

## Investigation of the Collapsed Lands Under the Sea Based on Cadastral and Topographic Survey

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### Abstract

Lands along the coast may be submerged in high water because of erosion by sea water, collapsing by itself, excavation by animals, and by tidal movement. From a cadastral point of view, some mistakes in registering a parcel located along the coast may cause the parcel to seem to be collapsed. Therefore, geological, physical oceanographic, and cadastral and topographic investigation are necessary to verify that the submerged land in high water collapsed after it was registered. This paper presents a cadastral and topographic investigation for proving a parcel has collapsed under the sea after registered. In this study, cadastral records and the boundary on cadastral maps were examined carefully to find any errors in them. If the topographic maps were drawn when the parcel was registered, it is good proof of topography of the land at that time. Topographic maps drawn recently were compared to those in the 1900s and in 1970s. In conclusion, cadastral records and maps as well as topographic maps play an important role in proving whether lands along the coast were collapsed or not.

*Keywords* : Collapsed Lands, Cadastral Record, Cadastral Map, Topographic Map

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### 1. Introduction

A parcel registered on the cadastre is called collapsed if it is submerged under the sea surface in high water. Lands along the coast may be submerged in high water because of erosion by sea water, collapsing by itself, excavation by animals, and by tidal movements. From a cadastral point of view, some mistakes in registering a parcel located along the coast may cause the parcel to seem to be collapsed. Therefore, geological, physical oceanographic, and cadastral and topographic investigation are necessary to verify that the submerged land in high water collapsed after registered.

River and sea belong to the government by law. When a parcel of land collapses under the water by any reason, and it was impossible to restore it, the government should erase the registration of the parcel (article 14, the Enforcement Ordinance of the Cadastral Law). Therefore, if some (or whole) parts of a parcel collapses by any reason under the water and the owner

couldn't restore it within a given period, the owner could not exercise his right on the parts of the parcel. Nowadays, the value of land along the coast in some regions is rising high. Moreover, there are no technical problems about restoration of collapsed land thanks to the developed civil engineering. These are the good reasons for the owner of collapsed land to demand the government to restore the right to it.

The Law of Public Water Surface Management was revised on February 8, 1999. According to the revised law, Ministry of Marine Affairs and Fisheries (MMAF), Korea, could permit the owner the restoration of the collapsed parcel if it is verified that the parcel collapsed after registered as well as if the value of restored land exceeds the cost of restoration. MMAF, Korea, designated 7 institutes including Kunsan National University (KNU) to investigate whether the parcel collapsed after registered. The Center for Investigation of Collapsed Land (CICL), KNU, has participated in the investigation of several parcels located in Seosan, Dangjin, Gunsan, and Busan. As a result

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of cadastral, topographic, geological, and oceanographic investigation, CIL, KNU concluded that some of them had collapsed after registered, and the remainder of them were not.

In this paper, typical examples of cadastral and topographic investigations for proving collapsed land are presented. As mentioned above, some mistakes in registering a parcel located along the coast as a new parcel or changing the registration of the parcel may cause the parcel to seem to be collapsed under the sea. The boundary lines, areas of each parcel on cadastral maps and cadastral records, were investigated carefully to find any errors in them. Old topographic maps are good proof of the topography of land at that time when the parcel was surveyed for registration. In this study, topographic maps surveyed recently were compared to those surveyed in 1900s and in 1970s.

## 2. The Cadastre and Map in Korea

### 2.1 The Cadastre and Topographic Map in 1910s

#### 2.1.1 The Cadastre

There were a lot of problems in land systems in the Chosun Dynasty (1392-1910). The problems included troubles of ownership between the owner and tenant farmer of the land. Because modern surveying hadn't been done, they didn't have modern cadastral systems defining area, boundary, lot number, and owner.

The Japanese Government-General of Chosun proclaimed "the Law for Land Investigation of Chosun" in 1912. It consisted of cadastral survey, land value investigation, and topographic survey.

In the cadastral survey, lot number, land use category, boundary, area, and owner of the parcel were investigated in order to establish land ownership. As a result of the work, the Land Cadastre (cadastral records and cadastral maps) were completed all over the country from 1910 to 1918. Also, the Forest & Mountain Cadastre were also completed from 1916 to 1924 (Lee, 1999).

