Impacts of Topographical Features and Agricultural Landuse Practices on the Farmlands Damaged by the Mid Niigata Prefecture Earthquake

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Summary

The Mid Niigata Prefecture Earthquake (MNPE) has brought about immense damages to the Japanese traditional agricultural community. The study area is well known for its landslide vulnerability, and lies on the active fault zone that divides the Japanese Island. Study was carried out at Yamakoshi Village, an intermountain agricultural region that is situated above the fault plane. Field surveys, interpretation of high-resolution aerial photos and analysis of local topography using high-resolution DEM data were performed for the study area. Following results were obtained by investigating the relationship between local topography and agricultural landuse practices, and earthquake led damages on agricultural fields.

Damaged area is a hilly mountainous area where complex formation of small ridges and valleys are present. In such places, harnessing local topography, a traditional complex farming: arrangements of paddy terrace and carp-breeding ponds alternately or block-wise, have been adopted. Sediment disasters led by the earthquake are predominant in the area. Damages are more severe and significant at paddy terraces and carp-breeding ponds that were constructed at depression (concavity) of the valleys. The damages are further escalated by snow and snow run off that presumably occurred during the following winter after the MNPE.

In the context of local topography of the study area, agricultural lands with favorable soil and water conditions tend to have high potentiality for earthquake sufferings. Developments on agricultural landuse planning that help in bringing disaster prevention are required.

This report performs retouch and correction in the already released paper[1)] in part, and translates it into English.

Key Word: **Mid Niigata Prefecture Earthquake, Farmlands damage, Traditional landuse, Topographical feature, Sediment-related disasters**

1. Introduction

The Mid Niigata Prefecture Earthquake (MNPE), which occurred on October 23, 2004 brought about an unprecedented disaster to the agricultural fields of Chuuetsu district in Niigata prefecture. Although this region was experiencing frequent slope failures, landslides due to its topographic features and heavy snowfalls in the region, traditional agricultural practices: farming on steep slopes, development and expansion of carp breeding-ponds had been kept on going. The MNPE generated innumerable sinkings and cracks over the farmlands as well as numerous slope failures and landslides in and around the rice terraces. And it was led huge sediment-related disasters in the agricultural fields. In addition, heavy snowfalls (more than 2 meters in depth) and snow runoff soon after the earthquake also did triggered several slope failures, provoking soil erosion and soil runoff; as a result, sediment-related disasters on the farmlands have accounted further more.

This study mainly deals on the details of the catastrophic damages occurred in the agricultural fields by the MNPE. Severely damaged areas were investigated by carrying out field surveys, and by interpreting aerial photos taken soon after the MNPE. The study has also attempted to assess the influences of local topography on the complex landuse and farming practices in the region.

We tried to speculate the relationship between the local topographical features and traditional landuse practices in the region using Digital Elevation Model (DEM) and orthorectified images in Geographic Information System (GIS).

2. Study Area

The damaged area that is struck by the MNPE locates near the coastal side of the Japanese Sea (**Fig.1**). Excluding low-lying flat areas around Shinano River and Japanese Sea, most of the region consist mountainous area, with heavy snowfall in winter. Most of the damaged areas are located in the villages where traditional agriculture is prevalent. Severely damaged areas are located in the mountainous slope where rice/paddy terracing is common and widely practiced. Apart from these, several carp-breeding ponds are also located in the region, as well known for varicolored-carp culture farming.

The direct cause of the disaster on the farmlands is due to the earthquake that scaled the magnitude of 6.8 (Japan Meteorological Agency Magnitude). While examining the earthquake-damaged farmlands, we considered following three factors:

1) Influences of local topography on farmlands damages.
2) Expansion of damages by snow and snow runoff during the following winter after the MNPE.
3) Impacts of the complex landuse, coexistence of rice terracing and carp breeding-ponds, on mountainous slope.

Fig. 1 Study area

Two settlements, namely Okubo and Iketani of Yamakoshi village in Nagaoka city, were selected for the study. These settlements have a typical agricultural field and the practice in Chuuetsu district. The severe damages caused by the MNPE have forced the settlers to refuge from their homes and lands. Disaster relief works and restoration of the settlements are in progress.

