75.1%–100%, respectively. This figure demonstrates that the delta+coast area suffered the most severe damage in comparison with other areas because the delta+coast area is situated in the lowland area. However, the tablelands+terrace area experienced the lowest level of damage because the tablelands+terrace area is located in the highland area. These results imply that geographical features can increase or reduce damage to villages.

Delta+coast (19 villages)

Ravine (34 villages)

Tableland, terrace+coast (13 villages)

Tableland, terrace (32 villages)

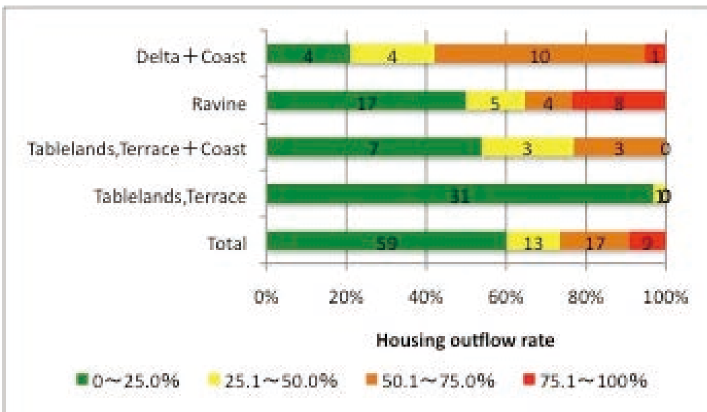

Figure 4: The relationship between each location's geographical features and housing outflow rates.

2.2 Disaster Mitigation Factors

We examined 32 villages in disaster area. And we checked the disaster mitigation elements in villages.

2.2.1 The relationship between housing outflow rates and disaster mitigation elements

Table 1: The relation between outflow rate housing and disaster mitigation

	Name of village	Municipality	Building outflow rate (%)	Housing outflow rate (%)	Disaster Mitigation elemnts
1	OHIWAI	RIKUZENTAKADA CITY	2.6	0.0	(a), (c)
2	TOMARI	RIKUZENTAKADA CITY	9.7	0.0	(c), (d)
3	NESAKI	RIKUZENTAKADA CITY	10.8	0.0	(a), (c), (d)
4	KOSHIDA	RIKUZENTAKADA CITY	12.6	0.0	(b), (c), (d)
5	MOSI	IWAIZUMI TOWN	12.7	0.0	(c), (d)
6	DAIYO	RIKUZENTAKADA CITY	9.6	2.5	(a), (d)
7	KONARI	IWAIZUMI TOWN	12.7	2.6	(c), (d)
8	NAKANO	IWAIZUMI TOWN	25.2	5.2	(d)
9	SESAWA	RIKUZENTAKADA CITY	12.5	8.3	(c)
10	OHISHI	KAMAISHI CITY	13.2	10.0	(a), (c)
11	FUNAKOSHI	YAMADA TOWN	26.3	10.4	(c), (d)
12	OZAKISHIRAHAMA	KAMAISHI CITY	33.3	14.0	(a), (d)
13	NIIHAMACHO	KAMAISHI CITY	27.7	17.9	(a), (d)
14	OHURA	YAMADA TOWN	28.9	19.6	(a)
15	HONGO	KAMAISHI CITY	34.5	20.0	(a), (c), (d)
16	KOSHIRAHAMA	KAMAISHI CITY	32.6	21.0	(a), (d)
17	KETOBE	KAMAISHI CITY	35.7	21.1	(d)
18	NAKASAWA	RIKUZENTAKADA CITY	31.6	21.4	(a), (d)
19	MATSUSHIMA	TANOHATA VILLAGE	37.4	23.7	(a), (d)
20	YANOURA	RIKUZENTAKADA CITY	30.6	25.6	(c)
21	RAGA	TANOHATA VILLAGE	39.7	28.4	(c), (d)
22	SASU	KAMAISHI CITY	44.3	29.6	(a), (b), (d)
23	HAMAKAWAME	YAMADA TOWN	53.3	41.7	(a), (d)
24	KOMOTO	IWAIZUMI TOWN	55.0	45.6	(a), (b)
25	HIRAGA	TANOHATA VILLAGE	57.6	52.3	(a), (c)
26	KOTORITANI	YAMADA TOWN	56.3	59.0	(a), (b)
27	TANOHAMA	YAMADA TOWN	65.9	59.4	(a)
28	HAKOZAKI	KAMAISHI CITY	69.2	62.4	(a)
29	KATAGISHI	KAMAISHI CITY	61.5	62.7	(a)
30	KUWANOHAMA	KAMAISHI CITY	85.5	80.0	(a)
31	MATSUMAESAWA	TANOHATA VILLAGE	78.8	81.4	(a)
32	RYOISHI	KAMAISHI CITY	88.9	89.0	(a)

Legend
(a) Seawall, (b) Forest, (c) Planning higher residence, (d) Residential arrangement

Table 1 illustrates the relationship between housing outflow rates and disaster mitigation elements. Disaster mitigation elements focused on this report are as follow:

(a) seawall; The bund to protect the village from tsunami .