There are two cadastral maps, Land Cadastral Map and Forest & Mountain Cadastral Map, in Korea. While the Land Cadastral Maps are drawn to scales of 1:500, 1:600, 1:1,000, 1:1,200, 1:2,400, the Forest & Mountain Cadastral Maps are drawn to scales of 1:3,000, 1:6,000. Especially, the lot number of the parcels drawn on Forest & Mountain Cadastral Map has a special code "San" before the integer number.

#### 2.1.2 Topographic Map

Japanese made two kinds of topographic maps in 1910s. They are classified into the Military Secret Map and the National Base Map. The Military Secret Maps for major regions of the Korean Peninsula were made at a scale of 1:50,000 (Grid N15'×E10') by naked eye observations and hand sketches from 1894 to 1906 (Nam, 1996).

The establishment of geodetic control networks, baseline measurements, arrangement of triangulations and level networks was completed all over the country from 1910 to 1918. During the period, 400 first-order, 2401 second-order, and 31,646 third-order; in total 34,447 triangulation stations were completely established. Also, five tidal stations were established in major ports around the coast of the Korean Peninsula. The Mean Sea Level was determined based on that tidal observation data. Then, leveling for some parts of the country was carried out referenced to the Mean Sea Level.

On the basis of these results, topographic surveying was carried out using plane tables, and the National Base Maps at a scale of 1:50,000 (Grid N15'×E10', 722 sheets) were produced from 1914 to 1918 (The Korean National Committee for IUGG, 1987).

### 2.2 The Cadastre and Map after 1945

During the confusion of the Korean War from 1950 to 1953, most of the triangulation stations and leveling benchmarks had been spoiled or destroyed. The government of Korea began to replant triangulation stations and benchmarks at the original sites or nearby in 1957. Then, triangulation and leveling observations were performed.

Also, many cadastral records and cadastral maps were lost during the Korean War. The lost cadastral records and cadastral maps were restored based on on-site surveys and fact-finding of the lands. When Korea became an information-oriented society, computerization of cadastral records and cadastral maps began in 1977 (Kang, 1994). Nowadays, most of the cadastral records and cadastral maps in Korea are managed and served in digital form.

On the other hand, the application of aerial survey has been schemed for the mapping and various inventory works of national resources on the basis of "Korea - The Netherlands Joint Project for Aerial Survey" in 1965. The production of National Base Map at a scale of 1:25,000 (Grid N7.5'×E7.5') and 1:50,000 (Grid N15'×E15') were completed by aerial survey in

1974. National Geography Institute (NGI) started to convert paper maps into digital maps in 1993 (Kim, 1994). Topographic maps of all over the country at a scale of 1:25,000 and 1:5,000 are served in digital form in Korea.

### **3. Investigation of the Cadastral Data**

#### **3.1 Check Points of the Cadastre**

According to the Cadastral Law (No. 4869), Korea, all parcels of land should be registered on the Land Registre, and all parcels of forest & mountain should be registered on the Forest & Mountain Registre. A Land Registre consists of the Land Cadastral Records and the Land Cadastral Maps. A Forest & Mountain Register consists of the Forest & Mountain Cadastral Records and the Forest & Mountain Cadastral Maps.

The cadastral records contain address, lot number, land use category, area, owner, and rank of the land value. On the other hand, a cadastral map is a vector map drawn on a paper. It gives us graphical information on the location and figure of the parcel. For proving a parcel collapsed under the water based on the cadastre, it is necessary to investigate that the parcel was registered correctly the first time, and renewed whenever the parcel was merged with neighborhood parcels or divided into smaller parts. Below are the check points of the cadastral records and cadastral map based on Cadastral Law (No. 4869) in Korea.

##### **3.1.1 Lot Number**

- Lot number is an integer or a couple of integers connected by "-". The first part is called the principle number, and the second part is called the vice number.
- When a new parcel is registered, its principle number is taken from a principle number of the neighboring parcel. The vice number follows the last vice number of the neighboring parcel. When a parcel registered on the Forest & Mountain Registre is transferred to the Land Registre, it is registered as a new parcel.
- When a parcel is divided into several parts of parcel, a part parcel has its original parcel's lot number. Lot numbers of the reminder part parcels consists of the principle number and the vice number. In this case, the principle number comes from the original parcel's and the vice number is given sequentially.

