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LOCAL COMMUNITY ACTIVITIES FOR DISASTER REDUCTION IN REGARD TO THE 2011 TSUNAMI

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Abstract

Disaster mitigation is among the most important issues the world is faced with. However, good governance at the time of mitigation needs to be combined with the presentation and analysis of scientific results with the real aim of making future activity more effective. In this study, we have analyzed factors included among the non-structural measures taken against the disaster. The differences between social activites are related to disaster mitigation in respect of the 2011 mega-tsunami. A questionnaire survey of social activities serving evacuation and disaster prevention in the southern part of the huge area of lowland in the Abukuma river basin was carried out, and differences were found between local community-level risk communication systems on each coastal landform and land use changes following the Great Eastern Japanese Earthquake and tsunami of 2011. The leadership of local community activities, presence of an evacuation system and repeated evacuation drill, knowledge sharing for prevention, good governance, hazard mapping in the local community and adequate risk communication were all found to play useful key roles in risk reduction as regards the tsunami.

Key words:
social activities • tsunami • disaster reduction • Japan

Introduction

Tsunamis comprise long-length waves generated by disturbances on the ocean floor or surface that encourage vertical displacement of the water column (McMurtry et al. 2004). As a tsunami approaches a coastline, the generated waves dump their energy and can inundate large areas, at the same time exerting sufficient impact to modify and restructure coastal landforms (Dawson 1999; Scheffers et al. 2008). On 11 March 2011, a Mega Earthquake (Mw 9.0) took place off the Pacific coast of northern Japan, giving rise to the infamous tsunami disaster. The earthquake in question occurred in a trench where the Pacific and

North American Plates meet (Meteorological Agency 2011). The coastal plain in Toholu region facing the Pacific Ocean was affected severely by the huge tsunami related to the 11 March Eastern Japan Earthquake in 2011. The maximum distance inland penetrated by the tsunami was 6 km, with an extensive area between the regions of Tohoku and Kanto experiencing the devastating effects. After the tsunami retreated, it was possible to observe how high the waters had risen in areas away from the plain, as for example along the Sanriku shoreline with its coast featuring rias. The highest point reached in these circumstances was some 38 m above the typical water leveal. The Tsunami height was not high in the coastal area itself, but local responses were of over 8 m in most severely affected areas of the coastal plain. These circumstances ensured the destruction of houses, felling of forest stands and destruction of harbor facilities and irrigation and drainage canals. The inundation area in Tohoku region extended to 561 km^2.

Umitsu and Takahashi (2011) tried to verify the direction taken by the tsunami and the flow of its waters by reference to different natural landform units and artificial landforms along the Sendai and Ishinomaki coastal plain, the basis for this work being Google Earth satellite data. In turn, Koarai et al. (2011) investigated the distribution of inundation depths relating to the tsunami, as well as the relationships as regards the destruction of buildings. In this way it was determined that buildings would typically collapse completely where the rapidly-influxing waters achieved a depth of around 3 m. Matsuta et al. (2011) prepared a disaster map for the 11 March tsunami on the scale of 1:25,000, on the basis of the interpretation of stereopaired aerial photographs taken immediately after the earthquake by the Geospatial Information Authority of Japan. This map proved useful when it came to supporting local residents in the aftermath of the tsunami. After the tsunami hit the Tohoku region, the intrusion map was published online (Haruyama 2013).

In line with information on geomorphology and disaster science taken together, we prepared a geomorphological land classification map of the lower Abukuma River with a view to discussing the spread of inundation. We further pointed out that back swamps and lowlands between sand ridges are among the main disaster target areas in the circumstances of flooding and tsunami intrusion (Taresawa & Haruyama 2013).

In Japan, there has been promotion of activity along the coasts and rivers in regard to the necessity for preventative civil engineering works to be carried out – *inter alia* involving the construction of sea walls, as well as river management in upper-stream basins. Great efforts have also been made in regard to forecasting and early warning systems, as well as flood-proofing construction to increase society's capacity to live with the prospect of natural disasters occurring, as well as to deal with the actual event. Work on sustainable land-use management, flood fighting and the creation of basins which may serve in the retention and retardation of influxes of water has also been hastened, though the overall governance in a land-use management policy that seeks to ensure disaster avoidance remains unsustainable. Hazard mapping and knowledge sharing with risk communication are the other essential issues providing for evacuations that will help people surviving in the event of a major disaster.

