EVALUATION AND DETECTION OF FILLED UP INLAND WATER AREA BY COMPARISON BETWEEN OLD AND NEW TOPOGRAPHIC MAPS IN OSAKA, JAPAN

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ABSTRUCT

Many Japanese big cities are developed in the delta areas along big rivers. For the anti-flood measure, meandering river channels have been filled up and changed to straight line around those cities. Around the Seto Inland Sea areas, southwest Japan, many irrigation ponds had been constructed to make up for shortage of agricultural water in summer. But, many ponds have been filled up and shifted to other land use by the process of urbanization. Those filled up inland water area is pointed out that those are weak for liquefaction from the earthquake damages of the past. Thus, the detection of the filled up inland water area is very important to grasp the weak area for the liquefaction damages on earthquake. In this paper, the filled up inland water area in the Osaka Plain is detected with GRASS GIS System by comparison between old and new topographic maps. Those detected filled up areas are compared with land use data. As the result of the study, 24 % of the filled up areas is used for public use which will be use as evacuation area at earthquake disaster. Those maps are available for the inspection of earthquake disaster weakness.

1. INTRODUCTION

Liquefaction phenomena and its damages to building structures at earthquake is recognized at the first in the 1964 Niigata Earthquake (Seed and Idriss, 1982). Many liquefaction damages are reported at the large magnitude earthquakes. In the 1995 Hyogoken-Nanbu (Kobe) Earthquake, the reclaimed land along the coastal area between Kobe and Osaka was widely screwed with liquefaction phenomena. Not only that, liquefaction was occurred in the inland area between Kobe and Osaka at this earthquake. Most of these inland areas are located in the filled up ponds and old channels(Mitamura, 1996). In many cases of the earthquake disasters, the artificial ground such as coastal reclaimed land and filled up inland water areas are pointed vulnerability to the liquefaction (Sasaki *et al*., 1981, Kamai and Shuzui, 2002; Kubota, 2003).

The liquefaction intensity of the ground material has been studied in detail and concrete with the geotechnical method by many researchers (Ishihara *et al*., 1980; Seed and Idriss, 1982; Zen and Yamazaki, 1990; etc.). Those geotechnical methods can clarify the liquefaction properties of the ground material with drilling data and dynamic test data. But, the information on the geotechnical properties of ground material is not evenly and widely distributed in the urbanized area and its surroundings. The evaluation on the distribution of the liquefaction fragility is very important to the impairment of the earthquake disaster. Many examples of the former earthquake disasters suggest that the artificial ground is very weak to the liquefaction. Therefore, for special distribution on the liquefaction fragility area, it is important to pick up the artificial ground such as filled up ponds and channels.

The Osaka Plain is located in the eastern side of the Seto Inland Sea area. In this area, precipitation is small at the busy faming season. Many irrigation ponds had been constructed for the reserve of irrigation water (Hamashima, 1994). But, most of these ponds has been filled up by the residential development. Many filled up inland water area is located in the Osaka Plain and surrounding area. Little attention has been given to the detection of the filled up inland water areas. In this paper, we reported the detection of the filled up inland water areas in the Osaka Plain with GRASS GIS System by the comparison between old and new topographic maps (Figure 1).

2. TOPOGRAPHY AND OUTLINE OF URBANIZATION

The Osaka Plain is formed in the deltaic low land at the river mouth of the Yodo and Yamato Rivers. In the central part of the Osaka Plain, the urbanized area of Osaka City is developed. The hilly areas are widely distributed in the northern and southern side of the Osaka Plain. The residential areas are located in the surrounding hilly areas. The Osaka Plain is located in the Osaka sedimentary basin which is active subsiding area during the Quaternary. Several active faults run along the boundary between low lands and mountains. The unconsolidated Quaternary formations of over 1000m thick fill up the Osaka sedimentary basin (Itihara, 1993). Many irrigation ponds and small channels are still remains in the low land areas and the margins of the hilly areas.

The Osaka as urbanized area has been developed since about 400 years ago. In the Edo Era (1603-1867), land reclamation at the river mouth and the dredging along the Yodo River were carried out for the farmland development and the maintenance of transportation by water. Those constructions were carried out by almost human power. Since the Meiji Era (1868-1912), when construction machines have been innovated to civil engineering works, harbor and river bank were improved in Osaka. After the World War II, Urban area has been expanded to the surrounding area. Especially, The hilly areas, such as Senri Hills (northern part) and Sennan-Senpoku Hills (southern part), where consist of the Plio-Pleistocene soft deposits, has been the development region as residential town.