(b) Forest; Such as a pine forest mitigation through forest zone.

(c) Planned residences on higher ground; A planned move of heights land in the past.

(d) Residential arrangement; Many houses are located in high land, if there is a difference 10 points more than Housing outflow rates to Building outflow rates

The table is put in order from the village where the housing outflow rates are low. Regardless of geographical feature, seawall has been checked in many villages. Villages where a housing outflow rates is low are many disaster mitigation elements.(OHIWAI, TOMARI, NESAKI, KOSHIDA, MOSHI, and so on) It can be indicated that multiplex defense was put into practice. However, serious damage (housing outflow rates are 60% or more) villages are only seawalls.

2.2.2 Case studies of disaster mitigation villages

Case 1: Housing arrangements at middle heights

Figure 5 describes Nakano (Iwaizumi Town). Geographically, Nakano is situated in a delta + coast area. This geographical feature can be said to be a type with serious damage.

With respect to land levels, this area can be classified into two zones: lowland and middle land. The village contains 322 buildings. The number of outflow buildings is 81. The total number of houses is 97. The total number of outflow houses is 5. In this village, significant damage occurred in the riverside area, which only contains fishery warehouses and related buildings. Village housing is located somewhat far from the river in the middle land zone. Therefore, it remained relatively safe from the disaster.

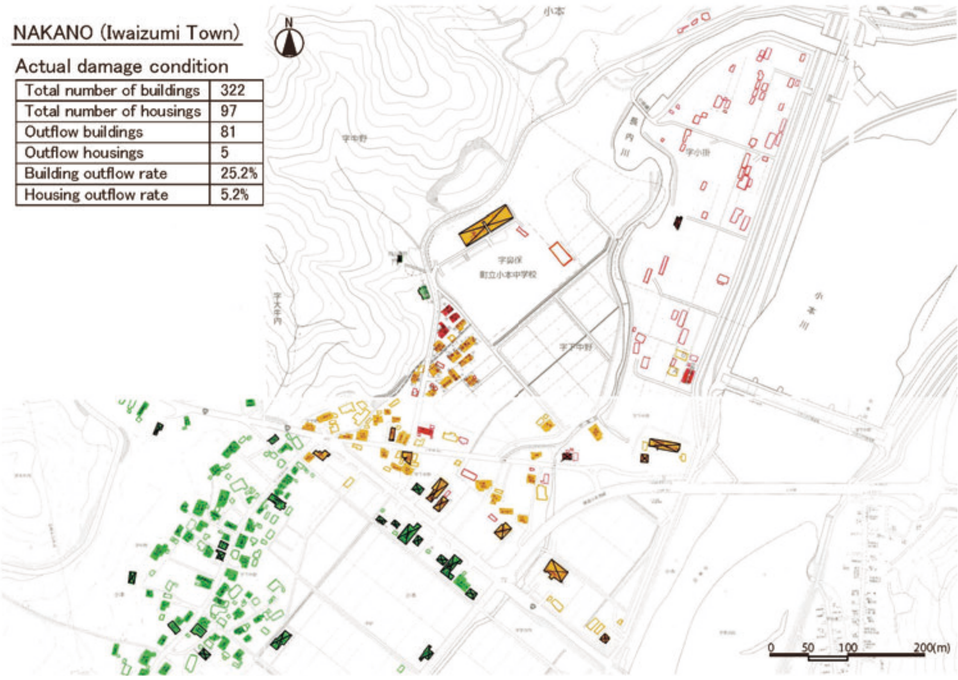

Figure 5: Housing arrangements at middle heights (NAKANO)

Case 2: Housing arrangements on a steep slope

Figure 6 provides a map of Niihama Cho (Kamaishi City). Geographically, Niihama Cho is situated in a small valley. With respect to land levels, this area can be classified into two zones: lowland + middle land. Niihama Cho contains 155 buildings. The number of outflow buildings is 43. The total number of houses is 67. The city contains only 12 outflow houses. The fishery factory, which is located in an area near the shore, suffered significant damage. However, most of the houses located in the small valley remained relatively safe from the tsunami.

