Environmental Changes in the Tokyo Lowland during the Historical Times (Last ca. 2,000 Years)

東京低地における歴史時代の環境変遷

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[**Abstract**] Historical change of landforms and water-space of the Tokyo Lowland are shown using micro-landforms in the plain, as well as the relationship between environmental changes and human activities.

On the basis of the Geomorphological Land Classification Map of the Tokyo Lowland (Kubo, 1993), I examined topographic maps from the 19th Century and historical documents, and them reconstructed the landforms in the late Middle Ages (15 to 16th Century), before the intense human modification of the land such as reclamation and river channel modification has advanced. According to this, Tokyo Lowland in the Middle Ages has deltaic area of the Tone River in the eastern part, while the remnant of Paleo-Tokyo Bay with an extensive tidal area is seen in the middle part.

Coastline of the Ancient (c. 8th Century) Tokyo Lowland was estimated by historical and archeological data. The coastline was located near the Mama Lagoon, which was described in *Man-yo-shu* (8th Century) in the western part, and near Asakusa sand bar in the eastern part. The coastline in the central part was estimated to be located inland side.

Reconstruction of landforms and water-space have seen shown as 1) Kofun to Nara Age (6-8th Century), 2) Late Middle Ages (15-16th Century), 3) Late Edo Era (early 19th Century) and 4) After the Meiji Restoration in 1868.

1. Introduction

In Japan, the coastal lowlands have experienced significant geomorphological changes during the past several thousand years due to global sea-level changes and to the fluvial deposition of major rivers. Further, during historical times, the lowlands have been among the most important areas in which humans have cultivated paddy rice and built cities such as Tokyo. Because of this, it is important to understand the environmental changes which have occurred in the coastal lowlands during the historical period (last ca. 2,000 years), not only by studying the natural sciences, but also by studying culture and history.

The Tokyo Lowland is located on the Kanto Plain, the largest plain in Japan. The lowland emerged after the culmination of the Holocene transgression (about 6,000 years ago), then it was formed by the fluvial deposition of the Tone-and-Ara River system. The delta formed by these rivers has advanced about 50 km offshore in the Paleo (Inner) Tokyo Bay during the last several thousand years. During historical times, the coastline

has continued to regress but the details of this regression are not well understood.

As the Tokyo Lowland has been the site of large-scale human habitation during the historical period (the city of Tokyo is located partially in this lowland), it has been intensely modified by human activities including reclamation, artificial landfills, and river and coastal improvements. Because of its importance as a location for human habitation, it is important to understand how the lowland emerged during historical times by natural and human actions.

In reconstructing paleoenvironments, sedimentological analysis is often used. However, in the Tokyo Lowland, it is not possible to use sedimentological or stratigraphic approaches to understand the geographical changes of the coastline and river courses during the historical period because the uppermost Holocene deposits are heavily disturbed by fluvial processes and human activity. Therefore, in this study, geomorphological evidence based on micro-landforms in the alluvial lowlands, and archeological and historical information are used to develop a 'historical geomorphology' of the Tokyo Lowland.

2. Geomorphological Features of the Tokyo Lowland

Kubo (1993) published a Geomorphological Map of the Tokyo Lowland showing the micro-landforms and changes in the drainage system based on field surveys, aerial photographs, and topographic maps from the 19th Century (Figure 1). The map shows the geomorphological condition of the Tokyo Lowland. It is mainly a deltaic lowland but it also includes many artificial landfills. The Lowland is surrounded by Pleistocene uplands (the Musashino, Omiya and Shimousa uplands) which are covered by a volcanic ash soil (the Kanto Loam) originated mainly from the Fuji and Hakone volcanoes. The Edo River, the Naka River, and the Ara River flow through the Tokyo Lowland. These rivers were once joined in the Nakagawa and Tokyo lowlands and made up the Tone-and-Ara River system. The main trunk of the Tone River now drains into the Pacific Ocean near the town of Choshi, but this change was the result of an artificial reorganization of the middle reaches of the Tone-and-Ara River system after the beginning of the 17th Century (*e.g.* Okuma, 1981).