Risk mapping based on geomorphology was proposed by Oya and Haruyama (1987), Haruyama (1993), Haruyama et al. (1996), Haruyama and Shida (2008). The geomorphological land classification map is one of the assessment maps for risk/hazard forecasting relating to water-related disasters in Asia, maps being utilized in contemporary flood-risk zoning. Local community activity is also of cardinal importance if the worst potential impacts of natural disasters are to be avoided (Haruyama 2007; Haruyama & Mizuno 2007; Haruyama & Tsujimura 2009).

This paper seeks to discuss risk reduction in line with local community activity in the context of disaster prevention and mitigation over the 11 March tsunami. Communication is seen as one of the important risk-reduction

processes which can be employed more effectively than hitherto to ensure better outcomes as and when future disasters occur.

Methodology

The study area is concentrated in the coastal plain area around Iwanuma, Watari and Yamamoto, all falling administratively within Miyagi Prefecture and experiencing very severe effects in the circumstances of the severe tsunami induced by the mega earthquake of 11 March 2011. We first prepared a geomorphological land-classification map of our study area because landform series and landform combinations on the fluvial plain are among the signals of disaster occurrence history, as well as important key factors in mitigation (Haruyama 1993). The geomorphological land classification map is evaluated for risk mapping related to the land use map in the tsunami intrusion area, as analyzed on the basis of aerial photos (1: 20,000) as interpreted with the aid of field surveying. The research flow of this study is as follows; first, geomorphological analysis linked with land-use change in respect of the tsunami damage; and second, questionnaire surveys of local community activities and disaster prevention activities in the study area, after the surveys, assessing the physical environment for vulnerability to the disaster and anlyzing human resources for mitigation influenced by local community activities relating to disaster prevention, evacuation and recovery (Fig. 1).

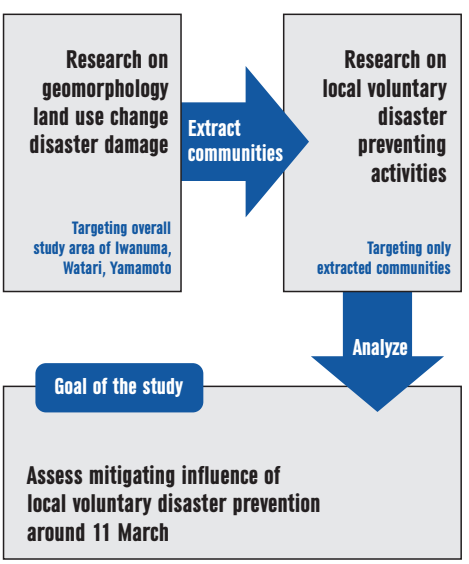

Figure 1. The flow chart for this study

Geographical setting of study area

The study area encompasses the coastal plain and the lower stretch of the River Abukuma. The administration zones are those of the city of Iwanuma and the towns of Watari and Yamamoto within Miyagi Prefecture in Tohoku region. The 2011 tsunami hit this coastal plain from east to west, eventually being brought to a stop at the boundary between the coastal lowland and the marine terraces. In some places the area inundated by the tsunami was limited by elevated highways, the railway, or geomorphological boundaries.

Different parts of the study area are assigned to four zones, as follows: 1) urban areas continuing to the extension of Sendai city, 2) rural areas earmarked for agriculture production, 3) scattered small fishing villages located along the coast, and 4) several historical 'Post Towns' settled since Mediaeval times and located along the edge of the marine terrace .

