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THE MARKETING OF URBAN HUMAN WASTE IN THE EARLY MODERN EDO/TOKYO METROPOLITAN AREA

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RÉSUMÉ
Parmi les problèmes que soulèvent les déchets, la gestion des excréments humains a historiquement été l'un des plus grands défis auxquels furent confrontées les grandes villes. Les écrits historiques indiquent que la société urbaine japonaise a adopté une approche unique à ce niveau. Au début de l'ère moderne, ces déchets étaient achetés par les fermiers de la périphérie des villes, qui les utilisaient comme engrais agricole, leur permettant en retour d'approvisionner le marché urbain en produits agricoles. Cet article aborde l'utilisation des excréments humains dans la région métropolitaine de Edo/Tokyo du XVII[e] au XX[e] siècle, en s'attardant particulièrement sur les impacts qu'elle occasionne au niveau de l'utilisation du sol.

MOTS-CLÉS ■ Traitement des déchets, histoire, agriculture, utilisation de l'espace, transports

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ABSTRACT
Abstract: Among other waste issues, the disposal of human waste has historically been one of the most serious challenges for major cities. The historical literature suggests that Japan's urban society took a unique approach to management of human waste. Throughout Japan's early modern period, human waste in the city was purchased by farmers living on the urban fringe and was used as an agricultural fertilizer. Using this "night soil," villages supplied fresh agricultural produce to the urban market. This article focuses on the use of urban human waste in the Edo/Tokyo metropolitan area, in relation to urban land use and transportation from the seventeenth to the early twentieth-century.

KEYWORDS ■ Waste management, history, agriculture, land use, transportation

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1. INTRODUCTION

Throughout history the development of advanced production and market exchange have been signal factors in stimulating urbanization. Yet even as urban agglomeration promotes both economic and cultural development, the concentration of populations in urban centers often creates problems of excessive waste and pollution.

Among other waste issues, the management of human excrement was historically one of the most serious problems in major European cities. In cities such as London and Paris from the twelfth to the seventeenth centuries, city dwellers often threw the contents of their chamber pots out of their windows into the streets below. These practices caused serious public health problems in addition to overall degradation of the living environment (Horan, 1996). In the US, waterborne diseases such as typhoid and cholera contributed to high mortality in urban populations, until comprehensive sewer systems were built during the early twentieth-century (Troesken, 2004).

A contrasting approach is seen in Japanese urban society during the Tokugawa period (1603-1867) which marked the early-modern period of Japanese history. Rather than simply throw bodily wastes out the window or engage in other unsafe practices, city dwellers in Japan sold human waste as agricultural fertilizer. This waste was referred to as *shimogoe* ("fertilizer from the bottom of a person") in Japan. In English, "night soil" was coined to depict human excrement used as fertilizer to grow crops, because the waste was collected during the night time. Although the collection of human waste was conducted during the day in Japan, the term "night soil" is used as a synonym of *shimogoe* in this article. Moreover, Japanese *shimogoe* included both human feces and urine. In many cases they were collected and used as a mixture, but in some areas they were collected in separate pots and marketed separately.

In Japan, farmers (or their agents) came door to door to collect and pay for the fertilizer. Where the actual owner of the privy and the person who excreted the waste were different, which was often the case in rental apartments, the night soil belonged to the landlords and they had control over the price. In the city of Edo (contemporary Tokyo), as well as in other major Japanese cities, the urban agglomeration of households facilitated extensive collection and circulation systems for night soil. Significantly, this business was conducted entirely by private agents, and was not a governmental initiative. In addition, night soil has been used in other parts of the world, such as China (Whitney, 1991) and Africa (Drechsel et al, 2001); but Edo/Tokyo's highly commercialized system for managing night soil was to a large extent unique.

Until the late nineteenth-century in Japan, night soil was one of the principal sources of agricultural fertilizer, especially in villages on the urban fringe. In the eighteenth and nineteenth centuries, competition for fertilizer acquisition led to the overpricing of night soil. In this period, therefore, farmers on the urban fringe were often in conflict with urban landlords, demanding that the latter lower the price of night soil (Ando, 1999; Aratake, 2001; Kobayashi, 1983; Watanabe, 1983).

The purpose of this article is to introduce the practice of the use of urban human waste in agricultural production in early-modern and modern Japan, focusing on the Edo/Tokyo Metropolitan Area, and examine its impact on land use in the urban fringe. I posit that the use of human waste as agricultural fertilizer depended on the interdependence between the city and the surrounding urban-fringe farming villages. Urban-fringe agriculture played a key role in providing fresh foodstuffs to the urban population, as well as in using the urban population's excrement as an input for agricultural production.

A close relationship existed between the urban population and the agricultural fields in the urban fringe of Tokyo and similar cities. The essence of the relationship is a twofold interdependence that is embodied in the interchange of fresh agricultural products and fertilizers. Many writings of early modern Japan, such as *Nôgyô Zensho* (Compendium of Agriculture, first published in 1697) and *Kôka Shunjû* (Spring and Autumn of Farming Business, 1707), comment on this interdependence. In recent historical literature, Watanabe (1983) examines the interdependence between urban and agricultural activities from the eighth to the late twentieth-century, and refers to the form of agriculture found in the urban fringe as *toshi kinkô nôgyô* (urban-fringe agriculture). More recently, Aratake (2003) examined the circulation of vegetables and human excrement around the Osaka metropolitan area in the nineteenth-century.

Yet Western scholarship has rarely addressed this topic. During the Tokugawa period, communication with foreign countries was limited due to the policy of isolation, and thus Westerners rarely observed waste management practices in Japan. In the late nineteenth and early twentieth-century, Western visitors to Japan such as Edward Sylvester Morse (1917) and Richard

Henry Brunton (1991) wrote about urban privy cleaning and commented on the use of the excrement in agricultural fields. More recently, Susan Hanley (1997) has written on urban sanitation and physical well-being in Tokugawa Japan. Hanley describes water provision and human waste management as a unique and effective alternative to the Western sewer system. The present paper seeks to contribute to the general history of human night soil use as a source of agricultural fertilizer, and aims as well to elucidate some of the practice's implications for the urban environment and public health.

The following section explores how urbanization and commercialization affected the traditional agricultural sector, especially via the use of fertilizers throughout the seventeenth and early nineteenth-century. The third section then describes the market for urban-fringe agriculture in relation to the use of night soil. The fourth section describes the condition and geographic distribution of urban-fringe agriculture in the late nineteenth-century, following the 1868 Meiji Restoration (the onset of the modern state and industrialization). During this period, the new administration compiled uniform nationwide statistics on agricultural production, land, and population. Analyses in this section are based on the government statistics on the post-restoration period. A brief conclusion is presented in the final section.

2. COMMERCIALIZATION OF JAPANESE AGRICULTURE AND USE OF FERTILIZERS

2.1 Traditional Agricultural Technology and the Use of Manures

Many significant changes occurred in agricultural production during the Tokugawa period. Smith (1959) points out that few of these changes were the consequence of new inventions, per se; rather, change was enabled through the spread of knowledge and tools. In 1697, the first agricultural handbook was published. Written by Miyazaki Antei, *Nôgyô Zensho* ["Compendium of Agriculture"] was a collection of ten volumes, filled with scientific treatises based on information from Chinese literature, as well as from the author's own experience and experiments. The book covered the full range of Japanese agriculture at that time; it includes a chapter on each of 19 varieties of grain, 57 vegetables, 11 grasses, 36 trees, and 22 herbs. In addition, there were separate essays on such subjects as planting, tillage, soils, fertilizers, irrigation, and the management of forest land (Smith, 1959).