Low ridges with old settlements on them are scattered over the Tokyo Lowland. These low ridges are mainly sandbars and natural levees. Sandbars occur around the upland rims, such as the one which stretches from Akabane to Ueno, and the former Edo-maeshima on which the present Tokyo Station is located. These sandbars are formed along the Musashino Upland. Sandbars also occur along the Shimousa Upland, for example, the sandbars at Ichikawa and Matsudo. Other groups of sandbars can be found at Asakusa and Gyotoku. The former seems to be formed along an isolated upland area while the latter seems to be formed along the lower Edo (former Tone) River. As sandbars are formed along coastlines, these sandbars show the locations of former coastlines. Sandbars also sometimes close the mouth of small valleys which dissect the uplands and cause back-swamp lowlands such as Shinobazu-no-ike Pond near Ueno.

In addition to the sandbars which indicate the location of former coastlines, low

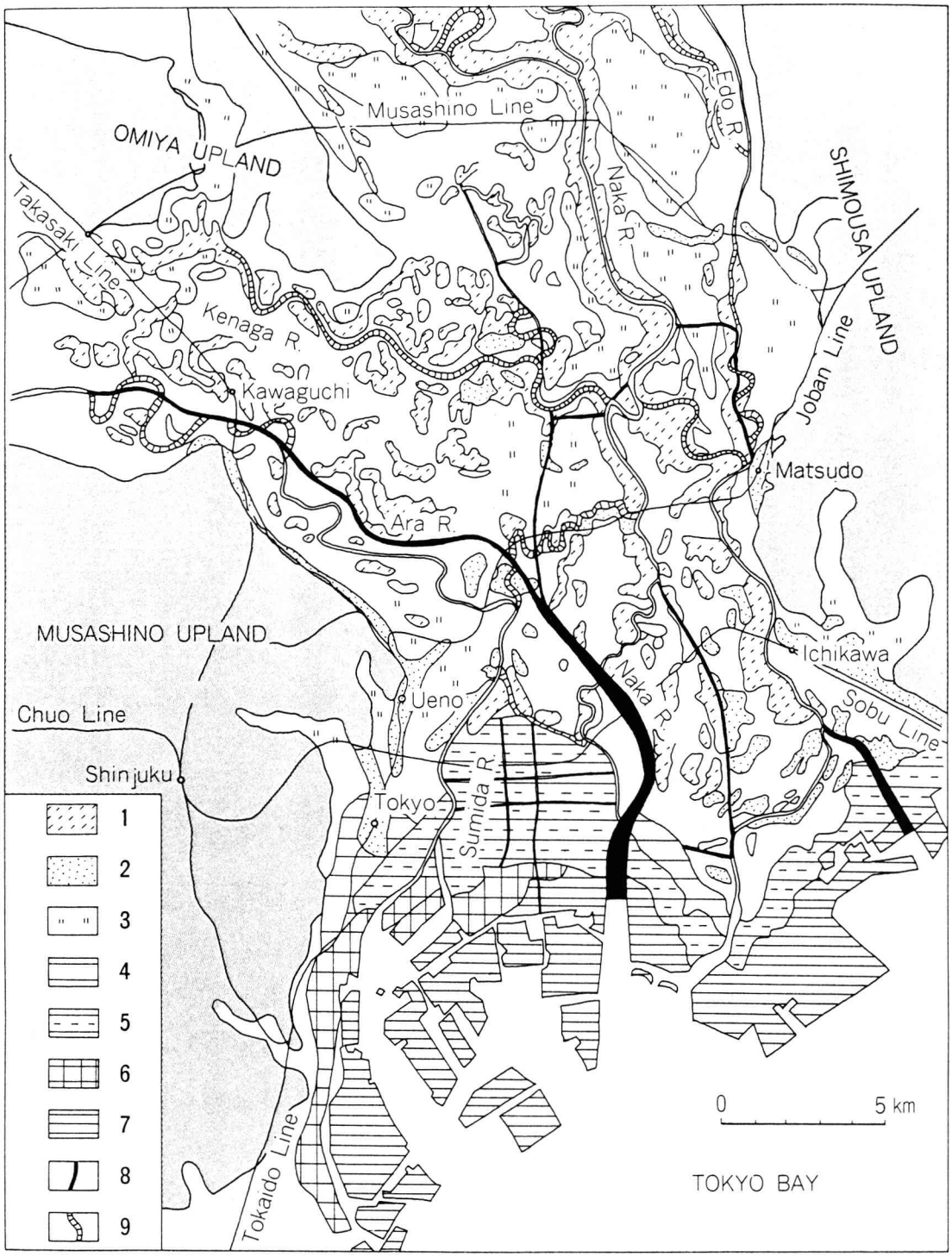

Figure 1 Geomorphological Map of the Tokyo Lowland (Kubo, 1993)
1:natural levee, 2:sand bar, 3:former pond/marsh, 4:reclaimed land (before 1603), 5:reclaimed land (1603-1868), 6:reclaimed land (1868-1945), 7:reclaimed land (1945-), 8:drainage channel/canal, 9:former river course