##### **3.1.2 Land Use Category**

- Each parcel has a categorical name based on its land use.
- According to Article 6, Cadastral Law, Korea, there are 24 land use categories including arable land, paddy field, orchard, pasture, forest and mountain, house site, school site, road, hybrid land, barren tract, tideland, etc.
- While barren tracts and tideland belong to forest and mountain, reed fields belong to hybrid land.

#### **3.2 Check Points of Cadastral Map**

##### **3.2.1 Boundary Delineation**

- In cadastral maps, boundary means the location and figure of a parcel.
- When the boundary between neighboring parcels is obscure in site, the boundary drawn on the cadastral map has priority over everything.
- When there are height differences between neighboring features, the boundary is the lower edge of the feature.
- When a parcel borders the sea, its boundary is at Approximate Highest High Water Level (AHHW). When a parcel borders a reservoir, its boundary is at full water level.

##### **3.2.2 Area Measurement**

- In the cadastre, area of a parcel means the area projected on the reference level plane.
- When the cadastral map is drawn by plane table surveying, the area is measured on the cadastral map with a planimeter.
- When a parcel is divided into several parcels, the difference between the area of a parcel before dividing and the summarized area of each divided parcel should be smaller than the allowable error of area,  $A = 0.0262M\sqrt{F}$ . Here, M is denominator of cadastral map scale. F is measured area.
- When a parcel drawn on the Forest & Mountain Cadastral Map is transferred to Land Cadastral Map, the difference between area measured on Land Cadastral Map and area measured on the Forest & Mountain Cadastral Map should be smaller than the allowable error of area, A.

### **4. Case Study**

As the land value grows and construction technology improves, the owners who think their land collapsed under the sea have asked for the government to permit them to restore the land into the original state. It is very

hard to find proof that the land collapsed under the sea after registered. In this study, investigation based on cadastral and topographic survey is introduced and discussed. Here are two case studies.

4.1 Case I

A parcel located at San 2-5, Bokun-Li, Songak-Myoun, Dangjin-Gun, Chungcheongnam-Do was investigated to verify that the whole of the parcel had collapsed after it had been registered (CICL, 2001a).

This parcel is located in the west end of Jeil Farm Dike along the south coast of Asan Bay. The overall geographical characteristic of the region is a Rias coast formed by geological subsidence over a long time. But, the upper part of Asan Bay has been rising up since Sabkyo Dike and Asan Dike were constructed.

4.1.1 Investigation of the Cadastral Record

The key points of the cadastral records are as follows.

- Original Register : exists
- Date of First Registration : May 25<sup>th</sup>, 1918
- Original Lot Number : San 2, Bokun-Li,
- Land Use Category : Forest & Mountain
- Original Ownership : Nation
- Area on the Cadastral Records : 8,406m<sup>2</sup>

The ownership of the parcel belonged to the nation

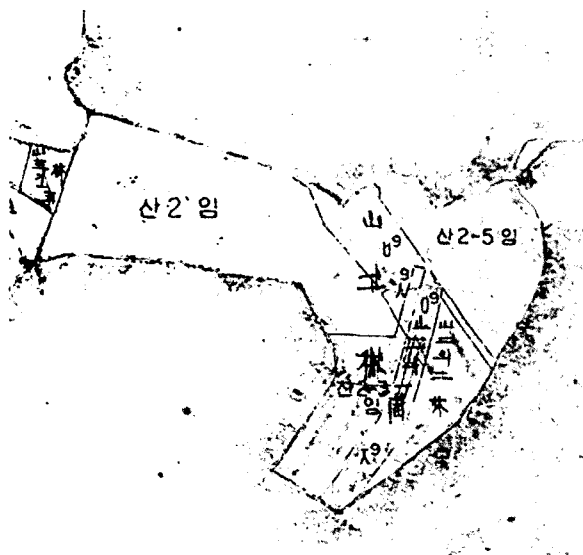


Fig. 1. Forest & Mountain Cadastral Map (1:6,000).

at first. It was transferred to a private person in 1931. Finally, his grandson received the ownership by inheritance in 1995.

Because the Jeil Farm Dike passes through the parcel "San 2", the parcel was divided into "San 2", "San 2-4", "San 2-5" in 1993. Judging based on the Cadastral Record, there are no doubtable errors that the parcel collapsed under the sea in high water.