The total population belonging to the three administrations is 95,736, and the average for the ratio of the population that is elderly exceeds 24.5%, with a declining birthrate and an ageing population (Tab. 1). Three administrations began in the early Edo Period (post-1600 era), and the main city core and town cores derive from the historical center zones originating in the Edo Period. The northern part of this coastal plain has been coming under population pressure thanks to the expansion of Sendai City into satellite city areas. The city of Iwanuma is located to the south of Sendai and is a transport junction. Iwanuma

Table 1. March 2011 inundation of the study area by the tsunami

	Total area (km^2)	Flooded area (km^2)	Flooded %	Total population	Number of victims
Iwanuma	61	29	47.54	44,153	149
Watari	74	35	47.30	35,670	306
Yamamoto	64	24	37.50	17,244	633
Total	199	88	44.22	97,067	1,088

Source: Geospatial Information Authority of Japan (GSI) 2011, 2010 Census, Police Department 2011.

has 44,187 people in its role as a satellite town of Sendai, and is occupied by large commercial land uses. Watari has only small rural villages for agriculture production and fishing, and the population is in decline overall. Yamamoto town has scattered rural localities near the hillside in the west and fishing villages along the coast, and the total population here too has been declining and the ratio of elder persons is the highand ratio of elder persons over 65 years old is 31.6%.

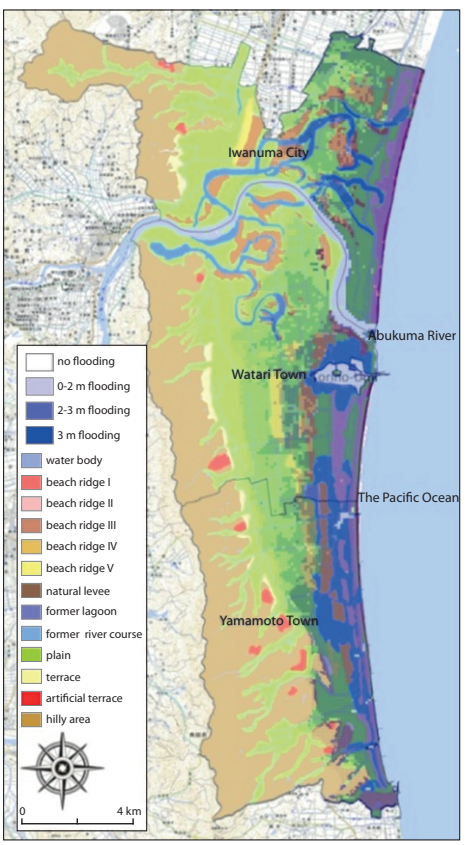

Figure 2. March 2011 Tsunami inundation zone superimposed on the geomorphological land classification map of the lower Abukuma river area

Source: based on data from Fukko-sien research team (2011).

Results

Landforms and land use within the study area

The mountain range of Abukuma features a gentle slope plus several marine terraces with dissected valley plains continuing to the coastal area. There are notably meandering river courses and natural levees with back swamps along the meandering river channels in the lower Abukuma. There are sand ridges running parallel with the coastline and these come together with a complex type in the southern part of Yamamoto. There are usually lowlands between the two sand ridges and these are former lagoons.

When the fluvial and marine geomorphology is set against the impacts of the tsunami it is seen that sand ridges along the coast, lowlands behind them and former lagoons were damaged more severely. Selected landforms are analyzed for victims (%) in the study area, and the results are presented in Table 2, along with those for a village on a landform not hit by the 11 March tsunami.

Table 2. Landforms and victims

Name of community	Population*	Main landform	Flooded (%)	Victim (%)
Tateshita	668	Natural levee	0	0.00
Ainokama	514	Beach ridges	100	8.17
Hasegama	273	Beach ridges	100	13.55
Hamayoshida-West	1,052	Former lagoon	100	12.00
1-chome	370	Natural levee	100	6.76
2-chome	185	Natural levee	100	0.54
Nakahama	1,074	Former lagoon	100	13.04

* Population data from 2010 for Iwanuma city and Watari town; from 2007 for Yamamoto town.