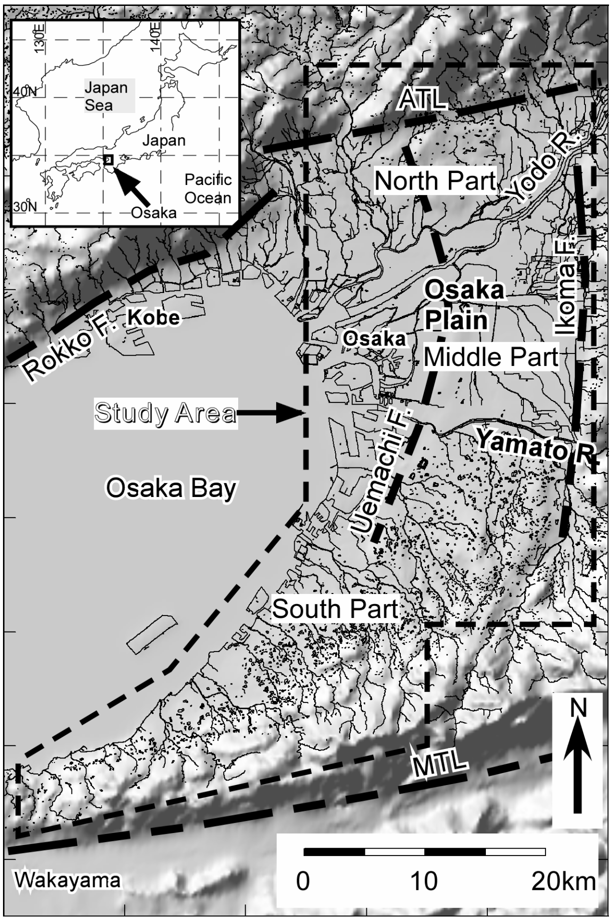

Figure 1. Location map of the study area.

3. METHODLOGY

At the fore past earthquake disasters, many liquefaction sites were located in the artificial ground, such as reclaimed area, filled pond, filled channel (Mitamura, 1996; Kubota,2003). Those sites has been almost reclaimed and filled up since the Meiji Era when the mechanization in civil engineering made progress at a fast clip in Japan. The first topographic maps by triangular surveying have been made since the Meiji Era (JGSI, 1970).

Thus, we can pick out the filled up inland water areas by the comparison between old and new topographic maps.

We use the 1/20,000 topographic maps, authorized from 1908 to 1914 by the now-defunct imperial army, as the base map. At first, we compared between the Meiji base maps and the current topographic maps with as follows.

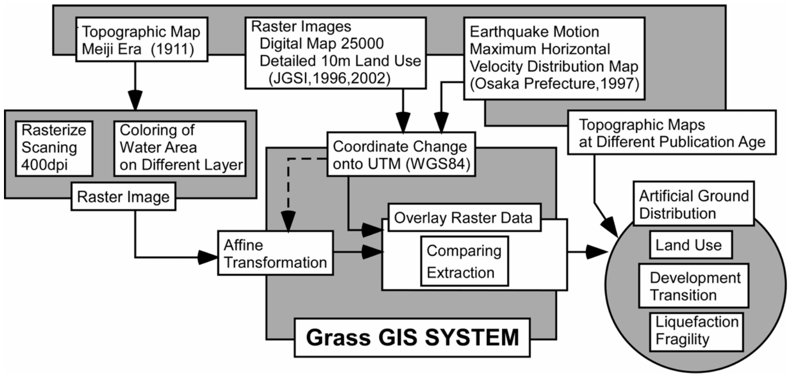

Figure 2. Flowchart of the operation on the detection of artificial ground.