ridges originating from natural levees can be seen along major rivers including the Edo River, the Naka River and the Ara River. Natural levees can also be seen along the Kenaga River, Koai-dame Pond and Furu-Sumida (former Sumida) River suggesting that these rivers were once major river channels.

In the Nakagawa Lowland where the former main trunk of the Tone River flowed, there is an obvious contrast between the natural levees and the back marshes. This suggests that there were extensive marshy lands such as the Nigohan-Numa marsh and Shiodome-Numa marsh in the Nakagawa Lowland. The reclamation of the Nakagawa Lowland began in the 17th Century, which was far later than the reclamation of the Tokyo Lowland. On the other hand, the contrast between the natural levees and back marshes is less obvious in the Tokyo Lowland because of its deltaic nature. There are clear differences in geomorphological features between Nakagawa Lowland and Tokyo Lowland.

Low ridges with irregular features can be seen in the southwestern Nakagawa Lowland near Soka City. These low ridges are located in the transitional area between the natural levees with back marshes and delta. Matsuda (1990a,b) pointed out that there was a major river mouth in this area, which formed a bird-foot delta.

Extensive landform transformation by human action is also an important element of Tokyo Lowland. Landfills, land reclamation, canals and flood channels, and broad 'below-sea-level areas' have been formed, completely modifying the original geomorphic features. The Tokyo Lowland is one of the most artificially modified lowlands in the world. To understand the historical and prehistoric changes of the Tokyo Lowland, we must attempt to reconstruct the landforms as they were before major human modification occurred.

3. Artificial Changes of River Channels and Coasts since the beginning of the 17th Century

Topographic maps of the Tokyo Lowland have been published since the beginning of the Meiji Era (1868-1912). These maps, called *Jinsoku-Zu*, or Prompt-Maps (S=1:20,000), show the landforms and drainage network at the end of the 19th Century (Figure 2).

In the 19th Century, the drainage system and coastal features (water-space) of the Tokyo Lowland was further modified but was different from the present system. The major rivers that flowed through the Tokyo Lowland were the Edo River, the Naka River, and the Sumida River. The present Ara River channel is an artificial flood channel constructed in the 20th Century. The size of the urban area of Tokyo was small at that time so that the major land use in Tokyo Lowland was agriculture.

The coastline extended from Tsukuda-jima Island and Ecchu-jima via the southern part of Koto Ward to the Edo River Delta. Reclaimed lands and salt pans can be seen along the coast.

The map also shows the landform of Tokyo Lowland in the late Edo Era, because there is little difference between Ino Tadataka's map surveyed in 1816. However, there have been artificial changes in Tokyo Lowland during the Edo Era (1603-1867). We have

Figure 2 Tokyo Lowland at the end of the 19th Century (*Jinsoku-Zu* topographic maps)

no surveyed maps earlier than the Ino's map. The information regarding the artificial changes made during the Edo Era discussed below is based on the examination of historical documents.

Artificial changes of the river system: The Tone and Ara rivers joined in the Nakagawa Lowland and drained into Tokyo Bay until the 17th Century. However, after that time, the entire river system of the lower Tone and Ara was modified. The Tone River was connected with the Kinu River, which flows directly into the Pacific Ocean. The former Tone River is now called the Naka River. The Ara River was separated from the Tone, and introduced into Arakawa Lowland and then joined with the Iruma River. Okuma (1981) has demonstrated that the main purpose of these changes in the river system was not for flood control, but mainly to improve water transportation.

The reclamation of Tokyo Bay has been taking place since the 17th Century (after the Edo Era; 1603-1867; Tokugawa Shogunate). By the end of the 20th Century, the coastline has been moved seaward about 9 km (Kubo, 1990, 1994).