Land use conditions

In this study area, the northern part has urban land use relating to the expansion of the city of Sendai. However, there are also paddy fields on the fluvial lowland, as well as forest land use and orchards or gardens located at the foot of the Abukuma range and on the marine terrace in the west. The principal land uses in each grid square were selected to prepare the Iwanuma-Yamamoto land use map, which includes sand ridges facing the coastline with coastal emergency forest and small fishing villages. Natural levee zones are producing to rural cores and urban land use cores, and thus slightly elevated natural levees also make way for crop fields. The lowlands between sand ridges have usually been paddyfields, though they are now intended to remain swampland on account of their having been affected by salinity (Fig. 3).

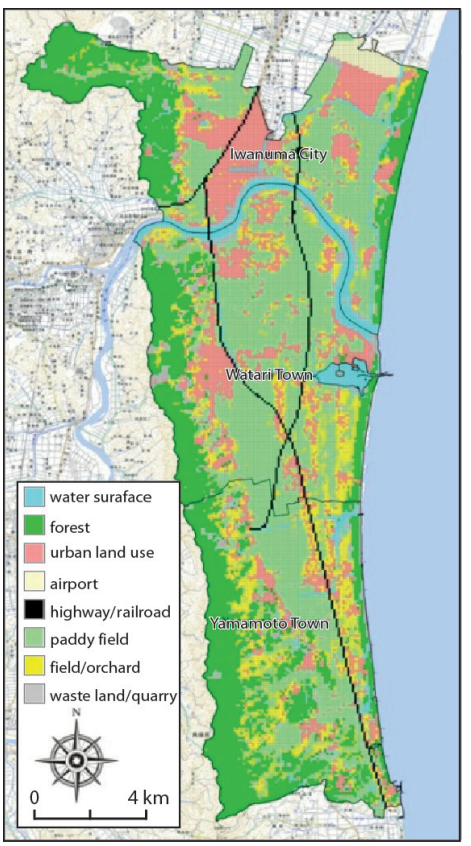

Figure 3. Land-use mesh map of Iwanuma--Yamamoto

Local activities and tsunami avoidance

There are three types of local community activity system in this study area. Disaster prevention and evacuation activities with community voluntary work involving members of each local community are analyzed following questionnaire studies, and these results are categorized as follows for dimemsion evaluation

(Fig. 5). There are different types of society, like urbanized satellite towns, traditional villages, traditional fishing villages and rural-urban mixed towns in the study area, all related with the micro-geomorphology of the fluvial-coastal plain. When the tsunami came inland in this study area, the villages and towns on the same landform types suffered different damage, because of differences in local voluntary disaster prevention (LVODP) activity. Appearing