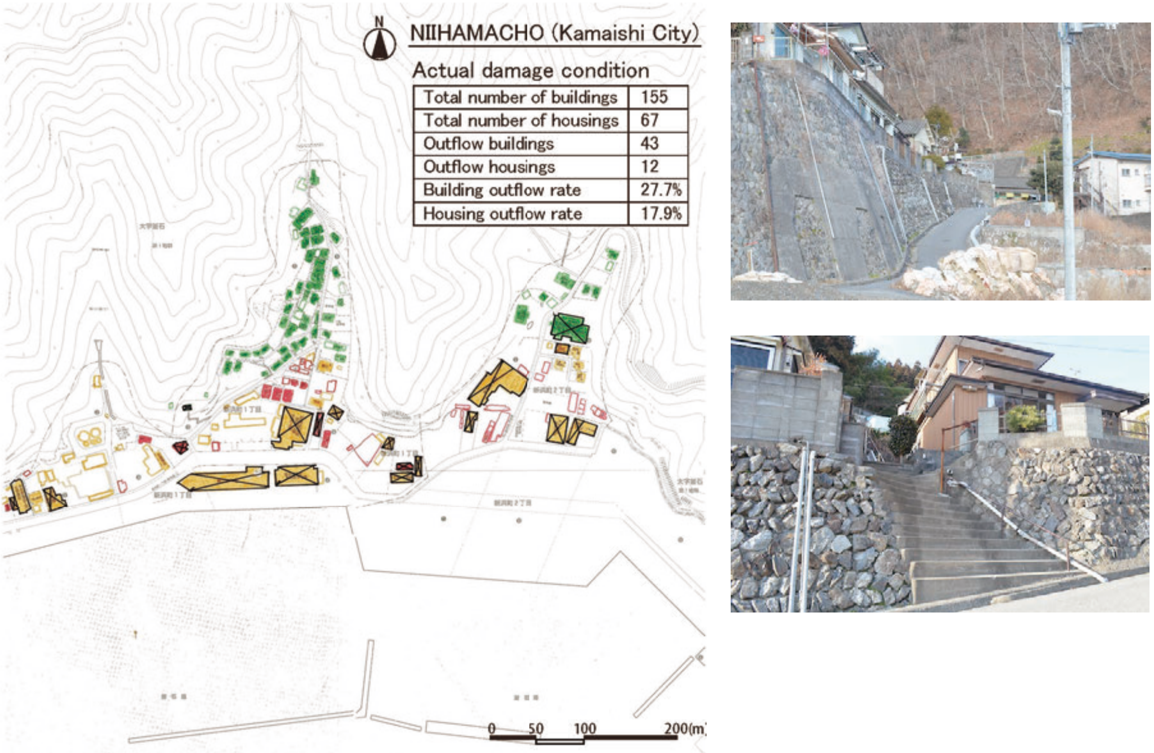

Figure 6: Housing arrangements on a steep slope (NIIHAMACHO)

Case 3: Past planned residences on higher ground

Figure 7 provides a map of Hongo (Kamaishi City). Geographically, Hongo is situated in a small valley. With respect to land levels, this area can be classified into lowland + middle land + highland area. Hongo contains 321 buildings. The number of outflow buildings is 111. The total number of houses is 165. The number of outflow houses is 33. The graphic illustrates planned higher relocations performed after the Showa Sanriku tsunami occurred in 1933. Houses were relocated to the highland to avoid tsunami damage. However, some houses located in the lowland near the sea after the village movement. Therefore, these houses suffered damage. Planned higher relocation was not necessarily successful.