At the beginning of the Edo Era, the Hibiya Inlet between the Edo castle and Edo-maeshima Island (sandbar) was filled. On the left side of the Sumida River, there are straight channels which meet at right angles suggesting that the channels are of artificial and this area must have been reclaimed. In the Muko-jima area along the Sumida River, there are areas which have the names of islands such as Ushi-jima and Tera-shima indicating that there probably once was a river mouth along Muko-jima.

There is also some evidence showing that marshes or lagoons were filled during the Edo Era. Reclamation also took place in many areas including; in the back marshes of the Nakagawa Lowland and the Arakawa Lowland, along the Ayase River in Adachi Ward, and on the site of the former Senzoku-ike Pond near Asakusa.

4. The Tokyo Lowland in the Middle Ages (12th to 16th Century)

By subtracting the artificial changes in landforms and water space after the 17th Century from the geomorphological map and the topographic maps of the 19th Century, I created a map showing reconstructed landforms of the Tokyo Lowland in the Middle Ages (Figure 3).

The Tone River trifurcated its distributaries in the Tokyo Lowland-the present Furu-Sumida/ Sumida, the Naka River and the Edo River. The Ara River joined with the Tone in the Nakagawa Lowland at Koshigaya, and the Iruma River joined with the Sumida River in the Tokyo Lowland.

The Sumida River formed the border between Musashi and Shimousa provinces. There are two rivers named Furu-Sumida now: one is seen between the present Katsushika Ward and Adachi Ward in the Tokyo Lowland, the other is seen between Kasukabe and Iwatsuki cities in the Nakagawa Lowland. The name Furu-Sumida (former Sumida) River represents the former Tone River as a provincial border. The former Furu-Sumida means that a major distributary of the Tone River flowed into the Sumida River in the Middle Ages.