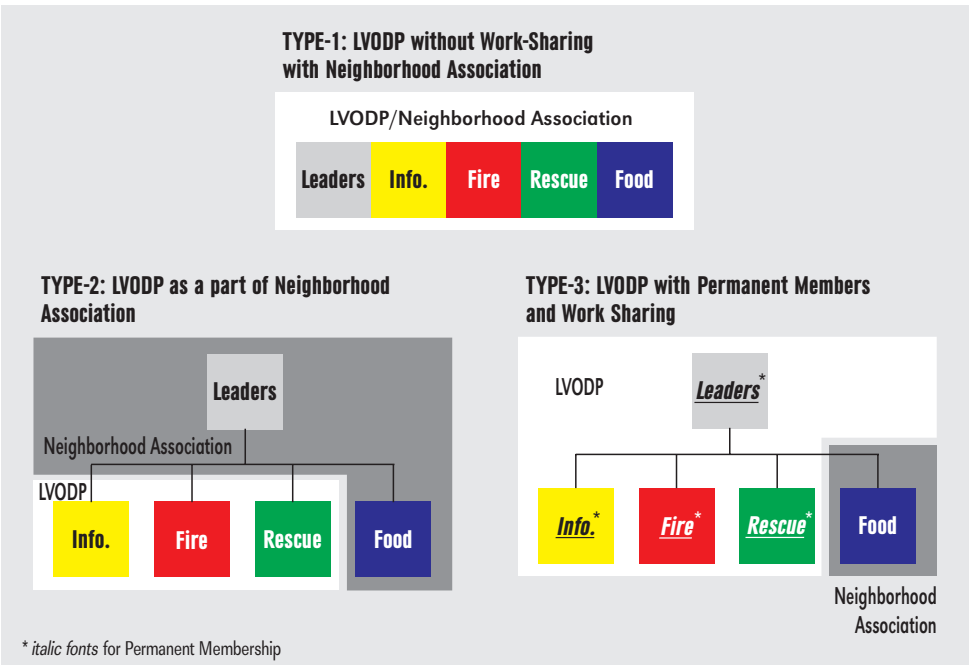

Figure 4. Local community activity types in the study area

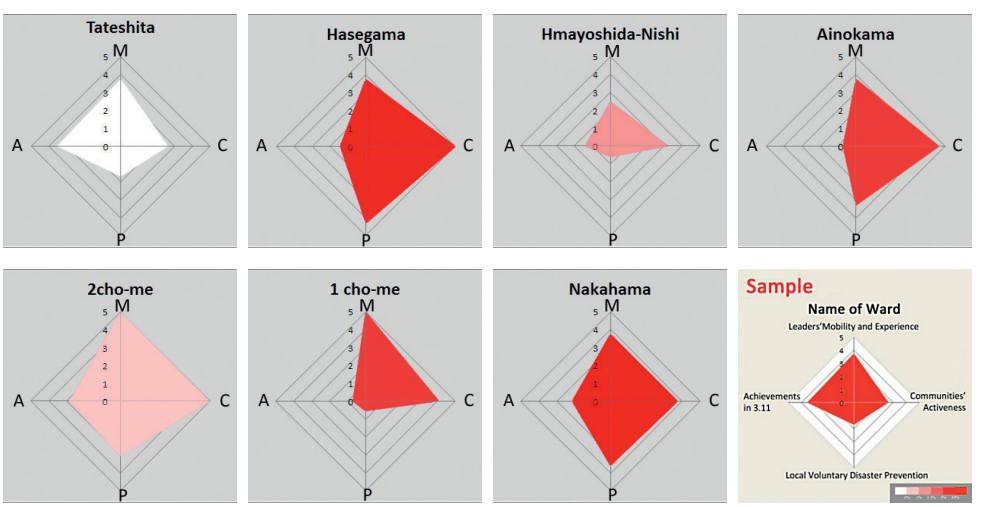

Figure 5. Selected local community activities serving in disaster prevention

first and foremost was a difference as regards the contribution to evacuations made by other communities. A farming village opened an evacuation camp in a community hall, which was managed by local volunteers.

Conclusion

The area of Iwanuma city encroached upon by the tsunami covered 29.3 km^3, while the corresponding figures for Watari and Yamamoto are of 35.6 and 24.4 km^2 respectively. This in turn denotes that 48.27% of Iwanuma was inundated, 48.63% of Watari and 37.53% of Yamamoto. The damage ratios differ from one another because of differences in the geomorphological conditions, such as sand ridges, valley plains, former lagoons, etc. The subsistence ratios for the 2011 tsunami disaster are different in each area, the highest values being the 99.66% noted for Iwanuma city, followed by 99.12% in Watari town and 96.21% in Yamamoto town. As regards micro-landforms along the shoreline, the 2m depth of limitation boundary for the tsunami intrusion is confirmed to the inland sand ridge, and natural levees located in the northern part of Watari town form another boundary. The narrow valley plain dissected on Mt. Abumuma in Yamamoto Town was also a target area for the tsunami intrusion, but the entrance on to valley plains also suffered because of the nickpoint of landforms. These micro-landforms played an important role as regards the occurrence of the disaster, though local community activities as regards disaster prevention works have also proved important in mitigation.

The geomorphological classification map for land along the river shows places vulnerable to water-related disasters in line with fluvial landform processes. These should be assessed from the point of view of future land-use planning with a view to mitigation. Other, local-community activities serving mitigation should be supported and promoted by local government in the name of future security.