3. Methods and Materials

The fundamental approach of the study is shown in **Fig. 2**.

Firstly, the detailed landuse and types of damages at every farmland plot within the study area were investigated by field survey carried out in July, 2005. In the investigation, agricultural landuse practices were categorized into three types: paddy field, upland and irrigated or carp-breeding pond. Similarly, damages were also categorized into three types: present or absent of damage, kind of damage, and grade (degree) of damage.

Secondly, an interpretation of aerial photographs was performed in order to identify the details of the type of landuse practices and damages on soon after MNPE. Therefore the aerial photographs taken in autumn 2002 and on 7th November 2004 were orthorectified using a high-resolution (20cm grids) digital elevation data (DEM), and used for identifying farmland damages and changes/alteration in the farmlands.

The results obtained from the field surveys and interpretation of orthorectified images were then

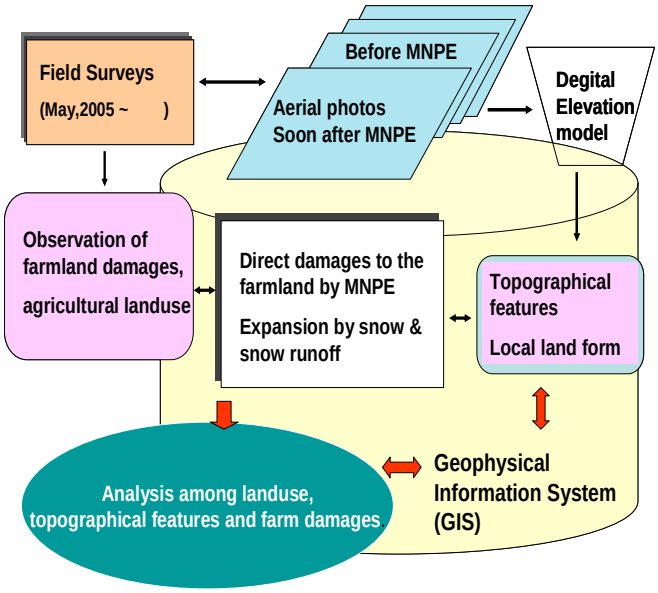

Fig. 2 Approach of the study

summarized and incorporated into the geo-database using GIS tools.

4. Results and Discussions

4.1 Formation of farmlands

The topographic features of the study area were extracted using DEM data (5m×5m grid). Each grid is classified by profile curvature and contour curvature (Troeh[2], Iwahashi et al.[3]): convex ridges; concave ridges ; convex valleys; and concave valleys were extracted for the study area (**Fig. 3**). These four topographic features were further categorized according to the slopes: gentle and steep. The spatial distribution of the topographic features of the study area is presented in **Fig. 4**. The study area has a complex topography with many undulating hills and streams.