The use of various types of manure is discussed in agricultural manuals of the Tokugawa period such as *Nôgyô Zensho* (1697), *Hyakushô Denki* [Farmer's Biography] (1682) and *Kôka Shunjû* [Spring and Autumn of Farming Business] (1707). It is evident from these sources that the use of animal and human wastes, green composts, and other wastes became popular among farmers throughout the seventeenth and eighteenth centuries.

As described in *Nôgyô Zensho*, traditional sources of fertilizer were supplied from within the farmers' household itself, or from within the small community of an agricultural village. As the knowledge and technologies of agriculture advanced and farmers became aware of the benefits of fertilizers, these sources came under increasing demand. In this section, I use the expression, "autarkic manure" in translation of the term *jikyû hiryô,* which started to appear in national statistics of agricultural manure in the late nineteenth-century. The word *jikyû* literally means "self-supplying". Although fertilizers secured through traditional sources were occasionally traded among households and in later periods across villages and towns, the geographical limit of its circulation was small. The range of circulation is especially circumscribed when compared to the typical commercial manures that are discussed in the following section.

The manures listed in the sixth section of the first volume of *Nôgyô Zensho* are excellent examples of autarkic manures. These include: green manures (*nae-goe*), grass manures (*kusa-goe*), ash manures (*hai-goe* or *yaki-goe*), dirt manures (*doro-goe*), and others such as liquid manures (*mizu-goe*). Green manures refer to sprouts of legumes that were used due to their physiological ability to fix atmospheric nitrogen. Grass manure is a traditional compost of grass collected from wooded areas. *Nogyô Zensho* encourages farmers to collect grass and to leave it on the floor of a stall so that it softens, or to leave it in a "manure house" (*koe-ya*) and wait for proper natural composting. Ash manures, consisting of the ashes of a variety of possible materials, are said to enhance the growth of crops, especially leaf vegetables. Dirt manures are the dirt accumulated in the floor of drainage, bathrooms, or other locations. They are supposed to be mixed with human night soil (*hito-goe*) and ash. Liquid manures are collected from the sewers of kitchens, baths, and "dirty things" (*kegarawashiki-mono*—perhaps human night soil). Although human night soil is not listed separately in this list, it is suspected many of these manures were used mixed with the thick (solid) part of night soil, known as "thick manure" (*koki-koe*).

2.2 Increased Use of Human Night Soil

Agricultural use of human night soil as fertilizer (as noted earlier, these were generally called *shimogoe*) is first evident in the Kinai region during the sixteenth-century. According to the first agricultural manual, *Shinmin Kangetsu Shû,* human night soil was used as fertilizer in the Shikoku region along with green manure. This latter was a mix of animal manure and shrubs, roots and grass collected from villages' marginal forestland (Oka, 1980). At this point, however, the use of night soil was limited only to upper-class farmers who had better access to the knowledge (Watanabe, 1983).

It was during the late seventeenth-century that night soil became to be widely and popularly used among farmers. In the famous Keian edict issued in 1649, the Tokugawa government delineated a wide variety of instructions for appropriate peasant behavior and lifestyles. Among these instructions, peasants were required to collect ash and human night soil properly, and to keep the night soil from water in rainy seasons. This suggests that the government tried to make peasants in the nation understand the importance of night soil in agricultural production.

Agricultural manuals such as *Nôgyô Zensho*, *Kôka Shunjû* [Spring and Autumn of Farming Business] authored by Tsuchiya Matazaburô in Kanazawa in 1707, and *Hyakushô Denki* [Farmer's Biography], written around 1682 in Mikawa region on Tôkaidô by an unknown author, give detailed instructions how to collect wastes and apply them as agricultural manure to different crops.

Hyakushô Denki devotes its sixth volume to a discussion of the importance and use of human night soil in agriculture. It describes how to install toilets so that farmers can collect the night soil effectively, as well as the effective timing of and amounts for fertilizing crops with night soil. Wasteful disposal of even a drop of *fujô*, or human waste, was strongly discouraged because "mindless disposal of *fujô* is filthy, first of all. The business of farmers is to create various crops. Any *fujô* fertilizes the soil, enhancing the growth of thousands of crops." (Cited in Watanabe, 1983. Translated by author.)

Watanabe (1983) notes that the author of *Hyakushô Denki* was familiar with the use of night soil to the extent that he could differentiate the quality of night soil depending on the persons' dietary habits. It argues that night soil from those who eat luxury foods and fish fertilizes the land and produces good crops, while night soil from those who eat poorly does not produce good crops. By this time, the urban population had a better diet than village farmers (in terms of access to a variety of foods, and especially to animal protein such as fish); therefore, Watanabe notes that farmers with night soil from the places of "prosperity" would be successful in growing a range of grains and vegetables. *Hyakushô Denki* emphasizes that "farm land close to a city is blessed with good access to the source of fertility," stressing the comparative advantage that proximity to cities provides concerning opportunities to obtain high-quality fertilizer.

Various tools were produced to transport night soil from a city to a village or from a store-place to a crop field. Among the most popular of these implements were buckets specifically designed for night soil (Watanabe, 1983). Volume 5 of *Hyakushô Denki* declares that "buckets for night soil (*koe-oke*) should be made strong and as narrow as barrels for *sake*, by tying wood such as cypress or cedar. Four of these buckets, filled with night soil in half of each bucket, should be tied to each other. Then, two of the buckets should be put on each side of a horse's back." In addition, "hoops made of bamboo should be thin and lightweight. Since the buckets are used daily to bring fertilizer to field, heavy weight may cause pain." The same source tells us that these buckets were produced in cities such as Kyoto, Osaka, and Edo, suggesting that the use of the buckets was especially popular around these big cities. Night soil continued to be the primary source of fertilizer in Japanese agriculture, especially in villages on the urban fringe, over the course of the country's agricultural development until the early twentieth-century. Peasants paid money to purchase night soil as valuable fertilizer, and eventually a market in urban night soil developed.

2.3 Development of Commercial Fertilizers

Among the important innovations that increased agricultural productivity, perhaps the most important was the spread of commercial fertilizers, which were called *kinpi*, literally meaning cash fertilizers. The most popular cash fertilizers included dried fish and oil cakes, as well as night soil collected in towns and cities. Fish fertilizers became available for inland peasants, through development of transportation from coastal fishing villages to inland agricultural villages, in the seventeenth-century. This fertilizer helped to change traditional agricultural production, in which most fertilizing sources were provided from within the villages' ecological system.

While night soil was also traded actively as a valuable economic good, its circulation system was quite different from the systems that existed for other traded fertilizers such as fish fertilizer. While night soil was circulated within small areas (within 20 km in the exceptional Edo/Tokyo metro area, and within 3-5 km in most rural towns), fish fertilizers were shipped in large volumes to a nation-wide market. Different fertilizers were also applied to different crops; fish fertilizers were applied primarily to non-food commercial crops such as cotton flowers and indigo (a dyestuff), while night soil was applied to vegetables. As I will discuss below, the market areas for these products corresponded to those of their fertilizers. While vegetables were perishable and sold only within the region where they were produced, cotton was shipped to Edo and other places (Furushima, 1963).