4.1.2 Investigation of the Cadastral Map

Because the land use category of the parcel was Forest & Mountain, the boundary of parcel was drawn on a scale of 1:6,000. Up to now, the original parcel "San 2" was divided into parts several times. Therefore the cadastral map has had many lines added on it (Fig. 1).

Searching for any errors on cadastral map, the boundaries of the parcel on Land Cadastral Map were compared to that of the Forest & Mountain Cadastral Map by overlapping. In case the two maps were drawn at the different scale, we have to coincide the scale of two maps. Moreover, a minimum of two reference points, control points or intersection points of grid, should be identified in each map. If there are not control points and intersection points of grid, intersection points of distinct feature, for example crossroads, can be used as substitutes for the reference points.

Because the scale of the Forest & Mountain Cadastral Map (1:6,000) was smaller than that of the Land Cadastral Map (1:1,200), the Forest & Mountain Cadastral Map (scale 1:6,000) was enlarged 5 times. Then, the two cadastral maps were overlapped based on the boundary and intersection points of road, paddy field, and arable land. As shown in Fig. 2, there are small slivers and overlaps along the boundary. However, overall boundary pattern of the parcels were matched throughout the cadastral map.

The areas of parcels measured on Forest & Mountain Cadastral Map by digital planimeter was not equal to that of the Cadastral Record. However, the differences of areas between them were smaller than the allowable error (Table 1).

Table 1. Areas of the Parcel (San-2) in the Cadastre.

Lot Number	Area (M <sup>2</sup> )			
	Cadastral Record (1)	Cadastral Map (2)	Error (2)-(1)	Allowable Error
San 2	43,041	42,495	546	658
San 2-5	8,406	8,131	275	291

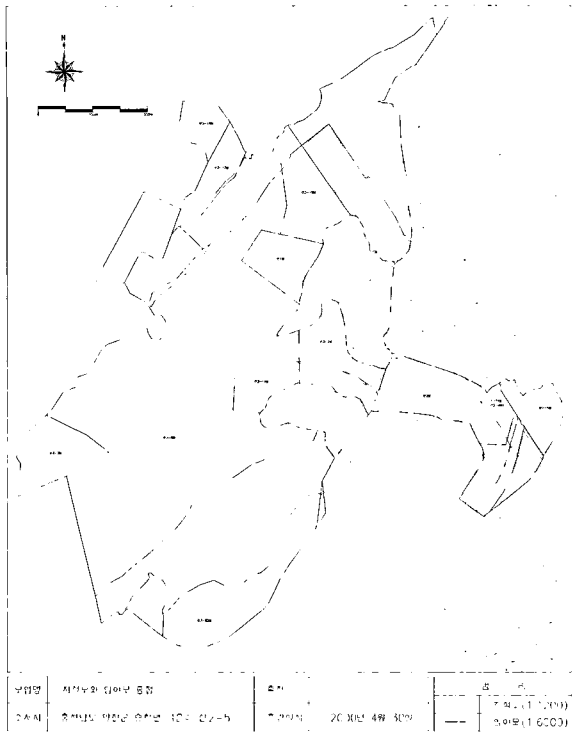


Fig. 2. The Forest & Mountain Cadastral Map overlaid with Land Cadastral Map(1:1,200).

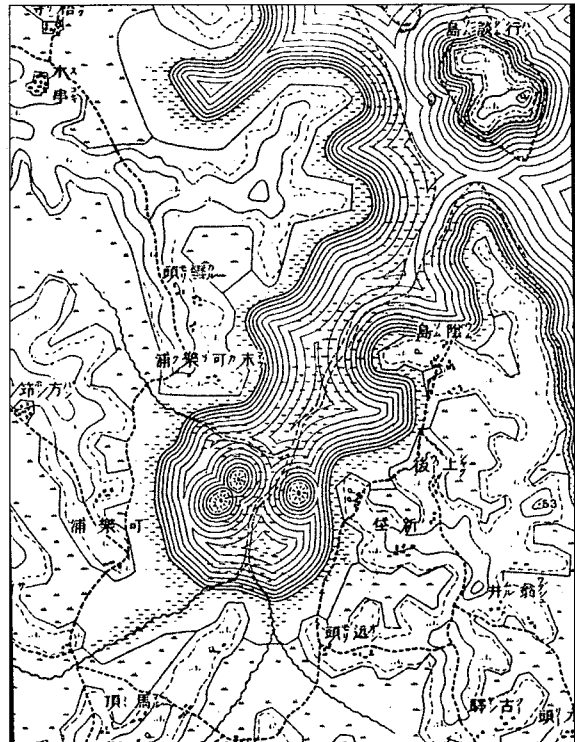


Fig. 3. Military Secret Map(1:50,000) in 1910s.