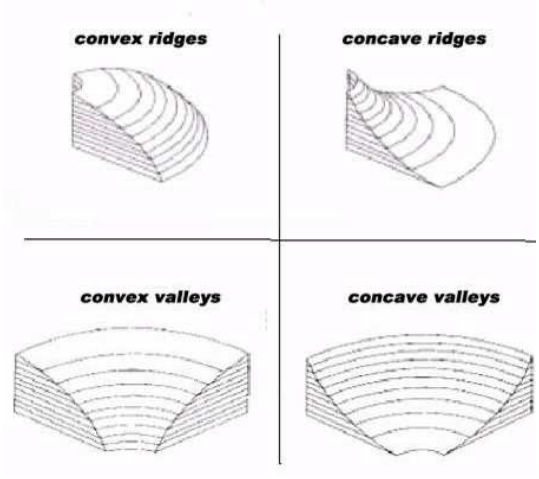

Fig. 3 Types of land form

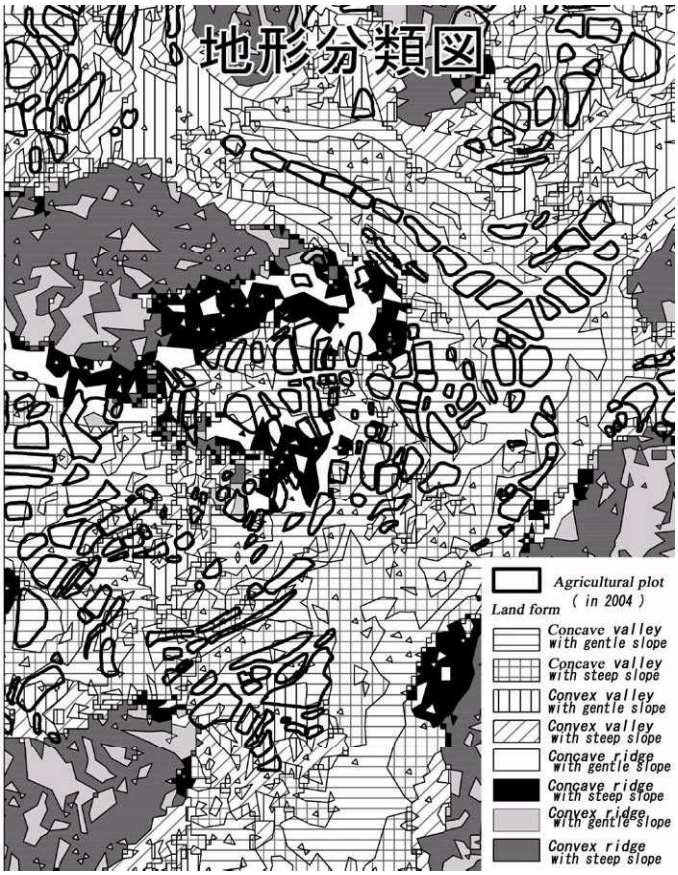

Fig. 4 Spatial distribution of topographical features

4.2 Traditional Land use

The spatial distribution of agricultural landuse in the study area is shown in **Fig. 5**. More than 600 plots of farmland are situated in the study area. The numbers of paddy plots, carp-breeding ponds and upland plots are >200, >200 and >100, respectively. The other plots cover the degraded and abandoned farmlands. The study area has comparatively many paddy fields; covering approx. 53% of the total area, whereas, carp-breeding ponds and upland cover 35% and 7% of the area, respectively. Despite of having unfavorable agricultural conditions in such mountainous areas, coverage of carp-breeding ponds is larger as one of paddy plots. Such traditional landuse and practices have been continuing since past.

Most of the farmlands are located at the concave valleys, convex valleys and convex ridges of the gentle mountain slopes. Farmlands at steep mountains are hardly located. About half of the paddy plots and breeding ponds are situated near the valleys, whereas, upland, degraded land and abandoned land are situated away from the valleys. Especially, more degraded and abandoned lands are located near the ridges or at convex contours.

Most of the paddy plots and carp-breeding ponds are constructed either alternately or by block-wise. In some cases, paddy plots and carp-breeding ponds are constructed alternately i.e., one after the other in a sequence, from ridge to valley forming a terrace landscape. In other cases, they are constructed block-wise, i.e., making blocks of paddy fields and carp-breeding ponds, separately. Carp-breeding ponds are generally located at the down stream of valleys, and only few do exist at/near the head water.