Furushima (1963) argues that the market area of commercial agricultural products reflected the extent to which the farmer was involved in the commercial economy. By selling their produce to an agent who had contact with the nation-wide market, farmers could obtain access to commercial fertilizers. While fish fertilizers were highly "commercial" and were harvested in large-scale fishing operations funded by commercial capital (Howell, 1995), human night soil was essentially a byproduct of basic human activities, which came to be "commercialized" only through interdependent resource exchange between a city and nearby agricultural villages.

3. THE EMERGENCE AND GEOGRAPHY OF URBAN-FRINGE AGRICULTURE

The emergence of castle towns and the commercial development of agriculture allowed villages at the fringe of a city to develop a unique form of agriculture. Farmers in these villages took advantage of low transportation costs to bring their products to the urban market. The short distance allowed these farmers to supply perishable vegetables, fruits or flowers to the urban market more promptly than other villages could. Proximity to the city also meant farmers could collect night soil produced by the urban population to use as agricultural fertilizer; as a result, they made heavy use of night soil. This section describes the emergence of the interdependence between the city and surrounding agricultural villages, which I refer to as urban-fringe agriculture. The location of urban-fringe agriculture was dependent on transport cost; riparian transport through river canals was much more efficient than ground transportation.

3.1 Growing Demand for Vegetables in Tokugawa Cities

Rapid urbanization during the Tokugawa period stimulated the demand for vegetables consumed by the urban population in various aspects: quantity, quality and variety. As the population density increased, the city could not be self-sufficient to meet its own demand for food. The quantity of the demand for vegetables that needed to be "imported" from outside the city boundary increased rapidly as well. Increased interregional communication, travel and trade and accumulation of capital in Edo allowed the city to grow as the center of culinary culture as well; thus the demand for a variety of vegetables was stimulated in the city. Culinary culture created a passion for "seasonal" foods among the Edo population. This demand led some villages to specialize in growing vegetables artificially in earlier seasons.

With the progress in agriculture and commercial development, people in the city were increasingly interested in their foods; numerous cookbooks published at this time illustrate the variety of ingredients that were available in the city. People were eager to learn how to prepare the ingredients into fancy meals. Outside of China, Japan was the only country in Asia in this period where cookbooks were published. The first of its kind is considered to be *Ryôri Monogatari* (the Story of Cooking) which was published in 1643. In the eighteenth-century the focus of cookbooks shifted from the practical to pure culinary pleasure (Hanley, 1997). With increased wealth, the urban population's interests in culinary luxuries grew. Many people had reached a level of income at which they could afford a varied diet and wished to experiment with new, rare or exotic foods.

The Japanese tradition of appreciating the seasons made it fashionable to enjoy seasonal vegetables, fruits or fish earlier than anyone else; the first supply of a particular food was called *hatsumono*, literally meaning the first of a kind, and was sold at unusually high prices. Watanabe (1983) cites a government edict, which made it illegal to grow and sell vegetables extraordinarily early, issued during the Tempô restoration (1842). The quote describes how restaurants in the city competed with each other to buy such vegetables and paid high prices, and how peasants responded to the demand by using various techniques such as building protective structures in the vegetable fields and even heating nurseries with charcoal.

3.2 The Urban Market and Distribution of Vegetables

In the city of Edo, the demand for vegetables from the villages was generated primarily by the lower classes; the wealthier city residents had more land available to them, and thus were able to generate more of their own vegetable production. Commoners, in contrast, especially tenants who came to the city as unskilled artisans or day laborers, lived in small *nagaya* (row house) apartments. The density in these sections of the city is estimated to have been 40,000 to 60,000 persons per square km, nearly 30 times denser than modern Tokyo in 1979 (Watanabe, 1983). Tenants of such apartments undoubtedly lacked land to cultivate, and thus became the largest market for vegetables that were grown in the outskirts of the city.

At the beginning of the Tokugawa period, vegetables for urban consumption were produced both in and around the city. Although many urban households were still producing vegetables for self consumption, farmers began to sell excess produce in the city. They came to the city on foot, calling names of the day's supplies in front of households' doors. Watanabe cites a government edict to limit such selling issued in 1609 as evidence suggesting that such business was common among peasants. The rapid growth of the city, however, quickly made such small, independent transactions inefficient. Permanent market places for vegetables began to be established; some people became full-time merchants specialized in the marketing of fresh vegetables. Markets naturally evolved in areas with transportation advantages. Areas in the north of the city, such as Kanda, Senju and Komagome, were among the first markets that sprang up at the edge of the city in the late sixteenth and early seventeenth centuries. As the city expanded Honjo-Yottsume, Kyobashi and Shimoya (1657-1680), followed by Ryôgoku, Hamachô, Nakanogô and Aoyama (1688-1735), also evolved as autonomous vegetable markets to serve urban residents.

3.3 The Use of Urban Night Soil in Urban-Fringe Agriculture

As the demand for vegetables grew and agricultural production became more intensive, the use of urbanites' night soil as fertilizer became popular among farmers in the urban fringe. As the practice became common, various forms of contracts between the supplier (urban population) and the consumer (farmer) appeared. Over the same period, a defined system of circulation and transportation of night soil developed.

Watanabe (1983) cites *Kôka Shunjû* to illustrate the use of human night soil in agricultural production on the fringe of Kanazawa (the castle town of Kaga domain). The use and collection systems, as well as the price of night soil were differentiated depending on the distance from the city to villages. In villages near the city (within 4km), urine which is heavier than feces was also demanded; whereas farmers from farther villages only collected feces in the city. The price of the fertilizer also varied depending on the seasonal demand:

> Seven or eight years ago they used to exchange the urine for rice straw; in winter until the beginning of spring, they gave two small bundles of straw for one *ka* (two buckets) of urine. From the end of the second month to the third month, they gave three to four bundles of straw for the same amount of urine, and in the beginning of summer, when a lot of fertilizer is needed; they gave six bundles of straw.
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> In the past six or seven years, most urban households have come to think that straw was an insufficient reward for their urine. Therefore peasants have started to grow more vegetable produce such as *daikon* radish, turnip, squash, and eggplant to pay for it. This in turn requires larger amounts of fertilizer, thus, every morning farmers harvest the grown vegetables and exchange them for the night soil. …Since the rooster year of Hôei (1702), all commoners, regardless or whether they are poor or rich, ask for cash to pay for their night soil. It's free during the winter, and from the end of the second month to the seventh or the eighth month the rate is from 30 *mon* to 145 *mon* at the highest. The price becomes high when peasants need large amounts of fertilizer (Translated by author. Tsuchiya, *Kôka Shunjû* quoted in Watanabe, 1983, p. 282).

The period when these manuals were written was also the time when it became popular to harvest multiple crops from the same plot of land within a year. In order to maximize harvests (mostly vegetables) shipped to the city, farmers around Kyoto planted ten different crops in the same lot. Although this practice was profitable, *Kôka Shunjû* states that it was not sustainable without extensive application of fertilizers (Yamada, 1980). This must be an important factor in the increase in demand for fertilizers, which drove up the price of night soil over time.

3.4 Collection Systems and the Market for Night Soil in Edo

The process of urbanization in early-modern Japan meant two things to farmers in nearby villages: increased demand for agricultural products, and increased production of urban wastes. The former induced development in the villages, converting forestland in the fringe to fields to plant vegetables and other crops. Because the forestland used to be the source of fertilizers in earlier periods, the development exacerbated the need of fertilizer from outside sources. Collection of wastes from urban households became commercialized and the price of night soil was driven up as the demand increased (Watanabe, 1983).