In the 15th Century, a minstrel named Socho commented about the embankments in

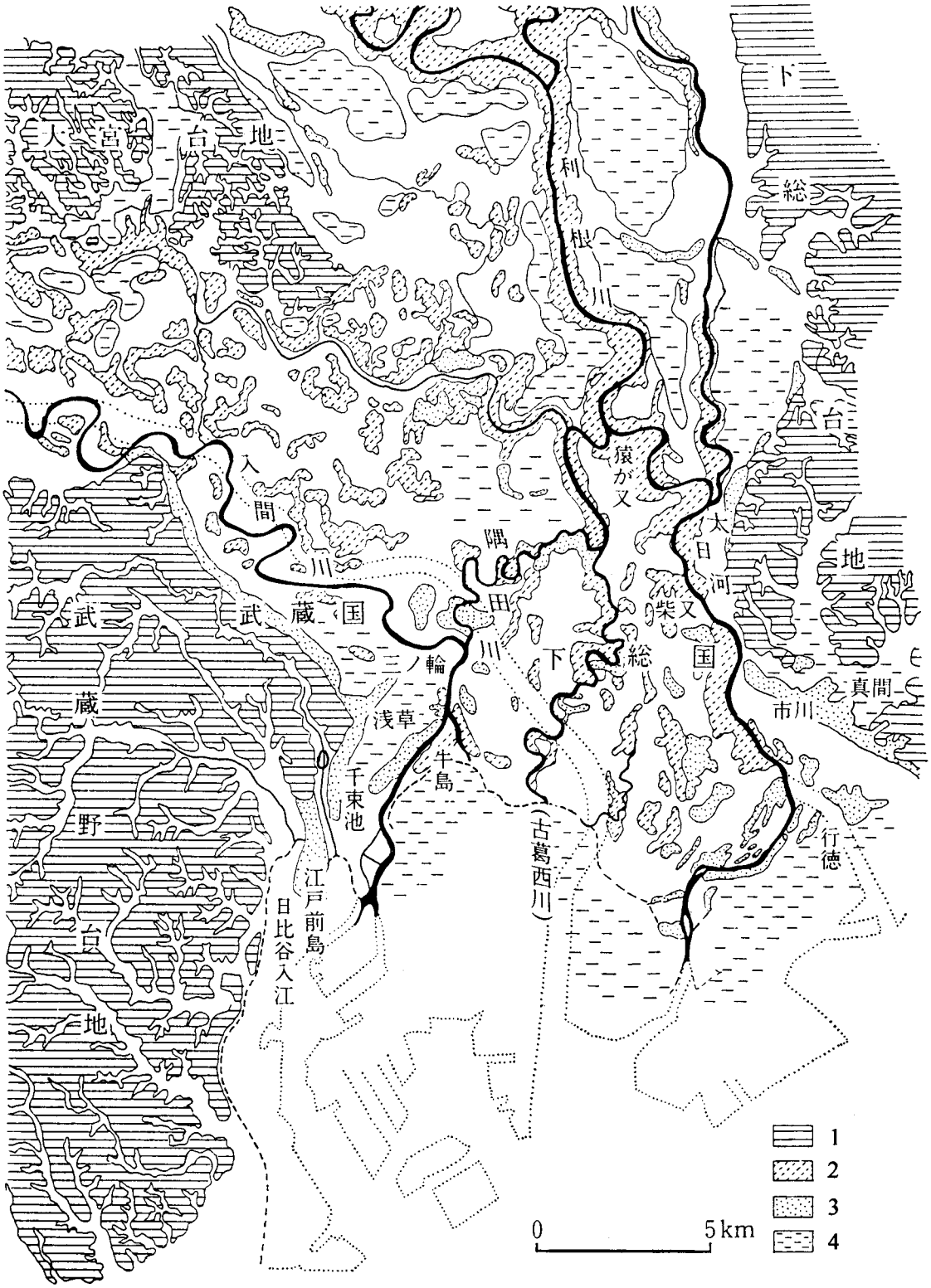

Figure 3 Tokyo Lowland in the Middle Ages (Kubo, 1994)
1: upland, 2: natural levee, 3: sand bar, 4: tidal flat/marsh

the Kasai province, eastern part of Tokyo Lowland. This suggests the development of Tokyo Lowland in the Middle ages.

Itabi, or steles with Buddha image, are evidence of medieval (Kamakura and Muromachi Era; 13th to 15th Century) settlements in the Kanto district. They are seen on almost of all low ridges in the Tokyo Lowland and show that most of the Tokyo Lowland was inhabited, with settlements located on low ridges at this time.

An extensive tidal area can be seen along the coast. The coastline entered into the almost of present Koto Ward, before the coastal reclamation started in the Edo Era. There were also broad inland wetlands in Nakagawa Lowland and Tokyo Lowland.

5. The Tokyo Lowland in Ancient and Prehistoric Times

Man-yo-shu is a collection of ancient poems edited in the late 8th Century. In it, there are some poems which focus on the Mama Lagoon of Katsushika, Shimousa province. The Mama Lagoon was located behind the Ichikawa sandbar which suggests that the ancient coastline was located along the Ichikawa sandbar.

The oldest population data in Japan was found at the Shoso-in warehouse of Todai-ji Temple in Nara (a former capital). It contains family registers from Katsushika in Shimousa Province in 721A.D. Two village names 'Kowa' and 'Shimamata,' correspond to the present Koiwa and Shibamata towns located in Edogawa and Katsushika wards in eastern Tokyo. These ancient villages are located on natural levees or sandbars where archeological sites since the Kofun Age (3-7th Century) can be seen.

The Senso-ji Temple on the Asakusa sandbar is one of the oldest temples in the Tokyo Lowland. There are historical accounts of this temple since the 7th Century and archeological evidence since the 8th Century (the Nara Age).

Archeological sites of Kofun Age are concentrated in some locations in the Tokyo Lowland. There are two centers of sites in the Tokyo Lowland: One is located between Koiwa and Shibamata (eastern Tokyo Lowland), and the other is located along the Kenaga River in the Northern part. The Kenega River has a distinct former river course with extensive natural levees which continues to the Naka River and the Edo River via Koaidame Pond in the lower reaches. In the upper reaches, the river course continues from the Arakawa Lowland to Kumagaya via Kawagoe. This former river course has extensive meanders of large magnitude suggesting that the Kenaga River was the former Tone-and-Ara River in prehistoric times, and that, later the Tone River shifted onto the Nakagawa Lowland. The age of this shift is estimated to be about 2,000 y. B. P. (Endo *et al.*, 1987).