The areas of irrigation ponds and river channels were picked up with coloring on different layers in the Raster images of the Meiji base maps, scanned on 400 dpi resolution. The Meiji maps, made with the polyconic projection governed by Bessel ellipsoid, are not able to be directly overlapped on the current map data made with Universal Transverse Mercator(UTM) projection on the WGS84 ellipsoid. After import of the images to the GRASS GIS System, the raster images of the Meiji maps were warped on the current UTM coordinate by the one-dimensional Affine transformation with more than 6 geo-reference points on the Meiji maps in the GRASS GIS system(US Army Corp. of Engineers, 1993). Those raster images were fit into 39±16m of RMS error which is mainly concerned with accuracy of topographic survey, contraction of map paper, etc. The current map UTM images are rasterized and converted from waterside line data in digital map 25000 (spatial data framework) made by Japanese Geographical Survey Institute. The calibrated images are compared with each other, and the filled up inland water area are picked up in the GRASS GIS system. The filled up inland water area are evaluated formation age and land usages with different stage maps from Meiji Era to recent and raster images of detailed digital information (10m grid land use ; JSGI, 1996).

4. DISTRIBUTION OF FILLED UP INLAND WATER AREA

The total area of the filled up inland water area and coastal reclaimed area is 7567 ha in the Osaka Plain and the surrounding area. Figure 3 shows the example of the distribution of the filled up water areas. In the middle part of the Osaka Plain between the Yodo and Yamato Rivers, there is the largest areas of the filled up inland water (1092 ha), most of which consists of filled up old river channels and canals (854 ha). In the southern part, south side of the Yamato River, where hilly area is widely distributed, there are many irrigation ponds still now. The filled up inland water area also covers the largest space in this part (757 ha).

The middle part of the Osaka Plain where is formed by the migration of the delta of the Yodo and Yamato Rivers. Thus, naturally, the many small channels were distributed and many canals were constructed for irrigation to the rice paddy fields in this plain. In the southern and northern part of the Osaka Plain, many irrigation pond which are banked up small valleys in the hilly area, were constructed at the margin of the hill. The expansion of urbanized area to the surrounding area of the Osaka City located in the central part of the Osaka Plain, made the shift form paddy fields to residential and industrial area. The water demand for irrigation is decrease due to land usage change. Therefore, irrigation ponds and canals for water supply have been filled up and changed land usage. The rate of the filled up inland water area is 35% of the total area of pond and channels at the Meiji Era. The coastal