During the early eighteenth-century, upper-class farmers, who had close relationships with urban warrior households, provided daily needs (fuel woods, charcoal or young plants to be grown in vegetable gardens) for the Edo castle or other *daimyô* estates from nearby villages. In return, these farmers had the privilege of cleaning and collecting wastes from toilets in the castle or *daimyô* estates. Since the upper-class warriors were wealthy and enjoyed a variety of foods, the night soil and kitchen wastes generated there were the best fertilizers in quality.

Although upper-class farmers controlled the access to the residences of upper-class warriors, the rapid expansion of the city and the increasing population in commoners' section gave peasants opportunities to collect night soil on their own. Sometimes villagers and urban residents made an explicit business contract for night soil transaction. *Kôka Shunjû* describes the collection practices employed by farmers who were 3-5 *ri* (12-20 km) away from the city of Kanazawa. Unlike farmers who were right next to the city, it was not efficient for them to come to the city to collect night soil on a daily basis. They instead had annual contracts called *tsuke-tsubo* with urban households. Their contract stipulated that the farmer would take all the night soil generated in the household in the year, and give a fixed amount of rice to the town household as a payment. The amount of the reward rice was five *to* (90 liters) for a household of seven to ten members, and was a half of that for a household of four or five members. In *nagaya* apartment communities in Edo, landlords held the property rights on their tenants' night soil. Therefore peasants had contracts with the landlords, and according to the contract, they brought cash to the landlords as reward for the night soil. As such transactions became common, the price of the night soil was standardized, establishing night soil as a market commodity. Farmers came to pick up the nightsoil every couple of weeks, which was then stored in field until it was used for planting (Watanabe, 1983).

3.5 The Cost of Transportation and the Geography of Urban-Fringe Agriculture in the Early Nineteenth-Century

As a fertilizer, a very important property of human night soil is that it contains large amount of water and is heavy in weight. For this reason, the cost of transportation became a limiting factor for its use. Watanabe (1983) cites *Kôka Shunjû* to illustrate the use of human night soil in agricultural production in the hinterland of Kanazawa (the castle town of Kaga domain).

> Within one *ri* [approximately 4 km] from Kanazawa in any direction they fertilize fields with urine and abundant manure. Within about three *ri* they use manure, rapeseed cake and dried sardine. Beyond four *ri,* manure, ash, dried sardine, and raw sardine are used. In remote areas they also use bushes and grasses (Translated by author. Tsuchiya, *Kôka Shunjû* quoted in Watanabe, 1983).

From this writing we learn that farmers who lived near the city heavily relied on the use of urine. It also says that urine was the primary fertilizer for farmers within one *ri* from the city; every morning they brought vegetables to exchange for urban households' urine.

When the night soil was transported over land, it had to be carried by a man, on horseback or on a small cart pulled by a man. They all mounted *koe-oke*, or buckets filled with the fertilizer. When a man carried night soil on his own, he mounted two *koe-oke* on both ends of a poll, and put the poll on his shoulder; this way he carried two *koe-oke* at a time and this load was called one *ka*. When a horse was used, it carried four *koe-oke* at a time so that the carrying capacity was two *ka*. Small man-powered carts (*ko-guruma*) were often employed as well and their capacity was also two *ka,* equivalent to four *koe-oke*. No matter which means were employed, therefore, transportation required a tremendous amount of labor.

In contrast, farmers in eastern villages were able to take advantage of riparian transportation. Since most boats had much larger capacity compared to ground transportation, moving ten buckets did not cost any more labor than moving two buckets at a time. Boats used to ship night soil were often called *koebune*, literally meaning "fertilizer boats." A boat of this kind could carry fifty *ka* of fertilizer at a time. Compared to ground

transportation, therefore, riparian transportation was 25 to 50 times more efficient in terms of carrying capacity. These boats shipped firewood, charcoal and vegetables produced on the way to the city, and brought the night soil back to home villages.

Either ground or riparian transportation, however, required certain costs to operate. With ground transportation, the cost of labor was critical; traveling to the city with farm products and bringing fertilizers back was a half day of work for someone in a village located 1.5 *ri* (5.9 km) from the city. In villages farther afield, it required a full day just to make a trip to carry 1-2 *ka* of night soil. Given these conditions, it was only possible for farmers who had *hôkô-nin* (full-time laborer in service) or could afford day laborers to collect fertilizers. In case of riparian transport, obtaining a boat meant a significant capital investment, and only those who could afford such a boat could start a business to ship and sell the fertilizer. Peasants who could not afford these transportation means had to rely on the rich farmers to sell them fertilizers.

4. IMPACTS OF POLITICAL CHANGE ON THE URBAN-FRINGE AGRICULTURE

4.1 Emergence of Modern Agricultural Science: 1868-1900

At the end of the Tokugawa period, agriculture was by far the most important industry in Japan, providing employment for roughly four out of five Japanese people (Francks, 1983). In the decades following the Meiji Restoration in 1868, the Japanese government took various measures to increase the productivity of the agricultural sector, which was the key to the country's economic development under the new administration.

It was in the 1870s that the new central government started to facilitate technological progress and academic research by hiring scholars and engineers from European countries and the United States. These scholars and engineers from Western countries were called *Oyatoi Gaikokujin* (hired foreigners) and at its peak Japan's government and private companies hired 600 to 900 people annually during the period from 1879-1899. Agricultural technology was one of the most important fields, reflecting the importance of agriculture in the nation's economy. These foreign scientists' efforts lead to the establishment of colleges of agricultural science in Sapporo in 1870 and in Tokyo in 1877 (Kawashima, 1929).

Oscar Kellner, a German agricultural scientist who served in the Komaba School of Agriculture (and later the Faculty of Agriculture at the Imperial University of Tokyo) for twelve years, starting from November of 1881, made countless contributions including the initiation of experimental research in agricultural chemistry. He led a number of inorganic chemistry research projects on fertilizers. His work included research on the use of phosphatic manures in rice production, as well as investigation of the contents of human night soil.

While Japan's traditional agricultural practices drew on experience, knowledge of plant physiology imported from the Western world enabled a new, scientific understanding of the functions of fertilizer. Information about the mechanisms of plant growth made it possible to understand the necessity of providing enough nitrogen (N), phosphate (P), and potassium (K) to grow crops; if a certain substance is lacking, it would prevent the growth of a plant even though other substances exist in abundance. The modern agricultural scientists began the process of reassessing the effects of various fertilizers through both theory and experiments.

New scientific information helped people to recognize the need for certain sources of manures such as phosphatic manures, which became popular in the early twentieth-century. Tsubame (1914) exhibits the three major contents (nitrogen, phosphate and potassium) of manures and the ratio of the total demand. As shown in Table 1, nitrogen was the most important and necessary manure content in Japanese agriculture because it is necessary for plants to grow but most plants cannot fix nitrogen from the air.

Table 1
Manure Demand by Content in Weight

Content	Nitrogen	Phosphate	Potassium
Percentage of Manure Demand in Japanese Agriculture	60%	30%	10%

Source: Tsubame (1914), p.8

As previously discussed, night soil was used as fertilizer over a long period of time. In the course of development in agricultural science in the late nineteenth-century, many experiments were conducted to examine the chemical contents and actual effectiveness of night soil. In addition, optimal use of manures for different types of crops was studied extensively in government-sponsored research institutes; by the 1910s substantial knowledge had accumulated on the properties of different types of fertilizers and their uses. Tsubame Sakuta authored a book titled *Shimogoe* (*Human Night Soil*) in 1914. This source provides a comprehensive set of information on the scientific basis of night soil's effects in growing crops

Since the types of soil, rainfall, temperature and many other factors substantially affect the effectiveness of fertilizer to grow crops, there is no single standardized method for the use of fertilizers. It is possible that different regions had different traditions in agricultural practices. However, books on agricultural science, including Tsubame's book, give significant insights on how fertilizers were applied.