Editors' note:
Unless otherwise stated, the sources of tables and figures are the author(s), on the basis of their own research.

References

Dawson A.G., 1999. *Linking tsunami deposits, submarine slides and offshore earthquakes*. Quaternary International, vol. 60, no. 1, pp. 119-126.

Fukkou-sien research team, 2011. *Reconstruction assistance. Survey archive*. http://fukkou.csis.u-tokyo.ac.jp/ [14 January 2014].

Haruyama S., 1993. *Geomorphology of the central plain of Thailand and its relationship with recent flood conditions*. Geo-Journal, vol. 31, no. 4, pp. 327-334.

Haruyama S., 2007. *Local community empowerment and security against natural disaster*. The Journal of Rural Planning, vol. 26, no. 2, pp. 105-109 [Japanese].

Haruyama S. (ed.), 2013. *Coastal geomorphology and vulnerability of disaster towards disaster risk reduction.* Tokyo: Terrapub.

Haruyama S., Mizuno S., 2007. *Disaster of 2004 Fukui flood and local prevention activities*. Natural Disaster Science, vol. 26, no. 3, pp. 307-322.

Haruyama S., Shida K., 2008. *Geomorphologic land classification map of the Mekong delta utilizing JERS-1S SAR Images*. Hydrological Processes, vol. 22, no. 9, pp. 1373-1381.

Haruyama S., Tsujimura A., 2009. *Possibility of community-based activities for disaster prevention-lesson from 2004 Toyoooka Flood.* E-Journal GEO, vol. 4, no. 1, pp. 1-20.

Haruyama S., Ohokura H., Simking T., Simking R., 1996. *Geomorphologic zoning for flood inundation using satellite data*. Geo-Journal, vol. 38, no. 3, pp. 273-278.

Koarai M., Takamoto O., Takamoto N., Izumi K., 2011. *Geographic characteristics of Tsunami flooded area by the Great East Japan Earthquake*. Geospatial Information Authority of Japan,

http://www.gsi.go.jp/common/000064460.pdf [14 January 2014].

Matsuta N., Sugito N., Goto H., Isiguro S., Nakata T., Watanabe M., Une H., Tamura T., Kumahara Y., Hori K., Hirouchi D., Umitsu M., Usui T., Suzuki Y., 2012. *Significance and background of mapping the area hit by the tsunami on March 11, 2011, Northeast Japan*. E-Journal GEO, vol. 7, no. 2, pp. 214-224.

McMurtry G., Watts P., Fryer G., Smith J.R., Imamura F. 2004. *Giant landslides, mega-tsunamis and paleo-sea level in the Hawaiian islands*. Marine Geology, vol. 203, no. 3-4, pp. 219-233.

Meteorological Agency, 2011. Tsunami Observation Information, http://www.jma.go.jp/jp/tsunami/observation_04_20110313180559.html [11 Novemeber 2011].

Oya M., Haruyama S., 1987. *Flooding and urbanization in the lowlands of Tokyo and vicinity*. Natural Disaster Science, vol. 9, no. 2, pp. 1-12.

Scheffers S., Scheffers A., Kelletat D., Bryant E.A., 2008. *The Holocene paleo-tsunami history of west Australia*. Earth and Planetary Science Letters, vol. 270, no. 1-2, pp.137-146.

Taresawa Y. Haruyama S., 2013. *Coastal Landform in the southern part of Miyagi Prefecture and 2011 Tsunami Disaster* [in:] S. Haruyama (ed.), Coastal geomorphology and vulnerability of disaster towards disaster risk reduction. Tokyo: Terrapub, pp. 87-96.

Umitsu M., 2011. *Tsunami direction in Sendai and Ishinomaki plain*. Proceedings of East Japan Mega Earthquake Symposium in a viewpoint of earth planet and human sphere, pp. 22-25.

Umitsu M., Takahashi M., 2007. *Geo-environmental features in the damages of the 2004 Indian Ocean tsunami in/around Banda Aceh, Indonesia*. E-journal GEO, vol. 2, no. 3, pp. 121-131.

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