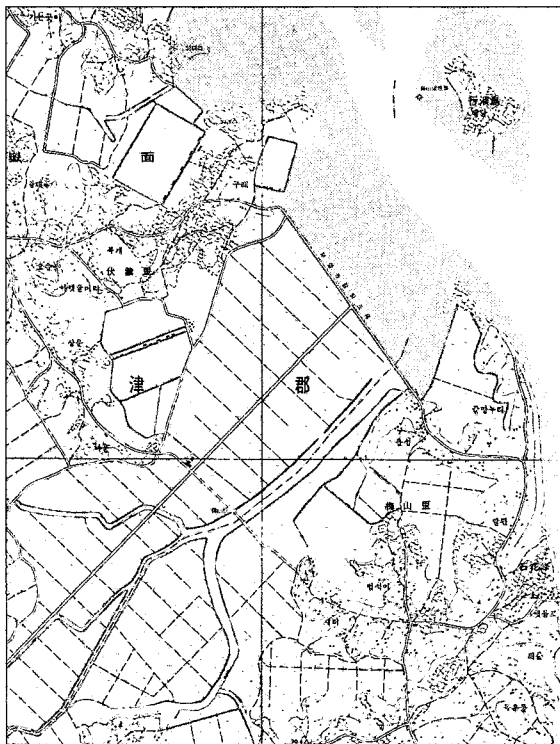


Fig. 4. The National Base Map(1:25,000) in 1987.

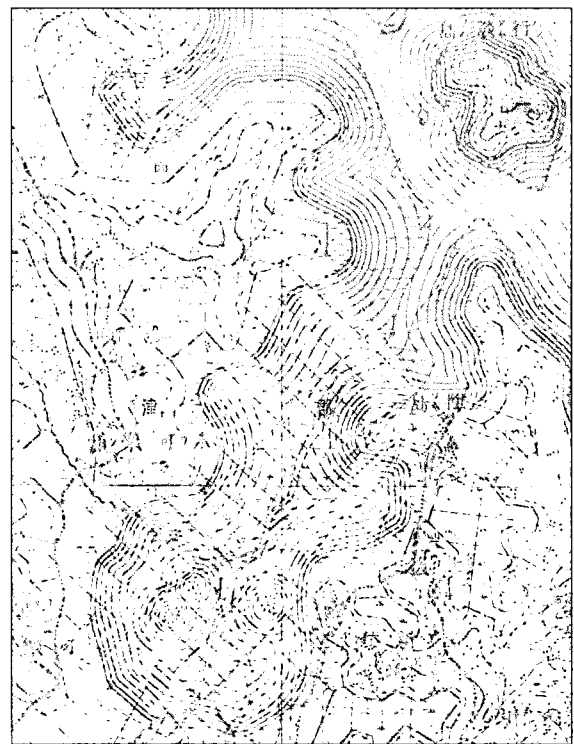


Fig. 5. The Military Secret Map(1:50,000) overlaid with National Base Map(1:25,000).

#### 4.1.3 Investigation of the Topographic Map

If we have a topographic map surveyed periodically, it is good proof to see the changes of topography of a certain region over the periods. As mentioned above, we have two kinds of topographic maps (scale 1:50,000) made by plane table survey in 1910's. Moreover, we have 3 kinds of topographic maps (scale 1:5,000, 1:25,000, and 1:50,000) made by aerial survey after 1974.

Two topographic maps were prepared in order to investigate any changes of coastline of the region. One was made based on eye observations and hand sketches in 1910's, called *Military Secret Map (1:50,000)*, and the *National Base Map (1:25,000)* was made by aerial survey in 1987. The *Military Secret Map (1:50,000)* was enlarged two times to make it the same scale as the *National Base Map (1:25,000)*. Then, the two topographic maps were overlapped based on the triangulation stations marked on both topographic maps. Because there are several reclaimed lands along the coast, most of the coastlines on the *Military Secret Map* became land on the *National Base Map* in 1987 except one region marked with a circle in Fig. 3. This means that the region was land in 1910's, but the region is submerged under the sea in high water at present. Thus, the parcels located in this region must have collapsed under the sea after they were registered.