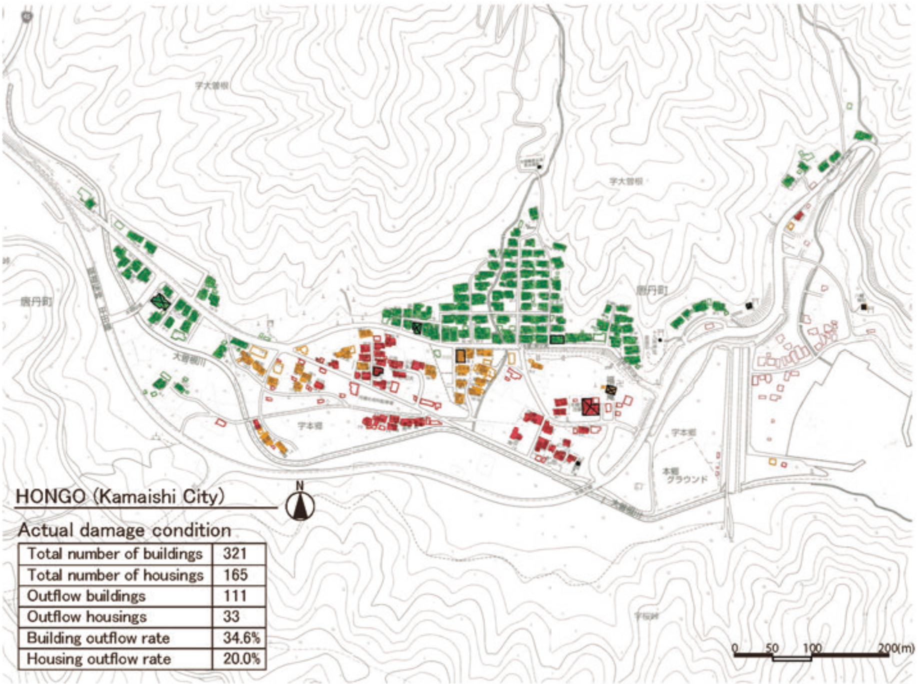

Figure 7: Past planned residences on higher ground (HONGO)

3. PROBLEMS IN RECONSTRUCTION TECHNIQUES IN FISHING VILLAGES

3.1. Outline and Present Condition of the Reconstruction System

The support of the national government is very important for housing reconstruction for disaster victims. Therefore, certain enterprises have been set up by the government for residential land development and housing reconstruction. Disaster victims and the local governments have to select a suitable enterprise from these. Most villages opt for group relocation to higher altitudes. An enterprise technique, "Promoting Group Relocation for Disaster Mitigation," is applied in many cases. The following aspects are involved.

A.) Entrepreneur

Chosen by the local government (Approval of the Minister of Land, Infrastructure and Transport (MLIT) is required).

B.) Steps involved in the work by enterprises

1. Conversion from a hazardous area to a damaged area. Acquisition of the residential land that has faced a disaster.
2. Development and maintenance of the residential land at a higher altitude. This process involves the relocation of ten or more housing scales into five or more houses in the case of the Great East Japan Earthquake.

C.) Assistance of nationality (subsidy rates; 3/4)

1. The acquisition of the residential area to be developed.

2. Enterprises provide assistance in housing reconstruction and buy new land for relocation.
3. Maintenance of public facilities in the residential area.
4. Acquisition of farmland in the relocation area, etc.
5. Creating workshops in residential areas, etc.
6. Assistance to housing relocation by providing the workers for this project.

In the formulation of an enterprise, municipalities respect the intentions of the residents in a hazardous area.
Currently (as of the end of March 2013), the stages followed by the enterprise in Promoting Group Relocation for Disaster Mitigation in Iwate Prefecture was employed in 54 areas in 7 different municipalities.

3.2. Problems in Disaster Prevention Plans for a Fishery Village

The reconstruction of a fishery village should be done with a different perspective than that taken to reconstruct a city or town. The culture of fishery villages is different than that of cities. A characteristic of fishery villages is that their occupation reflects their daily life.
A fishing port is the center of a village, and the housing areas are arranged along the center. The fishing port, which is a productive facility, is a place where villagers relax, and it also functions as an open space. That is, in fishery villages, the community and economy are maintained with the on fishing port at the center. In the recovery program, the residential area and disaster prevention plan that facilitates the continuation of the community should be formulated. That is, it is important that disaster prevention plans take into consideration the occupation of the people.

In light of this, the current recovery program proposal is slightly problematic. The left part of Figure 9 shows a typical example of the present plan. A zone represents the housing rearrangement plan of K village; there are 12 spots for residences and 40 for public restoration housing. In B and C zones, 14 and 7 spots, respectively, are for housing. D zone has 8 spots for public restoration housing.

To further the restoration of a huge part of a stricken area, the technique used in the development of residential sections of an outer city is applied to villages without any adaptation. The problems associated with this method are listed below.

1.) Spatial and social separation of the existing residence area that escaped the tsunami and creation of a new housing region.
2.) Relocation at a height creates a distance between the fisherman and the sea.