Most fertilizers traditionally used in Japan were sources of nitrogen, except for rice bran which was a source of phosphate. Human night soil was one of the most frequently and widely used nitrogen manure, among others such as green manure and animal manure (Kawashima, 2006). According to one estimate, 36 percent of the 340,000 tons of nitrogen manure consumed annually in Japan was supplied in the form of night soil. Although the use of some commercial fertilizers (e.g. soybean cake) became fairly popular by this time, night soil was heavily relied upon.

Kellner gave a scientific basis for traditional fertilizing practices in Japanese agriculture. Although the content of excrement varies depending on diet, life style (intensity of physical labor), age, health and gender, there is still one distinguishing property as manure: it is a good source of nitrogen, but if it is used by itself (without being complemented by other sources of manure), it does not provide sufficient phosphate. The contents of average adult Japanese night soil are shown in Table 2; this estimate is based on research conducted in 1887 by Oscar Kellner and Mori Yôtarô, in the Komaba School of Agriculture and Forestry (Tsubame, 1914). In order to see the variation among diets and intensity of physical labor, they collected samples from different Japanese population groups: farmers (who ate little meat or fish and engaged in intensive physical labor), urban residents (whose diet was more diverse compared to that of farmers), public officers (who worked in the office and did not engage in physical labor), and members of the armed forces (whose diet included substantial amounts of meat as well as fish).

Human night soil is essentially the residue of what people eat after they have absorbed necessary nutrients. The night soil of a population that ate a lot of fish and meat generally contained more nitrogen and phosphate. People whose diet was mostly vegetarian (cereals and vegetables) had night soil that was generally poor in nitrogen and phosphates, but rich in potassium and salt. When a person engages in intensive physical labor, the concentration of nitrogen and other useful nutrients in excrement are lower compared to a person who engages in office work, since the nutrients are well absorbed by the body to provide energy. Therefore night soil from the population that ate more protein and engaged in less physical labor (i.e., urban residents) worked more effectively to grow crops. For similar reasons, excrement of a toddler, child, or pregnant or breast-feeding woman was lower in content value since more nutrition is absorbed to build bones and muscles. Night soil in summer usually contains more fertilizing contents, since more water leaves the body as sweat rather than as urine.

Table 2
Contents of Average Japanese Night Soil

Content	Water	Organic matters	Nitrogen	Phosphate	Potassium	Salt	Ash
Average Japanese night soil	951.0	33.7	5.7	1.3	2.7	10.2	16.0

Unit: permil (1/1000) in weight
Source : Tsubame (1914), p. 38

The scientific understanding of the contents of human night soil also allowed researchers to compare the actual effectiveness of night soil with other major commercial manures. Tsubame examined the "true value" of night soil based on Kellner's experiment. By weight, nitrogen constitutes 0.57%, phosphoric acid constitutes 0.13%, and potassium constitutes 0.27%, of night soil. In contrast, nitrogen constitutes 13.5% of standard soybean cake, phosphoric acid constitutes 3.3% of superphosphate of lime, and potassium constitutes 14.8% of grass ash. From these comparisons, in order to meet the entire nitrogen requirement with human night soil, it would be necessary to use 24 times more by weight than would be necessary with soybean cake. Likewise, night soil weighs 25 times and 59 times more than commercial phosphoric or potassium fertilizer would, respectively. The difference results from the high water content in human night soil; this difference made the transport cost (as well as the labor cost to use the fertilizer in field) much higher for night soil compared to other commercial fertilizers.

4.2 Changes in Fertilizer Transportation

During the late nineteenth-century, production of vegetables in the urban fringe prospered and the demand for the urban night soil increased. Technology brought from Western cultures, as well as road improvement, made the transportation of fertilizer and agricultural products easier. While the modernization of Japanese cities required some small adjustments in the urban night soil market, agriculture in the urban fringe prospered throughout this period.

A land tax reform (*chiso kaisei*) was instituted in 1873; under the new system, taxes were calculated based on assessed land value, rather than on production estimates. Landowners were obliged to pay their tax in cash instead of rice. This reform also encouraged farmers to produce vegetables that brought them greater cash income per unit of land, even though this required more labor-intensive production processes (Francks, 1983). A year prior to the tax reform, the new government also created a new deed system that clearly defined ownership of real estate. In this process, former common forest lands in villages that had served as a source of green manure (grass and bushes) were defined as national land, and in many places peasants were prohibited from entering the area. By limiting access to sources of traditional fertilizers, this policy increased the demand for fertilizers brought from outside the village boundary.

Transportation technology such as improvement of roads also played an important role for advancing the market in human night soil. During the Tokugawa period, all wheeled vehicles were made of wood and pushed by men on muddy roads. But Japan was under pressure from a treaty with the U.S. and Great Britain to build satisfactory settlements for Europeans and Americans in Yokohama, where the international port was built, because the use of horse-drawn carts was necessary for these foreigners. Paving the roads became an urgent project for Japan. The nation hired a British civil engineer, Richard Henry Brunton, and his first project in Japan was to pave the road from Tokyo to Yokohama. This project was completed in the fall of 1870, and major streets in and around Tokyo were paved shortly after (Brunton, 1991).

The improvement of roads and streets allowed the use of carts as a popular means of transportation. Around 1874-1880, carts with an iron axle and wheels began to be produced, and came to be widely used among farmers for their work. This marked a "revolution" in transportation of agricultural products as well as that of fertilizers. The amount of night soil that one person could carry increased from 2 *ka* to 3 or 4 *ka* when a cart was used. The size of a standard *koe-oke*, responding to this change, also became larger: from 2 *to* to 2.8 *to* (Watanabe, 1991).

4.3 Geography of Urban-Fringe Agriculture in 1890: Evidence from *Nôji Chôsa*

Nôji Chôsa is the first nationwide agricultural inventory. The Meiji administration conducted this inventory to get hold of various aspects of agricultural activities, including the amount of production of crops, use of manures, financial conditions of peasants, and marketing of the produce. Some records from the Tokugawa period, such as *Bukô Sanbutsushi*, included the locations of agricultural productions but did not have the information on the quantity or value. *Nôji Chôsa*, in contrast, allows us to compare agricultural activities with quantitative information across counties in and around the Tokyo metropolitan area. Within this nationwide inventory, the record from Tokyo-fu (1890) sheds light on the condition of urban-fringe agriculture in the Tokyo Metroplitan area.

For the same period of time, the Prefectural Statistics (*Tokyô-fu Tôkeisho*) include data on population, occupation, land use and other figures that provide a sense of the general socio-economic condition of the region. Drawing on descriptions from these documents and an original GIS analysis based on the statistics, this section explores the economic geography of urban-fringe agriculture in the late nineteenth-century.