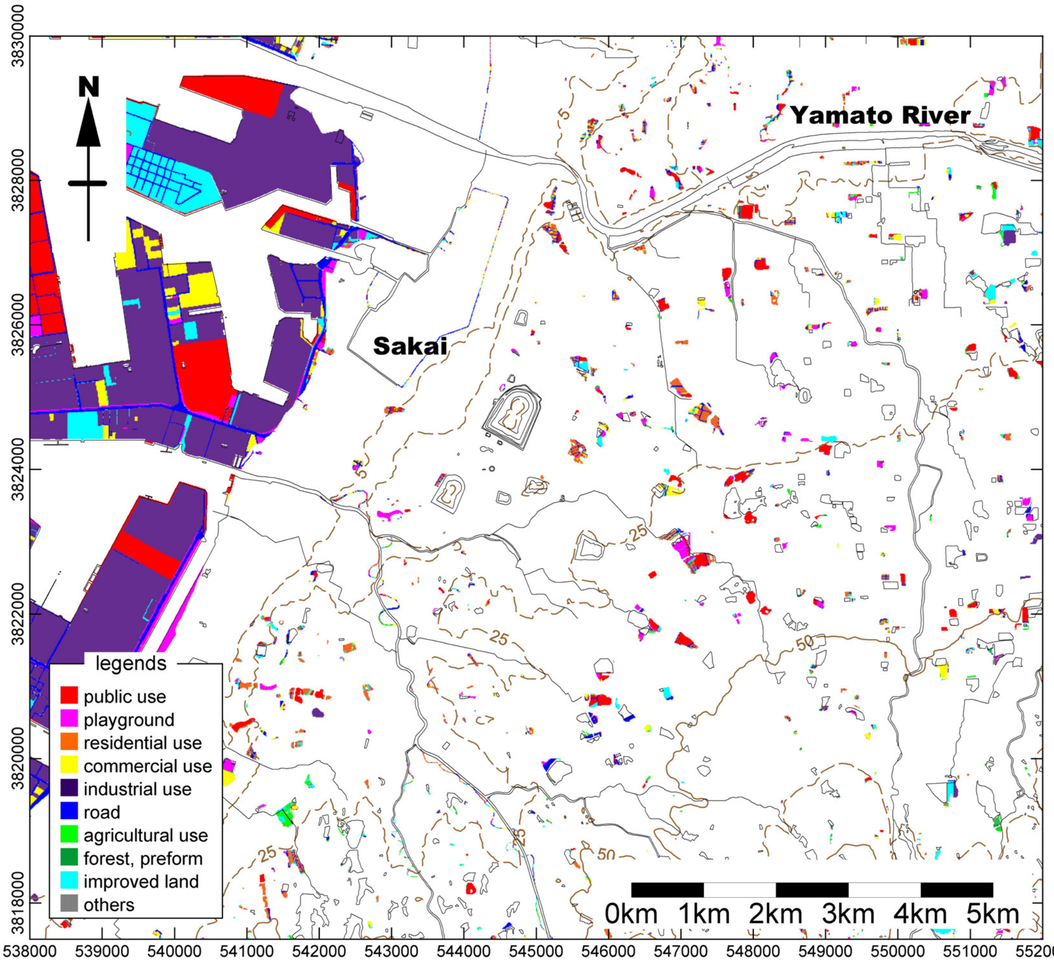

Figure 3. An examples of the distribution filled up inland water areas and coastal reclaimed land and its land usage in Sakai area (southern part of the Osaka Plain).

reclaimed area is 1.8 times to the total area of the filled up inland area in the study area.

We traced the transition of the filling of inland water area in Senboku and Minami-Kawachi areas where is in the middle and southern part of the Osaka Plain by comparison of maps produced at each stage. The developing of residential area until 1980 had the effect on decreasing of rice paddy fields. Around the same time, water area has been filled up and reclaimed (Figure 4).

5. USAGE OF FILLED UP INLAND WATER AREA

The irrigation ponds which have no supply to the rice paddy after the surrounding development treat as idled area. Usually, those irrigation ponds are attached to water utilization association. Thus, those filled up areas are turned to public space, such as playground, school, community center, etc (Figure 3). Areas with warm colors in Figure 3 show these public usage and residence. Many sites are using these applications.

The residential usage in the filled up inland water area accounts about 20% (Figure 5). The total of the playground and public facility in each region also exceed 20%. In the coastal reclaimed land, the industrial usage comes up to 40%. Those artificial grounds are fragile to the liquefaction at earthquake. Therefore, these maps on distribution and land usage of the filled up and reclaimed area are informative plats concerning with the hazard on earthquake.

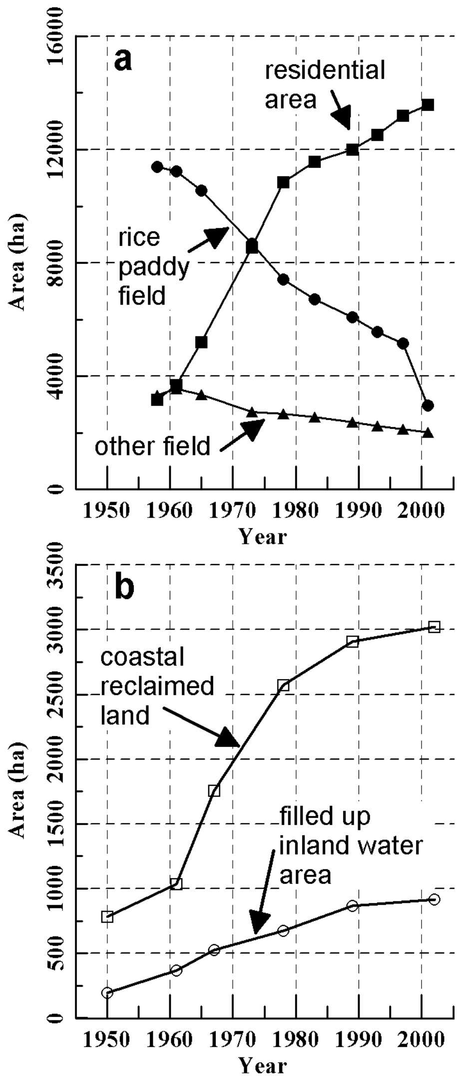

Figure 4. Transition of land usage and development of artificial ground. (a): land usage, (b) artificial ground.