During the Kofun Age (3-7th Century), settlements and tombs were concentrated on the low ridges along the former Tone River. On the basis of the religious remains excavated from the Iko Site in Adachi Ward, there must have been an important place of transportation that was located near the river mouth.

Archeological sites of the late Yayoi to Kofun Periods (100 A.D. to the 3rd Century) are located on the low ridges along the present Kenaga River and in the Katsushika district in the eastern part of the Tokyo Lowland (Figure 4). The sites along the Kenaga

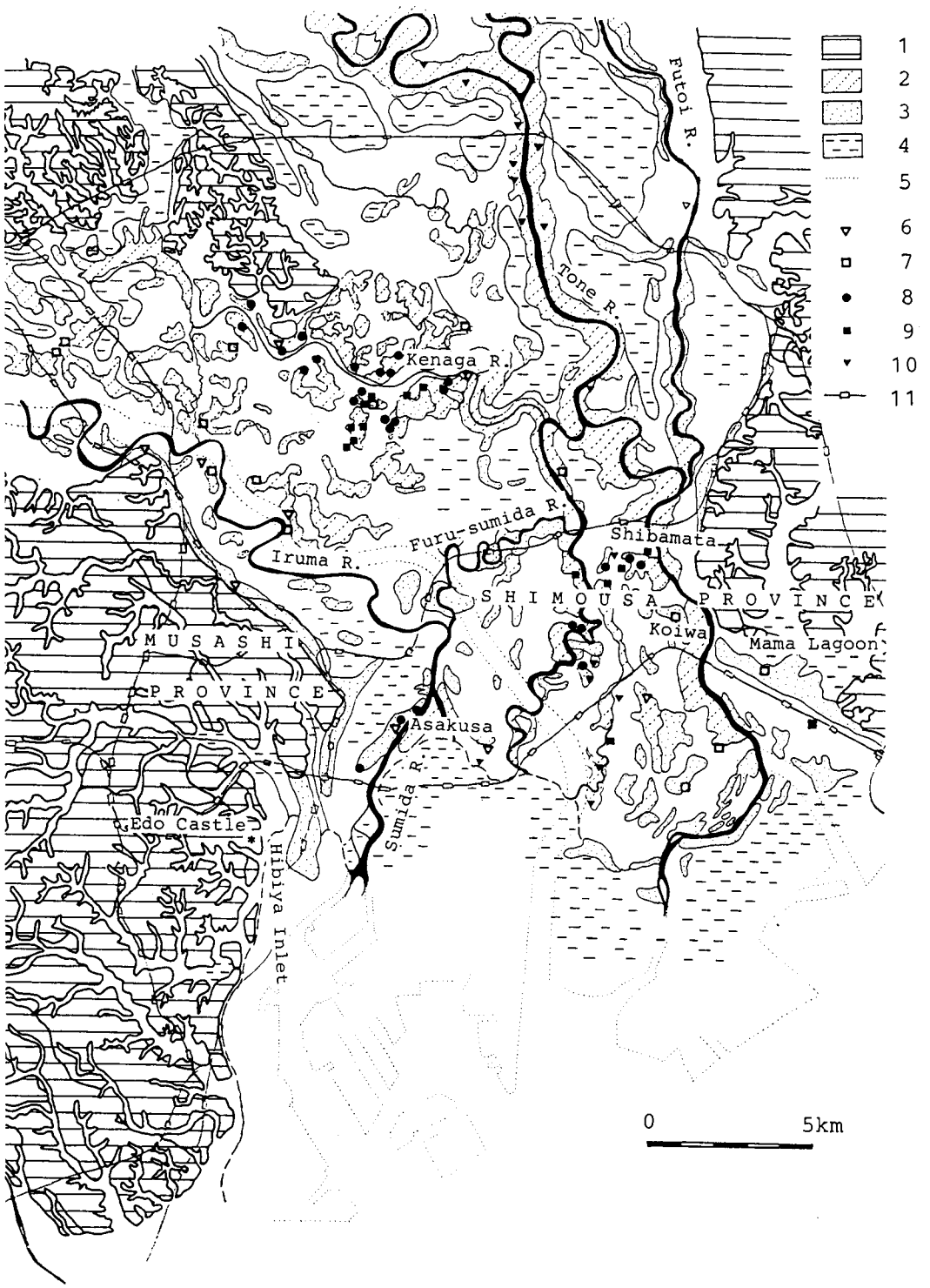

Figure 4 Distribution of archeological sites in the Tokyo Lowland
1: upland, 2: natural levee, 3: sand bar, 4: tidal flat and marsh, 5: recent river and coast, 6: Jomon pottery (ca.10,000-2,300y.B.P.), 7: Yayoi pottery (ca.300B.C.-300A.D.), 8: Kofun tomb (4-6th Century), 9: Haji and Sue potteries (4-9th Century), 10: after Haji, 11: JR line