4.3.1 Profile of Tokyo's Land Use: 1868-1890

The report of *Nôji Chôsa* for the Tokyo Metropolitan Area is divided into sections of fifteen wards (*ku*) and six counties (*gun*). The fifteen wards roughly corresponded to the former boundary of the city of Edo. Table 3 provides the summary of these boundaries, created from the Prefectural Statistics (*Tôkyô-fu Tôkeisho*) of 1890, and Figure 1 shows the boundaries of the city (tinted in pink) and surrounding counties. The boundary of the city almost corresponded to the official boundary of the former city of Edo. The Imperial Palace, built on the site of the former Edo Castle, constituted the very center of the city and was a part of Kôjimachi-ku.

The overall population of the city was 1,207,000, and the average density was 16,437 people/km^2. While the area of each ward was around five hundred hectares, population density greatly reflected land use planning in the Tokugawa Edo.

Districts where former warriors predominated enjoyed low population densities because many of them returned to their home regions. In contrast, few commoners left the city and the former commoners' districts such as Kanda-ku, Nihonbashi-ku, and Kyôbashi-ku had small areas; therefore, they continued to have high population densities. In fact, commercial activities increased in importance in the new capital. These wards then had extraordinarily high population densities; in Nihonbashi-ku, more than 47,000 people were crammed in an area as small as one square km. These population density figures are surprisingly high, if compared to the density of modern cities to which we often ascribe many urban problems.

The six counties surrounding the city of Tokyo (Ebara, Higashi-Tama, Minami-Toshima, Kita-Toshima, Minami-Aadachi and Minami-Katsushika) formed the hinterland for the city. In 1890, the population in these counties was only 323,000 persons in total. Except for the small portion of Minami-Toshima County (the present-day downtowns of Shinjuku and Shibuya), this area formed strictly agricultural villages, and the population densities were lower than 1,000 people/km^2.

Table 3
Summary of Wards and Counties in Tokyo: 1890

Ward/County	Total Area	Population	Density	% of Total Area		
	(ha)	(persons)	(persons/km2)	Paddy field	Dry Field	Residential
Kojimachi-ku	833.06	58,697	7,046	0.0	0.2	27.0
Kanda-ku	300.30	122,961	40,946	0.0	0.0	67.3
Nihonbashi-ku	298.12	139,427	46,769	0.0	0.0	61.6
Kyobashi-ku	336.70	104,447	31,021	0.0	0.0	44.2
Shiba-ku	758.38	118,393	15,611	1.2	9.4	47.1
Azabu-ku	381.62	50,121	13,134	2.6	14.4	57.0
Akasaka-ku	407.21	31,763	7,800	0.6	11.9	36.1
Yotsuya-ku	211.84	36,139	17,060	0.5	7.1	55.2
Ushigome-ku	497.36	46,485	9,346	3.5	9.5	49.1
Koishikawa-ku	620.83	48,035	7,737	3.1	25.9	36.9
Hongo-ku	466.51	62,124	13,317	4.0	12.9	52.9
Shimoya-ku	488.83	88,186	18,040	5.9	3.6	47.4
Asakusa-ku	466.61	124,177	26,612	9.8	0.9	55.3
Honjo-ku	590.18	97,938	16,594	14.1	2.5	57.6
Fukagawa-ku	689.56	78,768	11,423	12.3	3.2	43.8
Total of Wards	7,347.10	1,207,661	16,437	4.4	7.1	47.0
Ebara	10,229.69	87,189	852	20.0	45.3	7.8
Higashi-tama	4,609.70	20,523	445	10.0	54.3	6.7
Minami-toshima	2,438.29	33,087	1,357	8.0	48.6	12.4
Kita-toshima	10,462.45	76,019	727	20.1	49.4	7.3
Minami-adachi	4,890.86	40,074	819	56.9	23.5	6.8
Minami-katsushika	9,044.66	66,610	736	57.0	16.1	7.1
Total of Counties	41,675.64	323,503	776	30.6	38.6	7.5

Created by author based on *Tokyo-fu Tokeisho (Tokyo Prefectural Statistics),* 1890