## 4.2 Case II

Total 18 parcels located around 389, Sinyoung-Li, Poseung-Myoung, Pyungtaek-Si, Gyeonggi-Do were investigated to verify that the whole or parts of the parcels had collapsed after they were registered (CICL, 2001b).

These parcels are in the east end of Pyungtaek Port in Asan Bay. This region is the north side of Asan Bay, so that the overall geological characteristic of this region is similar to the case I study area.

#### 4.2.1 Investigation of the Cadastral Record

The key points of the cadastral records are as follows.

Original Registre : lost in 1950

Date of First Registration : unknown

Present Registre : restored in 1956

Original Lot Number : 389, Sinyoung-Li, etc.

Land Use Category : Arable Land (5 parcels)

River (1 parcel)

Forest & Mountain (12 parcels)

Original Ownership : unknown

Areas on the Cadastral Record : 1,894m<sup>2</sup>, etc.

The cadastral records of this region were lost during the Korean War in 1950. Therefore, the ownership of the parcels at the first registration is unknown. The ownership of these parcels began to be transferred after 1930. At present, 14 parcels belong to a owner of a business group, 3 parcels belong to 3 private persons, and one parcel belongs to the nation. An owner of a business group bought many parcels in this region to build an industrial complex. Though the original Cadastral Records were lost, it is guessed that all of the parcels under investigation were registered legally in 1910's. Judging based on the cadastral record, there are no doubtable errors that the parcels collapsed under the sea in high water.

#### 4.2.2. Investigation of the Cadastral Map

The land use category of the parcels under investigation are 3 kinds, forest & mountain, arable land, and river. All the parcels were drawn in Land Cadastral Map on a scale of 1:1,200. Checking any errors on the Land Cadastral Map, control surveying were done by GPS (System 300, Leica). Then, cadastral current state surveying was done by Total Station (TC 2002, Leica). Fig. 6 is the Land Cadastral Map overlaid with a map drawn by cadastral surveying on site for this investigation. There are some differences of boundary along the coast between these two maps. The boundary of the current coast used to be a part of land in 1910s. However, the boundaries of parcels located in inner lands agree with each map.

#### 4.2.3 Investigation of the Topographic Map

Comparing the coastline among cadastral map (1:1,200), National Base Map (1:5,000), and topographic map surveyed on site for the investigation, these three maps were overlaid based on Korean Plane Coordinates System. While the cadastral map was surveyed in 1910's, National Base Map was surveyed in 1991, and topographic map was surveyed in 2001. As we can see in Fig. 7, it is clear that the sea has been encroaching on the land along the coast year by year. Therefore, the parcels located along the coast in this region must have collapsed under the sea after they were registered.