River seem to be located on the older delta of the Tone-and-Ara River which flowed through the Arakawa Lowland. On the other hand, the sites in Katsushika are located on the younger delta of the Tone-and-Ara that flowed through the Nakagawa Lowland. Sites can also be seen on the sandbars along the upland rims. However, at that time, the central part of the Tokyo Lowland had not emerged from the sea.

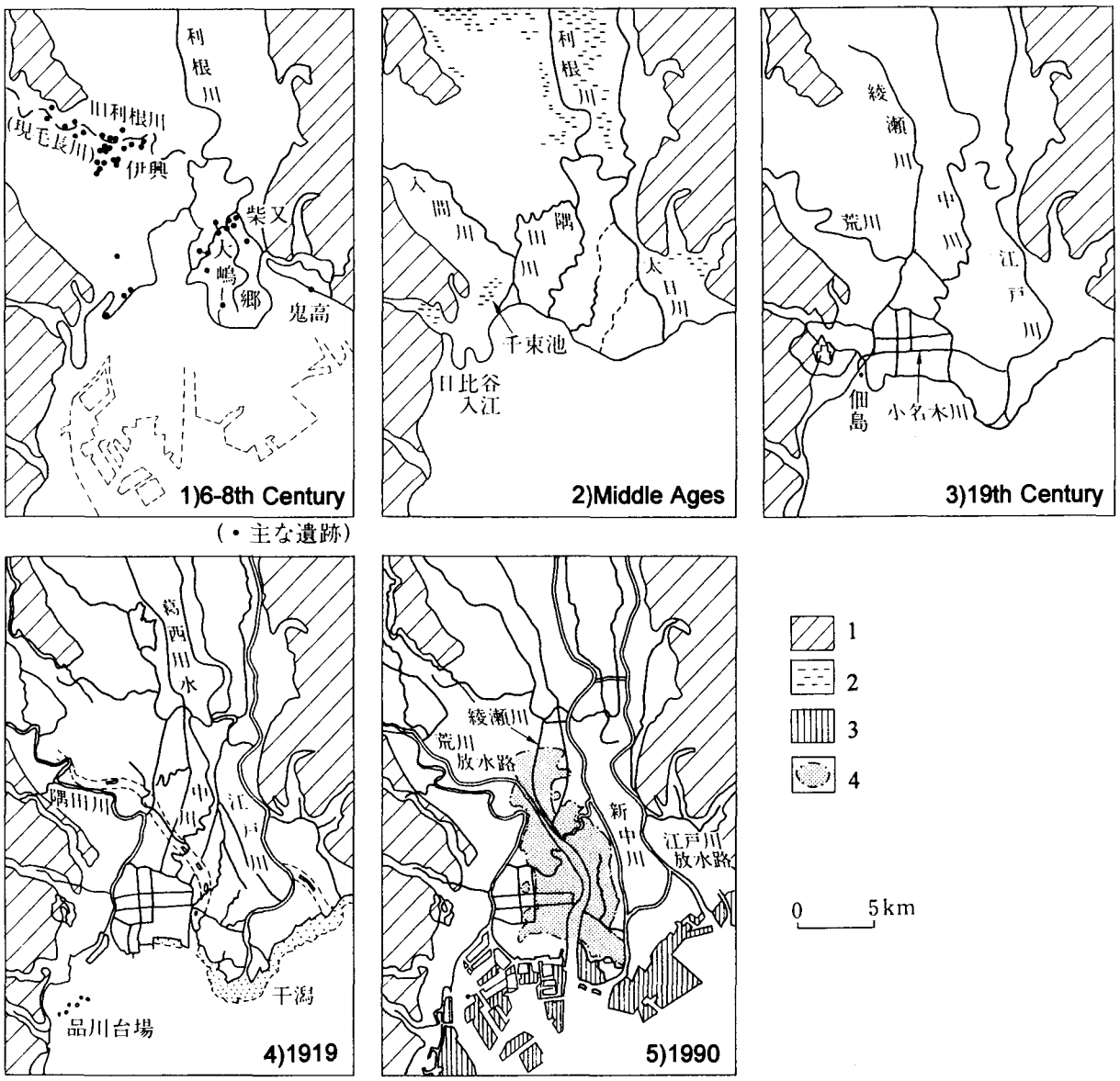

Figure 5 Environmental Changes of the Tokyo Lowland during Historical times(Kubo, 1994)
1: upland, 2: marsh, 3: reclaimed land after 1945, 4: Below-Sea-Level land

6. Environmental Changes during Historical Times

On the basis of examination of the geomorphology, historical documents, and archeological evidence, I reconstructed the change of landforms, river courses, and coastlines in the Tokyo Lowland since the Yayoi Age (200 B.C. to 200 A.D.).

The Tone-and-Ara River system has contributed to emerge the Inner Tokyo Bay during the late Holocene. The joined Tone-and-Ara flowed through the Arakawa Lowland and formed a bird-foot delta at the mouth (near Adachi Ward). The Tone River shifted its course from the Arakawa Lowland into the Nakagawa Lowland at about 2,000 y.B.P. so that the Nakagawa Lowland emerged rapidly. Accordingly, the younger Tone Delta was formed in the eastern Tokyo Lowland, and an inlet remained in the central part of the Tokyo Lowland between the new and old deltas. However, the old Tone-and-Ara River course remained as the Kenaga River.

Figure 5 shows the compiled changes in the Tokyo Lowland in historical times.

1) Kofun to Nara Age (6 to 8th Century): The remnant of the Inner Tokyo Bay is seen in the central part. Archeological sites are distributed on low ridges along the Kenaga River (Iko site and others), and in the Katsushika area (reported in the Shoso-in Documents).