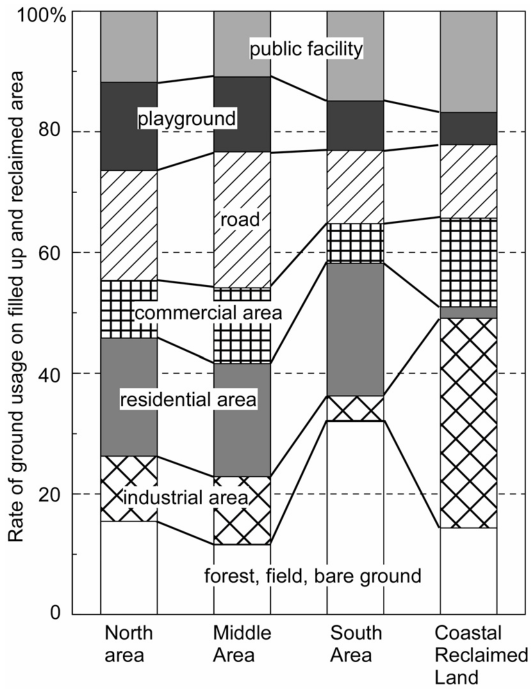

Figure 5. Rate of land use on filled up inland water area and coastal reclaimed land in regional division of the Osaka Plain.

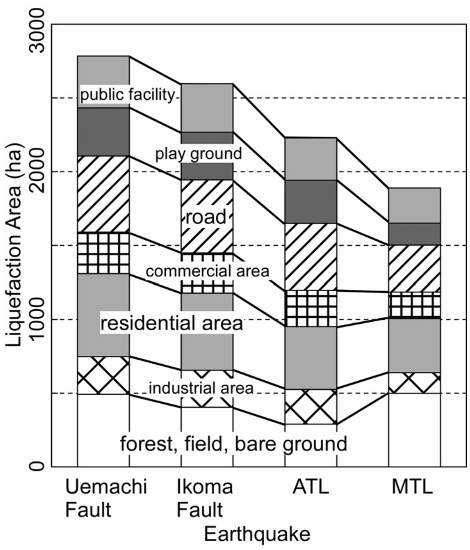

Figure 6. Land usage rate of the prospective liquefaction area on each earthquake scenario

As the preliminary application of thematic map, we tried to make liquefaction hazard maps of the artificial ground on several earthquake scenarios in the Osaka Plain. Matsuoka *et al.* (1993) suggested that Reclaimed land and fill up inland water area is occurred liquefaction with over 20 cm/sec of maximum horizontal earthquake motion. In the Osaka Plain, Osaka Prefecture (1997) has made the analysis of the earthquake motion on the scenarios along the

Uemachi Fault, Ikoma Fault, Arima-Takatsuki Tectonic Line (ATL), Median Tectonic Line (MTL), and made the distribution map of maximum horizontal velocity of earthquake motion in the Osaka Plain. We picked up the liquefaction area on the artificial ground with those earthquake motion maps and the discriminate parameter.

Figure 6 shows the land usage rate of the prospective liquefaction area on each earthquake scenario. The ground strong motion on the Uemachi and Ikoma Fault scenario which epicenter are located in the middle part of the Osaka Plain is distributed larger than the ATL and MTL scenario. Thus, the total liquefaction area is reflected in the distribution of strong motion. The rate of the area damage by liquefaction is similar on each earthquake scenario. The damages of public and residential use account the high rate (total rate: 40-50%). Those places will be use as the temporary emergency evacuation area at the earthquake disaster. But, many those public facilities are constructed in the filled up inland water area. The artificial ground will be able to make damages to those public facilities with liquefaction. Therefore, those public facilities on the filled up inland water area need to check up on earthquake strong motion.

6. CONCLUSION

The artificial ground such as filled up inland water area and coastal reclaimed land in the Osaka Plain and the surrounding area is detected by the comparison between old and new topographic maps with GRASS GIS System. Additionally, land usage on the artificial ground and liquefaction fragility is also picked up with overlay of the land use data and predicted earthquake ground motion data. Artificial ground has been rapidly developed along with expand of the urbanization in the Osaka Plain since 1950's. At that time, meandering rivers were remade to rectilinear channels, and inland water areas were also filled up on residential development. More than 20% of artificial ground is using as public usage such as community center, public school, playground where will be turned to emergency evacuation area at earthquake disaster. Those places need to the evaluation of seismic capacity. The thematic map on the artificial ground can inform the liquefaction fragility area and its land usage.

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