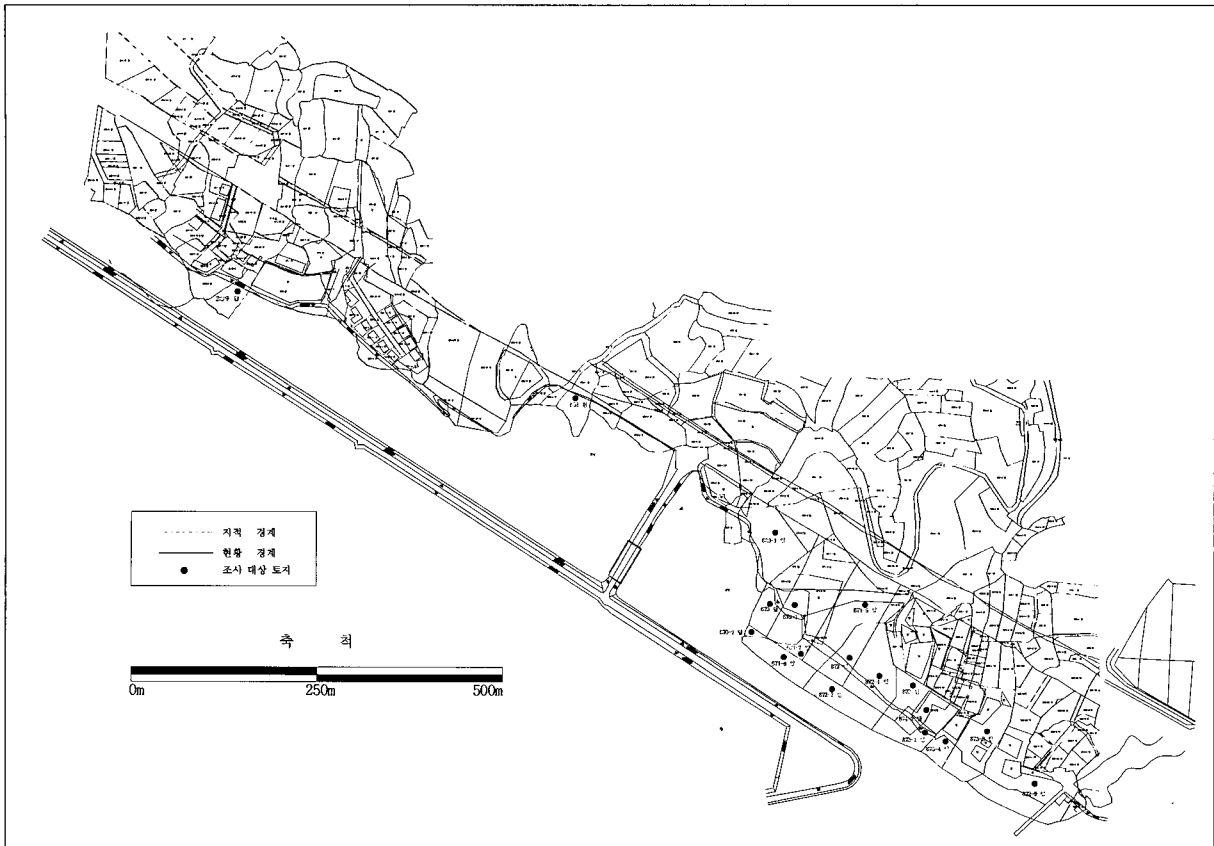


Fig. 6. Coastline Changes between the Land Cadastral Map and Map Surveyed for the Investigation.



Fig. 7. Coastline Changes in the Land Cadastral Map, the National Base Map, and Map Surveyed for the Investigation.

## 5. Discussion

We can set up some hypotheses to discriminate between land collapsed after registered and land wrongly registered. If the record in the cadastral records is improper, the disagreement of land boundary between cadastral map and the current topographic map may not mean the land collapsed. If the cadastral map was made based on incorrect control networks, the boundary on a cadastral map may disagree with the boundary on site. On the other hand, if the boundary of topographic map made when the land was registered is the same to that of the map made in recent years, it could be said that the boundary of the land hadn't collapsed.

As a result of cadastral investigation for the case, no distinct errors were found in the cadastral records besides the difference of area between cadastral records and cadastral maps. Although shrinkage or extension of map sheets caused some error of area calculation, it is reasonable to say that the cadastre does not contain decisive errors.

Because the parcels neighboring the investigated parcel have changed its land use category or its boundary, it was very hard to compare the boundary on the cadastral map with that of the surveyed site for this investigation.

Though the scale is not large enough to investigate collapsed land, topographic maps made in different eras gave good proof for the change of coastline. When the maps made in different eras were overlaid, the coastlines along the parcels of case study I and II show discrepancy to some extent. Based on the comparison between cadastral maps and topographic maps made in different eras, it is possible to say a part or whole parts of the parcels under investigation had collapsed under the sea after they were registered.

## 6. Conclusion

As a result of this study, it is known that cadastral and topographic survey and its maps play an important role in proving whether lands have collapsed or not.

There are some differences between the area written in cadastral records and that measured on cadastral map. Because the map drawn on paper is subject to be shrunken or extended, it is highly recommended to digitalize cadastral maps and topographic maps.

Though the scale of National Base Map (1:50,000) made in 1910s was insufficient to search coast change to 1m, it shows general trends of coastline changes in the long term.

For more reliable investigation of collapsed lands, it is desirable to archive aerial photographs or remote sensing images periodically covering coastal areas.

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