2) The end of the Middle Ages (15 to 16th Century): The Tone River trifurcated in the Tokyo Lowland in the Middle Ages and was the border area between Musashi and Shimousa provinces. The area between the present Sumida River and the Naka River was an extensive wetland or tidal flat. Inland wetlands were also dominant.

3) The late Edo Era (early 19th Century): Land reclamation and river improvements continued from the 17th Century so that the lower Tone River was reorganized into the Edo River, and the Sumida (lower Iruma) River into the Ara River. The Nakagawa Lowland was drained and reclaimed during the Edo Era. Coastal reclamation also took place to the south from Tsukuda-jima Island to the Onagi-gawa canal.

4),5) After the Meiji Restoration(1868): The flood channels of the Ara River and the Edo River were completed in 1930 and coastal reclamation progressed rapidly. Over-pumping of groundwater formed an extensive 'below-sea-level area'.

The Tokyo Lowland has been changed continuously by global sea-level change and fluvial processes or delta-formation. However, human activity has increasingly been responsible for modification of the Tokyo Lowland since the 17th Century, and has been especially predominant in the 20th Century.

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東京低地における歴史時代の環境変遷

久保純子

東京低地における歴史時代の地形や水域の変遷を，平野の微地形を手がかりとした面的アプローチにより復元するとともに，これらの環境変化と人類の活動とのかかわりを考察した。本研究では東京低地の微地形分布図を作成し，これをベースに，旧版地形図，歴史資料などから近世の人工改変（海岸部の干拓・埋立，河川の改変，湿地帯の開発など）がすすむ前の中世頃の地形を復元した。中世の東京低地は，東部に利根川デルタが広がる一方，中部には奥東京湾の名残が残り，おそらく広大な干潟をともなっていたのであろう。さらに，歴史・考古資料を利用して古代の海岸線の位置を推定した結果，古代の海岸線については，東部では「万葉集」に詠われた「真間の浦」ラグーンや市川砂州，西部は浅草砂州付近に推定されるが，中央部では微地形や遺跡の分布が貧弱なため，中世よりさらに内陸まで海が入っていたものと思われた。以上にもとづき，1)古墳～奈良時代，2)中世，3)江戸時代後期，4)明治時代以降各時期の水域・地形変化の復元をおこなった。

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