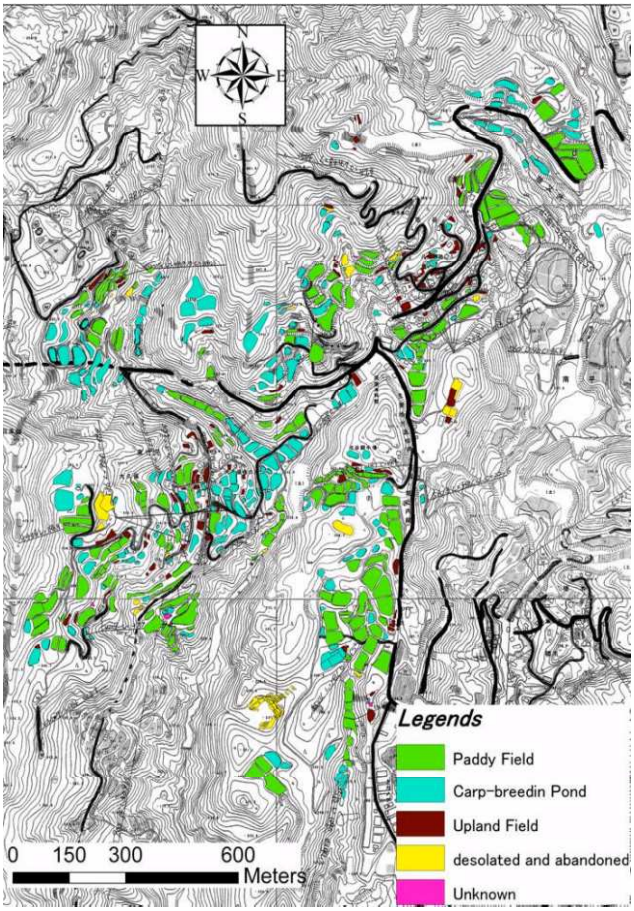

Fig. 5 Distribution of landuse in the study area

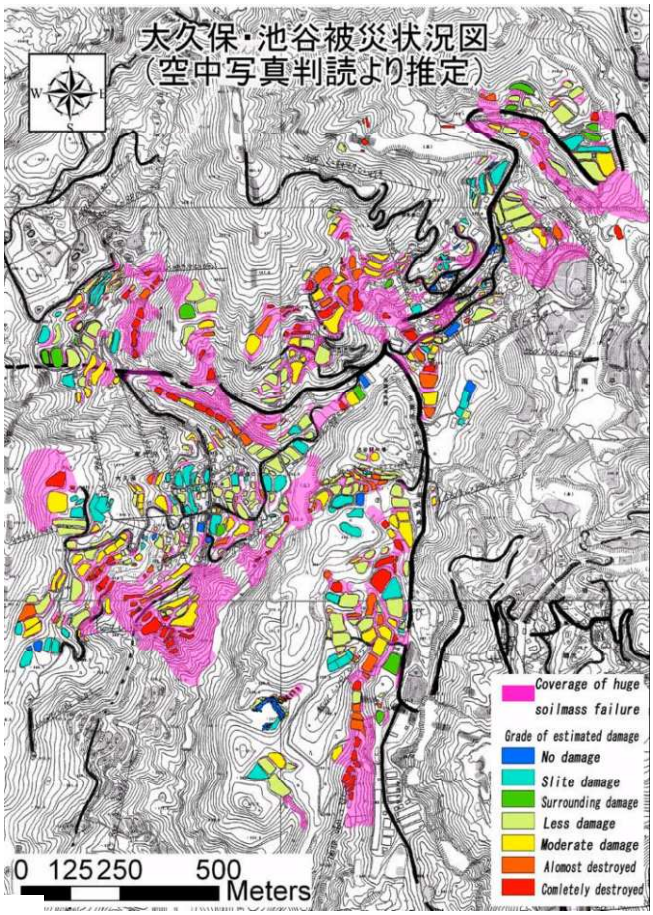

Fig.6 Distribution of estimated farm damage

4.3 Farmlands Damages soon after the MNPE

The damage to the farmlands that were estimated on soon after the MNPE from high-resolution images is shown in **Fig. 6**. In **Fig. 6**, seven types of estimated damages and coverage of huge mass failure that seemed to have attributed in the farmlands disaster, are presented.

The degree of damage (slight to less) received by the farmlands soon after the MNPE, are high in numbers as well as in areas. If the degree of damage (less to moderate) is considered, the numbers of the damaged farmlands become 306 plots, and the area becomes more than half of the total farmlands. It suggests most of the farmlands have received moderate damages. Other plots extracted as “no-damage or absent of damage” showed less average area (less standard deviation) in compare to other types of agricultural fields. From the analysis, it seems that small plot tends to have less damage.