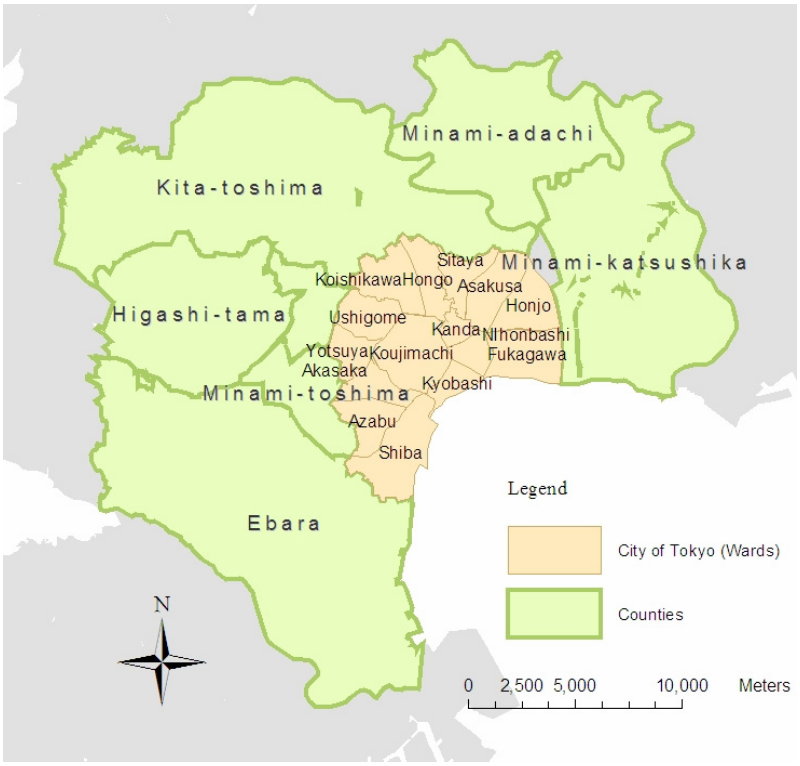

Fig. 1 — *Boundaries of the City of Tokyo and Surrounding Counties in 1890.*

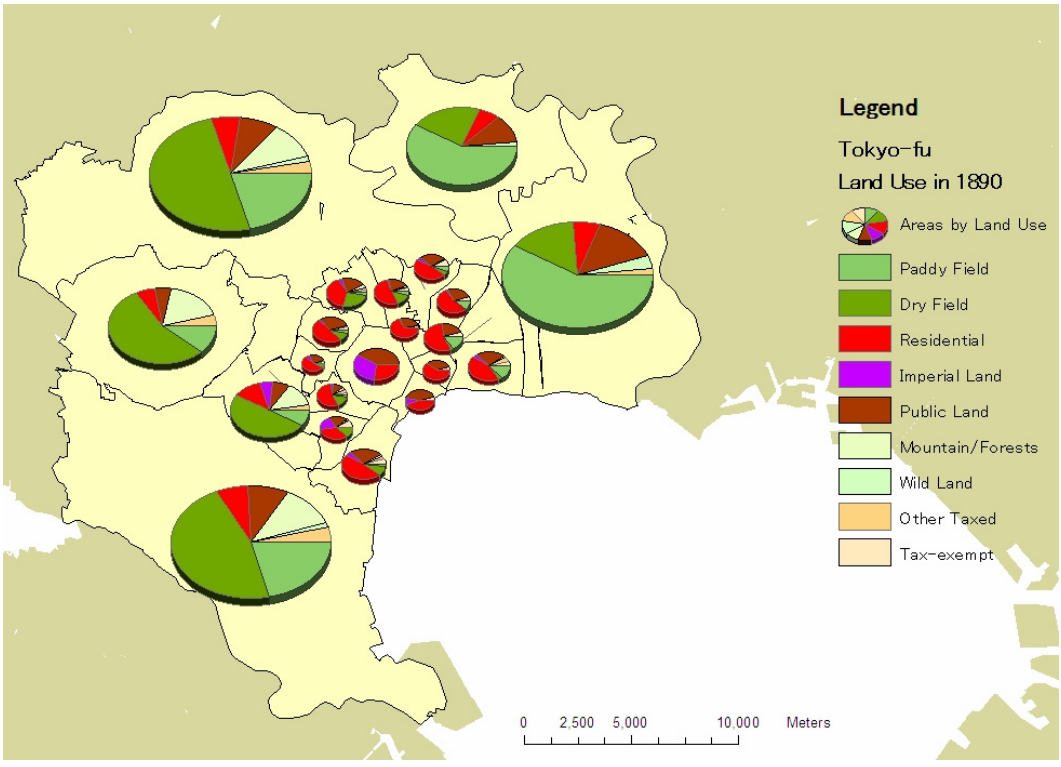

Fig. 2 — *Land Use in Wards and Counties of Tokyo-fu in 1890.*

The land use in each ward of the city and surrounding counties is available through the Prefectural Statistics. This information is summarized in Table 3 and Figure 2. The land use patterns we see here also confirm the urban-rural separation between the city wards and surrounding counties.

In the central four wards, land use was mostly categorized as "residential", "imperial" or "public," and there was virtually no agricultural land. Other wards on the outer edge of the city were 10-30 percent agricultural (paddy or dry field) but were mostly devoted to urban land use (residential or public). The relatively large portion of dry field in western wards can be explained as the legacy of the "tea and mulberry" policy, with which the Meiji Government promoted conversion of former warrior estates that became vacant after they left the city into tea and mulberry fields. As a result, Koishikawa-ku had 156.7 ha as agricultural fields that occupied more than 25% of the total area.

In contrast, most of the land in surrounding counties was agricultural (either paddy or dry field). In Minami-Toshima County, people who worked in nonagricultural sectors started to reside in the southwest areas that were closest to the city center; but the county as a whole still had 56.6 percent of its land as agricultural fields. In other counties the ratio exceeded 64 percent. In eastern counties (Kita-adachi and Minami-katsushika) that had low and wet land, as well as well-developed canal and irrigation through the rivers, more than half of the total land area was paddy field suited for paddy rice production. In western counties that had high and dry land, most of agricultural land was dry field suited for production of wheat, barley, beans and other vegetables. In the western counties, some areas were categorized as "mountains and forests;" there were also some areas categorized as "wild land."

4.3.2 Agricultural Production in Tokyo: 1890

Table 4 shows the distribution of agricultural production, based on *Nôji Chôsa*. As in most parts of Japan, rice fields accounted for the largest area of farm land as well as in the highest production value among all crops in Tokyo-fu. Total rice production was far below the total consumption of the city's population, however; in many cases rice was produced for self-consumption for the farmers' family members. Most rice sold in Tokyo's market was imported from other regions of Japan.

On the other hand, vegetables were specialties of the metropolitan region, and some were even exported to other regions. A majority of farmers brought their produce to vegetable markets, as well as selling to traders who came to the villages. In some (though fewer) cases, middlemen traveled to villages to contract purchases before the harvest of vegetables. It was also common for farmers themselves to bring their produce to the city and sell it directly to urban households as street vendors (Ôhashi, 1979a).

The most popular single vegetable produced in the Tokyo Metropolitan Area was white radish (*daikon*). They were most actively grown in three counties of Higashi-Tama, Minami-Toshima and Kita-Toshima. Not fully matured harvests were collected and cleaned to sell to a wholesaler from Tokyo Vegetables Market, and fully matured ones were dried and/or pickled and sold to middlemen.

Other vegetables that were particularly noticeable were eggplant and cucumber. The production of these vegetables was heavily concentrated in Minami-Katsushika County. These vegetables are usually grown in the summer; but in this county, the first was harvested and went out to the market in February. Because of their rarity, these vegetables were highly appreciated and highly priced. Due to the development of transportation networks, some of these vegetables were even exported to Hokkaido or other remote areas as novelties. Exports of eggplant and cucumber also increased over the course of the 1880s.

4.3.3 Transportation Means and the Use of Fertilizers

Nôji Chôsa also states what the major sources of agricultural fertilizers were for each ward and county. Wards and counties adjacent to the densely populated areas benefited from the easy access to human night soil, and used it as the primary (or in some cases the only) source of fertilizer. In contrast, counties which were farther from the city relied more on autarkic and commercial fertilizers, depending on their access to them. Per acreage of farm land, vegetables required more fertilizers than rice or other cereals. Therefore, vegetable production on the urban fringe was advantageous not only because of the ease of marketing the produce but also in terms of acquiring necessary fertilizers.

Table 4
Geographical Distribution of Agricultural Production by Crop

County	Crop	Rice	Soybean	Radish	Eggplant	Cucumber	White squash	Greens	Burdocks	Sweet potatoes	nursery trees	milk	fowl	eggs
	Unit	*koku*	*koku*	*kan*	*kan*	*kan*	*kan*	*kan*	*kan*	*kan*		*koku*		
Kojimachi-ku												805.8	5,547	
Kanda-ku												302.5	1,006	29,378
Nihonbashi-ku												298.4	35	16,740
Kyobashi-ku												916.4	458	2,290
Shiba-ku		63.0									20,774	919.0		
Azabu-ku		112.6									51,455		3,430	6,840
Akasaka-ku		1.9										422.5	9,720	61,200
Yotsuya-ku		16.3		1,000	100	100	100	1,000				336.0	3,600	150,000
Ushigome-ku		144.9	7.0	1,800	1,010	29		870	85	2,250	6,670	847.0	234	2,537
Koishikawa-ku		148.6	16.2	24,000	23,000					2,592	15,000	405.8	9,773	210,750
Hongou-ku		12.0		19,100	343	193	129	350				635.8	2,378	3,505
Shimoya-ku		12.6										580.6	11,217	16,200
Asakusa-ku		23.8					120	200				432.3	120	6,750
Honjo-ku		427.5										284.7	270	7,573
Fukagawa-ku		146.9	1.5	300	12,460	3,520	842	1,385				141.1	31	1,900
Total of Wards		1,110.1	24.7	46,200	36,913	3,842	1,191	3,805	85	4,842	93,899	7,327.9	47,819	515,663
Ebara		40,658.3	5,001.6	1,602,307	1,044,940	184,415	285,873	374,334	247,705	1,275,869	135,103	260.1	4,048	893,852
Higashi-tama		9,703.8	1,175.3	2,480,573	232,430	1,238	91,489	16,805	31,906	442,689	35,860	4.7	5,483	220,381
Minami-toshima		4,135.9	72.3	984,560	366,459	18,882	98,879	6,675	2,033	196,384	541,700	139.9	2,135	135,342
Kita-toshima		41,980.7	5,639.8	8,189,453	624,260	123,462	191,619	971,612	241,350	1,090,968	612,285	598.0	24,014	1,051,249
Minami-adachi		46,380.1	2,780.5	131,742	154,680	113,088	178,800	571,920	47,895	3,000			10,140	527,740
Minami-katsushika		95,309.0	2,068.0	161,907	2,048,990	1,731,074	1,515,732	7,083,920	26,700	10,875	29,410		10,220	389,977
Total of Counties		238,167.8	16,737.5	13,550,542	4,471,758	2,172,159	2,362,392	9,025,266	597,589	3,019,785	1,354,358	1,002.7	56,040	3,218,541
Total		239,277.9	16,762.2	13,596,742	4,508,671	2,176,001	2,363,583	9,029,071	597,674	3,024,627	1,448,257	7,222.3	97,306	3,704,826