The true revival of a fishery village will not be realized if these problems are not solved.

3.3. Relocation Planning that Restores the Existing Villages

In the case of a fishery village, although improvement of the safety of the area is important, a recovery program that is based on the community is quite problematic. Particularly, in the case of the fishery village in Sanriku, the housing area is located at a slightly elevated area

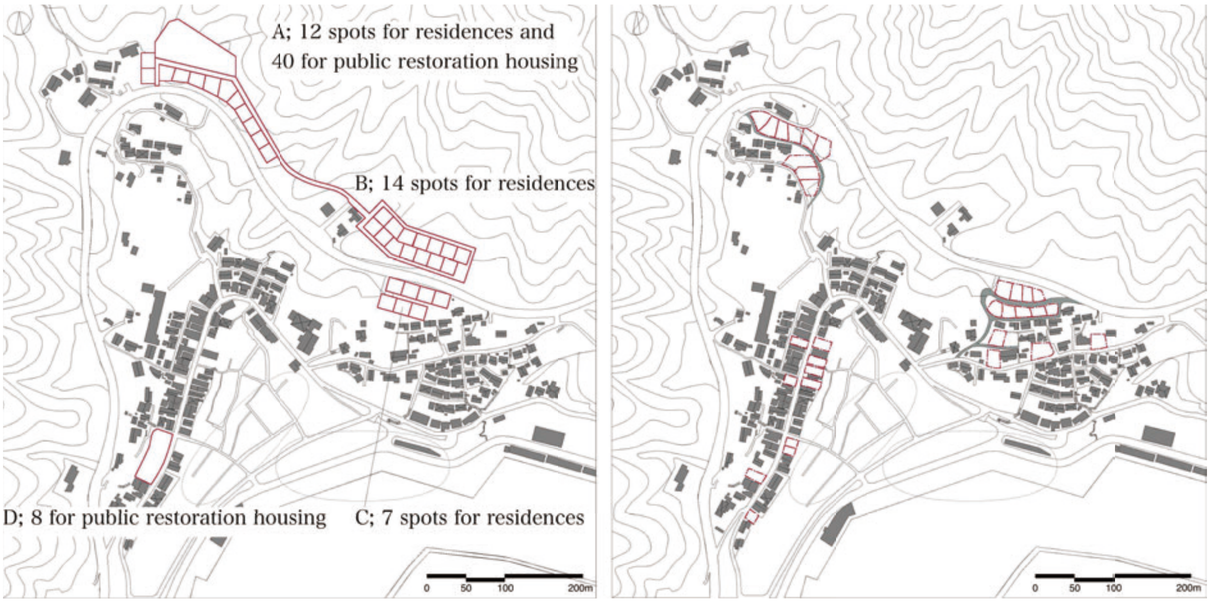

Figure 9: Traffic- based planning and village- based planning in K village

compared to the original location. A village that suffers serious damage will need large-scale maintenance because the disaster measures of the village are inadequate.

However, villages that incur minimum damage should not undergo large-scale maintenance. It is better to ensure safety through suitable land use based on restoration of the existing village. The right side of Figure 9 shows the existing village model in the fishery village (K village) under consideration. This proposal involves three steps:

1. Use of the vacant lot—except the hazardous zone— for residential purposes
2. Development of a small-scale residential area in the mountainside near the existing village
3. Formation of a network of public roads between the existing village and the new residential area

To protect the community and the regional economy, use vacant lots in the existing village is more beneficial than relocation at a height. However, in practice, planning this requires overcoming of obstacles such as land ownership issues and lack of entrepreneurship.

4. CONCLUSION

In this study, we analyzed the damages of 98 villages in the Sanriku coast. We found that in some villages about 60% or above of the housing area suffered serious damage of 60%, in others, 20% or less of the housing area was damaged. In short, we observed uneven damage to housing areas. This finding indicates that varying geographical features of the area and tsunami height influence areas differently. We also inspected village land use that contributed to mitigating the damage to housing areas, for example, communities in housing areas away from the shore and at a height were protected. We believe these plans can be applied to other areas.

The present recovery program that adopts the housing rearrangement system in Japan is an efficient disaster resistant plan. However, the existing plan may separate the community between the existing village and the new residential area, and thereby significantly change the social relationships between the villagers.

In order to maintain the social space of a village, planning needs to be based on the existing village and also ensure safety. We have thus presented the possibility of a recovery program that unifies the existing village.

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