Farmlands situated at ridges (mountain saddle) have less damage than those situated at valleys. Similarly, in compare to paddy fields and carp-breeding ponds, damages at farmlands, degraded lands and abandoned lands are small and less. Most of the scars located at valleys or at concavity near/around agricultural lands are seemed to have caused by slope failures; only few could be considered due to large-scale landslides. Those agricultural lands that were situated at valley stream/gully have highly affected by gully erosion and sediment flow of snowfall and snow runoff in the following winter.

4.4 Relationships among landform, landuse and damages

Paddy fields and carp-breeding ponds are easy to develop at valleys as soils and water facilities are rich in these areas. Contrary to those farmlands, degraded lands and abandoned arable lands are easy to develop at ridges or at convex contours, where soils are immature and water facilities are poor. However, valleys reveal better environment for paddy fields and carp-breeding ponds development, they tend to possess high and strong sediment related disaster potentiality. Specifically, valley

streams/gullies are the vitals for the sediment disasters (**Fig.7** and **Fig.8**).

The damages brought up by the MNPE have further accelerated and expanded by snow and snow runoff; most probably the paradoxical relationships between disaster prone local topography and traditional landuse practices of the region could be a vital cause for it.

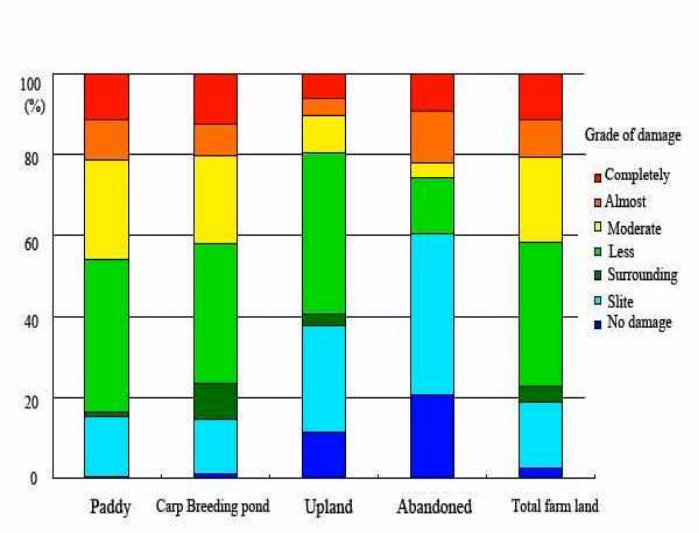

Fig.7 Relationships between farm damages and landuse

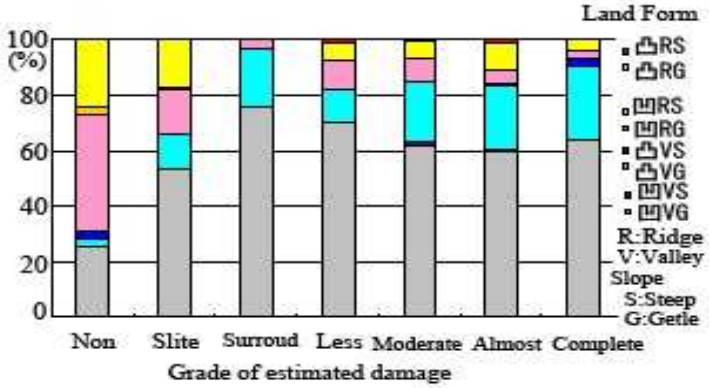

Fig.8 Relationships between farm damages and local land form

5. Conclusion

Although the study area is well known for its landslide vulnerability, rice terracing and carp-breeding have been maintained and adapted by conquering such unfavorable environments. Local techniques and know-how have always supported to bring the success in maintaining, adapting and extending traditional agricultural practices in the study area. Many hints and knowledge from these local techniques could be achieved by performing further research works on them. And adoption of these hints and knowledge into the present practices would help in seeking disaster prevention landuse practices. The results from the study suggest that the agricultural lands that bear favorable land utilization environments possess high potentiality for earthquake sufferings. Studies on developments of agricultural techniques that help in bringing disaster preventive landuse practices over unfavorable topography for agricultural landuse are imperative.

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