* Calculated based on *Tôkyô-fu Nôji Chôsa* (1890)

Table 5 shows the standard requirement of fertilizers for representative crops, as presented in Tsubame (1914). Although this type of information is not available for all kinds of crops, it is shown that commercial crops and vegetables require more fertilizers compared to cereals, on average. Particularly notable here is eggplant, which requires more than twice as much fertilizer as rice does per acre. In contrast, sweet potato requires less fertilizer compared to rice, barley or wheat. Comparing these characteristics to the locations of agricultural production discussed in earlier sections, we can see that the production of crops that required intensive fertilization, such as eggplant, greens, cucumber and squash, were concentrated in the areas that had particularly good access to urban night soil such as Minami-katsushika and Kita-toshima Counties.

Access to fertilizers, as of the late 1880s, is explicitly recorded as a part of the *Nôji Chôsa* survey. In urbanized wards, the primary source of fertilizers was night soil. In the central four wards, no crops were grown and thus no fertilizer was used.

Reports from other urbanized wards such as Yotsuya-ku, Koishikawa-ku, Hongô-ku, Ushigome-ku, Honjo-ku and Fukagawa-ku also state that their primary fertilizer was night soil. Occasionally, when the supply from their own households was not enough for farming, they purchased night soil from wholesalers in the city or had fixed-term (in many cases annual) contracts to purchase night soil from non-farming households in the neighborhood.

For villages in counties that had larger agricultural fields but were farther from the urban center, the use of night soil was limited by geographical factors (i.e., transport costs). Because of this, the survey form of *Nôji Chôsa* had sections on "Means of Transportation" and "Access to Fertilizers" next to each other. Counties in the East of Tokyo benefited from access to riparian transportation. Minami-katsushika county was the beneficiary of well-developed canals:

> Means of transportation: there are means of transportation for both boats and wheeled vehicles. The ward benefits from this convenience.
>
> Access to fertilizers: the urbanized districts of Tokyo are very close to the county. The large population in the city allows the county superior access to fertilizer. In addition, access through boats and carts allow us easy access to imports from other regions. (Translated by author. Ôhashi, 1979b, p. 317)

Minami-adachi and Kita-toshima counties also had superior access to fertilizers. In addition to the access through Arakawa and Nakagawa rivers, Minami-adachi county had access to Arakawa River as well as to the

Table 5
Fertilizer Requirement by Crop

Crop	Nitrogen	Phosphate	Potassium
rice (paddy)	2.00	1.30	1.30
rice (dry field)	1.70	1.30	1.30
barley, rye	2.30	1.40	1.90
wheat	1.40	1.20	1.40
millet (*awa*)	1.30	1.10	1.00
millet (*kibi*)	1.30	0.85	1.00
sweet potato (*kansho*)	1.00	0.80	1.30
canolla	2.00	1.40	1.60
indigo	4.00	2.00	1.80
hemp (*asa*)	2.90	2.30	3.00
mulberry (*kuwa*)	3.00	1.20	2.00
tea	3.00	1.50	1.50
radish (*rafu, daikon*)	2.50	1.50	2.00
eggplant (*nasu*)	5.00	2.00	3.00

Source: Tsubame (1914), p. 125-6. Unit: *kan*

newly developed railway (Kawagoe Railway) that helped to transport acquired fertilizers from the city of Tokyo.

Fertilizer use depended on location and access to the sources of fertilizer. Table 6 shows the standard fertilizing practice for rice production, per 1 *tan* of paddy field, as presented in *Tokyo-fu Nôji Chôsa*. From this table it is clear that the farmers used every type of good fertilizer that was available in their county and its vicinity, in order to minimize the cost of shipping; eastern counties used more human night soil, and the western counties (Ebara, Higashi-tama, and Minami-toshima) which did not have as convenient means of transportation as the eastern villages, had to apply a wider variety of fertilizers. Eastern counties relied more on the urban night soil.

From this evidence, it becomes clear that the geography of agriculture in the late nineteenth-century was determined by the means of transportation and resulting access to sources of fertilizer. The eastern counties took advantage of low transport costs through riparian transportation, and prospered through production of fertilizer-demanding vegetables.

Table 6
Quantity and Monetary Value of Fertilizers for Rice Production by County (per 1 *tan*)

County		**Ebara**		**Higashi-tama, Minami-toshima**		**Kita-toshima, Eastern**	
Type of Fertilizer	**unit**	**quantity**	**value**	**quantity**	**value**	**quantity**	**value**
Human night soil	*ka*	14.0	1.959	1.0	0.100	27.0	2.700
Dried sardine (*hoshika*)	*kan*	8.0	1.234				
Oilcakes	*kan*	5.6	1.361				
Seaweed	*ka*	6.0	0.347				
Herring cake (*shimekasu*)	*to*			3.0	1.500		
Sardine (*hoshikasu*)	*to*			3.0	0.875		
Soybean	*to*			1.5	0.750		
Weeds	*kan*			30.0	0.300		
Total			4.901		3.525		2.700

County		Kita-toshima, Western		Minami-adachi		Miami-katsushika	
Type of Fertilizer	unit	quantity	value	quantity	value	quantity	value
Human night soil	*ka**	15.0	1.500	216.0	1.500	30.0	2.700
Dried sardine (*hoshika*)	*kan*	12.5	2.500	12.0	3.000	12.5	3.000
Oilcakes	*kan*						
Total			4.000		4.500		5.700

*Created by author based on *Tokyo-fu Noji Chosa* (1890)
*Unit for the quantity of human night soil in Minami-adachi County is *kan* .
* Unit for the monetary value is *yen* .

5. CONCLUSION

Excrement in Edo/Tokyo and its surrounding areas during the early modern period and the late nineteenth-century have been examined. Urban human night soil as agricultural fertilizers became popular when early modern cities emerged during the seventeenth and eighteenth centuries. With the development of agricultural and transportation technology in the late nineteenth-century, the marketing of human night soil became more sophisticated. At the end of the nineteenth-century, the crops grown and the types of fertilizers used were chiefly determined by the proximity to the urban population, who represented the main consumers of farmers' produce as well as the source of fertilizer. Through bringing human excrement out of the city, this practice is considered to have greatly helped in preventing pandemic diseases. While growing foods with human night soil posed risks of oral infection or waterborne diseases, the custom of cooking foods thoroughly and drinking boiled water (or tea) kept this risk minimal (Hanley, 1997). The handling of night soil was considered to be hard work, but was not subject to cultural taboos.

Although it is beyond the scope of this article and was not mentioned, the demand for night soil fertilizer did not match the increased supply of it during the rapid expansion of Tokyo in the early twentieth-century, exacerbating the waste and sewer problem along with other various urban issues associated with rapid sprawl (Tajima, 2005). In the Japanese case, the environmental interdependence of the city and its fringe worked effectively only under certain conditions: the size of the city, agricultural and transportation technologies, and costs of resources such as other sources of fertilizer and labor. This article highlights a unique resource management practice that a Japanese city enjoyed in the course of modern urbanization. ◗

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